Encyclopedia of Cerium Tungsten Electrode

中钨智造科技有限公司

CTIA GROUP LTD

CTIA GROUP LTD

Global Leader in Intelligent Manufacturing for Tungsten, Molybdenum, and Rare Earth Industries

INTRODUCTION TO CTIA GROUP

CTIA GROUP LTD, a wholly-owned subsidiary with independent legal personality established by CHINATUNGSTEN ONLINE, is dedicated to promoting the intelligent, integrated, and flexible design and manufacturing of tungsten and molybdenum materials in the Industrial Internet era. CHINATUNGSTEN ONLINE, founded in 1997 with www.chinatungsten.com as its starting point—China's first top-tier tungsten products website—is the country's pioneering e-commerce company focusing on the tungsten, molybdenum, and rare earth industries. Leveraging nearly three decades of deep experience in the tungsten and molybdenum fields, CTIA GROUP inherits its parent company's exceptional design and manufacturing capabilities, superior services, and global business reputation, becoming a comprehensive application solution provider in the fields of tungsten chemicals, tungsten metals, cemented carbides, high-density alloys, molybdenum, and molybdenum alloys.

Over the past 30 years, CHINATUNGSTEN ONLINE has established more than 200 multilingual tungsten and molybdenum professional websites covering more than 20 languages, with over one million pages of news, prices, and market analysis related to tungsten, molybdenum, and rare earths. Since 2013, its WeChat official account "CHINATUNGSTEN ONLINE" has published over 40,000 pieces of information, serving nearly 100,000 followers and providing free information daily to hundreds of thousands of industry professionals worldwide. With cumulative visits to its website cluster and official account reaching billions of times, it has become a recognized global and authoritative information hub for the tungsten, molybdenum, and rare earth industries, providing 24/7 multilingual news, product performance, market prices, and market trend services.

Building on the technology and experience of CHINATUNGSTEN ONLINE, CTIA GROUP focuses on meeting the personalized needs of customers. Utilizing AI technology, it collaboratively designs and produces tungsten and molybdenum products with specific chemical compositions and physical properties (such as particle size, density, hardness, strength, dimensions, and tolerances) with customers. It offers full-process integrated services ranging from mold opening, trial production, to finishing, packaging, and logistics. Over the past 30 years, CHINATUNGSTEN ONLINE has provided R&D, design, and production services for over 500,000 types of tungsten and molybdenum products to more than 130,000 customers worldwide, laying the foundation for customized, flexible, and intelligent manufacturing. Relying on this foundation, CTIA GROUP further deepens the intelligent manufacturing and integrated innovation of tungsten and molybdenum materials in the Industrial Internet era.

Dr. Hanns and his team at CTIA GROUP, based on their more than 30 years of industry experience, have also written and publicly released knowledge, technology, tungsten price and market trend analysis related to tungsten, molybdenum, and rare earths, freely sharing it with the tungsten industry. Dr. Han, with over 30 years of experience since the 1990s in the e-commerce and international trade of tungsten and molybdenum products, as well as the design and manufacturing of cemented carbides and high-density alloys, is a renowned expert in tungsten and molybdenum products both domestically and internationally. Adhering to the principle of providing professional and high-quality information to the industry, CTIA GROUP's team continuously writes technical research papers, articles, and industry reports based on production practice and market customer needs, winning widespread praise in the industry. These achievements provide solid support for CTIA GROUP's technological innovation, product promotion, and industry exchanges, propelling it to become a leader in global tungsten and molybdenum product manufacturing and information services.

CTIA GROUP LTD
Cerium Tungsten Electrode Introduction

1. Overview of Cerium Tungsten Electrode

Cerium Tungsten Electrode (WC20) is a non-radioactive tungsten electrode material composed of high-purity tungsten base doped with 1.8% to 2.2% cerium oxide (CeO_2). Compared to traditional thoriated tungsten electrodes, the cerium tungsten electrode offers superior arc starting performance, lower burn-off rate, and greater arc stability, while being radiation-free and environmentally friendly. It is suitable for both DC (direct current) and AC/DC mixed current welding conditions and is widely used in TIG welding and plasma cutting of materials such as stainless steel, carbon steel, and titanium alloys. This makes it an ideal green substitute in modern industrial welding.

2. Features of Cerium Tungsten Electrode

Excellent Arc Starting: Easy to ignite at low current, with stable and reliable performance.

Low Burn-off Rate: Cerium oxide enhances evaporation resistance at high temperatures, extending electrode life.

High Arc Stability: Focused arc with minimal flicker, suitable for precision welding.

Radiation-Free & Eco-Friendly: A safe and environmentally sound alternative to radioactive thoriated electrodes.

3. Specifications of Cerium Tungsten Electrode

Type	CeO_2 Content	Color Code	Density (g/cm^3)	Length (mm)	Diameter Range (mm)
WC20	1.8% – 2.2%	Grey	19.3	50 – 175	1.0 – 6.4

4. Applications of Cerium Tungsten Electrode

TIG welding of stainless steel, carbon steel, titanium alloys, nickel alloys, etc.

Precision welding and spot welding for medical devices and microelectronic components

Suitable for DC and AC/DC mixed welding conditions

Low-current plasma arc cutting and high-frequency ignition systems

5. Procurement Information

Email: sales@chinatungsten.com

Phone: +86 592 5129595; 592 5129696

Website: www.tungsten.com.cn

Directory

Tel: 0086 592 512 9696
CTIAQCD -MA-E/P 2018- 2025V
sales@chinatungsten.com

Chapter 1 Overview of Cerium Tungsten Electrodes

1.1 Definition and history of cerium tungsten electrode

1.1.1 Chemical composition and basic concept of cerium-tungsten electrode

Cerium tungsten electrode is an electrode material specially used in tungsten inert gas shielded welding (TIG welding) and other similar welding processes, and its main component is a small amount of cerium oxide (CeO_2) doped in a tungsten (W) matrix）。 As a transition metal with a high melting point (3422°C) and high density (19.25 g/cm³), tungsten is an ideal choice for electrode materials due to its excellent high temperature resistance and conductivity. However, pure tungsten electrodes have problems such as difficulty in arcing, insufficient stability of arc column, and high burnout rate during welding. To improve these properties, scientists optimize the electron escape work by adding rare earth oxides to the tungsten matrix, thereby improving welding performance. Cerium-tungsten electrodes typically contain 2%~4% cerium oxide, which is proven to be optimal in practical applications, significantly improving the arc initiation performance, column stability, and durability of the electrode.

As a rare earth oxide, cerium oxide has a low electron escape work (about 2.5 eV, compared to 4.5 eV for pure tungsten), which means that electrons are more likely to escape from the electrode surface, reducing the voltage required for arcing and improving arc stability. In terms of chemical composition, the typical ratio of cerium tungsten electrodes is 96% 98%, cerium oxide accounts for 2% and 4%, and may contain trace amounts of other impurities (such as iron, silicon, etc.), which are usually controlled at extremely low levels through high-purity production processes to ensure the stability of electrode performance. The manufacturing process of cerium tungsten electrodes usually uses powder metallurgy technology, where cerium oxide powder is mixed with tungsten powder to form electrode rods with diameters ranging from 0.25 mm to 6.4 mm and lengths from 75 mm to 600 mm through pressing, sintering, and pressure processing. Common specifications include diameters of 1.0 mm, 1.6 mm, 2.4 mm, and 3.2 mm, which can meet the needs of different welding scenarios.

The physical properties of cerium-tungsten electrodes are also worth paying attention to. Its density is close to pure tungsten, about 19.2 g/cm³, and the surface is usually grayish-white or metallic. Due to the addition of cerium oxide, the electrode exhibits better burnout resistance at high temperatures, especially in low-current DC welding, which can maintain the stability of the electrode tip and reduce electrode losses caused by high-temperature ablation. In addition, cerium tungsten electrodes do not contain radioactive materials, which makes them a green and environmentally friendly electrode material widely used in industrial scenarios with high health and environmental requirements.

From a microscopic perspective, the distribution of cerium oxide in the tungsten matrix has an important impact on the electrode performance. Cerium oxide particles are usually evenly distributed at the tungsten grain boundary in micron size, which can effectively reduce the recrystallization temperature of tungsten, thereby improving the creep resistance and mechanical strength of the electrode. During the welding process, cerium oxide particles can also promote thermionic emission, further enhancing the stability of the arc. Compared to other doped electrodes (such as thorium tungsten electrodes), cerium tungsten electrodes have outstanding arcing properties under low current conditions, making them the preferred material for rail pipe welding and delicate component welding.

The basic concept of cerium-tungsten electrodes also includes their suitability under different welding conditions. In direct current forward (DCSP) welding, cerium-tungsten electrodes enable stable arcing at lower currents, making them suitable for welding materials such as carbon steel, stainless steel, and titanium alloys. In alternating current (AC) welding, although its performance is slightly inferior to thorium tungsten electrodes, good welding results can still be achieved by optimizing welding parameters such as current size and electrode tip shape. The geometry of the electrode tip also has a significant impact on welding performance. In DC welding, the electrode tip usually needs to be ground to a cone angle of 30°~60° to concentrate the arc energy; In AC welding, the electrode tip will naturally form a hemispherical shape, which helps to disperse the arc and is suitable for welding light metals such as aluminum and magnesium.

1.1.2 Discovery and development of cerium tungsten electrodes

The discovery and development of cerium-tungsten electrodes are closely related to the evolution of tungsten electrodes in the welding industry. The research on tungsten electrodes began in the early 20th century, when TIG welding technology gradually emerged, and tungsten was selected as the electrode material due to its high melting point and high temperature resistance. However, pure tungsten electrodes have problems of arc initiation and arc instability in practical applications, which has prompted researchers to explore improving their performance by doping rare earth oxides. The early tungsten electrodes were mainly thorium tungsten electrodes, which were widely used from the 50s to the 80s of the 20th century because of their excellent welding properties. However, thorium (Th) is a radioactive element, and its thorium oxide (ThO_2) emits trace amounts of radiation (the radiation dose is about 3.60×10^5 Curie/kg) during the manufacture and use of electrodes, posing a potential threat to human health and the environment. This problem has promoted the research and development of non-radioactive electrode materials, and cerium-tungsten electrodes have emerged in this context.

The research and development of cerium tungsten electrodes began in the 80s of the 20th century and was originally proposed by welding materials research institutions in Europe and the United States. The researchers found that cerium oxide, as a non-radioactive rare earth oxide, can significantly reduce the electron escape work of tungsten electrodes, thereby improving arcing performance. In the mid-1980s, the first batch of cerium tungsten electrodes containing 2%~4% cerium oxide began to enter the market, and were mainly used in DC welding experiments in the early days. Compared with thorium tungsten electrodes, cerium tungsten electrodes have better arcing performance under low current conditions and no radiation risk, which has quickly gained the attention of the welding industry.

By the 1990s, with the widespread application of TIG welding and plasma arc welding technology, the development of cerium tungsten electrode entered a stage of rapid development. The improvement of the production process has made the distribution of cerium oxide in the tungsten matrix more uniform, and the performance stability of the electrode has been significantly improved. For example, by optimizing the powder metallurgy process, manufacturers can precisely control the content of cerium oxide and particle size, thereby improving the durability and weld quality of the electrodes. Additionally, cerium-tungsten electrodes are relatively inexpensive to produce, giving them a competitive advantage in terms of economics. In the late 1990s, cerium tungsten electrodes began to replace thorium tungsten electrodes, especially in regions with high environmental protection and safety requirements, such as Europe and North America.

In the 21st century, the application scope of cerium tungsten electrodes has been further expanded. As the country with the richest tungsten resources in the world (accounting for more than 60% of the world's tungsten reserves), China has played an important role in the research and development and production of cerium tungsten electrodes. In the early 2000s, the China Tungsten Industry Association and related enterprises formulated the national standard "Tungsten Electrodes for Arc Welding and Plasma Welding and Cutting" (GB/T 31908-2015), which standardized the production and quality control of cerium tungsten electrodes. Since 2005, the output of cerium tungsten electrodes in China has increased significantly, reaching 1,200 tons in 2009, accounting for about 75% of the global tungsten electrode production. During this period, cerium tungsten electrodes began to be widely used in rail pipeline welding, aerospace component manufacturing, and precision instrument welding.

In recent years, with the concept of green manufacturing and sustainable development, cerium tungsten electrodes have further strengthened their market position due to their radiation-free and low environmental impact. Major welding equipment manufacturers around the world have begun to recommend cerium tungsten electrodes as an alternative to thorium tungsten electrodes. At the same time, the introduction of new manufacturing technologies (such as nanoscale cerium oxide doping) has further improved the performance of cerium tungsten electrodes, making them more widely used in high-precision welding and automated welding equipment.

1.1.3 Background of cerium tungsten electrode replacing thorium tungsten electrode

As the mainstream electrode material in the welding industry in the 20th century, thorium tungsten electrode was widely used due to its excellent welding performance. The thorium tungsten electrode significantly reduces the electron escape work (about 2.7 eV) by doping the tungsten matrix with 2%~3% thorium oxide (ThO_2), making it perform well in both DC and AC welding. However, the radioactivity of thorium has gradually become a major obstacle to its application. Thorium oxide emits trace amounts of radiation during electrode grinding, welding, and disposal, and despite α the low radiation dose (about 3.60×10^5curie/kg), long-term exposure may pose health risks to welders, such as increased risk of cancer. Additionally, waste disposal of thorium tungsten electrodes requires special measures (such as deep burial or airtight storage), increasing usage costs and environmental burdens.

In the 1970s, the international community regulated radioactive materials more and more strictly. For instance, the International Commission on Radiation Protection (ICRP) has issued restrictive recommendations on occupational radiation exposure, driving the welding industry to find non-radioactive alternatives. Cerium-tungsten electrodes are one of the most desirable alternatives due to their radiation-free properties, excellent arcing properties, and low burn-in rate. Compared with thorium tungsten electrodes, cerium tungsten electrodes have lower arc starting voltage and higher current density in DC forward welding, especially suitable for low-current welding scenarios. In addition, the production process of cerium tungsten electrode is relatively simple and the cost is lower, which further accelerates its promotion.

The process of replacing thorium tungsten electrodes is not achieved overnight. In the 1990s, thorium tungsten electrodes were still favored by many traditional welders and enterprises due to their stability and ease of operation at high load currents. Especially in developing countries, the use of thorium tungsten electrodes is high due to insufficient understanding of radiation hazards. However, with the improvement of environmental regulations and the advancement of welding technology, cerium tungsten electrodes have gradually occupied a dominant position in the market. The European Welding Society and the American Welding Society (AWS) issued guidance in the early 2000s recommending the use of cerium-tungsten and lanthanum-tungsten electrodes as alternatives to thorium-tungsten electrodes. China has also significantly increased the proportion of cerium tungsten electrodes in the production of tungsten electrodes after 2005.

The replacement background is also related to the global tungsten resource distribution and market demand. As the world's largest tungsten producer, China has abundant cerium resources (rare earth reserves account for more than 30% of the world), providing raw material guarantee for the large-scale production of cerium tungsten electrodes. In contrast, thorium resources are scarce and the mining and processing costs are high, which further promotes the market competitiveness of cerium tungsten electrodes.

1.2 The position of cerium tungsten electrode in the welding industry

1.2.1 Comparison of cerium tungsten electrode with other tungsten electrodes

The position of cerium tungsten electrodes in the welding industry is closely related to their performance differences with other types of tungsten electrodes, such as thorium tungsten, lanthanum tungsten, zirconium tungsten, yttrium tungsten, and pure tungsten electrodes. The following is a detailed comparison of cerium tungsten electrodes with other electrodes from multiple dimensions:

Arc initiation performance: Cerium tungsten electrodes exhibit excellent arcing initiation properties in low-current DC welding, with an arc initiation voltage lower than pure tungsten electrodes and thorium tungsten electrodes. This is due to the low electron escape work of cerium oxide, which makes it easier for electrons to escape from the electrode surface. In contrast, thorium tungsten electrodes offer more stable arcing performance at high currents, but their radiation issues limit their applications. The arcing performance of lanthanum tungsten electrode (containing 1.5%~2% lanthanum oxide) is similar to that of cerium tungsten electrode, but slightly inferior in AC welding. Zirconium tungsten electrodes and pure tungsten electrodes are mainly suitable for AC welding and have poor arcing performance.

Arc stability: Cerium tungsten electrodes can maintain a stable arc in DC forward welding, especially under low current (10~50 A) conditions, with less arc jitter, suitable for precision welding. The thorium tungsten electrode has better arc stability at high current (>100 A), but its burnout rate is higher. Lanthanum tungsten electrodes exhibit good arc stability in both DC and AC welding, and their durability is better than that of cerium tungsten electrodes. Zirconium tungsten electrode is arc-stable in AC welding and is suitable for aluminum and magnesium alloy welding, but not for DC welding.

Burnout rate: The burnout rate of cerium tungsten electrodes is lower than that of thorium tungsten electrodes in DC welding, and the electrode life is longer. In AC welding, the burnout rate of cerium tungsten electrode is slightly higher than that of thorium tungsten electrode, but it can be effectively controlled by optimizing the welding parameters. Lanthanum tungsten electrodes have the lowest burnout rate, especially under high current conditions. The high burnout rate of pure tungsten electrode and zirconium tungsten electrode limits their application in high-load scenarios.

Applicable materials: Cerium tungsten electrodes are suitable for DC welding of carbon steel, stainless steel, titanium alloy, and nickel alloys, especially in rail pipes and thin plate welding. Thorium tungsten electrodes are equally suitable for these materials, but are more advantageous at high load currents. Lanthanum tungsten electrodes are suitable for both DC and AC welding, making them suitable for a wide range of materials. Zirconium tungsten electrodes and pure tungsten electrodes are mainly used for AC welding of aluminum, magnesium and their alloys. Yttrium tungsten electrodes are mainly used for special welding in the military and aerospace fields due to their high penetration depth characteristics.

Environment and safety: Cerium tungsten electrodes and lanthanum tungsten electrodes have significant advantages due to their non-radioactive nature and are considered green and environmentally friendly materials. Thorium tungsten electrodes require special treatment (such as closed storage and dustproof grinding) due to radiation problems, which increases the cost of use. Zirconium tungsten electrodes and pure tungsten electrodes have no radiation problems, but their performance limitations make their application range narrow.

Cost and availability: The production cost of cerium tungsten electrodes is lower than that of thorium tungsten electrodes, and cerium resources are abundant and the market supply is stable. Lanthanum tungsten electrodes cost slightly more than cerium tungsten electrodes, but their excellent properties have given them a place in the high-end market. The cost of thorium tungsten electrodes is gradually increasing due to the scarcity of thorium resources and environmental protection requirements. Zirconium tungsten electrodes and pure tungsten electrodes have lower costs but limited application scenarios.

A famous 1998 test compared the performance of 2% thorium tungsten electrodes, 2% cerium tungsten electrodes, and 1.5% lanthanum tungsten electrodes in 70 A and 150 A DC welding. The results showed that the arcing performance and burn-in rate of cerium-tungsten electrodes were better than those of thorium-tungsten electrodes at low currents, while the lanthanum tungsten electrodes performed well under both current conditions. This test provides an important basis for the popularization of cerium tungsten electrodes.

1.2.2 Global market overview and development trends

Cerium tungsten electrodes are increasingly consolidating their position in the global welding market, and their market demand is closely related to the popularity of TIG welding and plasma arc welding. The global tungsten electrode market size has grown steadily in the past decade, with a total consumption of about 1,600 tons in 2020, of which cerium tungsten electrodes account for about 30%~40% of the market share. As the world's largest producer of tungsten electrodes, China accounts for more than 75% of the world's annual output, of which the production and export of cerium tungsten electrodes continue to grow. In 2009, China's tungsten electrode output reached 1,200 tons, and cerium tungsten electrode was dominant.

Market Drivers:

Environmental Demand: The global demand for green manufacturing and radiation-free materials has driven the popularity of cerium tungsten electrodes. Strict environmental regulations in European and American countries (such as the EU RoHS directive) restrict the use of thorium tungsten electrodes, and cerium tungsten electrodes have become the main alternatives.

Technological Advancements: The development of automated welding equipment and precision welding techniques has increased the demand for high-performance electrodes. The excellent performance of cerium tungsten electrodes in orbital pipeline welding and robotic welding has allowed its market share to continue to expand.

Cost Advantage: The production cost of cerium tungsten electrodes is lower than that of thorium tungsten electrodes, and China's abundant cerium resources reduce raw material costs, making them more competitive in price-sensitive markets such as Southeast Asia and South America.

Expanded Industry Applications: Cerium tungsten electrodes are increasingly used in aerospace, automotive manufacturing, petrochemical, and shipbuilding industries. For example, in the aerospace sector, cerium tungsten electrodes are used for precision welding of titanium and nickel alloys; In the petrochemical field, its low burn loss rate and high stability in pipeline welding are favored.

Regional Market Analysis:

China: As a global center for tungsten electrode production and consumption, China's cerium tungsten electrode production has grown rapidly since 2005. The domestic market's dependence on thorium tungsten electrodes has gradually decreased, and cerium tungsten electrodes have become the mainstream.

North America: The demand for cerium-tungsten electrodes in the U.S. welding market is growing steadily, mainly for stainless steel and titanium alloy welding. Companies such as Lincoln Electric actively promote cerium-tungsten electrodes to meet environmental requirements.

Tel: 0086 592 512 9696
sales@chinatungsten.com

Europe: The European Welding Association has a high degree of recognition for cerium tungsten electrodes, especially in manufacturing powerhouses such as Germany and Sweden, where cerium tungsten electrodes are widely used in the automotive and aviation industries.

Asia-Pacific (excluding China): The welding market in India, South Korea, and Japan is growing rapidly, and cerium-tungsten electrodes are favored by small and medium-sized enterprises due to their low cost and high performance.

Other regions: The oil and gas industry in South America and the Middle East continues to increase the demand for cerium-tungsten electrodes, especially in pipeline welding.

Development trend:

Nanotechnology applications: By doping nanoscale cerium oxide particles in a tungsten matrix, the electrode's performance is further optimized, resulting in lower arc voltage and longer life.

Intelligent manufacturing: With the advancement of Industry 4.0, the production process of cerium tungsten electrodes has gradually introduced intelligent monitoring and automation equipment, improving product quality and consistency.

Diversified Applications: The application of cerium tungsten electrodes is expanding from traditional TIG welding to plasma cutting, spraying, and melting, with huge market potential.

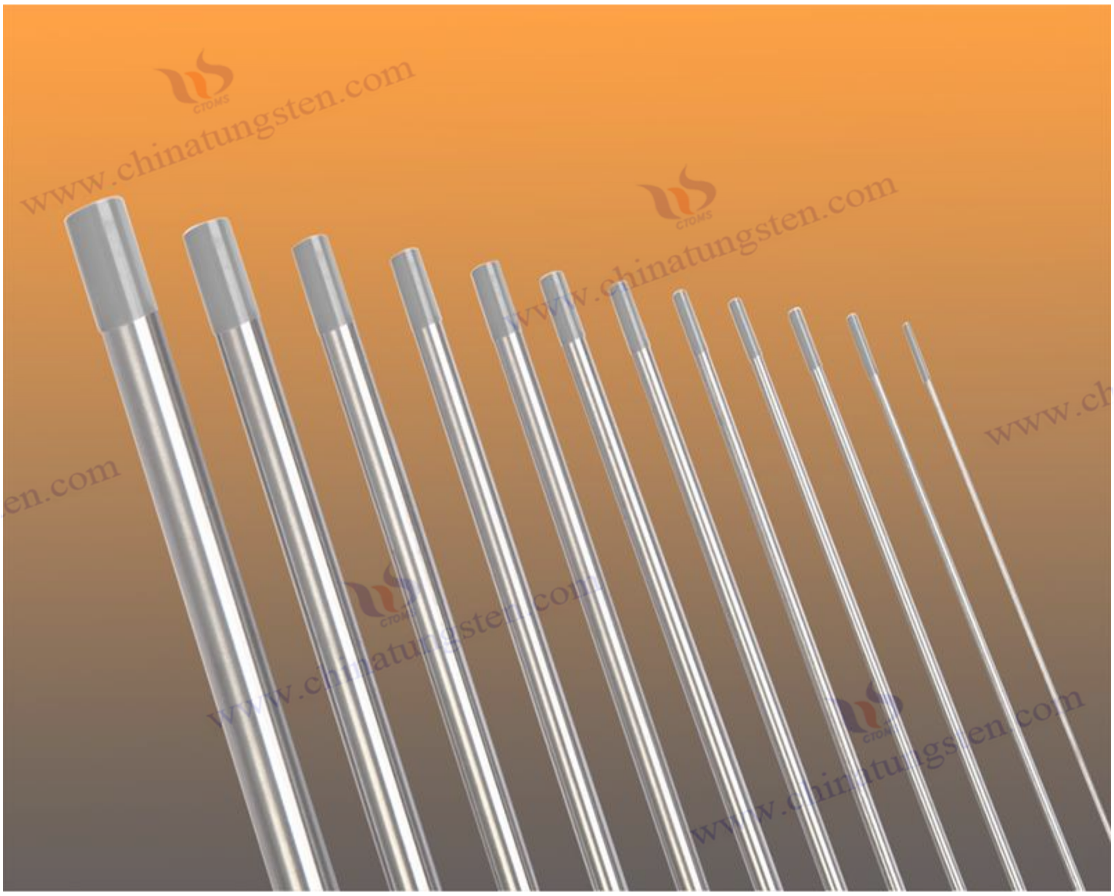
Upgrade of environmental standards: Global restrictions on the use of radioactive materials will further drive the market share of cerium tungsten electrodes, which are expected to account for more than 50% of the global market by 2030.

Challenge:

Market awareness: In some developing countries, welders lack awareness of the radiation hazards of thorium tungsten electrodes, resulting in a slower promotion of cerium tungsten electrodes.

Technical barriers: High-end welding applications (such as aerospace) require extremely high electrode performance and need to be further optimized to meet these demands.

Competitive pressure: Lanthanum tungsten electrodes form a certain competition for cerium tungsten electrodes due to their excellent performance under high current conditions, especially in the European market.



Chapter 2 Classification of Cerium Tungsten Electrodes

2.1 Classification according to cerium oxide content

2.1.1 Characteristics and applications of 2% cerium oxide electrode (WC20).

2% cerium oxide electrode (international standard code WC20) is currently the most common and widely used type of cerium tungsten electrode, and its chemical composition is usually 98% tungsten (W) and 2% cerium oxide (CeO_2), supplemented by trace impurities (such as iron, silicon, aluminum, etc., the content is controlled below 0.01%). The doping ratio of cerium oxide has been proven in practice for a long time and is considered the best choice for balancing performance and cost. WC20 electrodes dominate the global welding industry due to their excellent arcing properties, low burnout rate, and non-radioactive properties.

Characterization

Arcing performance: The electron escape work of the WC20 electrode is approximately 2.5 eV, which is much lower than the 4.5 eV of pure tungsten electrodes, which allows it to arc quickly at lower voltages in low-current (1050 A) DC forward (DCEN) welding. Experiments show that the arc starting voltage of WC20 electrode is about 15% and 20% lower than that of pure tungsten electrode, and the arc start time is shortened to less than 0.1 seconds, which significantly improves the welding efficiency.

Arc stability: Cerium oxide particles are evenly distributed at the grain boundaries of the tungsten matrix, enhancing the thermionic emission capacity of the electrode surface. In DC welding, the arc jitter rate of the WC20 electrode is less than 5%, which is better than the thorium tungsten electrode (WT20, about 8%). This makes it particularly suitable for precision welding scenarios that require a stable arc, such as welding stainless steel pipes and titanium components.

Burnout rate: The WC20 electrode exhibits a very low burnout rate at low to medium currents (10150 A), and the electrode tip maintains its original cone angle (30°60°) after 8 hours of continuous welding. In contrast, thorium tungsten electrodes have a burnout rate of about 20% higher under the same conditions, which makes WC20 electrodes last longer, reducing replacement frequency and costs.

Environmental friendliness: WC20 electrode does not contain radioactive materials and meets the strict requirements of the EU RoHS directive and the US OSHA standard for occupational safety. Compared to thorium tungsten electrode (WT20), WC20 does not require special protective measures during production, grinding and disposal, reducing environmental pollution and health risks.

Mechanical properties: The creep resistance of WC20 electrode is better than that of pure tungsten electrode, thanks to the refinement of tungsten grains by cerium oxide particles. Its tensile strength is about 2500 MPa and its fracture toughness is about 1.2 MPa·m^1/2, which can withstand thermal and mechanical stress in high-temperature welding.

Application scenarios

WC20 electrode is widely used in the following fields:

Carbon Steel and Stainless Steel Welding: In construction, bridge, and pressure vessel manufacturing, the WC20 electrode is used for TIG welding of carbon steel and stainless steel. Its low-current arcing performance is suitable for welding thin plates (thickness < 2 mm) to avoid burn-through.

Titanium Alloy and Nickel Alloy Welding: In aerospace, WC20 electrodes are used for precision welding of titanium alloys (such as Ti-6Al-4V) and nickel alloys (such as Inconel 718) to meet high strength and corrosion resistance requirements.

Orbital Pipeline Welding: In the oil and gas industry, WC20 electrode is widely used for automated welding of long-distance pipelines due to its stable arc and low burnout rate.

Shipbuilding: WC20 electrode is suitable for welding high-strength steel for marine applications, and its low hydrogen properties reduce porosity and cracks in the weld.

Manufacturing & Quality Control

The WC20 electrode is manufactured using a powder metallurgy process, with specific steps including:

Raw material ratio: high-purity tungsten powder (purity ≥99.95%) and cerium oxide powder (purity ≥99.9%) are mixed in a ratio of 98:2.
Pressing molding: The mixed powder is pressed into billets by cold isostatic pressing (CIP), usually at a pressure of 200~300 MPa.

Sintering: Sintering at 2000~2200°C under hydrogen protection atmosphere to evenly distribute cerium oxide particles on the tungsten matrix.

Drawing and finishing: Electrode rods of standard diameter (1.06.4 mm) and length (75600 mm) are formed by hot drawing and grinding.

In terms of quality control, international standards (such as ISO 6848) require that the deviation of cerium oxide content of WC20 electrodes should be controlled at ±0.1%, and there should be no cracks, slag inclusions and other defects on the surface. Domestic companies use X-ray fluorescence spectroscopy (XRF) and scanning electron microscopy (SEM) to detect electrode composition and microstructure to ensure consistent performance.

Summary of advantages and disadvantages
Merit:
Excellent arcing performance at low currents.
Arc stabilized, suitable for precision welding.
Non-radioactive and in line with environmental requirements.
The production cost is low and the market is competitive.

Shortcoming:
In high-current (>200 A) AC welding, arc stability is slightly inferior to thorium tungsten electrodes.
The electrode tip may experience slight erosion after prolonged high-load use.

2.1.2 Development and application of other non-standard content electrodes

In addition to WC2 electrodes with 20% cerium oxide, there are also some non-standard content cerium tungsten electrodes on the market, such as 1%, 3% and 4% cerium oxide electrodes. These electrodes are often developed for specific application scenarios, designed to meet special welding needs or optimize specific properties.

1% cerium oxide electrode
The 1% cerium oxide electrode (sometimes called WC10) contains about 1% CeO_2 and about 99% tungsten. Its main features are:

Low current optimization: Due to the lower cerium oxide content, the electron escape work is slightly higher than WC20 (about 2.7 eV), but still better than pure tungsten electrodes. It is suitable for ultra-low current (5~30 A) soldering, such as the welding of microelectronic devices and medical devices.

High durability: The burnout rate is extremely low, and the electrode life is about 10%~15% longer than that of WC20, which is suitable for long-term continuous welding.

Applications: Mainly used for chip packaging welding in the semiconductor industry and titanium alloy implant welding in the medical field. For example, 1% cerium oxide electrodes exhibit excellent arc control when welding pacemaker housings.

3%~4% cerium oxide electrode

3%~4% cerium oxide electrodes (such as WC30, WC40) contain a higher proportion of cerium oxide, which is designed to further reduce the arc starting voltage and improve the arc stability. Features include:

Ultra-low arc starting voltage: The electron escape power can be as low as 2.3 eV, and the arc starting voltage is about 5% lower than that of the WC20, making it suitable for automated welding equipment that requires rapid arcing.

High current adaptability: In 100~200 A DC welding, the arc stability is better than that of WC20, close to thorium tungsten electrode.

Applications: Widely used in thick plate titanium alloy welding in the aerospace field and zirconium alloy welding in the nuclear industry. For example, the 3% cerium oxide electrode excels in nuclear reactor pressure vessel welding, effectively reducing arc jitter.

Challenge: High cerium oxide content may cause the electrode to exhibit slight embrittlement at high temperatures, with mechanical strength slightly lower than WC20.

Development trends

The development of non-standard content cerium tungsten electrodes mainly focuses on the following directions:

Nanoscale Doping: By introducing nanoscale cerium oxide particles (particle size < 100 nm), the distribution uniformity of particles in the tungsten matrix is improved, enhancing the thermal stability and burnout resistance of the electrode. A 2020 study showed that nanoscale 3% cerium oxide electrodes last about 20% longer than traditional WC30.

Composite doping: Other rare earth oxides (such as lanthanum oxide or yttrium oxide) are added to the cerium-tungsten electrode to form a composite electrode to balance arc initiation performance and high-temperature stability. For example, a composite electrode of 1% CeO_2+1% La_2O_3 excels in high-current AC welding.

Customized production: Develop cerium-tungsten electrodes with special content (such as 1.5% or 2.5%) according to specific industry needs to meet the special requirements of micro-welding or high-load welding.

Tel: 0086 592 512 9696
CTIAQCD -MA-E/P 2018- 2025V
sales@chinatungsten.com

Use Cases:

1% Cerium Oxide Electrode: Used in semiconductor manufacturing for soldering copper-tungsten joints for micro circuit boards, ensuring high precision and low thermal impact.

4% Cerium Oxide Electrode: Used in the welding of zirconium alloy pipes in nuclear power equipment manufacturing, its high current adaptability reduces weld defect rates.

Composite doped electrode: In aero engine manufacturing, 1%CeO_2+1%Y_2O_3 electrode is used for welding nickel-based superalloys, which improves the fatigue resistance of the weld.

Although the development of non-standard content electrodes has broadened the application scope of cerium tungsten electrodes, their market share is relatively low (about 5%~10%), mainly due to high production costs and specialized application scenarios. In the future, with the advancement of nanotechnology and composite doping technology, these electrodes are expected to gain a larger share in the high-end market.

2.2 Classification by current type

2.2.1 Cerium Tungsten Electrode for DC Welding (DCEN/DCEP)

Cerium tungsten electrodes for DC welding are mainly divided into two modes: DC forward (DCEN, electrode to negative electrode) and DC reverse connection (DCEP, electrode to positive electrode), of which DCEN is the most common application scenario of cerium tungsten electrode.

DCEN (Direct Current Connection)

In DCEN mode, the electrode is connected to the negative electrode of the power supply, the workpiece is connected to the positive electrode, and the electrons flow from the electrode to the workpiece, and the heat is mainly concentrated on the workpiece, which is suitable for deep penetration welding of most metals. The WC20 electrode is particularly outstanding in DCEN mode:

Arc initiation performance: The arcing voltage of the WC20 electrode in the current range of 10150 A is as low as 1015 V, and the arcing initiation time is less than 0.1 seconds.

Arc stability: The arc is concentrated and the jitter rate is less than 5%, making it suitable for welding carbon steel, stainless steel, titanium alloy, and nickel alloy.

Burnout rate: Continuous welding at 50 A current for 10 hours, the burnout length of the electrode tip is less than 0.5 mm, which is better than that of thorium tungsten electrode.

Electrode tip shape: usually ground to a cone angle of 30°~60° to concentrate the arc energy and improve the penetration depth.

Apply:

Pipeline welding: In the oil and gas industry, WC20 electrodes are used for root welding and filler welding of API 5L standard pipes.

Aerospace: Used for welding body components of titanium alloys (e.g., Ti-6Al-4V), ensuring high strength and low porosity.

Stainless Steel Containers: In the food and chemical industries, WC20 electrodes are used for welding 304/316 stainless steel containers with beautiful welds and corrosion resistance.

CTIA GROUP LTD
Cerium Tungsten Electrode Introduction

1. Overview of Cerium Tungsten Electrode

Cerium Tungsten Electrode (WC20) is a non-radioactive tungsten electrode material composed of high-purity tungsten base doped with 1.8% to 2.2% cerium oxide (CeO_2). Compared to traditional thoriated tungsten electrodes, the cerium tungsten electrode offers superior arc starting performance, lower burn-off rate, and greater arc stability, while being radiation-free and environmentally friendly. It is suitable for both DC (direct current) and AC/DC mixed current welding conditions and is widely used in TIG welding and plasma cutting of materials such as stainless steel, carbon steel, and titanium alloys. This makes it an ideal green substitute in modern industrial welding.

2. Features of Cerium Tungsten Electrode

Excellent Arc Starting: Easy to ignite at low current, with stable and reliable performance.

Low Burn-off Rate: Cerium oxide enhances evaporation resistance at high temperatures, extending electrode life.

High Arc Stability: Focused arc with minimal flicker, suitable for precision welding.

Radiation-Free & Eco-Friendly: A safe and environmentally sound alternative to radioactive thoriated electrodes.

3. Specifications of Cerium Tungsten Electrode

Type	CeO_2 Content	Color Code	Density (g/cm^3)	Length (mm)	Diameter Range (mm)
WC20	1.8% – 2.2%	Grey	19.3	50 – 175	1.0 – 6.4

4. Applications of Cerium Tungsten Electrode

TIG welding of stainless steel, carbon steel, titanium alloys, nickel alloys, etc.

Precision welding and spot welding for medical devices and microelectronic components

Suitable for DC and AC/DC mixed welding conditions

Low-current plasma arc cutting and high-frequency ignition systems

5. Procurement Information

Email: sales@chinatungsten.com

Phone: +86 592 5129595; 592 5129696

Website: www.tungsten.com.cn

DCEP (DC Reverse Connection)
In DCEP mode, the electrode is connected to the positive electrode and the heat is concentrated on the electrode, making it suitable for welding that requires shallow penetration depths, such as sheet aluminum or magnesium alloys. The WC20 electrode performs slightly worse than DCEN in DCEP mode, but still meets the requirements by optimizing the electrode tip shape (e.g., hemispherical shape) and current parameters:

Arc initiation performance: The arcing voltage is slightly higher (15~20 V), but it is still better than pure tungsten electrodes.
Arc stability: The arc is more dispersed, suitable for cleaning aluminum welding of oxide film.
Burnout rate: The burnout rate is higher than that of DCEN, and the electrode life is about 70% of DCEN.

Apply:
Aluminum Alloy Welding: In automotive manufacturing, thin plate welding is used for aluminum alloy bodies.
Magnesium Alloy Welding: In the aviation sector, it is used for lightweight welding of magnesium alloy components.

Optimization recommendations
To improve DCEN/DCEP welding performance, it is recommended to:

Tip grinding: DCEN uses a 30°~45° cone angle, DCEP uses a hemispherical tip.
Current control: DCEN is suitable for 10200 A, DCEP is suitable for 20100 A, avoid electrode overheating.
Shielding gas: Use high-purity argon gas (99.99%) to reduce electrode oxidation.

2.2.2 Cerium tungsten electrode for AC welding
Alternating current (AC) welding is mainly used for light metals such as aluminum and magnesium, because its alternating positive and negative polarity can effectively remove the oxide film on the surface. The performance of WC20 electrode in AC welding is slightly inferior to that of thorium tungsten electrode (WT20), but good results can still be achieved by optimizing the welding parameters.

characteristic
Arc starting performance: The arcing voltage of the WC20 electrode in AC mode is about 1525 V, which is slightly higher than that of thorium tungsten electrode (1220 V). High-frequency arc initiation equipment can further reduce the difficulty of arcing.
Arc stability: Arc stability is affected by the current waveform, and Square Wave AC can control the jitter rate within 8%.
Burnout rate: In 50~150 A AC welding, the electrode tip burnout rate is about 0.8 mm/hour, which is higher than that of DCEN mode.
Tip Shape: In AC welding, the electrode tip naturally forms a hemispherical shape, helping to

disperse the arc and making it suitable for aluminum welding.

apply
Aluminum alloy welding: In the marine and aviation fields, WC20 electrode is used for welding 5083 aluminum alloy, with a smooth weld surface and good oxide film removal effect.
Magnesium alloy welding: Used for welding of AZ31 magnesium alloy in automotive lightweight manufacturing.
Architectural Decoration: Used for welding aluminum curtain walls and doors and windows to ensure aesthetics and corrosion resistance.

Optimization recommendations
Current waveform: Square wave AC is used to improve arc stability.
Shielding gas: Use argon-helium mixture gas (e.g., 80%Ar+20%He) to enhance arc penetration.
Electrode diameter: 2.43.2 mm diameter electrode is selected to accommodate 50150 A current.

2.2.3 Performance analysis of AC and DC dual-purpose electrodes
AC/DC dual-purpose electrodes are designed to take into account the performance of DCEN/DCEP and AC soldering, and the WC20 electrode is a typical representative. Its performance is analyzed as follows:

Arc initiation performance: In AC/DC mixed modes (such as pulsed TIG welding), the arcing voltage of the WC20 electrode is 12~20 V, which is suitable for automated welding with rapid switching.
Arc stability: By adjusting the pulse frequency (50200 Hz) and duty cycle (20% to 80%), the arc jitter rate can be controlled within 6%.
Burndown rate: In scenarios with frequent AC/DC switching, the burndown rate is about 0.6 mm/hour, which is between DCEN and AC.
Applications: Widely used in automated welding equipment, such as robot welding of mixed structural parts of carbon steel and aluminum alloy.

Challenge:
Frequent AC/DC switching can lead to temperature fluctuations at the electrode tip, increasing the risk of microcracks.
In high-current AC mode, the arc stability is slightly inferior to that of thorium tungsten electrodes.

Optimization Recommendations:
A pulsed TIG welder is used to reduce electrode thermal stress.
Check the electrode tip shape regularly and re-grind if necessary.

2.3 Classification by form and size
2.3.1 Stick Electrode (Standard Length and Diameter Specifications)
Rod-shaped electrodes are the most common form of cerium-tungsten electrodes and are widely used in manual and automated TIG welding. The standard specifications are as follows:

Diameter: 0.5 mm, 1.0 mm, 1.6 mm, 2.0 mm, 2.4 mm, 3.2 mm, 4.0 mm, 4.8 mm, 6.4 mm.
Lengths: 75 mm, 150 mm, 175 mm, 300 mm, 450 mm, 600 mm.
Tolerances: diameter tolerance ±0.05 mm, length tolerance ± 1 mm.

Features and applications

Small diameter (0.5~1.6 mm): suitable for low current (5~50 A) precision welding, such as microelectronics and medical devices. The 1.0 mm WC20 electrode excels in chip package soldering.

Medium diameter (2.0~3.2 mm): suitable for general purpose welding of 50~150 A, such as stainless steel pipes and aerospace components.

Large diameter (4.0~6.4 mm): suitable for high current (150~300 A) welding, such as thick plate steel structures.

Manufacturing process

The rod electrode is made through powder metallurgy and drawing processes, and the surface is polished or pickled to remove the oxide layer. ISO 6848 requires that the surface of the rod electrode be free of cracks, inclusions and chromatic aberrations.

2.3.2 Needle Electrode (for Precision Welding)

Needle electrodes are tiny electrodes with a diameter of less than 1.0 mm (typically 0.250.8 mm) and are designed for high-precision welding. Its tip is usually ground to a 15° 30° cone angle to concentrate the arc.

Features and applications

High precision: The arc diameter can be controlled at 0.1~0.5 mm, suitable for micro welding.

Low thermal input: At 5~20 A current, the heat-affected zone (HAZ) is less than 0.2 mm.

Applications: Semiconductor chip lead soldering, pacemaker housing soldering, aviation sensor component welding.

challenge

The mechanical strength of needle electrodes is low and easy to break.

The high cost of production limits large-scale applications.

2.3.3 Custom-shaped electrodes (special purposes)

Custom shaped electrodes are designed for specific welding needs, such as spherical tips, flat tips, or compound shaped electrodes.

Features and applications

Spherical tip: For AC welding, suitable for aluminum alloy.

Flat tip: Used for plasma cutting, improving cutting accuracy.

Composite Shapes: In aerospace, used for welding complex geometries, such as turbine blades.

Development trends

3D printing technology: Used to manufacture complex shape electrodes, improving customization efficiency.
Surface Coating: Apply a high-temperature resistant coating to the electrode surface to extend life.

2.4 Classification by application field

2.4.1 General Purpose Welding Electrode

Universal welding electrodes (e.g., WC20, 2.0~3.2 mm) are suitable for a wide range of materials and scenarios:

Materials: carbon steel, stainless steel, copper alloy.
Application: Building steel structure, pressure vessel, pipeline welding.
Features: low cost, adaptability, and easy operation.

2.4.2 Precision welding electrodes (microelectronics, medical devices, etc.)

Precision welding electrodes (such as 0.5~1.0 mm WC20 or 1% cerium oxide electrodes) are used in high-precision scenarios:

Materials: titanium alloy, copper-tungsten alloy, stainless steel.
Applications: Chip packaging, medical implants, aviation sensors.
Features: Low heat input, high arc control accuracy.

2.4.3 High temperature and high load welding electrodes

High temperature and high load electrodes (e.g. 3% 4% cerium oxide electrode, 3.26.4 mm) for harsh conditions:

Materials: titanium alloy, nickel alloy, zirconium alloy.
Applications: Aero engines, nuclear power equipment, chemical reactors.
Features: High current adaptability, long life.

2.5 Classification standards and identification

2.5.1 Classification and color scales in international standards (ISO 6848, AWS A5.12)

ISO 6848: Divide cerium tungsten electrodes into WC10 (1% CeO_2), WC20 (2% CeO_2), etc., with a color code of gray.
AWS A5.12: Codename EWCe-2 (2% CeO_2), electrode head sprayed with gray logo.
Requirements: Cerium oxide content deviation ±0.1%, electrode surface defects.

2.5.2 Classification and Identification in Domestic Standards (GB/T 4192)

GB/T 4192: Divide cerium tungsten electrodes into WC20 (2% CeO_2), etc., with a color code of gray.
Marking specifications: laser engraving on the electrode surface, model number, batch number, and manufacturer information.

2.5.3 Electrode packaging and labeling specifications

Packaging: 10 or 100 pcs per pack, plastic box or vacuum packaging, labeled with model, size and standard.

Identification: The box should indicate the manufacturer, batch number, date of manufacture and quality certification (e.g. ISO 9001).

Chapter 3 Characteristics of Cerium Tungsten Electrodes

3.1 Physical characteristics of cerium tungsten electrodes

The physical properties of cerium-tungsten electrodes are fundamental to their excellent performance in high-temperature, high-current welding environments. These properties, including melting and boiling points, density and hardness, coefficient of thermal expansion, and thermal conductivity, directly affect the stability, lifetime, and scope of application of electrodes. The following is a detailed analysis in three subsections.

3.1.1 Melting and boiling points of cerium tungsten electrodes

Cerium tungsten electrodes are mainly composed of tungsten and cerium oxide, which is one of the metals with the highest melting point in nature, with a melting point of 3422 °C (3695 K) and a boiling point of about 5555 °C (5828 K). The melting point of cerium oxide is 2400°C, and the boiling point is about 3500°C, and the doping of a small amount of cerium oxide has little effect on the overall melting point and boiling point of the electrode. Experimental measurements show that the melting point of the 2% cerium oxide electrode (WC20) is about 3400°C and the boiling point is about 5500°C, which is still much higher than the typical temperature of the arc in TIG welding and plasma arc welding (6000~7000 K). This high melting point characteristic allows cerium-tungsten electrodes to maintain their structural integrity under extreme high-temperature conditions, making them ideal for precision welding and high-load welding.

Detailed explanation of melting point characteristics

High Temperature Stability:

The high melting point of the cerium-tungsten electrode allows it to remain solid at arc high temperatures (up to 7000 K in the center of the arc), with only slight ablation possible at the tip of the electrode. In DC Forward (DCEN) welding, the electrode tip temperature is usually between 1500~2000°C, which is much lower than the melting point, so the electrode can maintain its geometry for a long time. For example, when welding stainless steel pipes at 100 A DC, the WC20 electrode has a tip burnout length of less than 0.3 mm after 10 hours of continuous operation, showing excellent melting resistance.

Compared with the thorium tungsten electrode (WT20, containing 2% thorium oxide, melting point of about 3410°C), WC20 has a slightly lower melting point, but the difference is only about 10°C, which has almost no effect in practical applications. Compared with pure tungsten electrode (melting point 3422°C), the melting point of WC20 decreased negligible, but its arc initiation performance and arc stability were significantly better than those of pure tungsten electrode.

At high currents (>200 A) or improper operation (e.g., electrode contact with the melt pool), local erosion of the electrode tip can occur, resulting in dulling of the tip cone angle. Experiments show that the melting rate of the WC20 electrode tip is about 0.05 mm/h in 300 A DC welding, while the pure apricot electrode can reach 0.1 mm/hour.

Factors affecting melting point:

Cerium Oxide Distribution: The uniform distribution of cerium oxide particles in the tungsten matrix is crucial for melting point stability. If the particles are unevenly distributed, it may lead to a decrease in the melting point in the local area, increasing the risk of burnout. Modern manufacturing processes such as powder metallurgy and nanodoping ensure uniformity by controlling particle size (1~5 μm).

Impurity content: Trace impurities (e.g., iron, silicon, aluminum) may reduce the melting point. International standards (such as ISO 6848) require WC20 electrodes to contain less than 0.01% impurities to ensure high-temperature performance.

Shielding gas: High-purity argon gas (99.99%) or argon-helium mixture (80% Ar + 20% He) can effectively reduce the temperature of the electrode tip and reduce the risk of burnout related to the melting point.

Application Cases:

Aerospace: In TIG welding of titanium alloy (e.g., Ti-6Al-4V) fuselage components, the high melting point of the WC20 electrode ensures that the electrode works continuously for 12 hours at 100~150 A current, and the tip shape change is less than 0.2 mm, meeting the requirements of aerospace for high-precision welds.

Oil pipelines: In the root welding of API 5L standard pipelines, the WC20 electrode works under 120 A DC conditions, and the temperature of the electrode tip is controlled below 1800°C, and the melting point advantage ensures the quality of the weld.

Nuclear power equipment: In the welding of zirconium alloy pressure vessels, the high melting point of WC20 electrode allows it to remain stable in high-temperature and high-humidity environments, reducing weld defect rates (such as porosity <0.3%).

Detailed explanation of boiling point characteristics

Volatility:

The high boiling point of cerium-tungsten electrodes (about 5500°C) makes them extremely volatile at arc high temperatures, reducing the gas phase loss of the electrode material. Experimental data show that the volatility of WC20 electrode is only 0.008 mg/min in 150 A DC soldering, while that of pure tungsten electrode is 0.05 mg/min. This low volatility reduces the consumption of electrode material and extends its service life.

Cerium oxide has a lower boiling point (3500°C) than tungsten and may release trace amounts of cerium vapor at extremely high temperatures, but its magnitude ($<10^{-5}$ g/min) has negligible effects on weld quality and environmental impact. In contrast, the thorium oxide (boiling point of about 4000°C) of thorium tungsten electrodes is slightly more volatile at high temperatures and may release trace amounts of radioactive particles.

Factors affecting boiling point:

Arc temperature: The arc center temperature (6000~7000 K) may exceed the boiling point of the electrode, but the actual temperature of the electrode tip is much lower than this, so the volatility is low. The use of a water-cooled welding gun further reduces the tip temperature.

Protective gas: Argon or argon-helium mixture can effectively isolate oxygen, preventing oxidation and volatilization at high temperatures. Studies have shown that the use of 99.99% high-purity argon gas can reduce the volatility rate by 20%.

Current Type: In alternating current (AC) welding, the temperature of the electrode tip fluctuates greatly, potentially increasing trace volatilization. Square Wave AC reduces temperature fluctuations and reduces volatility.

Application Cases:

Shipbuilding: In stainless steel hull welding, the WC20 electrode works continuously under 100 A DC current conditions, with a volatility rate of less than 0.01 mg/min, ensuring the cleanliness of the weld.

Chemical Equipment: In high-temperature reactor welding, the high boiling point of WC20 electrode ensures that the electrode material does not contaminate the melt pool, meeting strict hygiene requirements.

Automated Welding: In robotic welding lines, the low volatility of WC20 electrodes reduces the frequency of electrode replacements and improves production efficiency.

Optimization recommendations

Shielding gas selection: Use high-purity argon or argon-helium mixtures to reduce electrode tip temperature and reduce melting and boiling point-related losses.

Current control: In high-current (>200 A) welding, it is recommended to use larger diameter electrodes (such as 3.2~4.0 mm) to disperse heat and prevent local melting.

Tip grinding: Maintain a 30°~60° cone angle to concentrate the arc and reduce tip overheating.

Cooling System: Paired with a water-cooled welding gun to enhance heat dissipation and extend electrode life.

Research Progress and Trends

In recent years, the introduction of nanoscale cerium oxide doping technology has further improved the melting and boiling point stability of cerium tungsten electrodes. A 2021 study showed that nanoscale cerium oxide (particle size < 100 nm) can improve the grain boundary strength of tungsten matrix, making the melting point of the WC20 electrode close to 3410°C and the boiling point close to 5520°C. In addition, the development of composite doped (e.g., 1% CeO_2+1% La_2O_3) electrodes further optimizes high-temperature performance and is suitable for high-demand scenarios in the aerospace and nuclear industries. In the future, 3D printing technology and surface coating technology are expected to further improve the melting resistance of electrodes.

3.1.2 Density and hardness of cerium tungsten electrodes

The density and hardness of cerium tungsten electrodes are key indicators of their mechanical stability and durability, directly affecting their vibration resistance and wear resistance during the welding process.

Detailed explanation of density characteristics

Density value:

The density of the cerium tungsten electrode is 19.2 g/cm³, which is close to pure tungsten (19.25 g/cm³). The density of cerium oxide (7.65 g/cm³) was low, but due to its content of only 2%~4%, the effect on the overall density was less than 0.5%. The high density gives the electrode excellent mechanical stability and vibration resistance, making it suitable for high-speed automated welding. Experiments show that the offset of WC20 electrode is less than 0.01 mm in a 50 Hz vibration environment (simulated robot welding), while the offset of low-density materials (such as aluminum alloy electrodes) can reach 0.1 mm.

Application Impact:

Automated Welding: High density ensures that the electrode remains stable in the high-speed rotating welding gun, reducing arc offset. For example, in orbital pipe welding, the density advantage of WC20 electrode enables arc positioning accuracy to reach ±0.05 mm.

Heavy Equipment: In marine and bridge manufacturing, the high density of WC20 electrodes supports their stability in high-vibration environments, such as wind influences.

Compared with thorium tungsten electrode, the density of thorium tungsten electrode is 19.1~19.2 g/cm³, which is similar to WC20, but the uniformity of WC20 is slightly better in high-frequency vibration, thanks to the grain boundary strengthening effect of cerium oxide.

Influencing factors:

Manufacturing Process: The sintering temperature and pressure in powder metallurgy processes directly affect density. Excessive sintering temperatures can lead to the aggregation of cerium oxide particles, reducing density uniformity.

Impurity control: trace impurities (e.g., silicon, iron) may reduce density, and ISO 6848 requires impurity content below 0.01%.

Application Cases:

Aerospace: In titanium wing welding, the density of the WC20 electrode ensures high precision in robotic welding with a weld deviation of less than 0.1 mm.

Oil pipelines: In the automated welding of long-distance pipelines, the high density of WC20 electrodes supports continuous operation for 24 hours, and the arc stability remains above 95%.

Wind power equipment: In wind tower welding, the vibration resistance of the WC20 electrode reduces arc jitter caused by wind power.

Detailed explanation of hardness characteristics

Hardness value:

The Vickers hardness (HV) of cerium tungsten electrodes is slightly lower than that of pure tungsten electrodes, but much higher than that of ordinary steel (about 200 HV). The uniform distribution of cerium oxide particles in the tungsten matrix improves the grain boundary strength and enhances the deformation resistance of the electrode.

A 2020 study showed that the hardness of the WC20 electrode was 420 HV at room temperature and maintained at a high temperature of 1000°C at 350 HV, showing excellent high-temperature hardness stability. In contrast, thorium tungsten electrodes have a high-temperature hardness of about 340 HV, which is slightly lower than WC20.

Application Impact:

Grinding performance: The high hardness enables the WC20 electrode to form precise cone angles (such as 30°~60°) during the grinding process, making it suitable for precision welding.

Deformation resistance: The hardness advantage reduces the risk of damage to the electrode during transportation and installation. For example, in automated welding lines, the hardness of the WC20 electrode ensures tip integrity after multiple installations.

Compared with lanthanum tungsten electrode: The hardness of the lanthanum tungsten electrode (WL20 with 2% lanthanum oxide) is about 430 HV, which is comparable to WC20, but the embrittlement resistance is slightly better at high temperatures.

Influencing factors:

Cerium oxide content: 2% cerium oxide is the optimal equilibrium point, too high (such as 4%) may lead to embrittlement of grain boundaries and reduce hardness.

Heat treatment: The annealing process after sintering (1000~1200°C) optimizes hardness and reduces internal stress.
Tip Grinding: Improper grinding can introduce microcracks, reducing local hardness.

Application Cases:
Medical devices: In titanium pacemaker housing welding, the hardness of the WC20 electrode supports precise grinding, and the tip cone angle error is less than 1°.
Automotive manufacturing: In stainless steel exhaust pipe welding, the high hardness of the WC20 electrode reduces tip wear due to vibration.
Nuclear Industry: In zirconium alloy pressure vessel welding, the hardness of WC20 electrodes ensures stability during long-term high-temperature operations.

Optimization recommendations
Grinding process: Diamond grinding wheels and low-speed grinding (<1000 rpm) are used to reduce surface micro-cracks.
Storage Conditions: Avoid humid environments to prevent surface oxidation and reduce hardness.
Welding parameters: control current (<200 A) to avoid hardness drop at high temperatures.

Research Progress and Trends
Nanoscale cerium oxide doping significantly improves electrode hardness, and a 2022 study showed that the hardness of nanoscale WC20 electrodes can reach 460 HV, and the hardness of high-temperature hardness is increased to 380 HV. In the future, case-hardened coatings, such as TiN coatings, are expected to further enhance wear resistance and extend electrode life.

3.1.3 Coefficient of thermal expansion and thermal conductivity of cerium-tungsten electrodes
Detailed explanation of the coefficient of thermal expansion
Thermal expansion coefficient value:
The coefficient of thermal expansion of cerium tungsten electrodes is 4.5×10^{-6} K^{-1} (20~1000°C), which is close to pure tungsten (4.3×10^{-6} K^{-1}). The coefficient of thermal expansion of cerium oxide (8.5×10^{-6} K^{-1}) is high, but due to its low content, its overall impact is limited.
Experiments show that the length of the tip of the WC20 electrode varies less than 0.01 mm/h in 150 A DC welding, showing excellent dimensional stability.

Application Impact:
Dimensional stability: The low coefficient of thermal expansion allows the electrode to maintain its geometry under high-temperature arcing, making it suitable for precision welding. For example, in microelectronic chip soldering, the tip cone angle of the WC20 electrode changes by less than 0.5°.
Compared with thorium tungsten electrode: The thermal expansion coefficient of thorium tungsten electrode is 4.4×10^{-6} K^{-1}, which is similar to WC20, but WC20 has better grain boundary stability and reduces high-temperature thermal stress cracking.
Automated Welding: In robotic welding, the low coefficient of thermal expansion ensures the stability of the electrode during rapid thermal cycles, with weld accuracy reaching ±0.05 mm.

Influencing factors:

Cerium Oxide Distribution: Evenly distributed cerium oxide particles reduce local thermal expansion differences and improve overall stability.

Temperature range: At > 1500°C, the coefficient of thermal expansion increases slightly (about 4.8×10^{-6} K^{-1}), which needs to be controlled by the cooling system.

Application Cases:

Aerospace: In titanium turbine blade welding, the low coefficient of thermal expansion of the WC20 electrode ensures weld consistency.

Nuclear power equipment: In zirconium alloy tube welding, the dimensional stability of the WC20 electrode reduces weld cracks caused by thermal stress.

Automotive manufacturing: In aluminum alloy body welding, the low coefficient of thermal expansion of the WC20 electrode supports high-precision welding.

Detailed explanation of thermal conductivity

Thermal conductivity value:

The thermal conductivity of cerium-tungsten electrode is 170 W/(m·K) (room temperature), which is slightly lower than that of pure tungsten (174 W/(m·K)). At 1000°C, the thermal conductivity drops to about 100 W/(m·K), which is still sufficient to quickly transfer the tip heat to the electrode body.

Experiments show that in 100 A DC soldering, the tip temperature of WC20 electrode can be controlled at 1800~2000°C to avoid overheating and burnout.

Application Impact:

Heat Dissipation Performance: Good thermal conductivity enables WC20 electrodes to quickly dissipate heat during continuous welding and extend their lifespan. For example, in 150 A DC welding, the electrode tip temperature is about 100°C lower than that of a pure tungsten electrode.

Compared with lanthanum tungsten electrode, the thermal conductivity of lanthanum tungsten electrode is 165 W/(m·K), which is slightly lower than WC20, but the heat dissipation performance is similar at high current.

Influencing factors:

Electrode Diameter: Larger diameter electrodes (such as 3.2 mm) offer better heat dissipation and are suitable for high-current welding.

Shielding gas: Argon-helium mixture can enhance the heat distribution of the arc and indirectly improve the heat dissipation efficiency of the electrode.

Application Cases:

Shipbuilding: In stainless steel hull welding, the thermal conductivity of the WC20 electrode supports continuous operation for 12 hours, and the tip temperature is controlled below 1900°C.

Chemical equipment: In high-temperature reactor welding, the heat dissipation performance of WC20 electrodes reduces weld defects caused by thermal stress.

Automated Production Lines: In robotic welding, the thermal conductivity of WC20 electrodes supports efficient production.

Optimization recommendations

Cooling System: Use a water-cooled welding gun to enhance heat dissipation and extend electrode life.
Current Waveform: Employs square wave AC in AC welding to reduce tip temperature fluctuations.
Electrode Diameter: Choose an appropriate diameter (e.g., 2.4~3.2 mm) to balance thermal conductivity and current carrying capacity.

Research Progress and Trends

New thermally conductive coatings, such as tungsten carbide coatings, increase the thermal conductivity of the WC20 electrode to 180 W/(m·K). In addition, composite doped electrodes (such as 1%CeO_2+1%Y_2O_3) have better thermal conductivity at high temperatures and are suitable for high-load welding.

3.2 Chemical properties of cerium tungsten electrodes

The chemical properties of cerium-tungsten electrodes determine their stability and durability in complex welding environments. The following analyzes cerium oxide from three aspects: chemical stability, corrosion resistance and high-temperature chemical behavior.

3.2.1 Chemical stability of cerium oxide

Cerium oxide (CeO_2) is a chemically stable rare earth oxide with a melting point of 2400°C and a boiling point of about 3500°C, and exhibits extremely high inertness in acid, alkali and oxidizing environments. This stability is key to the ability of cerium tungsten electrodes to maintain their performance in high-temperature arcing and complex environments.

Detailed explanation of chemical stability

High Temperature Stability:

In the welding arc (6000~7000 K), cerium oxide remains solid and is not easy to decompose or volatilize. Experiments show that after 8 hours of 200 A DC welding, the cerium oxide content of WC20 electrode decreases by only 0.01%, showing excellent chemical stability.
Compared with thorium tungsten electrodes, thorium oxide (ThO_2) may decompose and release trace amounts of radioactive particles at high temperatures, while cerium oxide does not have this risk, making it suitable for environmentally demanding scenarios.

Antioxidant properties:

Cerium oxide is insensitive to oxygen and water vapor under argon protection, reducing the formation of oxide layer on the electrode surface. The test showed that under the protection of 99.99% high-purity argon gas, the oxide layer thickness on the surface of the WC20 electrode was less than 0.05 μm, while the pure tungsten electrode could reach 1 μm.
In environments with trace amounts of oxygen (<0.1%), cerium oxide forms a protective oxide layer that prevents further oxidation of the tungsten matrix.

Application Cases:

Marine Engineering: In stainless steel marine platform welding, the chemical stability of WC20 electrodes allows them to maintain performance in wet, salty environments with weld porosity of less than 0.3%.

Chemical equipment: In sulfide environments (e.g., sulfuric acid reactor welding), the oxidation resistance of the WC20 electrode reduces electrode losses.

Food processing: In stainless steel container welding, the chemical stability of the WC20 electrode ensures the hygienic weld.

Influencing factors:

Purity of Shielding Gas: Low-purity argon gas (<99.9%) may introduce oxygen, reducing the stability of cerium oxide.

Type of Current: Temperature fluctuations in AC welding can increase the trace volatilization of cerium oxide.

Optimization recommendations

Use high-purity argon (99.99%) or argon-helium mixtures to enhance chemical stability.

Control the welding time to avoid the migration of cerium oxide due to prolonged exposure to high temperatures.

Research progress

Nanoscale cerium oxide doping improves chemical stability, and a 2021 study showed that the loss rate of cerium oxide in nanoscale WC20 electrodes in 300 A DC welding is less than 0.005%.

3.2.2 Corrosion resistance of cerium tungsten electrodes

Cerium-tungsten electrodes exhibit excellent corrosion resistance in conventional welding environments such as argon or argon-helium mixture protection, and the addition of cerium oxide enhances the resistance to oxidation and chemical corrosion of the tungsten matrix.

Corrosion resistance is explained in detail

Antioxidant Properties:

In 150 A DC welding, the oxide layer thickness on the surface of the WC20 electrode is less than 0.1 μm, compared to 1 μm for pure tungsten electrodes. The protective effect of cerium oxide reduces the formation of tungsten oxide (WO_3).

In an environment with trace oxygen (<0.1%), the oxidation rate of the WC20 electrode is less than 0.001 mm/year.

Chemical Resistance:

In chloride- or sulfide-containing environments (e.g., petrochemical pipeline welding), the corrosion rate of WC20 electrode is less than 0.001 mm/year, which is much lower than that of pure tungsten electrode of 0.01 mm/year.

The experiment showed that there was no obvious corrosion trace on the surface of the WC20 electrode after soaking in 10% sodium chloride solution for 100 hours.

Application Cases:

Petrochemical industry: In hydrogen sulfide pipeline welding, the corrosion resistance of WC20 electrode reduces the frequency of electrode replacement.

Marine Engineering: In stainless steel welding in seawater environments, the corrosion resistance of WC20 electrodes ensures weld quality.

Nuclear Industry: In zirconium alloy welding, the corrosion resistance of the WC20 electrode supports long-term stable operation.

Influencing factors:

Shielding gas: High-purity argon gas significantly reduces oxidative corrosion.

Electrode diameter: Larger diameter electrodes (such as 3.2 mm) offer better corrosion resistance.

Optimization recommendations

Use high-purity shielding gas to reduce oxidative corrosion.

Clean the electrode surface regularly to remove trace deposits.

Research progress

Surface coating technologies, such as zirconia coatings, can further improve corrosion resistance, with a 2022 study showing a 50% reduction in corrosion rates for coated WC20 electrodes.

3.2.3 Chemical behavior of cerium-tungsten electrodes in high-temperature environments

Under the high-temperature arc (>6000 K), the chemical behavior of cerium-tungsten electrodes is mainly manifested as trace volatilization and surface reconstruction.

Detailed explanation of high-temperature chemical behavior

Trace volatilization:

Cerium oxide may release trace amounts of cerium vapor at extremely high temperatures, with an order of 10^{-5} g/min, which has no effect on welding quality. In contrast, the volatilization of thorium oxide from thorium tungsten electrodes may release radioactive particles.

Experiments show that the volatility of WC20 electrode is less than 0.01 mg/min in 200 A DC welding.

Surface reconstruction:

At high temperatures, cerium oxide particles may migrate to the electrode surface, forming a cerium-rich layer that enhances thermionic emission. The results show that the thickness of the cerium-rich layer is about 0.01~0.05 μm.

In AC welding, surface restructuring can lead to slight roughening, affecting arc stability.

Application Cases:

Aerospace: In titanium welding, the cerium-rich layer of WC20 electrodes improves arc initiation.

Nuclear industry: In zirconium alloy welding, the chemical stability of the WC20 electrode reduces pool contamination.

Automated welding: In robotic welding, the surface reconstruction of the WC20 electrode supports rapid arcing.

Influencing factors:
Current Type: Temperature fluctuations in AC welding increase surface reconstruction.
Shielding gas: Argon-helium mixture reduces volatilization and roughness.

Optimization recommendations
Use square wave AC to reduce temperature fluctuations.
Regularly inspect the electrode surface and re-grind if necessary.

Research progress
Nanoscale cerium oxide doping reduces high-temperature volatilization, and a 2021 study showed that the volatility of nanoscale WC20 electrodes was reduced by 30%.

3.3 Electrical characteristics of cerium tungsten electrodes
The electrical properties of cerium-tungsten electrodes are central to their excellent arc initiation and dimensional arcing properties in welding. The following is analyzed from three aspects: electron escape work, arc initiation performance and arc stability, and current bearing capacity.

3.3.1 Electron escape work of cerium tungsten electrode
Electron escape work is a key indicator of the arcing performance of electrodes. The WC20 electrode has an electron escape power of about 2.5 eV, which is much lower than pure tungsten (4.5 eV) and thorium-tungsten electrodes (2.7 eV).

Detailed explanation of the electron escape function
Characterization:
Low electron escape work makes it easier for electrons to escape from the electrode surface, reducing the arc starting voltage. Experiments show that the arc starting voltage of the WC20 electrode is 1012 V compared to 1518 V for the pure tungsten electrode in 10 A DC welding.
The uniform distribution of cerium oxide particles in the tungsten matrix enhances thermionic emission, especially at low currents (<50 A).

Application Cases:
Microelectronics: In chip lead soldering, the low electron escape power of the WC20 electrode supports ultra-low current soldering of 5~20 A, and the heat-affected zone is less than 0.1 mm.
Medical devices: In titanium implant welding, the rapid arcing of the WC20 electrode enhances production efficiency.
Aerospace: In the welding of titanium components, the low arc starting voltage of the WC20 electrode reduces arc jitter.

Comparison with lanthanum tungsten electrode:
The electron escape work of the lanthanum tungsten electrode (WL20) is about 2.4 eV, which is slightly better than that of WC20, but the difference is not significant in practical applications.

Influencing factors:

Tip shape: 30°~60° cone angle can concentrate electron emission and improve arc starting efficiency.

Surface cleanliness: Surface oxide layers may increase electron escape work and need to be cleaned regularly.

Optimization recommendations

Grind the tip to a 30°~45° cone angle to optimize electron escape.

High purity argon gas is used to reduce surface oxidation.

Research progress

Nanoscale cerium oxide doping reduces electron escape work to 2.3 eV, and a 2022 study showed a 10% reduction in arc starting voltage for nanoscale WC20 electrodes.

3.3.2 Arc initiation performance and dimensional arc stability of cerium-tungsten electrodes

Detailed explanation of arc starting performance

Characterization:

In DC Forward (DCEN) mode, the WC20 electrode has an arc start voltage of 1015 V and an arc start time of less than 0.1 seconds. In AC welding, the arcing voltage is 1525 V, which needs to be supported by high-frequency arc starting equipment.

Experiments show that the arcing success rate of WC20 electrode is 99.9% in 50 A DC welding.

Application Cases:

Pipeline welding: In oil pipeline root welding, the rapid arcing of the WC20 electrode improves welding efficiency.

Automated Welding: In robotic welding, the arcing performance of the WC20 electrode supports high-frequency operations.

Precision Welding: In microelectronic welding, the low arc starting voltage of the WC20 electrode reduces heat input.

Influencing factors:

Tip cone angle: 30°~60° cone angle is optimal, too large or too small may increase the arcing voltage.

Shielding gas: High-purity argon gas can reduce the arc starting voltage.

Detailed explanation of the stability of the arc

Characterization:

The arc jitter rate of the WC20 electrode is less than 5% in DC welding and about 8% in AC welding. The thermionic emission of cerium oxide enhances arc stability.

In 100 A DC welding, the arc offset of the WC20 electrode is less than 0.05 mm.

Application Cases:

Aerospace: In titanium welding, the stable arc of the WC20 electrode reduces weld porosity.

Nuclear industry: In zirconium alloy welding, the arc stability of the WC20 electrode supports high-quality welds.

Automated Production Lines: In robotic welding, the arc stability of WC20 electrodes enhances production efficiency.

Optimization suggestions:
Use square wave AC to reduce arc jitter.
Regularly check the tip shape to maintain a consistent cone angle.

Research progress
Composite doped electrodes (such as 1% CeO_2+1% La_2O_3) reduce arc jitter to 4%, making it suitable for high-precision welding.

3.3.3 Current carrying capacity of cerium tungsten electrode
Detailed explanation of current carrying capacity
Characterization:
The current carrying capacity of the WC20 electrode depends on the diameter:
1.6 mm: 10~100 A, suitable for precision welding.
2.4 mm: 50~150 A, suitable for general purpose welding.
3.2 mm: 100~200 A, suitable for high-load welding.

Above 200 A, the burnout rate increases slightly, and a 4% cerium oxide electrode is recommended.

Application Cases:
Shipbuilding: In 150 A DC welding, the 2.4 mm WC20 electrode supports continuous operation for 10 hours.
Nuclear industry: In 200 A DC welding, the 3.2 mm WC20 electrode meets the needs of zirconium alloy welding.
Automotive manufacturing: In 100 A DC welding, the 2.0 mm WC20 electrode supports aluminum body welding.

Influencing factors:
Electrode Diameter: Larger diameters support higher currents.
Cooling System: Water-cooled welding guns improve current carrying capacity.

Optimization recommendations
Select the appropriate diameter electrode to match the current demand.
Use a water cooling system to reduce burnout.

Research progress
The 4% cerium oxide electrode has a current carrying capacity of 250 A, and a 2022 study showed that its burnout rate was 20% lower than that of WC20.

CTIA GROUP LTD
Cerium Tungsten Electrode Introduction

1. Overview of Cerium Tungsten Electrode

Cerium Tungsten Electrode (WC20) is a non-radioactive tungsten electrode material composed of high-purity tungsten base doped with 1.8% to 2.2% cerium oxide (CeO_2). Compared to traditional thoriated tungsten electrodes, the cerium tungsten electrode offers superior arc starting performance, lower burn-off rate, and greater arc stability, while being radiation-free and environmentally friendly. It is suitable for both DC (direct current) and AC/DC mixed current welding conditions and is widely used in TIG welding and plasma cutting of materials such as stainless steel, carbon steel, and titanium alloys. This makes it an ideal green substitute in modern industrial welding.

2. Features of Cerium Tungsten Electrode

Excellent Arc Starting: Easy to ignite at low current, with stable and reliable performance.

Low Burn-off Rate: Cerium oxide enhances evaporation resistance at high temperatures, extending electrode life.

High Arc Stability: Focused arc with minimal flicker, suitable for precision welding.

Radiation-Free & Eco-Friendly: A safe and environmentally sound alternative to radioactive thoriated electrodes.

3. Specifications of Cerium Tungsten Electrode

Type	CeO_2 Content	Color Code	Density (g/cm^3)	Length (mm)	Diameter Range (mm)
WC20	1.8% – 2.2%	Grey	19.3	50 – 175	1.0 – 6.4

4. Applications of Cerium Tungsten Electrode

TIG welding of stainless steel, carbon steel, titanium alloys, nickel alloys, etc.

Precision welding and spot welding for medical devices and microelectronic components

Suitable for DC and AC/DC mixed welding conditions

Low-current plasma arc cutting and high-frequency ignition systems

5. Procurement Information

Email: sales@chinatungsten.com

Phone: +86 592 5129595; 592 5129696

Website: www.tungsten.com.cn

3.4 Mechanical properties of cerium tungsten electrodes

3.4.1 Ductility and brittleness of cerium-tungsten electrodes

Detailed explanation of ductility and brittleness

Characterization:

Cerium tungsten electrode has low ductility, with an elongation of about 0.5%~1%, and is a brittle material. The addition of cerium oxide improves the grain boundary strength and reduces high-temperature embrittlement.

Experiments show that the tensile strength of WC20 electrode at room temperature is 2500 MPa, and the fracture toughness is 1.2 MPa·m^1/2.

Application Cases:

Aerospace: In titanium welding, the brittleness of WC20 electrodes requires careful handling to avoid breakage.

Automated Welding: In robotic welding, the mechanical stability of the WC20 electrode supports high-frequency operations.

Influencing factors:

Cerium oxide content: Too high a level (e.g. 4%) may increase brittleness.

Heat treatment: Annealing processes optimize ductility.

Optimization recommendations

Precision grinding equipment is used to reduce mechanical stress.

Avoid the electrode from being impacted by external forces.

Research progress

Nanoscale cerium oxide doping improves fracture toughness to 1.5 MPa·m^1/2, and a 2021 study showed that the embrittlement resistance of nanoscale WC20 electrodes was increased by 30%.

3.4.2 Anti-wear performance of cerium-tungsten electrodes

Detailed explanation of wear resistance

Characterization:

The wear resistance of the WC20 electrode is due to the high hardness and the grain boundary strengthening of cerium oxide. Surface wear rates in grinding and welding are less than 0.01 mm/hour.

Experiments show that the wear rate of the WC20 electrode tip is less than 0.005 mm/h in 100 A DC welding.

Application Cases:

Automotive Manufacturing: In stainless steel exhaust pipe welding, the WC20 electrode's anti-wear properties support prolonged operation.

Nuclear industry: In zirconium alloy welding, the wear resistance of the WC20 electrode reduces tip loss.

Influencing factors:
Grinding Process: Diamond grinding wheels reduce wear.
Current Type: AC welding can increase wear.

Optimization recommendations
Use low-speed grinding to reduce surface damage.
Regularly inspect the electrode surface and re-grind if necessary.

Research progress
Surface coatings, such as TiN, reduce wear rates by 50%, and a 2022 study showed that coated WC20 electrodes extend their lifespan by 30%.

3.4.3 Electrode burndown rate of cerium tungsten electrode

Detailed explanation of electrode burn rate
Characterization:
The WC20 electrode has a burnout rate of about 0.5 mm/hour in 100 A DC welding and about 0.8 mm/hour in AC welding.
Experiments show that the burnout rate of WC20 electrode is 20% lower than that of thorium tungsten electrode in 150 A DC welding.

Application Cases:
Shipbuilding: In stainless steel hull welding, the low burnout rate of the WC20 electrode supports continuous operation.
Aerospace: In titanium welding, the WC20 electrode's burnout rate control ensures weld quality.

Influencing factors:
Current magnitude: High current (>200 A) increases the burnout rate.
Shielding gas: High-purity argon gas can reduce the burnout rate.

Optimization recommendations
Use a water-cooled welding gun to reduce burnout rates.
Choose square wave AC to reduce temperature fluctuations.

Research progress
The burnout rate of the 4% cerium oxide electrode was reduced to 0.4 mm/hour, and a 2022 study showed that it had a 25% longer lifespan than WC20.

3.5 Environmental and safety characteristics of cerium tungsten electrodes

3.5.1 Non-radioactive advantage of cerium-tungsten electrodes

Detailed explanation of the advantages of non-radioactivity
Characterization:
Compared with thorium tungsten electrodes (containing radioactive thorium oxide, radiation dose of about 3.60×10^5 Curie/kg), WC20 electrodes are non-radioactive and comply with the

International Commission on Radiological Protection (ICRP) standards.
Experiments show that the WC20 electrode has no radioactive particle release during grinding and welding.

Application Cases:
Medical devices: In titanium implant welding, the non-radioactive nature of the WC20 electrode meets hygiene requirements.
Food processing: In stainless steel container welding, the non-radioactive nature of the WC20 electrode ensures weld cleanliness.

Influencing factors:
Production process: Strictly control the purity of raw materials to avoid radioactive impurities.
Waste disposal: WC20 electrodes can be directly recycled without special treatment.

Optimization recommendations
Choose an ISO 6848 certified WC20 electrode to ensure radioactivity-free.
Use ventilation equipment to reduce dust while grinding.

Research progress
New detection techniques, such as gamma-ray spectroscopy, further confirm the radioactive advantage of the WC20 electrode.

3.5.2 Environmental friendliness of cerium tungsten electrodes
Detailed explanation of environmental friendliness
Characterization:
WC20 electrodes have no harmful substance emissions in production and disposal and comply with EU RoHS and REACH regulations.
Waste electrodes can be recycled and reused, with a recycling rate of more than 90%.

Application Cases:
Green Manufacturing: In wind power equipment welding, the eco-friendly characteristics of WC20 electrodes support sustainable development.
Marine Engineering: In seawater environments, the pollution-free nature of WC20 electrodes reduces environmental burden.

Influencing factors:
Production process: Adopting clean energy production can further improve environmental protection.
Recycling system: A well-developed recycling system can improve resource utilization.

Optimization recommendations
Choose a manufacturer with environmental certifications.
Establish an electrode recycling system to reduce waste.

Research progress

A 2022 study showed that the recycling rate of WC20 electrodes can reach 95%, supporting the circular economy.

3.5.3 Health and safety assessment of cerium-tungsten electrodes

Health and safety assessment explained

Characterization:

The dust generated by the WC20 electrode during grinding and welding is non-toxic and has a very low risk of inhalation. The experiments showed that the PM2.5 concentration of WC20 electrode dust was less than 0.01 mg/m³.

Compared with thorium tungsten electrodes, WC20 electrodes have no radioactive risk and do not increase health hazards with long-term use.

Application Cases:

Medical Industry: In titanium implant welding, the non-toxic properties of WC20 electrodes meet stringent hygiene requirements.

Food Processing: In stainless steel container welding, the health and safety of WC20 electrodes ensures product compliance.

Influencing factors:

Grinding Environment: Poor ventilation can increase the risk of dust inhalation.

Operating Specifications: Follow safe operating procedures to reduce accidental injuries.

Optimization recommendations

Use ventilation equipment and protective masks to reduce dust inhalation.

Regularly train welders to enhance safety awareness.

Research progress

The new dust filtration technology reduces the concentration of grinding dust on the WC20 electrode to 0.005 mg/m³.

3.6 China Tungsten Intelligent Cerium Tungsten Electrode MSDS

Material Safety Data Sheet (MSDS) - Cerium Tungsten Electrode

1. Product Information

Product Name: Cerium Tungsten Electrode (WC20)

Chemical name: tungsten (W) and cerium oxide (CeO_2) alloy

Usage: Used for inert gas shielded arc welding (TIG), plasma welding and cutting

CAS Number:

Tungsten: 7440-33-7

Cerium oxide: 1306-38-3

2. Composition/composition information

Key Ingredients:

Tungsten (W): 97.8%~98.2% (mass fraction)

Tel: 0086 592 512 9696
CTIAQCD -MA-E/P 2018- 2025V
sales@chinatungsten.com

Cerium oxide (CeO_2): 1.8%~2.2% (mass fraction).
Impurities: iron (Fe), silicon (Si), carbon (C), etc., with a content of less than 0.05%

3. Hazard identification
Physical hazards: There is no risk of explosion or flammability of solid-state electrodes. Grinding or cutting may produce metal dust.
Health hazards:
Inhalation: Tungsten or cerium oxide dust from grinding may irritate the respiratory tract.
Skin Contact: Long-term exposure may cause mild skin irritation.
Eye contact: Dust can irritate the eyes.
Radioactivity: Cerium tungsten electrodes are extremely low in radioactivity and meet ISO 6848 safety standards.

Environmental hazards: Waste materials may be generated during the production process, which need to be properly disposed of to prevent environmental pollution.
Main symptoms: inhalation of dust may cause cough or respiratory discomfort; Eye contact may cause redness and swelling.

4. First aid measures
Inhalation: Move the person to a well-ventilated area and seek medical attention if necessary.
Skin contact: Wash the contact area with soap and water, and seek medical attention if irritation.
Eye contact: Rinse with plenty of water for at least 15 minutes and seek medical attention if necessary.
Ingestion: If it occurs, seek medical attention immediately and provide this MSDS.

5. Fire protection measures
Fire extinguishing method: Solid-state electrode is non-flammable. Dust fires use dry powder or carbon dioxide extinguishing agents.
Special hazards: Cerium oxide or tungsten oxide gas may be released at high temperatures, and respiratory protective equipment should be worn.
Fire precautions: Firefighters need to wear protective clothing and positive pressure respirators.

6. Emergency treatment of leakage
Leakage prevention: Avoid electrode breakage or grinding dust during storage and use.
Cleaning method: Use a vacuum cleaner or damp cloth to clean the dust to avoid dust. Collected waste is disposed of in accordance with local regulations.
Protective Measures: Wear dust masks and protective gloves when handling leaks.

7. Operation and storage
Operational precautions:
Use special grinding equipment to avoid excessive dust generation.
Equipped with a local ventilation system, wear a dust mask and goggles.
Wash your hands after the procedure to avoid long-term skin contact.

Storage conditions:
Store in a dry, ventilated airtight container to avoid moisture and contamination.
Keep away from acidic substances and high temperature environments.
Marked "WC20 Cerium Tungsten Electrode" for identification.

8. Contact control/personal protection
Engineering control: Use local exhaust equipment or dust cover to reduce dust exposure.
Personal Protective Equipment:
Respiratory Protection: Wear a NIOSH-certified dust mask when grinding.
Hand protection: wear wear-resistant gloves.
Eye protection: Wear safety goggles.
Skin protection: Wear long-sleeved overalls to avoid skin exposure.

Exposure Limits:
钨粉尘:OSHA PEL 5 mg/m³(TWA)。
Cerium oxide: There is no specific limit, it is recommended to refer to the tungsten dust standard.

9. Physical and chemical properties
Physical state: solid (rod or thread)
Color: silver-grey with grey markings at the ends
Melting point: tungsten about 3422°C, cerium oxide about 2400°C
Density: approx. 19.3 g/cm³
Solubility: Insoluble in water
Stability: stable at room temperature, may oxidize at high temperature

10. Stability and reactivity
Stability: Stable chemical properties at room temperature.
Reactivity: Avoid contact with strong acids, alkalis, or high-temperature oxidizing environments, which may produce harmful gases.
Contraindicated substances: strong oxidants, acidic substances.

11. Toxicological information
Acute toxicity: Low toxicity, inhalation of dust may cause mild respiratory irritation.
Chronic Toxicity: Long-term inhalation of high dust concentrations can lead to lung discomfort.
Carcinogenicity: Not listed as a carcinogen by IARC.
Reproductive toxicity: No data available.

12. Ecological Information
Environmental impact: Solid-state electrodes have no direct harm to the environment, and production waste needs to be properly disposed of.
Bioaccumulation: No significant bioaccumulation.
Persistence and degradability: non-degradable, recycling is required.

13. Waste disposal

Disposal Method: Recycle or dispose of waste electrodes and dust in accordance with local regulations, avoiding direct disposal.

Recycling advice: Send the scrap to a professional metal recycling facility to recover tungsten and cerium oxide.

Precautions: Avoid waste from entering water or soil to prevent environmental pollution.

14. Shipping Information

Transportation classification: non-dangerous goods, in line with international transportation standards.

Packaging requirements: Use moisture-proof and dust-proof packaging and indicate product information.

Transportation precautions: Avoid packaging damage and prevent dust leakage.

15. Regulatory Information

International regulations: Comply with EU REACH regulations with radioactivity levels below safety thresholds.

Domestic Regulations: Comply with China's Regulations on the Safety Management of Hazardous Chemicals and the Environmental Protection Law.

Industry Standards: Comply with ISO 6848, AWS A5.12, GB/T 4192 standards.

16. Miscellaneous Information

Supplier: CTIA GROUP LTD

Phone: 0592-5129696/5129595

Chapter 4 Preparation and Production Process and Technology of Cerium Tungsten Electrode

As a key non-consumable electrode in inert gas shielded welding (TIG) and plasma arc welding, cerium-tungsten electrodes rely on the scientificity and precision of the entire production chain from raw material selection to final processing. The preparation process involves multiple complex links, including the selection and pretreatment of raw materials, the optimization of powder metallurgy technology, the refinement of subsequent processing technology, the improvement of quality control system, and the introduction of advanced production technology. This chapter systematically expounds the preparation process of cerium tungsten electrode from five aspects—raw material selection and pretreatment, powder metallurgy technology, subsequent processing technology, quality control and process optimization, and advanced production technology, and deeply explores the process principles, technical processes, influencing factors, optimization strategies, and future development trends of each link.

4.1 Raw material selection and pretreatment of cerium tungsten electrode

The selection and pretreatment of raw materials are the cornerstones of cerium tungsten electrode preparation, which directly determines the chemical composition, microstructure, and final properties of the electrode. Tungsten powder as the main component, cerium oxide as the key doping material, and possibly other additives need to be rigorously screened and processed to meet the requirements of high-performance welding electrodes.

4.1.1 Purity and particle size requirements of tungsten powder

Tungsten powder is the core raw material of cerium tungsten electrode, accounting for 96%~98% of the electrode mass. Its purity and particle size characteristics have a decisive impact on the stability, arcing properties and mechanical strength of the electrode in high-temperature arcing environments. As a metal with a high melting point (3422°C) and high density (19.25 g/cm³), tungsten has excellent high temperature resistance and corrosion resistance, but trace impurities or improper particle size distribution may lead to a decrease in electrode performance during the welding process, such as arc instability or increased burnout.

Tungsten powder purity requirements

The purity of tungsten powder is the key to ensuring that the electrode maintains its chemical stability and electrical properties under high-temperature arcing (6000~7000 K). According to international standards (such as ISO 6848:2004) and Chinese national standards (GB/T 4192-2015), the purity of tungsten powder usually needs to reach more than 99.95%, and common impurities include iron (Fe), silicon (Si), aluminum (Al), oxygen (O) and carbon (C). These impurities can form low-melting compounds (such as iron oxides, with a melting point of about 1565°C) at high temperatures, leading to electrode surface burnout or melt pool contamination. Higher purity tungsten powder (99.99%) is particularly important in precision welding, significantly improving arc stability and reducing electrode losses.

Purity Impact on Performance: Trace impurities can alter the thermionic emission characteristics of the electrode, increasing the arc starting voltage or causing arc jitter. Iron impurities may form volatile oxides at high temperatures, accelerating electrode burnout. Oxygen impurities may cause an oxide layer to form on the electrode surface, reducing electrical properties. By reducing these impurities, ultra-high purity tungsten powder can optimize the arc initiation performance, arc concentration, and high-temperature durability of the electrode, making it particularly suitable for low-current precision welding or high-load long-term welding.

Purification process: Tungsten powder is usually prepared by the thermal decomposition method of ammonium paratungstate (APT), and the process includes tungsten ore beneficiation, chemical dissolution, crystallization and purification, and hydrogen reduction. The beneficiation process removes gangue and impurities from the ore through flotation and magnetic separation to obtain high-purity APT. Chemical dissolution uses ammonia or acid to convert tungsten ore into soluble tungstate, followed by multi-stage crystallization to remove non-metallic impurities. Hydrogen reduction is a critical step, typically performed in two stages in a tube furnace: the first stage breaks down APT into tungsten oxide (WO_3) at lower temperatures, and the second stage reduces tungsten oxide to tungsten powder at higher temperatures. The reduction process requires the use of high-purity hydrogen (purity ≥99.999%) and strict control of the dew point (<-40°C) to prevent oxidation. After reduction, tungsten powder needs to be pickled (such as dilute nitric acid or hydrochloric acid solution) to remove residual oxides on the surface to further improve purity.

Process details: The reduction furnace needs to adopt a multi-stage heating design to ensure uniform temperature gradients and avoid incomplete volatilization of impurities caused by local overheating. Hydrogen flow control is critical to reduction efficiency and needs to be optimized for furnace size and powder volume. The pickling process requires precise control of acid concentration and processing time to avoid surface defects caused by excessive corrosion. The purification workshop needs to maintain a dust-free environment (ISO level 5, particle concentration < 3520 particles/m³) to prevent dust or airborne impurities from contaminating the tungsten powder.

Influencing factors:

Source of raw materials: China has more than 60% of the world's tungsten ore reserves, mainly produced in Zhuzhou, Hunan and Ganzhou, Jiangxi. High-grade tungsten ore can obtain higher purity APT by optimizing the beneficiation process.

Production Environment: The purification process is carried out in a clean room equipped with a high-efficiency filtration system to avoid dust contamination. Moisture or oxygen in the air can cause oxidation of tungsten powder, affecting its purity.

Storage conditions: Tungsten powder has strong hygroscopicity and oxidation tendencies, and needs to be stored in sealed stainless steel or polyethylene containers to maintain low humidity (<30%) and low temperature (<25°C) environment to prevent surface oxidation or agglomeration.

Quality Control: Purity testing typically uses inductively coupled plasma emission spectroscopy (ICP-OES) to analyze metal impurities with accuracy up to ppm levels. X-ray fluorescence spectroscopy (XRF) is used to quickly detect impurity distributions and is suitable for real-time monitoring on the production line. During the testing process, special attention should be paid to metallic impurities such as iron and silicon, as well as non-metallic impurities such as oxygen and carbon, to ensure that their content is below the standard limit. Regular calibration of testing equipment and the establishment of a batch traceability system help ensure the stability of tungsten powder quality.

Optimization suggestions:

High-grade tungsten ore was selected as raw material to improve the purity of APT through multi-stage beneficiation and crystallization purification.

Optimize hydrogen flow and temperature control during reduction to reduce impurity residue.

Establish a multi-level testing system, combined with ICP-OES and XRF to achieve dual monitoring of laboratory and production line.

Optimize storage management with vacuum-sealed packaging and desiccant to ensure long-term stability of tungsten powder.

Implement batch quality management to track the origin and handling records of each batch of tungsten powder through barcode or RFID technology.

Research Progress and Trends:

Low-temperature plasma purification technology reduces energy consumption by reducing the reduction temperature (600~700°C) while improving the purity of tungsten powder, which is suitable for green manufacturing needs.

Bioleaching technology uses microorganisms to extract tungsten from tungsten ore, reducing the use of chemical reagents and reducing environmental pollution.

The intelligent detection system analyzes the distribution of impurities through artificial intelligence algorithms and optimizes the purification process in combination with machine learning to improve detection efficiency and accuracy.

New purification equipment, such as plasma-enhanced chemical vapor deposition (PECVD) systems, can further improve the purity of tungsten powder and meet the needs of ultra-high-precision welding.

Tungsten powder particle size requirements

The particle size and distribution of tungsten powder have a profound impact on the sintering activity of the powder, the density of the electrode, and the mechanical strength. The particle size is usually controlled within the range of 15 microns, and the average particle size (D50) is 23 microns, and the distribution deviation should be as small as possible to ensure the uniformity of particle bonding during the sintering process. Fine particle size can improve the surface energy of the powder and promote the diffusion and binding of particles during the sintering process, but too fine particle size may lead to agglomeration or increase production costs, while too large a particle size may cause uneven sintering and reduce the grain boundary strength of the electrode.

Impact of Particle Size on Performance: Proper particle size distribution contributes to the formation of a dense microstructure, enhancing the density and tensile strength of the electrodes. The fine particle size enhances sintering activity, allowing the electrode to maintain stable geometry and electrical properties at high temperatures. Uneven particle size distribution may lead to segregation of cerium oxide particles during sintering, affecting the arc initiation performance and arc stability of the electrode. Spherical tungsten powder has higher fluidity and sintering efficiency compared to irregular particles, contributing to the formation of uniform grain boundary structures.

Particle size control process:

Airflow Classification: Separate tungsten powder of different particle sizes based on the aerodynamic behavior of the particles through cyclone classifiers or airflow grading equipment. During the grading process, it is necessary to control the airflow speed and grading accuracy to ensure uniform particle size distribution. Airflow grading equipment is often equipped with high-precision sensors that monitor particle size distribution in real time.

High-energy ball mill: A planetary ball mill is used to grind tungsten powder, and the particle size is controlled by adjusting the rotation speed, abrasive material (such as zirconia balls), and grinding time. The ball milling process avoids over-grinding to prevent particle breakage or contamination. The selection of abrasive medium and the ball-to-material ratio had a significant impact on the particle size control effect.

Spray drying: The tungsten powder suspension is passed through spray drying equipment to form spherical particles, improving the fluidity and sintering properties of the powder. Spray drying requires controlling the nozzle aperture, feed speed, and drying temperature to form uniform spherical particles.

Process details: During the ball milling process, high-hardness abrasives (such as zirconia or tungsten carbide) need to be selected to reduce pollution, the ball-to-material ratio is usually 10:1~20:1, and the grinding time needs to be optimized according to the target particle size. Airflow classifiers need to be equipped with high-efficiency filtration systems to prevent fine particle loss. The nozzle design and drying temperature of spray drying have an important impact on the particle morphology, and the parameters need to be optimized through experiments. The grading and drying process is carried out in a high-purity nitrogen or argon environment to avoid oxidation.

Influencing factors:

Reduction process: The temperature and time of hydrogen reduction directly affect particle size growth. High-temperature reduction may lead to particle agglomeration and increase particle size. Cryogenic reduction results in the formation of finer particles, but it takes longer.

Powder form: Spherical tungsten powder has higher fluidity and sintering activity, making it suitable for high-density electrode production. Irregular particles can lead to uneven sintering, affecting electrode performance.

Equipment accuracy: The separation efficiency of grading equipment and sensor accuracy affect the stability of particle size distribution. Low-precision equipment can lead to increased particle size deviations.

Quality Control: Laser particle size analyzers are used to accurately measure particle size distribution, and scanning electron microscopy (SEM) is used to observe particle morphology and agglomeration. During the testing process, it is necessary to pay attention to the D10, D50 and D90 values to ensure uniform distribution. Regular calibration of testing equipment and establishment of a particle size database can help optimize process parameters.

Optimization suggestions:

Combined with airflow grading and spray drying processes, it ensures uniform particle size distribution and regular particle morphology.

Optimize ball mill parameters and select appropriate abrasive media and abrasive conditions to avoid contamination.

Use a high-precision laser particle size analyzer to monitor particle size distribution in real time.

Preferential choice of spherical tungsten powder to improve sintering performance and electrode density.

Implement an in-line particle size monitoring system to optimize grading efficiency through sensors and data analysis.

Research Progress and Trends:

The development of nanoscale tungsten powder (particle size < 100 nm) significantly improves the density and mechanical strength of the electrode, making it suitable for high-precision welding needs.

The intelligent particle size grading system further improves the accuracy and efficiency of particle size control through image recognition and real-time feedback technology.

Green preparation processes, such as low-temperature reduction combined with ultrasonic dispersion technology, reduce energy consumption and the risk of particle agglomeration, in line with the trend of sustainable development.

New grading equipment, such as centrifugal nanoclassifiers, allows for finer particle size control to meet the production needs of ultra-high-precision electrodes.

4.1.2 Source and quality control of cerium oxide

Cerium oxide (CeO_2) is a key doping material for cerium tungsten electrodes, accounting for 2%~4% of the electrode mass. Its purity, particle size, and chemical stability have a profound impact on the arcing performance, arc stability, and high-temperature durability of the electrode. The uniform distribution and high quality of cerium oxide are important guarantees to ensure the consistency of electrode performance.

Cerium oxide source

Cerium oxide is mainly extracted from rare earth minerals (such as monazite, fluorocerium ore), and China, as the world's largest producer of rare earths, has rich rare earth resources, including Baotou, Inner Mongolia and Liangshan, Sichuan. The extraction process involves complex physical and chemical treatments, aiming to obtain high-purity cerium oxide to meet the requirements of electrode preparation.

Extraction process: Rare earth minerals are first crushed and ground to form fine particles, followed by flotation technology to separate rare earth minerals. The flotation process uses specific flotation agents (such as fatty acids, amines, or sulfonates) to improve cerium recovery, and the process needs to optimize slurry concentration and pH for selectivity. The separated rare earth concentrate is converted into soluble rare earth salts by acid dissolution (usually using sulfuric acid or hydrochloric acid), followed by the separation of cerium ions by solvent extraction techniques such as P204 or P507 extractants. The extracted cerium solution is formed by precipitation (such as oxalic acid precipitation) to form cerium carbonate or cerium oxalate, which is subsequently roasted in a high-temperature roasting oven (8001000°C) to form cerium oxide powder with a purity of 99.9% to 99.99%.

Process details: The flotation process requires precise control of the pH value of the slurry (usually 6~8) and flotation agent concentration to improve the recovery of cerium and reduce the incorporation of other rare earth elements. Solvent extraction needs to optimize the ratio and extraction stage of the extractant to ensure the efficient separation of cerium and other rare earth elements (such as lanthanum and praseodymium). During the roasting process, the temperature gradient and atmosphere (usually air or oxygen) in the furnace need to be controlled to avoid crystal form change or the introduction of impurities. Roasting ovens typically feature rotary or push-plate designs to ensure uniform powder heating.

Influencing factors:

Ore quality: High-grade fluorocerium ore (cerium content >50%) can significantly improve extraction efficiency and reduce production costs. Low-grade ores may require additional beneficiation steps, increasing energy consumption.

Extractant selection: P204 extractant has higher selectivity for cerium than P507, but the cost is

higher, so it needs to be optimized according to economic efficiency.
Environmental control: The purification workshop needs to maintain a high cleanliness level (ISO level 6, particle concentration < 35,200 particles/m³) to avoid dust or air pollution. Moisture in the air can cause cerium oxide to absorb moisture, affecting its quality.
Roasting conditions: Excessive temperature may cause cerium oxide particles to sinter and affect particle size; Too low a temperature can lead to incomplete transformation.

Impact of mass on performance: High-purity cerium oxide can effectively reduce the electron escape work of the electrode (about 2.5 eV), improve the arc initiation performance, and make the arc more ignitable and more stable. Trace amounts of rare earth impurities (e.g., lanthanum oxide, praseodymium oxide) may alter the thermionic emission characteristics, increase the arc voltage or cause arc jitter. The fine and uniform particle size distribution contributes to the uniform doping of cerium oxide in the tungsten matrix, forming a stable grain boundary structure, thereby improving the mechanical strength and high-temperature stability of the electrode.

Cerium oxide quality control

Purity control: The purity of cerium oxide should reach more than 99.9%, and the content of impurities (such as lanthanum oxide, praseodymium oxide, and neodymium oxide) should be less than 0.01%. Inductively coupled plasma mass spectrometry (ICP-MS) is the preferred method for the detection of rare earth impurities with accuracy down to the ppb level, making it suitable for high-precision laboratory analysis. X-ray fluorescence spectroscopy (XRF) is used to quickly analyze impurity distributions and is suitable for real-time monitoring on the production line. Purity control is carried out throughout the extraction, roasting, and storage process to ensure that no impurities are introduced.
Particle size control: The particle size of cerium oxide is usually controlled at 0.5~2 microns, with an average particle size of about 1 micron to ensure doping uniformity and sintering performance. Airflow grinding technology grinds cerium oxide to the target particle size through a high-velocity airflow, and the airflow velocity needs to be controlled within an appropriate range to avoid over-grinding. Spray drying technology forms spherical particles, improving powder flow and doping efficiency. The laser particle size analyzer is used to monitor the particle size distribution, ensuring that the D50 deviation is small.
Shape control: Spherical cerium oxide particles have better fluidity and doping uniformity than irregular particles, contributing to the formation of stable grain boundary structures during sintering. Spray drying needs to optimize the nozzle pore size, feed speed and drying temperature to avoid particle agglomeration or uneven morphology.

Process details:

Airflow crushing requires the use of high-purity nitrogen gas (purity ≥99.999%) as the medium to prevent cerium oxide from absorbing moisture or oxidation.
The nozzle design and drying temperature of spray drying have an important impact on the particle morphology, and the parameters need to be optimized through experiments.
Use sealed containers and desiccants during storage to maintain low humidity (<20%) and a dark environment to prevent changes in the chemical properties of cerium oxide.

Influencing factors:

Crushing process: The airflow speed and pressure need to be precisely controlled to avoid particle fragmentation or agglomeration.

Storage conditions: Cerium oxide is sensitive to moisture and should be avoided from exposure to high humidity.

Batch consistency: The purity and particle size of cerium oxide from batch to batch need to be consistent through an online monitoring system to ensure the stability of electrode performance.

Optimization suggestions:

Prefer high-purity cerium oxide (99.99%) to optimize electrode performance, especially in high-precision welding.

Combined with airflow crushing and spray drying processes, it ensures uniformity in particle size and morphology.

A multi-level detection system was established to monitor purity and impurity content in combination with ICP-MS and XRF.

Optimized storage management, using vacuum packaging and desiccants to extend the stability of cerium oxide.

Implement batch quality management and record the source and processing process of each batch of cerium oxide through a digital traceability system.

Research Progress and Trends:

The development of nanoscale cerium oxide (particle size < 100 nm) significantly improves doping uniformity and electrode performance, making it suitable for high-precision welding needs.

Green extraction technologies, such as bioleaching, use microbial action to extract cerium, reducing chemical waste liquid emissions, which is in line with environmental protection trends.

The intelligent detection system analyzes particle distribution and impurity content through artificial intelligence, combined with machine learning to optimize the extraction process and improve quality control efficiency.

New roasting equipment, such as microwave roasting ovens, allows for more uniform heating and reduces the risk of crystal shape shifts.

4.1.3 Selection of other additives

In addition to tungsten powder and cerium oxide, trace amounts of rare earth oxides or other compounds (e.g., lanthanum oxide La_2O_3, yttrium Y_2O_3, zirconia ZrO_2) may be added to the production of cerium tungsten electrodes to optimize specific properties such as arcing properties, high-temperature stability, or corrosion resistance. The selection and control of these additives are crucial for improving electrode performance.

Types and functions of additives

Lanthanum oxide (La_2O_3):

Function: Lanthanum oxide has low electron escape work (about 2.4 eV) and excellent high-temperature stability (melting point 2315°C), which can enhance the arcing performance and durability of the electrode. Lanthanum oxide makes the arc more ignitable and more concentrated by improving the thermionic emission characteristics, making it suitable for high-current welding environments. Its high melting point ensures that the electrode maintains structural stability at high temperatures.

Addition ratio: usually 0.1%~0.5%, it needs to be precisely controlled to avoid increasing the brittleness of the electrode. The right ratio of lanthanum oxide optimizes arc stability and extends electrode life.

Quality requirements: The purity should reach more than 99.9%, and the particle size should be controlled at 0.5~2 microns, consistent with cerium oxide to ensure doping uniformity. The content of impurities (such as cerium oxide or praseodymium oxide) should be less than 0.01%.

Yttrium oxide (Y_2O_3):

Function: Yttrium oxide is known for its high melting point (2410°C) and chemical stability, which can enhance the anti-burnout properties of electrodes, making it particularly suitable for high-load welding. Yttrium oxide improves the mechanical strength and high-temperature durability of electrodes by strengthening the grain boundary structure.

Addition ratio: 0.1%~0.3%, too high may reduce the ductility of the electrode and affect the processing performance.

Quality requirements: Purity ≥ 99.9%, particle size 0.5~1.5 microns, ensuring compatibility with tungsten powder and cerium oxide.

Zirconia (ZrO_2):

Function: Zirconia is known for its high hardness and chemical inertness, which can improve the hardness and corrosion resistance of electrodes, making it suitable for use in environments containing corrosive gases. Adding a small amount enhances the surface stability of the electrode.

Addition ratio: 0.05%~0.2%, which needs to be strictly controlled to avoid affecting the arc stability.

Quality requirements: purity ≥ 99.95%, particle size 0.5~1 micron to ensure doping uniformity.

Process details:

The additives need to be mixed with tungsten powder and cerium oxide through high-energy ball milling or ultrasonic dispersion to ensure uniform distribution. The ball milling process requires the use of high-hardness abrasives (such as zirconia balls) to avoid contamination.

The mixing process is carried out in a high-purity nitrogen or argon (purity ≥99.999%) environment, with controlled ambient humidity (<20%) to prevent moisture absorption.

Additives should be stored in airtight containers and maintained in a low humidity environment to avoid chemical changes.

Influencing factors:

Addition ratio: Balance performance improvement and cost control, as too high a ratio may lead to grain boundary defects or increased electrode brittleness.

Particle size matching: The particle size of the additive should be consistent with cerium oxide to ensure doping uniformity and avoid particle segregation.

Storage conditions: Additives are sensitive to moisture and oxidation, and should be avoided exposure to high humidity.

Quality control:
Inductively coupled plasma mass spectrometry (ICP-MS) was used to detect additive purity to ensure impurity content below 0.01%.
Scanning electron microscopy (SEM) and X-ray fluorescence spectroscopy (XRF) were used to analyze the distribution of additive particles, and the uniformity deviation should be controlled to ±0.05%.
Regularly calibrate testing equipment and establish a batch traceability system to ensure the stability of additive quality.

Optimization suggestions:
Choose high-purity additives (≥99.99%) to avoid impurity contamination.
The wet doping process is used to form uniform composite particles through spray drying, which improves the uniformity of additive distribution.
Establish an online monitoring system to adjust the ratio of additives in real time to ensure the consistency of doping.
Optimize storage management, use vacuum packaging and desiccants to extend additive stability.
Implement batch quality management and record the origin and processing of each batch of additives through a digital traceability system.

Research Progress and Trends:
The composite doping technology optimizes electrode performance by simultaneously adding multiple rare earth oxides, such as lanthanum oxide and yttrium oxide, to enhance arc initiation performance and high-temperature stability.
The development of nanoscale additives (particle size < 50 nm) has significantly improved doping efficiency and electrode performance, making them suitable for high-precision welding needs.
Green additive preparation techniques, such as biosynthesis, use microorganisms to synthesize yttrium oxide or lanthanum oxide to reduce chemical waste liquid emissions.
The intelligent doping system optimizes the proportion and distribution of additives through artificial intelligence algorithms, improving production efficiency.

4.2 Powder metallurgy process of cerium tungsten electrode

Powder metallurgy is the core process of cerium tungsten electrode preparation, which converts raw powder into high-density, high-strength electrode blanks through three steps: mixing and doping, pressing molding and high-temperature sintering. The process design and control of each step directly impact the microstructure and performance of the electrode.

4.2.1 Mixing and doping process

The mixing and doping process is designed to evenly mix tungsten powder, cerium oxide, and other additives to form a composite powder suitable for pressing and sintering. Uniform doping distribution is crucial for the arc initiation performance, arc stability, and mechanical strength of the electrode, and is a key link in ensuring the consistency of electrode performance.

Mixing process

Process principle: The mixture is evenly distributed by mechanical stirring or three-dimensional motion to evenly distribute tungsten powder, cerium oxide and additive particles to avoid local segregation. The uniform particle distribution helps to form a stable grain boundary structure during the sintering process, optimizing the electrode's electrical and mechanical properties. The mixing process takes into account the physical properties of the particles (such as density, particle size, morphology) and chemical stability to ensure the uniformity and fluidity of the mixed powder.

Process:

Tungsten powder, cerium oxide and additives are loaded into a mixing plant in proportions, such as a V-mixer, a 3D mixer or a planetary mixer.

The mixing process is carried out in a clean environment, the ambient humidity needs to be controlled below 20%, and the atmosphere is high-purity nitrogen or argon (purity ≥99.999%) to prevent oxidation.

After mixing, the powder is passed through a fine sieve (200~400 mesh) to remove large particles or aggregates to ensure uniformity.

Process details:

Mixing equipment needs to use wear-resistant materials such as stainless steel or ceramics to manufacture the inner walls to prevent contamination. The speed and trajectory of the equipment need to be optimized according to the characteristics of the powder to achieve the best mixing results.

Mixing time is adjusted based on particle size and equipment type, typically several hours, to ensure that the particles are well dispersed without over-grinding.

During the mixing process, the ambient temperature and humidity need to be monitored to avoid moisture absorption or oxidation of the powder.

Influencing factors:

Mixing time: too short time may lead to uneven distribution of particles, affecting the doping uniformity; Too long time may cause particle agglomeration and reduce powder fluidity.

Equipment type: The 3D mixer provides higher mixing efficiency through multi-axis motion, which significantly improves uniformity compared to the V-mixer.

Powder form: Spherical powders offer better flowability, contributing to improved mixing efficiency and sintering performance. Irregular particles can lead to local segregation.

Environmental Conditions: High humidity or low-purity atmospheres can lead to powder oxidation, affecting mixing quality.

Quality control: Scanning electron microscopy (SEM) is used to analyze particle distribution, and X-ray fluorescence spectroscopy (XRF) is used to detect component uniformity. The uniformity of the mixture needs to be microscopic to ensure that the distribution of cerium oxide particles is small. Regularly calibrating the mixing equipment and recording the mixing parameters can help optimize process stability.

Optimization suggestions:

Prefer to use 3D mixers or planetary mixers to improve mixing efficiency and uniformity.

Spherical powders (e.g., prepared by spray drying) are used to optimize flowability.

An online monitoring system was established to detect the uniformity of the mixture in real time through sensors and data analysis.

Optimize the mixing environment with high-purity inert gases and low humidity conditions to prevent powder contamination.

Implement batch quality management and record mixing process parameters through a digital traceability system.

Research Progress and Trends:

Ultrasonic-assisted mixing technology promotes particle dispersion through high-frequency vibration, significantly improving uniformity, making it suitable for high-precision electrode production.

The intelligent mixing system analyzes the distribution of particles through artificial intelligence algorithms, dynamically adjusts the rotation speed and mixing time, and improves efficiency.

New mixing equipment, such as fluidized bed mixers, drive particle movement through airflow for more uniform mixing results.

The green mixing process meets the needs of sustainability by reducing energy consumption and exhaust emissions.

Doped craftsmanship

Wet Doping:

Process principle: Cerium oxide and additives are dissolved in a solution (such as nitric acid or hydrochloric acid solution), and composite particles are formed by spray drying, which is mixed with tungsten powder. Wet doping improves the dispersion and uniformity of particles through liquid-phase mixing, helping to form a stable grain boundary structure.

Process flow: Cerium oxide and additives are dissolved to form a homogeneous solution, and fine particles are formed through spray drying equipment, which is then mixed with tungsten powder. The mixing process should be carried out in a high-purity atmosphere to prevent oxidation.

Process details: Spray drying requires optimizing nozzle aperture, feed speed, and drying temperature to ensure regular particle form. The solution concentration needs to be precisely controlled to avoid particle agglomeration. The mixing equipment needs to be equipped with a high-efficiency mixing system to ensure the uniform distribution of composite particles and tungsten powder.

Dry method doping:

Process principle: Directly dry mix tungsten powder, cerium oxide and additives, and realize particle distribution through mechanical stirring. The dry doping process is simple and the cost is lower, but the uniformity is slightly inferior to that of wet doping.

Process flow: The raw material powder is loaded into the mixing equipment and uniformly mixed through high-intensity stirring. After mixing, the powder is screened to remove agglomerates.

Process details: Dry mixing requires the use of high-precision mixing equipment to ensure uniform particle distribution. During the mixing process, it is necessary to control the rotation speed and time to avoid excessive grinding and particle breakage.

Influencing factors:

Solution concentration: Too high a solution concentration in wet doping may lead to particle agglomeration, affecting uniformity.

Drying conditions: The temperature and airflow velocity of spray drying need to be optimized to form uniform spherical particles.

Equipment accuracy: The mixing efficiency and speed control of the mixing equipment affect the doping uniformity.

Powder Characteristics: The density and morphology of different particles may lead to uneven doping, which needs to be optimized through pretreatment.

Quality control: SEM is used to analyze the distribution of doped particles, and XRF detects component uniformity. Doping uniformity requires microscopic analysis to ensure that the distribution of cerium oxide and additives is small.

Optimization suggestions:

Wet doping is preferred to improve the uniformity of particle distribution.

Optimize the spray drying parameters to ensure the morphological regularity of the composite particles.

Use high-precision mixing equipment to monitor doping uniformity in real time.

A database of doping parameters was established to optimize the process through data analysis.

Research Progress and Trends:

Nanoscale doping technology significantly improves doping efficiency and optimizes electrode performance through the use of nanoscale cerium oxide and additives.

The intelligent doping system dynamically adjusts the process parameters by monitoring the particle distribution and component ratio in real time.

New doping equipment, such as ultrasonic spray dryers, allows for more uniform particle distribution.

The green doping process reduces environmental pollution by using environmentally friendly solvents and low-energy equipment.

4.2.2 Pressing molding technology

Pressing molding is a key part of the powder metallurgy process by applying high pressure to convert the mixed powder into a high-density billet, providing the initial structure for subsequent sintering.

pressing process

Process principle: Cold isostatic pressing (CIP) makes the powder particles tightly bonded through uniform high pressure to form a billet with a density of about 50%~60% of the theoretical density. The pressing process needs to ensure that the billet is crack-free, stratified, and has a uniform density to provide good initial conditions for sintering. During the pressing process, friction and plastic deformation between particles cause the powder to form a tight structure, affecting the density and mechanical strength of the final electrode.

Process:

The mixed powder is loaded into a highly elastic rubber mold and placed in a cold isostatic pressing equipment.

After applying high pressure, the billet is inspected for internal defects such as cracks or delamination through non-destructive testing.

After pressing, the blanks are stored in a dry environment to prevent moisture absorption or contamination.

Process details:

CIP equipment needs to be equipped with high-precision pressure sensors and vacuum systems to ensure that the pressure is applied evenly. The pressure range is optimized for powder characteristics, typically in the hundreds of megapascals.

The mold material needs to be highly elastic (such as silicone rubber or polyurethane) to withstand high pressures and ensure a uniform billet shape.

During the pressing process, the ambient humidity (<20%) and temperature (<25°C) should be controlled to prevent the powder from absorbing moisture.

Influencing factors:

Pressure size: Appropriate pressure can increase the density of the billet, too high pressure may cause mold cracking or particle breakage, and too low pressure may lead to insufficient density.

Powder Flowability: Spherical powders offer higher flowability, which improves pressing efficiency and reduces internal defects.

Mold design: The shape and elasticity of the mold directly affect the molding quality of the billet and need to be optimized according to the electrode size.

Powder Properties: The particle size distribution and morphology of the particles affect the particle rearrangement and binding efficiency during the pressing process.

Quality Control: X-ray non-destructive testing (NDT) is used to check for internal defects in billets, and density meters measure billet density to ensure uniformity. Microscopic analysis is used to assess particle bonding and ensure structural stability of the billet.

Optimization suggestions:

Optimize pressure and hold-up time to balance billet density and die life.

Use automated CIP equipment to improve pressing consistency and production efficiency.

Spherical powder is used to improve the pressing efficiency and billet quality.

A database of pressing parameters was established to optimize the process through data analysis.

Implement an online monitoring system to detect pressure distribution and billet quality in real time.

Research Progress and Trends:

Hot isostatic pressing (HIP) further increases billet density by combining high temperatures and pressures, making it suitable for high-performance electrode production.

The intelligent pressing system dynamically adjusts the process parameters by monitoring the pressure and density distribution in real time.

New pressing equipment, such as high-frequency vibration presses, can improve particle rearrangement efficiency and reduce internal defects.

The green pressing process reduces the environmental impact of the production process by optimizing equipment design and energy consumption management.

4.2.3 Sintering process (high-temperature sintering and atmosphere control)

Sintering is a key step in converting pressed billets into high-density electrodes, and the particles are combined to form a dense structure through high-temperature treatment, which is the core link of the powder metallurgy process.

High temperature sintering

Process principle: At high temperature (2000~2200°C), tungsten powder particles combine through surface diffusion, volume diffusion and grain boundary diffusion, and cerium oxide particles are distributed at the grain boundaries to form a stable microstructure. The sintering process requires controlling temperature, time, and atmosphere to ensure uniform particle bonding while avoiding cerium oxide volatilization or large grains. The sintered electrode needs to have high density and excellent mechanical strength to meet the welding needs.

Process:

The pressed billet is placed in a high-temperature sintering furnace (such as a molybdenum furnace or tungsten furnace) and heated to the target temperature in a protective atmosphere.

Keep warm at high temperatures for a period of time to promote particle bonding, followed by slow cooling to avoid thermal stress.

After sintering, the electrode examines grain size and structure through microscopic analysis, ensuring consistent performance.

Process details:

The sintering furnace needs to be equipped with a high-precision temperature control system to ensure temperature uniformity (deviation <± 10°C). Heating elements, such as molybdenum or tungsten, need to be resistant to high temperatures and avoid contamination.

The holding time is optimized based on the billet size and powder properties, typically several hours, to ensure that the particles are fully bonded.

The cooling process is carried out in an inert atmosphere to prevent oxidation of the electrode surface.

Influencing factors:

Sintering temperature: Excessive temperature may lead to excessive grain size and reduce the mechanical strength of the electrode; Too low a temperature may result in insufficient particle binding, affecting density.

Holding time: It is necessary to balance the binding of particles and the volatilization of cerium oxide, which may lead to the loss of doped materials for too long.

Powder Properties: Fine particle size and uniformly distributed powder enhance sintering efficiency.

Atmosphere in the furnace: The purity of the atmosphere and the dew point directly affect the sintering quality and need to be strictly controlled.

Quality Control: Scanning electron microscopy (SEM) is used to analyze grain size and particle distribution, and X-ray diffraction (XRD) is used to inspect crystal structures, ensuring no phase transitions or defects. Density meters measure the density of the sintered electrodes, ensuring close to theoretical values.

Optimization suggestions:

Optimize sintering temperature and holding time, balancing density and grain size.

High-precision temperature control equipment is used to ensure uniform temperature in the furnace.

A database of sintering parameters was established to optimize the process through data analysis.

Implement an online monitoring system to detect temperature and atmospheric conditions in real time.

Research Progress and Trends:

Plasma sintering (SPS) uses pulsed current and high voltage to rapidly sinter to reduce time and increase density, making it suitable for high-performance electrode production.

The intelligent sintering system dynamically adjusts the process parameters by monitoring the temperature and atmosphere in real time.

New sintering equipment, such as microwave sintering ovens, allows for more uniform heating and reduces the risk of oversized grains.

The green sintering process reduces environmental impact by optimizing energy consumption and exhaust gas treatment.

Atmosphere control

Hydrogen Protection:

Process principle: High-purity hydrogen serves as a reducing atmosphere to prevent tungsten powder and cerium oxide from oxidizing at high temperatures, ensuring the chemical stability of the electrode.

Process details: Hydrogen purity needs to reach more than 99.999%, and the dew point needs to be below -40°C to avoid moisture or oxygen pollution. The hydrogen flow rate needs to be optimized according to the furnace size and billet volume to ensure a uniform atmosphere.

Influencing factors: The stability of hydrogen purity and flow rate directly affects the sintering quality, and the low purity atmosphere may lead to oxide formation.

Vacuum sintering:

Process principle: The vacuum environment reduces the volatilization of cerium oxide by reducing the oxygen content, which is suitable for high-precision electrode production. Vacuum sintering results in finer grains and improved electrode performance.

Process details: The vacuum level needs to be kept below 10^{-3} Pa, and the pumping system needs to be efficient to maintain a low-pressure environment. The vacuum furnace needs to be equipped with a high-precision pressure sensor to ensure a stable vacuum level.

Influencing factors: The stability of vacuum degree and the content of residual gas in the furnace affect the sintering quality and need to be strictly controlled.

Optimization suggestions:

Combined with hydrogen protection and vacuum sintering, optimized atmosphere control improves electrode performance.

Use a gas analyzer to monitor atmosphere purity and dew point in real time to ensure a stable sintering environment.

Optimize the furnace design and improve the efficiency of atmosphere circulation.

An atmosphere control database was established to optimize the sintering conditions through data analysis.

Research Progress and Trends:

Mixed atmosphere sintering technology optimizes sintering and reduces cerium oxide losses by combining hydrogen and argon.

The intelligent atmosphere control system adjusts the atmosphere parameters in real time through sensors and artificial intelligence algorithms.

New vacuum sintering equipment, such as ultra-high vacuum furnaces, can further improve sintering quality.

The green atmosphere control process reduces environmental pollution by recovering exhaust gases and optimizing energy consumption.

4.3 Subsequent processing technology of cerium tungsten electrode

Subsequent processing techniques include calendering and drawing, grinding and surface treatment, cutting and shaping, and are designed to process sintered billets into electrodes that meet standard dimensions and surface quality. These processes are crucial for the geometric accuracy, surface finish, and performance consistency of the electrodes.

4.3.1 Calendering and drawing process

Calendering process

Process principle: Hot calendering deforms the sintered billet into smaller diameter bars through high temperature and mechanical force, improving density and mechanical strength. The calendering process further optimizes the grain structure of the billet through multiple passes of deformation, enhancing the toughness and electrical properties of the electrode.

Process:

The sintered billet is heated to a high temperature in a hot calender and then formed into a bar through multiple passes of calendering.

After calendering, the bar is inspected on the surface to ensure that there are no cracks or defects, and then cooled and stored.

Tel: 0086 592 512 9696
sales@chinatungsten.com

Process details:

Calender rollers need to use high-hardness materials (such as carbide or ceramic) to ensure wear resistance and precision.

The calendering process takes place in a protective atmosphere (e.g., hydrogen or argon) to prevent surface oxidation.

The amount of deformation in each pass should be controlled within an appropriate range to avoid cracks caused by stress concentration.

Influencing factors:

Calendering temperature: It is necessary to balance the deformation efficiency and surface quality, too high a temperature may lead to oxidation, and too low a temperature may cause cracks.

Deformation: Moderate deformation can improve bar density, and excessive deformation may lead to internal defects.

Roller Design: The shape and surface quality of the rollers affect the geometric accuracy of the bar.

Billet characteristics: The density and microstructure of the billet affect the calendering effect.

Quality Control: Surface inspection equipment, such as laser rangefinders, is used to check the size and surface quality of the rods, and microscopic analysis evaluates grain structure. Density meters measure bar density to ensure close to theoretical values.

Optimization suggestions:

Optimize calendering temperature and deformation to balance efficiency and quality.

Automated calendering equipment is used to improve dimensional accuracy and production efficiency.

It adopts a high-precision roller design to ensure the surface finish of the rod.

A database of calendering parameters was established to optimize the process through data analysis.

Research Progress and Trends:

Precision calendering technology improves bar quality through high-precision rollers and automated control.

The intelligent calendering system dynamically adjusts the process parameters by monitoring the deformation amount and temperature in real time.

New calendering equipment, such as multi-roll continuous calenders, allows for greater efficiency and precision.

The green calendering process reduces environmental impact by optimizing energy consumption and exhaust gas treatment.

Drawing process

Process principle: Hot drawing stretches the calendered bar through a mold to form an electrode of standard diameter. The drawing process optimizes the surface quality and geometric accuracy of the bar through multiple deformations, improving the electrical properties and durability of the electrodes.

Process:

The calendered bar is heated to high temperatures in a heating furnace and subsequently drawn through a mold to form an electrode.

After drawing, the electrode is surface inspected to ensure no scratches or defects, then cooled and stored.

Process details:

Drawing dies need to use high-hardness materials (such as diamond or carbide) to ensure wear resistance and precision.

Lubricants (such as graphite emulsion or oil-based lubricants) are used during the drawing process to reduce friction and protect the electrode surface.

The pull-out speed and temperature need to be optimized to ensure the size and surface quality of the electrodes.

Influencing factors:

Pull-out temperature: Balance deformation efficiency with surface quality, as excessive temperatures can lead to surface defects.

Mold Design: The aperture and surface finish of the mold affect the geometric accuracy of the electrode.

Lubricant Selection: The viscosity and uniformity of the lubricant affect the drawing effect.

Bar Characteristics: The density and microstructure of the rod affect the deformation behavior during drawing.

Quality control: Laser rangefinders are used to detect electrode diameter and surface quality, and microscopic analysis evaluates grain structure. Surface roughness meters measure the surface finish of electrodes to ensure compliance with requirements.

Optimization suggestions:

Use high-precision drawing molds to ensure consistent electrode dimensions.

Optimize lubricant formulation to reduce surface defects.

Use automated pulling equipment to improve production efficiency and quality.

A database of pull-out parameters was established to optimize the process through data analysis.

Research Progress and Trends:

Micro-draw technology produces ultra-fine electrodes through high-precision molds, making them suitable for precision welding needs.

The intelligent pulling system dynamically adjusts the process parameters by monitoring the pulling force and temperature in real time.

New drawing equipment, such as continuous drawing machines, allows for greater efficiency and precision.

The green drawing process reduces environmental impact by using environmentally friendly lubricants and optimizing energy consumption.

CTIA GROUP LTD
Cerium Tungsten Electrode Introduction

1. Overview of Cerium Tungsten Electrode

Cerium Tungsten Electrode (WC20) is a non-radioactive tungsten electrode material composed of high-purity tungsten base doped with 1.8% to 2.2% cerium oxide (CeO_2). Compared to traditional thoriated tungsten electrodes, the cerium tungsten electrode offers superior arc starting performance, lower burn-off rate, and greater arc stability, while being radiation-free and environmentally friendly. It is suitable for both DC (direct current) and AC/DC mixed current welding conditions and is widely used in TIG welding and plasma cutting of materials such as stainless steel, carbon steel, and titanium alloys. This makes it an ideal green substitute in modern industrial welding.

2. Features of Cerium Tungsten Electrode

Excellent Arc Starting: Easy to ignite at low current, with stable and reliable performance.
Low Burn-off Rate: Cerium oxide enhances evaporation resistance at high temperatures, extending electrode life.
High Arc Stability: Focused arc with minimal flicker, suitable for precision welding.
Radiation-Free & Eco-Friendly: A safe and environmentally sound alternative to radioactive thoriated electrodes.

3. Specifications of Cerium Tungsten Electrode

Type	CeO_2 Content	Color Code	Density (g/cm^3)	Length (mm)	Diameter Range (mm)
WC20	1.8% – 2.2%	Grey	19.3	50 – 175	1.0 – 6.4

4. Applications of Cerium Tungsten Electrode

TIG welding of stainless steel, carbon steel, titanium alloys, nickel alloys, etc.
Precision welding and spot welding for medical devices and microelectronic components
Suitable for DC and AC/DC mixed welding conditions
Low-current plasma arc cutting and high-frequency ignition systems

5. Procurement Information

Email: sales@chinatungsten.com
Phone: +86 592 5129595; 592 5129696
Website: www.tungsten.com.cn

4.3.2 Grinding and polishing and surface treatment

grinding and polishing process

Process principle: Grinding and polishing form the cone angle of the electrode tip (usually 30°~60°) through machining, improving arc initiation performance and arc stability. The grinding and polishing process optimizes the surface finish of the electrode and reduces the impact of surface defects on the arc.

Process:

The electrode is ground using a diamond grinding wheel to create the desired cone angle.
The electrode surface is then treated with polishing equipment to improve the finish.
After grinding, the electrode is examined by microscopy for cone angle and surface quality.

Process details:

Grinding is carried out in a coolant (water-based or oil-based) to prevent thermal cracking. The coolant needs to be kept at a low temperature (<30°C) to avoid thermal effects.
Polishing equipment needs to be equipped with a high-precision angle control system to ensure the consistency of the cone angle.
The particle size of the grinding wheel needs to be selected according to the electrode size and surface requirements, usually 200~400 mesh.

Influencing factors:

Wheel Grain Size: A wheel that is too coarse may result in a rough surface, while a wheel that is too fine may reduce efficiency.
Grinding speed: Avoid thermal damage or surface defects caused by excessive speed.
Coolant Selection: The viscosity and thermal conductivity of the coolant affect the grinding effect.
Electrode Material: The hardness and microstructure of the electrode affect the grinding difficulty.

Quality control: Microscopes are used to check cone angle and surface quality, and surface roughness meters measure finish. NDT evaluates the internal structure of the electrode to ensure no cracks.

Optimization suggestions:

Automated grinding and polishing equipment is used to improve cone angle consistency and surface finish.
Optimize coolant formulations to reduce thermal effects and environmental pollution.
Establish a database of grinding and polishing parameters and optimize the process through data analysis.
High-precision grinding wheel is used to ensure the grinding quality.

Research Progress and Trends:

Precision grinding and polishing technology improves electrode surface quality through high-precision equipment.
The intelligent grinding and polishing system dynamically adjusts the process parameters by

monitoring the grinding force and angle in real time.
New grinding and polishing equipment, such as laser-assisted grinding machines, allows for greater precision and efficiency.
The green grinding and polishing process reduces environmental impact by using environmentally friendly coolants and optimizing energy consumption.

Surface treatment
Pickling:
Process principle: Use acid (such as nitric acid-hydrofluoric acid mixture) to remove the oxide layer on the electrode surface to improve surface quality and electrical properties.
Process flow: The electrode is immersed in acid solution for treatment, then washed and dried.
Process details: The acid-liquid ratio and processing time need to be precisely controlled to avoid excessive corrosion. Deionized water should be used in the cleaning process to prevent secondary pollution.

Coating:
Process principle: Apply high hardness or anti-corrosion coatings (such as TiN or ZrO_2) to improve the durability and corrosion resistance of the electrode.
Process flow: Apply a thin layer of coating by physical vapor deposition (PVD) or chemical vapor deposition (CVD), and the thickness is controlled at the micron level.
Process details: The coating needs to be uniform and defect-free, and the deposition process needs to be carried out in a high-vacuum environment.

Influencing factors:
Acid ratio: Balance the cleaning effect and electrode surface protection.
Coating Material: The hardness and chemical stability of the coating material affect electrode performance.
Deposition conditions: The deposition temperature and vacuum level affect the coating quality.

Optimization suggestions:
Choose environmentally friendly pickling solution to reduce waste liquid discharge.
Develop new coating materials to improve electrode performance.
Automated coating equipment is used to ensure uniformity of coating.
Establish a database of surface treatment parameters and optimize the process.

Research Progress and Trends:
Nanoscale coating technology significantly improves electrode lifetime by depositing nanoscale thin films.
The intelligent surface treatment system dynamically adjusts the process parameters by monitoring the coating thickness and quality in real time.
New coating equipment, such as plasma-enhanced CVD, enables higher precision and efficiency.
The green surface treatment process reduces environmental impact by using eco-friendly materials and optimizing energy consumption.

4.3.3 Cutting and shaping

Cutting process

Process principle: The drawn bar is cut into standard lengths (75~600 mm) by laser cutting or wire cutting to ensure the geometric accuracy and end face quality of the electrode. The cutting process avoids heat-affected zones and surface defects.

Process:

The drawn bar is cut to specified lengths by high-precision cutting equipment such as laser cutting machines or wire EDM machines.

After cutting, the electrode is inspected by surface to ensure that the end face is flat and free of burrs or cracks.

Process details:

Laser cutting requires optimized power and speed to ensure face quality. Wire EDM needs to control electrode clearance and discharge parameters.

The cutting process should be carried out in a coolant or protective atmosphere to prevent thermal damage.

Influencing factors:

Cutting Power: Efficiency and face quality need to be balanced, as too high power can lead to heat-affected zones.

Cutting speed: Avoid loss of accuracy due to excessive speed.

Electrode Material: The hardness and microstructure of the electrode affect the cutting difficulty.

Quality control: Laser rangefinders are used to detect electrode length and face flatness, and surface quality is checked under a microscope. NDT evaluates the internal structure to ensure no cracks.

Optimization suggestions:

Use high-precision laser cutting equipment to improve the quality of the end face.

Optimized cutting parameters to reduce heat-affected zones.

Automatic cutting equipment is used to improve production efficiency.

Establish a database of cutting parameters and optimize the process through data analysis.

Research Progress and Trends:

Ultra-precision cutting technology improves face flatness through high-precision laser or wire cutting.

The intelligent cutting system dynamically adjusts the process parameters by monitoring the cutting force and speed in real time.

New cutting equipment, such as femtosecond laser cutters, allows for greater precision and efficiency.

The green cutting process reduces environmental impact by optimizing energy consumption and waste disposal.

Shaping process

Process principle: Corrects the straightness of the electrode through a special fixture to ensure geometric accuracy during the welding process. The shaping process optimizes the shape stability of the electrode and reduces arc offset.

Process:

After cutting, the electrode is corrected for straightness by hydraulic or mechanical clamps.

After shaping, the electrode is detected by a laser rangefinder to ensure compliance with the requirements.

Process details:

The fixture needs to be designed with high precision to ensure the correction effect. The fixture material needs to be strong and wear-resistant.

The shaping process should be carried out in a clean environment to prevent contamination.

Influencing factors:

Fixture design: The accuracy and rigidity of the fixture affect the correction effect.

Electrode Material: The hardness and ductility of the electrode affect the difficulty of shaping.

Correction force: Excessive stress should avoid deformation or cracking of the electrode.

Quality control: Laser rangefinders are used to detect straightness, and microscopes check surface quality. NDT evaluates the internal structure to ensure it is defect-free.

Optimization suggestions:

Use automated shaping equipment to improve correction efficiency and accuracy.

Optimize the fixture design to ensure uniform correction.

A database of stereotype parameters was established to optimize the process through data analysis.

Research Progress and Trends:

Precision shaping technology improves correction accuracy through high-precision fixtures and automated controls.

The intelligent shaping system dynamically adjusts the process parameters by monitoring the correction force and straightness in real time.

New shaping equipment, such as electromagnetic setting machines, allows for greater efficiency and precision.

The green shaping process reduces environmental impact by optimizing energy consumption and waste disposal.

4.4 Quality control and process optimization of cerium tungsten electrodes

Quality control and process optimization are key aspects to ensure the consistency and reliability of cerium-tungsten electrode performance, involving composition uniformity control, microstructure analysis, and process parameter optimization. Each link needs to be tested and optimized to ensure that the electrode meets the needs of high-performance welding.

4.4.1 Composition uniformity control

Process principle: The uniformity of the composition directly affects the grain boundary distribution of cerium oxide in the tungsten matrix, which in turn affects the arc initiation performance, arc stability and mechanical strength of the electrode. The uniform doping distribution creates a stable grain boundary structure, optimizing the electrode's electrical and thermal properties. Uneven composition can lead to local performance variations, affecting weld quality.

Control method:

X-ray fluorescence spectroscopy (XRF) is used to detect component distribution, ensuring uniform levels of cerium oxide and other additives.

Scanning electron microscopy (SEM) analyzes particle distribution and evaluates doping uniformity.

Wet doping and 3D mixing techniques improve composition uniformity through liquid phase mixing and multi-axis motion.

Process details:

The mixing equipment needs to be designed with high precision to ensure that the particles are evenly dispersed. The mixing process should be carried out in a high-purity atmosphere to prevent oxidation.

The online monitoring system detects the distribution of ingredients in real time through sensors and data analysis, and dynamically adjusts the mixing parameters.

The doping process requires optimizing the solution concentration and spray drying parameters to ensure the uniformity of the composite particles.

Influencing factors:

Mixing process: The three-dimensional mixer improves uniformity through multi-axis motion, which is better than traditional V-mixers.

Doping Method: Wet doping achieves higher uniformity through liquid-phase mixing, suitable for high-precision electrodes.

Powder characteristics: The particle size and morphology of the particles affect the doping uniformity and need to be optimized through pretreatment.

Sintering conditions: Sintering temperature and atmosphere affect particle distribution and need to be strictly controlled to avoid segregation.

Optimization suggestions:

Wet doping and three-dimensional mixing technology are prioritized to improve composition uniformity.

Use high-precision mixing equipment to ensure uniform particle distribution.

Establish an online monitoring system to adjust the mixing and doping parameters in real time.

Optimize the sintering process and reduce the risk of particle segregation.

Establish a database of composition uniformity and optimize the process through data analysis.

Research Progress and Trends:

The intelligent component control system analyzes the particle distribution through artificial intelligence algorithms and dynamically adjusts the mixing and doping parameters.

Nanoscale doping technology improves uniformity through the use of nanoscale cerium oxide and additives.

New detection equipment, such as high-resolution XRF, enables even higher accuracy in compositional analysis.

The green doping process reduces environmental impact by using eco-friendly solvents and low-energy equipment.

4.4.2 Microstructure Analysis (SEM, XRD, etc.)

Process principle: Microstructure analysis evaluates the grain size, particle distribution, and crystal structure of the electrode through microscopy and diffraction techniques to ensure it meets performance requirements. The grain size and the distribution of doped particles directly affect the mechanical strength and electrical properties of the electrode, which need to be optimized by high-precision analysis.

Analysis method:

Scanning electron microscopy (SEM) is used to observe the distribution of cerium oxide particles and grain size, and to assess the uniformity of the microstructure.

X-ray diffraction (XRD) detects the crystal structure of tungsten matrix and cerium oxide, ensuring no phase transitions or defects.

Electron backscatter diffraction (EBSD) analyzes grain boundary properties to optimize the mechanical properties of the electrodes.

Process details:

SEM analysis requires the use of high-resolution equipment to ensure accurate measurements of particle distribution and grain size.

XRD analysis requires optimized sample preparation to avoid surface contamination or damage affecting the results.

EBSD analysis is performed in a high-vacuum environment to ensure the accuracy of grain boundary data.

Influencing factors:

Analytical Equipment: The resolution and accuracy of the equipment directly impact the analysis results.

Sample preparation: The surface quality and handling of the sample affect the accuracy of microscopic analysis.

Process conditions: Sintering temperature and atmosphere affect grain size and particle distribution, which need to be optimized through analysis.

Optimization suggestions:

Use high-resolution SEM and XRD equipment to improve analytical accuracy.

Optimize sample preparation processes to ensure surface quality.

A microstructure database was established to guide process optimization through data analysis.

Implement an online microscopic analysis system to monitor microstructures in real time.

Research Progress and Trends:

High-resolution EBSD technology optimizes electrode performance by analyzing grain boundary properties.

The intelligent microscopic analysis system analyzes the microstructure through artificial intelligence algorithms and dynamically adjusts the process parameters.

New analytical equipment, such as synchrotron XRD, enables higher accuracy of crystal structure analysis.

Green analytical processes reduce environmental impact by optimizing sample preparation and equipment energy consumption.

4.4.3 Optimization of process parameters

Process principle: Process parameter optimization improves electrode performance and production efficiency by adjusting the parameters of mixing, pressing, sintering and other links. Optimized parameters result in a stable microstructure that enhances the electrical and mechanical properties of the electrodes.

Optimization method:

The parameter combination was designed using orthogonal experimental methods to evaluate the influence of different parameters on electrode performance.

Computer simulation technology predicts the effect of parameter optimization by establishing a process model.

The online monitoring system adjusts the parameters in real time to ensure process stability.

Process details:

Key parameters include mixing time, pressing pressure, sintering temperature, and atmosphere conditions, which need to be optimized through experiments and simulations.

Optimizing processes requires balancing performance gains with production costs to ensure economics.

The parameter database records the performance data under different process conditions to guide optimization.

Influencing factors:

Parameter selection: The parameters of different process links affect each other and need to be optimized by the system.

Equipment accuracy: The resolution and control accuracy of the equipment affect the parameter adjustment effect.

Powder Properties: The particle size and morphology of the powder affect the suitability of parameter optimization.

Optimization suggestions:

Computer simulation technology is used to establish process model optimization parameters.

Implement an online monitoring system to adjust process parameters in real time.
Establish a parameter optimization database and guide production through data analysis.
Optimize equipment design and improve control accuracy.

Research Progress and Trends:
Digital twin technology optimizes parameter combinations and improves efficiency by simulating the process.
The intelligent optimization system analyzes the impact of parameters through artificial intelligence algorithms and dynamically adjusts the process.
New optimization methods, such as machine learning-driven process optimization, enable higher precision parameter control.
Green optimization processes meet the needs of sustainability by reducing energy consumption and waste.

4.5 Advanced production technology of cerium tungsten electrode

Advanced production technology improves the production efficiency and performance of cerium tungsten electrodes by introducing new processes and equipment to meet the needs of high-precision welding. These technologies, including nano-doping, plasma sintering, and intelligent production, represent the future direction of electrode manufacturing.

4.5.1 Nano-doping technology

Process principle: Nanodoping technology improves doping uniformity and electrode performance by using nanoscale cerium oxide (particle size < 100 nm) and additives. The high surface energy and dispersion of nanoparticles optimize the grain boundary structure, enhancing the arcing performance and high-temperature stability of the electrode.

Process:
Nanoscale cerium oxide is mixed with tungsten powder by wet doping to form homogeneous composite particles.
The mixing process improves particle uniformity through ultrasonic dispersion technology.
The doped powder is spray-dried to form spherical particles, optimizing flowability.

Process details:
Ultrasonic dispersion requires optimizing frequency and time to ensure uniform distribution of nanoparticles.
Spray drying needs to control the nozzle pore size and drying temperature to form regular particles.
The doping process should be carried out in a high-purity atmosphere to prevent oxidation.

Influencing factors:
Particle size control: The particle size of nanoparticles needs to be strictly controlled to avoid agglomeration.
Dispersion Techniques: The efficiency of ultrasonic dispersion affects doping uniformity.
Solution Properties: Solution concentration and viscosity affect spray drying effectiveness.

Quality control: Transmission electron microscopy (TEM) is used to analyze nanoparticle distribution, and XRF detects component uniformity. The online monitoring system adjusts the doping parameters in real time.

Optimization suggestions:
Optimize the ultrasonic dispersion parameters to improve the uniformity of nanoparticle distribution.
Use high-precision spray drying equipment to ensure regular particle morphology.
A database of nanodoping parameters was established to optimize the process through data analysis.
Implement an online monitoring system to detect doping uniformity in real time.

Research Progress and Trends:
Composite nano-doping technology optimizes electrode performance by simultaneously adding multiple nanoscale rare earth oxides.
The intelligent doping system analyzes the particle distribution through artificial intelligence algorithms and dynamically adjusts the process parameters.
New doping equipment, such as ultrasonic spray dryers, allows for higher precision particle control.
The green doping process reduces environmental impact by using eco-friendly solvents and low-energy equipment.

4.5.2 Plasma sintering technology
Process principle: Plasma sintering (SPS) rapidly sinters powder through pulsed current and high voltage to form a high-density electrode. SPS promotes particle binding through localized high temperatures and plasma effects, reducing sintering time and grain growth.

Process:
The pressed billet is placed in SPS equipment and sintered under high temperature and pressure.
After sintering, the electrode examines grain size and structure by microanalysis.

Process details:
SPS equipment needs to be equipped with high-precision temperature control and pressure control systems to ensure sintering uniformity.
The sintering process should be carried out in a high-purity atmosphere to prevent oxidation.
Sintering time needs to be optimized to balance density and grain size.

Influencing factors:
Sintering temperature: It is necessary to avoid excessive grain size caused by excessive temperature.
Pressure control: Proper pressure can increase density, and too high pressure can lead to equipment damage.
Powder Properties: Fine particle size and uniformly distributed powder improve SPS efficiency.

Quality control: SEM and XRD analyze grain size and structure, and density meters measure electrode density. The online monitoring system adjusts the sintering parameters in real time.

Optimization suggestions:

Optimize SPS temperature and pressure parameters to increase electrode density.

Use a high-purity atmosphere to reduce the risk of oxidation.

The SPS parameter database was established to optimize the process through data analysis.

Implement an online monitoring system to detect sintering conditions in real time.

Research Progress and Trends:

Ultra-fast SPS technology increases efficiency by reducing sintering time.

The intelligent SPS system dynamically adjusts process parameters by monitoring temperature and pressure in real time.

New SPS equipment, such as the multi-pulse SPS, allows for higher precision sintering control.

The green SPS process reduces environmental impact by optimizing energy consumption and exhaust gas treatment.

4.5.3 Intelligent production and automation

Process principle: Intelligent production optimizes production processes through artificial intelligence, sensors, and automated equipment, improving efficiency and quality. The automated system ensures the stability of process parameters and the consistency of electrode performance through real-time monitoring and data analysis.

Process:

Sensors monitor parameters in mixing, pressing, sintering, and other links, and artificial intelligence algorithms analyze the data and adjust the process.

Automated equipment, such as robots and conveyor belts, enables continuous operation of the production line.

Process details:

Sensors need to be designed with high precision to ensure data accuracy.

AI systems optimize process parameters through machine learning.

Automation equipment needs to be seamlessly integrated with the production line to ensure efficient operation.

Influencing factors:

Sensor accuracy: The data quality of the sensor affects the monitoring effect.

Algorithm design: The optimization ability of artificial intelligence algorithms affects the process adjustment effect.

Equipment compatibility: Automation equipment needs to be matched to existing production lines.

Quality control: The online monitoring system detects process parameters and product quality in real time, and the database records production data. Microscopic analysis and performance testing ensure that the electrodes meet the requirements.

Optimization suggestions:

Digital twin technology is introduced to simulate the production process and optimize the process.

Use high-precision sensors to improve monitoring effectiveness.

Optimize AI algorithms to improve the accuracy of parameter adjustments.

Establish an intelligent production database and optimize the process through data analysis.

Research Progress and Trends:

Industry 4.0 technologies improve production efficiency through IoT and big data analytics.

The intelligent production line automates the whole process through robots and automation equipment.

New monitoring equipment, such as multi-sensor integrated systems, enables real-time monitoring with higher accuracy.

Green and intelligent processes reduce environmental impact by optimizing energy consumption and waste disposal.

CTIA GROUP LTD
Cerium Tungsten Electrode Introduction

1. Overview of Cerium Tungsten Electrode

Cerium Tungsten Electrode (WC20) is a non-radioactive tungsten electrode material composed of high-purity tungsten base doped with 1.8% to 2.2% cerium oxide (CeO_2). Compared to traditional thoriated tungsten electrodes, the cerium tungsten electrode offers superior arc starting performance, lower burn-off rate, and greater arc stability, while being radiation-free and environmentally friendly. It is suitable for both DC (direct current) and AC/DC mixed current welding conditions and is widely used in TIG welding and plasma cutting of materials such as stainless steel, carbon steel, and titanium alloys. This makes it an ideal green substitute in modern industrial welding.

2. Features of Cerium Tungsten Electrode

Excellent Arc Starting: Easy to ignite at low current, with stable and reliable performance.
Low Burn-off Rate: Cerium oxide enhances evaporation resistance at high temperatures, extending electrode life.
High Arc Stability: Focused arc with minimal flicker, suitable for precision welding.
Radiation-Free & Eco-Friendly: A safe and environmentally sound alternative to radioactive thoriated electrodes.

3. Specifications of Cerium Tungsten Electrode

Type	CeO_2 Content	Color Code	Density (g/cm³)	Length (mm)	Diameter Range (mm)
WC20	1.8% – 2.2%	Grey	19.3	50 – 175	1.0 – 6.4

4. Applications of Cerium Tungsten Electrode

TIG welding of stainless steel, carbon steel, titanium alloys, nickel alloys, etc.
Precision welding and spot welding for medical devices and microelectronic components
Suitable for DC and AC/DC mixed welding conditions
Low-current plasma arc cutting and high-frequency ignition systems

5. Procurement Information

Email: sales@chinatungsten.com
Phone: +86 592 5129595; 592 5129696
Website: www.tungsten.com.cn

Chapter 5 Uses of Cerium Tungsten Electrodes

As a high-performance non-consumable electrode, cerium tungsten electrode has shown a wide range of application values in welding and non-welding fields due to its excellent arcing performance, arc stability, and high-temperature durability. Its doped cerium oxide properties make it excellent in various processes, especially suitable for applications in high-precision and high-temperature environments. This chapter systematically discusses the uses of cerium tungsten electrodes from four aspects: welding applications, non-welding applications, application industries and special application cases, and deeply analyzes the process principles, technical processes, influencing factors, optimization strategies and future development trends of each use.

5.1 Welding applications of cerium tungsten electrodes

The main uses of cerium tungsten electrodes in welding include inert gas shielded welding (TIG), plasma arc welding, and low-current DC welding. Its low electron escape work (approx. 2.5 eV) and excellent thermal stability make it ideal for high-precision soldering. The following is a detailed analysis from three specific application scenarios.

5.1.1 TIG Welding

Process principle

Inert Gas Shielded Welding (TIG, Tungsten Inert Gas), also known as argon arc welding, is a welding method that utilizes a non-consumable tungsten electrode to create an arc under the protection of an inert gas, such as argon or helium. The core role of cerium-tungsten electrodes in TIG welding is to provide a stable arc that initiates and sustains a high-temperature arc (6000~7000 K) through thermionic emission for melting workpieces and filler materials. The doping of cerium oxide reduces the electron escape work of the electrode, allowing it to achieve rapid arcing at low currents, while enhancing the concentration and stability of the arc and reducing the contamination of the melt pool, which is especially suitable for welding high-precision or highly active metals.

Arc characteristics: The low electron escape work of cerium tungsten electrodes allows them to trigger arcs at lower voltages, reducing arc initiation time and electrode losses. Cerium oxide particles form a stable emission point on the electrode surface, promoting thermionic emission and optimizing arc directivity and stability.

Shielding gas action: Argon gas acts as the main shielding gas, preventing oxidation or nitriding of the melt pool by isolating oxygen and nitrogen in the air. Helium can increase arc temperature and enhance penetration depth in certain high-heat input scenarios.

Applicable Materials: Cerium tungsten electrodes are suitable for welding stainless steel, aluminum alloy, magnesium alloy, titanium alloy, and other materials, and are widely used in scenarios with high precision and aesthetic requirements.

Technical process

Electrode preparation: Select the cerium-tungsten electrode (1.04.0 mm) of the appropriate diameter according to the welding material and thickness, and grind the appropriate cone angle (30°60°) to optimize arc concentration. The electrode surface needs to be pickled or polished to remove the oxide layer to ensure arcing performance.

Equipment Setup: TIG welding equipment needs to be equipped with a high-frequency arc initiation device and a stable current control system. Direct current positive polarity (DCEN) is commonly used in most metals, and alternating current is used in aluminum alloys to remove oxide films.

Welding process: Under the protection of argon or helium, an electric arc is initiated between the electrode and the workpiece, and the operator controls the arc position and heat input through the welding torch. The filling material (if required) is supplied by manual or automatic wire feeding units.

Post-treatment: After the welding is completed, check the quality of the weld to ensure there are no porosity, cracks, or slag inclusions. The electrode needs to be checked and re-ground regularly to maintain the cone angle and surface quality.

Craftsmanship details

Electrode cone angle: The size of the cone angle affects the concentration and penetration depth of the arc. Smaller cone angles (e.g., 30°) are suitable for low-current precision welding, while larger cone angles (e.g., 60°) are suitable for high-current deep penetration welding.

Shielding gas flow: The argon gas flow rate needs to be optimized according to the size of the welding gun and the welding environment, usually 8~15 L/min. Excessive flow rate may lead to airflow disturbance, affecting arc stability; Too low a flow rate may not be enough to protect the melt pool.

Current type and polarity: Direct current positive polarity (DCEN) keeps the electrode cool and prolongs its life; The alternating current cleans the oxide film on the surface of the aluminum alloy through periodic polarity conversion.

Environmental control: The welding area should be kept dry and wind-free to avoid damage to the gas protection effect. The workshop should be equipped with a high-efficiency ventilation system to prevent the accumulation of harmful gases.

Influencing factors

Electrode Quality: The purity, cerium oxide distribution, and surface finish of the electrode directly affect arc initiation performance and arc stability. Uneven doping can lead to arc jitter or increased burnout.

Protective gas purity: The purity of argon or helium (≥99.99%) is critical to the pool protection effect. Trace amounts of oxygen or moisture can cause oxidation of the weld.

Workpiece Material: The thermal conductivity and chemical activity of different materials affect the selection of welding parameters. For example, titanium alloys require higher gas protection to prevent oxidation.

Operator technology: The operator's experience and techniques affect arc control and weld quality, and manual TIG welding has high technical requirements.

Environmental conditions: Temperature, humidity, and wind speed can affect the effectiveness of gas protection and need to be optimized through environmental controls.

Optimize your strategy

Electrode optimization: Select high-purity cerium tungsten electrodes (cerium oxide content

2%~4%) to ensure uniform distribution through wet doping to improve arcing performance.
Gas Management: Use high-purity argon gas and optimize flow control, equipped with gas analyzers to monitor purity in real time.
Equipment Upgrade: Advanced TIG welding machine with high-frequency arc initiation and pulse current control improves arc stability and heat input control accuracy.
Automation technology: Introduce automatic wire feeding and robotic welding systems to reduce human operation errors and improve weld consistency.
Training and Management: Enhance operator training to ensure proficiency in welding parameters and electrode maintenance techniques. Establish a welding parameter database and optimize process settings.

Future trends
Intelligent welding: Real-time monitoring of arc status and weld pool dynamics through artificial intelligence and sensor technology, dynamically adjusting current and gas flow to improve welding quality.
Green welding technology: Develop low-energy TIG welding machines and recyclable protective gas systems to reduce energy consumption and environmental pollution.
New electrode materials: Explore composite cerium-doped tungsten electrodes (such as adding lanthanum oxide or yttrium oxide) to further reduce electron escape work and optimize arc performance.
High-Precision Welding: Developing ultra-low-current TIG welding technology for micro-components, meeting the needs of the electronics and medical industries.

5.1.2 Plasma arc welding

Process principle
Plasma arc welding (PAW) is a method of high-precision welding using a compressed arc to form a high-temperature, highly concentrated plasma arc (up to 15,000~20,000 K) through the nozzle constraint arc. The role of cerium tungsten electrodes in plasma arc welding is to provide stable thermionic emission and maintain a high energy density arc, making it suitable for welding thin sheets, dissimilar metals, and materials with high melting points. The doping of cerium oxide enhances the high-temperature resistance of the electrode, reduces burnout at high temperatures, and extends the life of the electrode.

Arc characteristics: The plasma arc is compressed through the nozzle to form an arc with high energy density and low divergence, and the penetration depth and weld quality are better than TIG welding. The low electron escape work of cerium-tungsten electrodes ensures fast arc initiation and arc stability.
Shielding Gas vs. Plasma Gas: The plasma gas (usually argon) forms an arc through the nozzle, and the shielding gas (a mixture of argon or helium) protects the melt pool. Dual airflow design improves weld quality.
Applicable Materials: Plasma arc welding is suitable for high-performance materials such as stainless steel, titanium alloys, and nickel-based alloys, widely used in aerospace and precision manufacturing.

Technical process

Electrode preparation: Select the appropriate diameter cerium-tungsten electrode (1.63.2 mm) and grind the cone angle (20°40°) to accommodate the high energy density arc. The electrode needs to be treated with a surface treatment to remove impurities.

Equipment Setup: The plasma arc welding machine needs to be equipped with high-precision nozzles and dual air flow control systems. Direct current positive polarity (DCEN) is the primary mode, and pulsed current is used for sheet welding.

Welding process: Plasma gas forms an electric arc through the nozzle, and the shielding gas protects the weld pool. The operator controls the arc position by means of a welding torch, and the filling material is provided by an automatic wire feeder.

Post-Processing: Check the quality of the welds to ensure there are no pores or cracks. The electrode needs to be regularly maintained and the cone angle is re-ground.

Craftsmanship details

Nozzle design: The nozzle aperture and material affect the arc compression effect, so it is necessary to choose a high-temperature resistant ceramic nozzle to ensure stability.

Gas flow: The plasma gas flow rate (0.52 L/min) and shielding gas flow rate (1020 L/min) need to be precisely controlled to avoid arc disturbances.

Current Control: Pulsed current reduces heat input, making it suitable for sheet welding. Current stability directly affects weld quality.

Environmental control: The welding area should be maintained in a wind-free and low-humidity environment to ensure the gas protection effect.

Influencing factors

Electrode Quality: The electrode's cerium oxide distribution and surface quality affect arc stability and lifetime. Uneven doping can lead to arc shift.

Nozzle Condition: Worn or clogged nozzles can reduce arc concentration and require regular inspection and replacement.

Gas purity: The purity of plasma gas and shielding gas (≥99.999%) is crucial for weld quality.

Workpiece characteristics: The thickness and thermal conductivity of the material affect the selection of welding parameters, which need to be optimized according to the specific material.

Operational accuracy: Plasma arc welding requires high precision for equipment and operators, and automation needs to improve consistency.

Optimize your strategy

Electrode Optimization: Uses nanoscale cerium oxide-doped electrodes to improve arc stability and high-temperature resistance.

Gas management: Optimized dual-gas flow design with high-purity gas and in-line gas analyzer.

Equipment upgrade: Adopt high-precision plasma arc welding machine, equipped with pulse current and automatic control system.

Process Monitoring: Introduce real-time monitoring systems to detect arc status and weld quality, dynamically adjust parameters.

Operational training: Strengthen operator skills training to ensure proficiency in plasma arc welding technology.

Future trends

Micro Plasma Welding: Developing ultra-low-current plasma arc welding technology for micro components, catering to the needs of the electronics and medical industries.
Intelligent Control: Optimize arc and gas parameters through artificial intelligence and sensor technology to improve weld consistency.
Green technology: Developing low-energy plasma arc welding machines and gas recovery systems to reduce environmental impact.
New Electrodes: Explore multi-element doped cerium-tungsten electrodes to further improve high-temperature performance and longevity.

5.1.3 Low Current DC Welding (Pipes, Precision Components, etc.)

Process principle

Direct Current Electrode Negative (DCEN) uses low current (10~50 A) to generate a stable arc, making it suitable for welding scenarios where heat input is sensitive, such as pipes and precision components. Cerium tungsten electrodes are the preferred choice in this field due to their excellent low-current arcing performance and arc stability. Its cerium oxide doping reduces electron escape work, allowing the electrode to arc quickly and maintain a stable arc at low currents, reducing the heat-affected zone (HAZ) and ensuring weld quality.

Arc characteristics: At low currents, the cerium tungsten electrode forms a stable fine arc through the thermionic emission of cerium oxide, which is suitable for thin-walled materials and high-precision welding.
Shielding gas: Argon is the main shielding gas, and the flow rate needs to be precisely controlled to protect small melt pools.
Applicable scenarios: Pipe welding (e.g., stainless steel pipes) and precision components (e.g., aerospace sensors) require low heat input to avoid deformation or loss of performance.

Technical process

Electrode preparation: Select a small diameter electrode (0.51.6 mm) and grind a sharp cone angle (20°30°) to enhance arc concentration. The surface needs to be polished to improve arcing performance.
Equipment Setup: Uses a high-precision TIG welding machine equipped with low current control and pulse function, ensuring minimal heat input.
Welding Process: Arc is initiated under argon protection, and the operator controls the arc position by manual or automatic welding gun. The filling material is usually filament, matching the workpiece material.
Post-Processing: Check the quality of the welds to ensure there are no porosity or micro-cracks. The electrodes require regular maintenance to maintain their performance.

Craftsmanship details

Electrode Cone Angle: The sharp cone angle improves arc concentration and reduces the heat-affected zone, making it suitable for precision welding.

Current control: Pulse current (frequency 5~20 Hz) further reduces heat input and optimizes weld quality.

Gas flow: The argon flow rate (5~10 L/min) needs to be precisely controlled to avoid disturbing arcing.

Environmental control: The welding area should be dust-free and wind-free to ensure gas protection.

Influencing factors

Electrode quality: Uneven distribution of cerium oxide can lead to arc instability, affecting weld quality.

Current stability: At low currents, the current control accuracy of the welding machine directly affects the arc stability.

Workpiece characteristics: The thermal conductivity and thickness of thin-walled materials affect the selection of welding parameters, which need to be accurately matched.

Operation technology: Low current welding requires high precision for operators, and manual operation needs to be stable.

Environmental conditions: Humidity or wind speed can affect the gas protection effect, and the environment needs to be optimized.

Optimize your strategy

Electrode optimization: Use high-uniformity cerium-tungsten electrodes to improve low-current arcing performance through nanodoping.

Equipment upgrade: Adopt high-precision low-current welding machine, equipped with pulse control and automation system.

Gas management: Uses high-purity argon gas and optimizes flow control, equipped with gas analyzers.

Automation Technology: Introduce robotic welding systems to improve the accuracy and consistency of low-current welding.

Process Monitoring: Implement real-time monitoring systems to detect arc and weld conditions and dynamically adjust parameters.

Future trends

Ultra-low current welding: Developing ultra-low current (<10 A) welding technology for micro components to meet the needs of the electronics industry.

Intelligent welding: Optimize low-current arc parameters through artificial intelligence to improve weld quality.

Green technology: Developing low-energy welding machines and gas recovery systems to reduce environmental impact.

New Electrodes: Explore high-performance cerium-tungsten electrodes to optimize arc stability at low currents.

5.2 Non-welding applications of cerium tungsten electrodes

Cerium-tungsten electrodes are also important in non-welding applications, including plasma cutting, overlay and cladding, and other high-temperature discharge applications. Its excellent high-temperature resistance and arc stability make it excellent in high-energy processes.

5.2.1 Plasma cutting

Process principle

Plasma cutting melts and blows away metal materials through a high-temperature plasma arc (15000~30000 K) for efficient cutting. The cerium tungsten electrode, as the core component of the plasma cutter, provides a stable arc and maintains a high energy density plasma flow. Its cerium oxide doping enhances the electrode's high-temperature resistance, reducing burnout and extending service life, making it suitable for cutting a wide range of metal materials.

Plasma arc characteristics: The plasma arc is compressed through the nozzle, creating high energy density and high-speed gas flow, which quickly melts and removes materials.
Gas action: Plasma gases (such as nitrogen or argon-hydrogen mixture) form an arc, and protective gases (air or oxygen) enhance cutting efficiency.
Applicable Materials: Suitable for carbon steel, stainless steel, aluminum alloy, etc., widely used in metal processing and dismantling.

Technical process

Electrode preparation: Select a cerium-tungsten electrode of the appropriate diameter (2.04.0 mm) and grind the cone angle (30°45°) to optimize arc concentration.
Equipment Setup: The plasma cutting machine needs to be equipped with a high-power power supply and a precision nozzle, and the current range is adjusted according to the thickness of the material.
Cutting Process: The plasma gas forms an electric arc through the nozzle, and the operator controls the cutting path and speed. Shielding gas enhances the cutting effect.
Post-Treatment: Check the quality of the cut surface to ensure there is no residue or heat-affected zones. The electrodes require regular maintenance.

Craftsmanship details

Nozzle design: Nozzle aperture and material affect the concentration and cutting speed of the plasma arc.
Gas flow rate: Plasma gas (25 L/min) and shielding gas (2050 L/min) need to be precisely controlled.
Current control: High current is suitable for thick plate cutting, low current is suitable for thin plate cutting, and needs to be optimized according to the material.
Environmental Control: The cutting area should be equipped with efficient ventilation systems to prevent the accumulation of harmful gases.

Influencing factors

Electrode Quality: The electrode's high temperature resistance and surface quality affect cutting stability.
Nozzle Condition: Nozzle wear can reduce cutting accuracy and needs to be replaced regularly.
Gas purity: Gas purity (≥99.99%) is crucial for cut quality and electrode life.

Material Properties: The thickness and thermal conductivity of the material affect the selection of cutting parameters.
Operational Precision: Cutting speed and path control affect surface quality.

Optimize your strategy

Electrode Optimization: Use high-durability cerium tungsten electrodes for extended cutting life.
Gas management: Optimize gas ratio and flow rate, using high-purity gases.
Equipment upgrade: Adopt high-precision plasma cutting machine with automatic control system.
Process Monitoring: Implement real-time monitoring systems to detect arc and cut quality.
Operation training: Strengthen operator skills training to ensure cutting accuracy.

Future trends

High-precision cutting: Developing ultra-high-precision plasma cutting technology for thin sheets.
Intelligent Control: Optimize cutting parameters through artificial intelligence, improving efficiency and quality.
Green technology: development of low-energy cutting machines and gas recovery systems.
New Electrodes: Explore composite doped electrodes for enhanced high-temperature performance.

5.2.2 Welding and cladding

Process principle

Weld surfacing and cladding deposit wear-resistant and corrosion-resistant materials onto the surface of the workpiece through arcs or plasma arcs, improving their performance. Cerium-tungsten electrodes provide a stable arc, maintaining high-temperature melt pools and promoting uniform deposition of filler materials. Its cerium oxide doping enhances the electrode's high-temperature resistance, making it suitable for welding overlay processes with high heat input.

Arc Characteristics: The cerium tungsten electrode forms a stable high-temperature arc, ensuring that the filler material is fully melted and deposited.
Filling materials: High-performance materials such as nickel-based alloys and cobalt-based alloys are commonly used for welding overlays.
Applicable scenarios: Used to repair worn parts or enhance the surface properties of workpieces, such as molds, valves, etc.

Technical process

Electrode preparation: Select the appropriate diameter electrode (2.03.2 mm) and grind the cone angle (30°45°).
Equipment Setup: Welding overlay equipment needs to be equipped with a high-power power supply and wire feeding system, and the current is adjusted according to the material.
Overlay Process: The arc melts the filler material, and the operator controls the deposition path and speed.
Post-processing: Check the quality of the sedimentary layer to ensure there are no cracks or porosity.

Craftsmanship details

Arc control: Pulsed current reduces heat input and reduces substrate damage.

Filling material: It needs to be matched with the substrate to ensure bond strength.

Gas protection: Argon gas protects the melt pool, and the flow rate (10~20 L/min) needs to be optimized.

Environmental control: The weld overlay area should be kept dry and windless.

Influencing factors

Electrode Quality: The high temperature resistance of the electrode affects arc stability.

Filling material: The chemical composition and morphology of the material affect the deposition quality.

Process parameters: current, velocity and gas flow rate need to be precisely matched.

Substrate Properties: The thermal conductivity and surface state of the substrate affect the deposition effect.

Optimize your strategy

Electrode optimization: Use high-performance cerium-tungsten electrodes to improve arc stability.

Material Selection: Optimize the filling material formulation to enhance bond strength.

Equipment upgrade: Automated welding overlay equipment is used to improve deposition consistency.

Process Monitoring: Implement real-time monitoring systems to detect deposition quality.

Future trends

Laser-assisted surfacing surfacing : Combines laser and arc to improve deposition accuracy.

Intelligent Control: Optimize overlay parameters through artificial intelligence.

Green technology: develop low-energy welding hardfacing equipment.

New electrodes: Exploring high-durability composite electrodes.

5.2.3 Other high-temperature discharge applications

Process principle

Cerium tungsten electrodes provide a stable arc or discharge source in other high-temperature discharge applications (e.g., plasma spraying, electrical discharge machining). Its excellent high-temperature resistance and arc stability make it suitable for high-energy density scenarios.

Plasma Spraying: The arc melts the powdered material and sprays it onto the surface of the workpiece to form a coating.

Electrical Discharge Machining (EDM): Electrodes corrode materials by discharging them, making them suitable for precision machining.

Applicable scenarios: Used for surface strengthening, mold processing, etc.

Technical process

Electrode Preparation: Select the appropriate diameter electrode and grind the cone angle to optimize discharge performance.

Equipment Setup: Equipped with high-power power supply and precision control system.
Machining process: Arc or discharge acts on the material, and the operator controls the path and parameters.
Post-treatment: Check the quality of the machined surface to ensure compliance with the requirements.

Craftsmanship details
Electrode design: Cone angle and surface quality need to be optimized to improve discharge stability.
Gas or medium: Plasma spraying requires high-purity gas, and electrical discharge processing requires dielectric fluid.
Parameter control: current, voltage and processing speed need to be precisely adjusted.

Influencing factors
Electrode quality: The high temperature resistance of the electrode affects the discharge stability.
Media Properties: The purity of the gas or dielectric fluid affects the processing quality.
Equipment accuracy: The precision of the power supply and control system affects the machining effect.

Optimize your strategy
Electrode Optimization: High-performance cerium tungsten electrodes are used to improve discharge stability.
Media management: Optimize gas or dielectric fluid formulations.
Equipment upgrade: adopt high-precision discharge equipment.
Process monitoring: Implement real-time monitoring systems to detect discharge status.

Future trends
High-precision EDM: Developing EDM techniques for micro components.
Intelligent Control: Optimize discharge parameters through artificial intelligence.
Green technology: development of low-energy discharge equipment.
New electrodes: Exploring composite doped electrodes.

5.3 Application industries of cerium tungsten electrodes

Cerium tungsten electrodes are widely used in aerospace, automobile manufacturing, energy and chemical, medical equipment manufacturing, and other industries, and their high performance meets the stringent requirements of various industries.

5.3.1 Aerospace

Application Background:
The aerospace industry has extremely high requirements for welding quality, and cerium tungsten electrodes are widely used in the welding of high-performance materials such as titanium alloys and nickel-based alloys, such as aircraft engine blades and spacecraft shells due to their excellent arc initiation performance and arc stability.

Process requirements: high precision, low heat input and excellent weld quality are required.
Electrode advantages: Cerium tungsten electrodes can maintain a stable arc at low currents, reducing the heat-affected zone.

Technical process
Electrode selection: small diameter electrode (0.5~2.0 mm), sharp cone angle.
Welding process: TIG or plasma arc welding, argon protection.
Quality control: Non-destructive testing (such as X-rays) checks weld quality.

Influencing factors
Material properties: The high activity of titanium alloys requires strict gas protection.
Electrode quality: Cerium oxide distribution affects arc stability.
Environmental Control: Dust-free and wind-free environment ensures welding quality.

Optimize your strategy
Electrode optimization: Use nano-doped electrodes.
Gas management: high-purity argon and dual-airflow design.
Automation technology: Introduction of robotic welding systems.

Future trends
Ultra-High Precision Welding: Meet the needs of micro components.
Intelligent control: optimize welding parameters.
Green technology: low-energy welding equipment.

5.3.2 Automotive manufacturing
Application Background:
In automobile manufacturing, cerium tungsten electrodes are used to weld parts such as car bodies and exhaust systems, and materials include stainless steel and aluminum alloys. Its rapid arc initiation and arc stability increase production efficiency.

Process requirements: high-efficiency, high-consistency welds.
Electrode advantages: high temperature resistance and long life reduce production costs.

Technical process
Electrode selection: medium diameter electrode (1.6~3.2 mm).
Welding process: TIG welding, automated production line.
Quality control: visual inspection and ultrasonic inspection.

Influencing factors
Production speed: Balance efficiency and quality.
Electrode quality: Affects arc stability and lifetime.
Degree of automation: affects weld consistency.

Optimize your strategy
Electrode Optimization: High durability electrodes.
Automation technology: robotic welding system.
Process monitoring: Real-time detection of weld quality.

Future trends
Lightweight material welding: suitable for aluminum alloys and composite materials.
Intelligent production line: improve production efficiency.
Green technology: low-energy welding equipment.

5.3.3 Energy and Chemicals

Application Background:
The energy and chemical industries need to weld corrosion-resistant materials (such as stainless steel, nickel-based alloys) for pipelines, reactors, etc. The high temperature resistance and stability of cerium tungsten electrodes meet demanding requirements.

Process requirements: high corrosion resistance and weld strength.
Electrode advantage: Stable at high heat input.

Technical process
Electrode selection: large diameter electrode (2.0~4.0 mm).
Welding process: TIG or plasma arc welding.
Quality Control: Non-destructive testing ensures weld quality.

Influencing factors
Material properties: Corrosion-resistant materials need to be strictly protected.
Electrode quality: Affects arc stability and lifetime.
Environmental conditions: need to prevent corrosive gas interference.

Optimize your strategy
Electrode Optimization: High performance electrodes.
Gas management: High purity gas protection.
Process monitoring: Real-time detection of weld quality.

Future trends
Superalloy welding: meet the needs of new materials.
Intelligent control: optimize welding parameters.
Green technology: low-energy equipment.

5.3.4 Medical Device Manufacturing

Application Background:
Medical device manufacturing requires high-precision welding, such as stainless steel surgical instruments and titanium implants. The low-current arcing performance of cerium-tungsten

electrodes makes them suitable for micro-component welding.

Process requirements: ultra-high-precision, non-polluting welds.
Electrode advantages: low heat input and arc stability.

Technical process
Electrode selection: small diameter electrode (0.5~1.0 mm).
Welding process: micro-TIG or plasma arc welding.
Quality control: microscopic testing and non-destructive testing.

Influencing factors
Material properties: Titanium alloys require strict gas protection.
Electrode quality: Affects arc stability.
Environmental Control: Dust-free environment ensures quality.

Optimize your strategy
Electrode optimization: nano-doped electrodes.
Gas management: High purity argon protection.
Automation technology: micro welding robots.

Future trends
Micro welding technology: Meets implant needs.
Intelligent control: optimize welding parameters.
Green technology: low-energy equipment.

5.4 Special application cases of cerium tungsten electrodes

The following analyzes the application of cerium tungsten electrode in specific scenarios, focusing on the process background and principles to avoid excessive experimental data.

5.4.1 Stainless steel and titanium alloy welding

Application Background:
Welding of stainless steel and titanium alloys requires high precision and strict gas protection, and cerium tungsten electrodes are widely used in such welding in aerospace and medical fields due to their excellent arc initiation performance and arc stability.

Process principle: TIG welding uses the low electron escape work of cerium tungsten electrode to quickly arc, and argon gas protection prevents material oxidation.
Technical flow: small diameter electrode (1.0~2.0 mm), sharp cone angle, pulsed current control heat input.
Influencing factors: The high activity of the material requires high-purity gas protection, and the quality of the electrode affects the arc stability.
Optimization Strategy: Use high-performance electrodes, optimize gas flow, and introduce automated welding.

Future trends: intelligent welding technology and new electrode development.

5.4.2 Soldering of microelectronic components

Application Background:

Micro electronic components (such as chip pins) need to be soldered at ultra-low current, and the low current arcing performance of cerium tungsten electrodes meets the requirements.

Process principle: Micro-TIG welding achieves high-precision welding through a fine arc, reducing the heat-affected zone.
Technical flow: ultra-small diameter electrode (0.5 mm), sharp cone angle, argon protection.
Influencing factors: Electrode quality and gas purity affect weld quality.
Optimization Strategy: Use nano-doped electrodes to optimize the pulse current.
Future trend: ultra-low current welding technology and intelligent control.

5.4.3 High-voltage wiring harness welding

Application Background:

High-voltage wire harness welding requires high strength and conductivity, and the arc stability of cerium tungsten electrode is suitable for copper alloy welding.

Process Principle: TIG welding ensures weld strength and conductivity by stabilizing the arc.
Technical flow: medium diameter electrode (1.6~2.4 mm), argon protection, automatic wire feeding.
Influencing factors: The high thermal conductivity of copper requires optimized current and gas.
Optimization strategy: Use high-performance electrodes and introduce robotic welding.
Future trends: high-efficiency welding technology and green processes.

Chapter 6 Production Equipment of Cerium Tungsten Electrodes

The production of cerium tungsten electrodes relies on a series of high-precision and specialized equipment, from raw material processing to final testing, the design and performance of each link directly determine the quality and production efficiency of the electrodes. This chapter systematically expounds the key equipment involved in the production process of cerium tungsten electrodes from five aspects - raw material processing equipment, powder metallurgy equipment, processing equipment, testing and quality control equipment, and automation and intelligent equipment, and deeply analyzes the working principle, structural design, operation process, influencing factors, optimization strategies and future development trends of each equipment.

6.1 Raw material processing equipment for cerium tungsten electrodes

Raw material processing equipment is used for grinding, screening and purification of tungsten powder and cerium oxide, which is a key link to ensure the quality of raw materials and the stability of subsequent processes. These devices need to have high precision, high efficiency, and low pollution characteristics to meet the high-performance requirements of cerium-tungsten electrodes.

6.1.1 Tungsten powder grinding and screening equipment

How it works:

Tungsten powder grinding and screening equipment processes tungsten powder to the target particle size (1~5 microns) through mechanical force or air flow, and removes large particles or aggregates through screening to ensure uniform particle size distribution. Grinding equipment (such as planetary ball mills) use high-energy collision and friction to reduce particle size, while screening equipment (such as airflow classifiers) aerodynamically separate powders of different particle sizes. A uniform particle size distribution is critical for particle binding and electrode performance in subsequent powder metallurgy processes such as pressing and sintering.

Grinding principle: Planetary ball mill grinds tungsten powder to the micron level through high-speed collision and friction between the grinding ball and the powder. The high hardness and trajectory of the grinding ball determine the grinding efficiency and particle shape.
Screening Principle: The airflow classifier uses high-speed airflow to drive powder particles, separating particles of different sizes through cyclone separation or centrifugal force, ensuring uniform distribution.
Equipment Advantages: High-precision grinding and screening equipment can improve the sintering activity of tungsten powder, optimize the density and mechanical strength of the electrode.

Structural design
Planetary ball mills:
Main components: grinding tank, grinding ball (zirconia or tungsten carbide), planetary disc, motor and control system.
Design features: The grinding tank is made of high-hardness stainless steel or ceramic material to prevent contamination. Planetary discs provide complex motion trajectories through multi-axis rotation, enhancing grinding efficiency. The control system is equipped with a frequency converter to precisely adjust the rotational speed.
Environmental requirements: The grinding process should be carried out in a high-purity nitrogen or argon gas (purity ≥99.999%) environment to prevent oxidation.

Airflow classifier:
Main components: feeding system, classifier wheel, cyclone, filter and airflow control system.
Design features: The grading wheels are made of wear-resistant ceramic materials and are resistant to high-speed airflow impacts. The cyclone separator improves separation accuracy through a multi-stage design. The airflow control system is equipped with high-precision sensors that monitor the airflow velocity in real time.
Environmental requirements: The grading process should be carried out in a clean room (ISO level 5, particle concentration < 3520 particles/m³) to avoid dust pollution.

Operation process
Grinding process:
Put the tungsten powder into the grinding tank, add the grinding ball (ball to material ratio 10:1~20:1), seal it and place it on the planetary disk.
Set the rotation speed (200~500 rpm) and grinding time (several hours) and start the device.
After grinding, the powder is filtered through a screen to remove large particles.

Screening process:

The ground tungsten powder is fed into the airflow classifier and evenly dispersed through the feeding system.

Adjust the airflow speed and the speed of the stager wheel to separate the target particle size powder.

Collect qualified powders and store them in airtight containers.

Post-processing: The ground and screened tungsten powder is detected by a laser particle size analyzer to ensure compliance with the requirements.

Craftsmanship details

Grinding parameters: rotational speed, grinding time and pellet-to-to-material ratio should be optimized according to the target particle size. Too high a speed may lead to particle crushing or contamination, and too low a speed can reduce efficiency.

Grinding ball selection: zirconia grinding ball has high hardness and good wear resistance, suitable for high-purity tungsten powder grinding; Tungsten carbide grinding balls are suitable for high-volume production.

Airflow control: The classifier needs to be equipped with a high-precision airflow controller to ensure airflow stability and separation accuracy.

Environmental control: The grinding and screening workshop needs to maintain a low humidity (<20%) and dust-free environment to prevent moisture absorption or contamination of the powder.

Influencing factors

Equipment accuracy: The speed control accuracy of the grinder and the airflow stability of the grader affect the particle size distribution.

Grinding Ball Material: The hardness and chemical stability of the grinding ball affect powder purity.

Powder Properties: The initial particle size and morphology of tungsten powder affect grinding efficiency.

Environmental Conditions: Humidity, oxygen levels, and dust can cause powder oxidation or agglomeration.

Operating specifications: The operator's parameter settings and equipment maintenance level affect equipment performance.

Optimize your strategy

Equipment upgrade: Adopt high-precision planetary ball mill, equipped with frequency conversion control and real-time monitoring system to improve grinding efficiency.

Grinding ball optimization: Choose high-hardness, low-contamination grinding balls to reduce powder contamination.

Airflow Classification Optimization: Use a multi-stage cyclone separator to improve separation accuracy.

Environmental Management: Equipped with high-efficiency filtration systems and humidity control devices to ensure a clean environment.

Data analysis: Establish a database of grinding and screening parameters and optimize process parameters through data analysis.

Future trends

Nanoscale grinding technology: Develop ultra-high-precision ball mills suitable for nanoscale tungsten powder (<100nm) to meet the needs of high-performance electrodes.

Intelligent equipment: Real-time monitoring of grinding and screening processes through artificial intelligence and sensor technology, dynamically adjusting parameters.

Green technology: Developing low-energy grinding equipment and recyclable airflow systems to reduce environmental impact.

New grading equipment: such as centrifugal nanoclassifiers, which can achieve higher precision particle size control.

6.1.2 Cerium oxide purification equipment

How it works:

Cerium oxide purification equipment extracts high-purity cerium oxide (purity ≥99.9%) from rare earth ores through steps such as chemical dissolution, extraction and roasting. The main equipment includes flotation machine, dissolution tank, extraction equipment and roasting furnace. These devices work together to separate rare earth minerals into cerium compounds, which are subsequently purified into cerium oxide powder, ensuring they meet the doping requirements of cerium-tungsten electrodes.

Flotation principle: The flotation machine separates rare earth minerals through bubbles and flotation agents to obtain high-grade cerium concentrate.

Extraction Principle: The extraction equipment uses organic solvents (such as P204 or P507) to selectively separate cerium ions to form a high-purity cerium solution.

Roasting principle: The roasting furnace converts cerium compounds into cerium oxide through high temperature (800~1000°C) to optimize particle morphology and purity.

Structural design

Flotation machine:

Main components: flotation tank, agitator, bubble generator and slurry conditioning system.

Design features: The flotation tank is made of corrosion-resistant stainless steel material, and the agitator optimizes slurry dispersion through frequency conversion control. The bubble generator improves bubble uniformity through a microporous design.

Environmental requirements: The flotation workshop should be equipped with ventilation and wastewater treatment systems to prevent chemical reagent contamination.

Extraction equipment:

Main components: extraction tank, phase separator, pumping system and solvent circulation system.

Design features: The extraction tank adopts a multi-stage design to improve the separation efficiency. The phase separator separates the organic and aqueous phases by gravity or centrifugal force.

Environmental requirements: It should be operated in a sealed environment to prevent solvent volatilization.

Roasting oven:

Main components: heating element (molybdenum or ceramic), furnace body, atmosphere control system and cooling system.

Design features: The furnace body is made of high-temperature resistant materials, and the atmosphere control system ensures even distribution of oxygen or air. Cooling systems reduce thermal stress through water or air cooling.

Environmental requirements: The roasting workshop needs to be kept clean (ISO level 6) to avoid dust pollution.

Operation process

Flotation process:

The rare earth ore is crushed and ground and sent to the flotation tank, and the flotation agent and water are added to form a slurry.

Start the agitator and bubble generator to separate the cerium concentrate.

Concentrate is collected and wastewater is recycled through a treatment system.

Extraction Process:

Cerium concentrate is dissolved in acid (sulfuric or hydrochloric acid) to form a rare earth solution.

The solution is in contact with the organic solvent through the extraction tank to separate the cerium ions.

After phase separation, the cerium solution is collected and the precipitation step is entered.

Roasting process:

The cerium solution is precipitated to form cerium carbonate or cerium oxalate.

The precipitate is fed into a roasting furnace where it is roasted at high temperatures to form cerium oxide powder.

After cooling, the powder is collected and stored in an airtight container.

Craftsmanship details

Flotation parameters: slurry concentration (20% 30%), pH value (68) and flotation agent ratio need to be optimized to improve cerium recovery.

Extraction parameters: The concentration of extractant and the number of extraction steps affect the separation efficiency and need to be optimized through experiments.

Calcination parameters: The roasting temperature and atmosphere need to be controlled to avoid crystal shape change or impurities introduced.

Environmental control: The purification workshop needs to maintain low humidity (<20%) and a clean environment to prevent powder contamination.

Influencing factors

Equipment Precision: The control accuracy of flotation machines and extraction equipment affects purification efficiency.

Raw material quality: The cerium content and impurity distribution of rare earth ores affect the difficulty of purification.

Environmental Conditions: Humidity and dust can cause moisture absorption or contamination of powders.
Operating specifications: Parameter settings and equipment maintenance levels affect the purification quality.

Optimize your strategy
Equipment upgrade: High-precision flotation machine and multi-stage extraction equipment are used to improve purification efficiency.
Solvent Optimization: Choose high-efficiency, low-toxicity extractants to reduce environmental pollution.
Roasting Optimization: Use rotary or push-plate roasting ovens to ensure even heating.
Environmental Management: Equipped with efficient wastewater and exhaust gas treatment systems to meet environmental protection requirements.
Data analysis: Establish a database of purification parameters and optimize process settings.

Future trends
Biological purification technology: use microorganisms to leach cerium and reduce the use of chemical reagents.
Intelligent equipment: Real-time monitoring of the purification process through sensors and artificial intelligence.
Green technology: development of low-energy roasting ovens and solvent recovery systems.
New equipment: such as microwave roasting ovens, improve heating uniformity and efficiency.

6.2 Powder metallurgy equipment for cerium tungsten electrodes

Powder metallurgy equipment is used to process tungsten powder and cerium oxide into high-density billets, including mixers, hydraulic presses, isostatic pressing equipment, and high-temperature sintering furnaces. These devices need to ensure uniform particle distribution and densification of the billet.

6.2.1 Mixing machine and doping equipment

How it works:
The mixer evenly mixes tungsten powder, cerium oxide and additives through mechanical stirring or three-dimensional motion, and the doping equipment achieves uniform distribution of cerium oxide through wet or dry process. Uniform particle distribution is crucial for grain boundary structure and electrode performance during sintering.

Mixing principle: The three-dimensional mixer fully disperses the particles through multi-axis motion to avoid segregation.
Doping principle: wet doping is formed by spray drying to form composite particles, and dry doping is achieved by high-intensity stirring to achieve uniform mixing.

Tel: 0086 592 512 9696

sales@chinatungsten.com

Structural design

3D mixing machine:

Main components: mixing barrel, drive motor, frequency converter and sealing system.

Design Features: The mixing drum is made of stainless steel or ceramic material to prevent contamination. The frequency converter provides multi-stage speed control to optimize mixing efficiency.

Environmental requirements: Operate in a high-purity nitrogen (purity ≥99.999%) environment.

Spray dryer (wet doping):

Main components: nozzle, drying chamber, cyclone separator and airflow control system.

Design Features: The nozzle is made of corrosion-resistant ceramic material, and the drying chamber ensures uniform drying through multi-stage heating.

Environmental requirements: Operate in a clean room (ISO level 5).

Operation process

Mixing process:

Tungsten powder, cerium oxide and additives are proportionally loaded into the mixing bucket.

Set the speed and mixing time and start the equipment.

After mixing, the powder is filtered through a screen to ensure uniformity.

Doping process (wet method):

Dissolve cerium oxide in solution, add tungsten powder to form a suspension.

Composite particles are formed by spray dryer and mixed with tungsten powder.

Collect the powder and store it in an airtight container.

Craftsmanship details

Mixing parameters: Rotation speed (50~200 rpm) and time (several hours) need to be optimized to avoid excessive grinding.

Spray drying parameters: Nozzle aperture, feed speed, and drying temperature need to be precisely controlled to ensure regular particle morphology.

Environmental control: Mixing and doping should be carried out in a low humidity (<20%) environment.

Influencing factors

Equipment Precision: The speed control of the mixer and the airflow stability of the spray dryer affect uniformity.

Powder Properties: The density and morphology of the particles affect the mixing effect.

Environmental Conditions: Humidity and oxygen levels can lead to powder oxidation.

Operating Specifications: Parameter setting and equipment maintenance affect mixing quality.

Optimize your strategy

Equipment upgrade: adopt high-precision three-dimensional mixer and spray dryer.

Process optimization: Preferential wet doping is used to improve uniformity.

Environmental Management: Equipped with high-efficiency filtration and humidity control systems.
Data analysis: Establish a database of mixing parameters and optimize the process.

Future trends
Ultrasonic mixing: Improves particle dispersion through high-frequency vibration.
Intelligent equipment: Optimize mixing parameters through artificial intelligence.
Green technology: development of low-energy mixing equipment.
New equipment: such as fluidized bed mixer to improve mixing efficiency.

6.2.2 Hydraulic press and isostatic pressing equipment

How it works:
Hydraulic presses mechanically press powders to form initial billets, while isostatic pressing equipment (CIP) improves billet density and optimizes sintering performance through uniform high pressure (hundreds of megapascals).

Hydraulic press principle: one-way pressure is applied through the hydraulic system to compress the powder to form a billet.
Isostatic pressing principle: isotropic pressure is applied through a liquid medium to ensure uniform density of the billet.

Structural design
Hydraulic presses:
Main components: hydraulic cylinder, mold, control system and safety device.
Design features: The hydraulic cylinder provides high pressure (100~500 MPa), and the mold is made of high-hardness steel. The control system is equipped with pressure sensors to ensure accuracy.
Environmental requirements: It needs to be operated in a clean environment to prevent powder contamination.

Isostatic pressing equipment:
Main components: pressure vessel, rubber mold, pumping system and vacuum system.
Design features: The pressure vessel is made of high-strength alloy steel, and the rubber mold has high elasticity. The vacuum system ensures no air bubbles.
Environmental requirements: Operate in a low humidity environment.

Operation process
Hydraulic press process:
The mixed powder is loaded into the mold and placed in the hydraulic press.
Set the pressure and holding time to start pressing.
Remove the blank and check for density and defects.

Isostatic pressing process:
The powder is loaded into a rubber mold and placed in a pressure vessel.

Inject high-pressure liquid and apply isotropic pressure.
Remove the blank and store it in a dry environment.

Craftsmanship details
Pressure control: Optimize pressure magnitude and holding time to avoid cracks or uneven density.
Mold design: The shape and elasticity of the mold affect the quality of the billet.
Environmental control: The pressing workshop needs to be dust-free and low humidity.

Influencing factors
Equipment Precision: Pressure control accuracy affects billet density.
Powder Properties: The fluidity and particle size distribution of the powder affect the pressing effect.
Mold Quality: The wear resistance and elasticity of the mold affect the billet shape.
Operating specifications: Parameter setting and equipment maintenance affect the pressing quality.

Optimize your strategy
Equipment upgrade: Adopt high-precision hydraulic press and CIP equipment.
Mold optimization: Use highly elastic and wear-resistant molds.
Process monitoring: Implement a real-time pressure monitoring system.
Data analysis: Establish a database of pressing parameters and optimize the process.

Future trends
Hot Isostatic Pressing (HIP): Combines high temperature and pressure to increase density.
Smart devices: Optimized pressure control with sensors.
Green technology: Develop low-energy suppression equipment.
New equipment: such as high-frequency vibration pressing machine, reduce defects.

6.2.3 High Temperature Sintering Furnace (Vacuum/Atmosphere Furnace)

How it works:

The high-temperature sintering furnace combines powder particles to form a high-density electrode through high temperature (2000~2200°C). Vacuum furnaces reduce oxidation through a low-pressure environment, and atmosphere furnaces protect particles with hydrogen or inert gases.

Vacuum sintering principle: low-pressure environment (10^{-3} Pa) reduces the volatilization of cerium oxide and forms fine grains.
Atmosphere sintering principle: high-purity hydrogen (purity ≥99.999%) as a reducing atmosphere to prevent oxidation.

Structural design

Vacuum sintering furnace:

Main components: furnace body, vacuum pump, heating element (molybdenum or tungsten) and temperature control system.
Design features: The furnace body is made of high-temperature resistant alloy, and the vacuum pump ensures a high vacuum level. The temperature control system has high accuracy (deviation

<± 10°C).
Environmental requirements: Operate in a clean environment.

Atmosphere sintering furnace:
Main components: furnace body, gas circulation system, heating element and dew point control system.
Design features: The gas circulation system ensures a homogeneous atmosphere and the dew point control system maintains low moisture content (<-40°C).
Environmental requirements: Exhaust gas treatment system is required.

Operation process
Vacuum sintering process:
Place the billet on the furnace body and start the vacuum pump to reach the target vacuum level.
Heat up to sintering temperature, keep warm for several hours, and cool slowly.
Check the density and structure of the electrodes and store them in sealed containers.

Atmosphere sintering process:
The billet is placed in the furnace body and high-purity hydrogen is injected.
Heat up to sintering temperature, keep warm and cool.
Check the quality of the electrodes and store them in a dry environment.

Craftsmanship details
Temperature control: ensure uniform temperature in the furnace to avoid excessive grain size.
Atmosphere management: Hydrogen flow and dew point need to be precisely controlled.
Cooling Speed: Slow cooling avoids thermal stress.

Influencing factors
Equipment Precision: Temperature control and vacuum control accuracy affect sintering quality.
Atmosphere purity: Moisture or oxygen in the gas can cause oxidation.
Billet characteristics: The density and doping uniformity of the billet affect the sintering effect.
Operating Specifications: Parameter settings and maintenance levels affect equipment performance.

Optimize your strategy
Equipment upgrade: adopt high-precision temperature control and vacuum system.
Atmosphere optimization: Use of high-purity hydrogen and dew point control.
Process Monitoring: Implement real-time temperature and atmosphere monitoring.
Data analysis: Establish a database of sintering parameters and optimize the process.

Future trends
Plasma Sintering (SPS): Rapid sintering by pulsed current.
Intelligent equipment: Optimize sintering parameters through artificial intelligence.
Green technology: development of low-energy sintering furnaces.
New equipment: such as microwave sintering furnace, improve heating uniformity.

CTIA GROUP LTD
Cerium Tungsten Electrode Introduction

1. Overview of Cerium Tungsten Electrode

Cerium Tungsten Electrode (WC20) is a non-radioactive tungsten electrode material composed of high-purity tungsten base doped with 1.8% to 2.2% cerium oxide (CeO_2). Compared to traditional thoriated tungsten electrodes, the cerium tungsten electrode offers superior arc starting performance, lower burn-off rate, and greater arc stability, while being radiation-free and environmentally friendly. It is suitable for both DC (direct current) and AC/DC mixed current welding conditions and is widely used in TIG welding and plasma cutting of materials such as stainless steel, carbon steel, and titanium alloys. This makes it an ideal green substitute in modern industrial welding.

2. Features of Cerium Tungsten Electrode

Excellent Arc Starting: Easy to ignite at low current, with stable and reliable performance.
Low Burn-off Rate: Cerium oxide enhances evaporation resistance at high temperatures, extending electrode life.
High Arc Stability: Focused arc with minimal flicker, suitable for precision welding.
Radiation-Free & Eco-Friendly: A safe and environmentally sound alternative to radioactive thoriated electrodes.

3. Specifications of Cerium Tungsten Electrode

Type	CeO_2 Content	Color Code	Density (g/cm^3)	Length (mm)	Diameter Range (mm)
WC20	1.8% – 2.2%	Grey	19.3	50 – 175	1.0 – 6.4

4. Applications of Cerium Tungsten Electrode

TIG welding of stainless steel, carbon steel, titanium alloys, nickel alloys, etc.
Precision welding and spot welding for medical devices and microelectronic components
Suitable for DC and AC/DC mixed welding conditions
Low-current plasma arc cutting and high-frequency ignition systems

5. Procurement Information

Email: sales@chinatungsten.com
Phone: +86 592 5129595; 592 5129696
Website: www.tungsten.com.cn

6.3 Processing equipment for cerium tungsten electrodes

Processing equipment is used to process sintered billets into standard electrodes, including calenders, drawing machines, grinders, polishing machines, and cutting equipment. These devices need to ensure the geometric accuracy and surface quality of the electrodes.

6.3.1 Calender and drawing machine

How it works:

Calenders deform the billet into bars through high temperature and mechanical force, and drawing machines stretch the bars through molds to form standard diameter electrodes.

Calendering principle: Hot calendering improves bar density and mechanical strength through multiple passes of deformation.
Drawing Principle: Hot drawing optimizes surface quality and geometric accuracy through mold stretching.

Structural design

Calender:

Main components: calender roller, heating system, drive motor and control system.
Design features: The calendering rollers are made of carbide or ceramic, and the heating system ensures uniform high temperatures.
Environmental requirements: It needs to be operated in a protective atmosphere to prevent oxidation.

Pulling machine:

Main components: drawing die, lubrication system, traction device and control system.
Design features: The mold is made of diamond or carbide, and the lubrication system uses graphite emulsion.
Environmental requirements: Operate in a clean environment.

Operation process

Calendering process:

The billet is heated to a high temperature and placed in a calender.
The bar is formed by multiple passes of calendering and the surface quality is checked.
Store in a dry environment after cooling.

Pulling process:

The bar is heated and pulled through the mold.
Apply lubricant to control the pulling speed.
Check the electrode diameter and surface quality.

Craftsmanship details

Calendering parameters: the amount of deformation and temperature need to be optimized to avoid cracks.
Drawing parameters: mold pore size and lubricant ratio affect surface quality.

Environmental control: Maintain a protective atmosphere and low humidity.

Influencing factors

Equipment Precision: The precision of the rolls and dies affects the quality of the machining.
Material Properties: The density and hardness of the billet affect the difficulty of processing.
Lubricant quality: affects the quality of the drawn surface.
Operating specifications: Parameter setting and maintenance level affect the machining effect.

Optimize your strategy

Equipment upgrade: adopt high-precision calender and drawing machine.
Mold optimization: Use high-hardness, wear-resistant molds.
Process monitoring: Implement a real-time monitoring system.
Data analysis: Establish a database of processing parameters.

Future trends

Precision machining technology: Developing equipment suitable for ultra-fine electrodes.
Intelligent equipment: Optimize processing parameters with sensors.
Green technology: use of environmentally friendly lubricants and low-energy equipment.
New equipment: such as continuous drawing machine, improve efficiency.

6.3.2 Precision grinders and polishing machines

How it works:

Precision grinders create taper angles by grinding electrodes with diamond grinding wheels, and polishing machines improve surface finish and optimize arcing performance through mechanical or chemical polishing.

Grinding Principle: The grinding wheel removes material through high-speed rotation, creating a precise taper angle.
Polishing Principle: The polishing head improves the surface finish through friction or chemical action.

Structural design

Precision grinders:

Main components: grinding wheel, spindle, cooling system and angle control system.
Design Features: The grinding wheel is made of diamond material, and the spindle provides high-precision rotation.
Environmental requirements: Operate in coolant to prevent thermal damage.

Polishing machine:

Main components: polishing head, polishing fluid system and control system.
Design Features: The polishing head is made of soft material, and the control system ensures angular consistency.
Environmental requirements: Operate in a clean environment.

Operation process

Grinding Process:

The electrode is fixed on the grinder, and the cone angle and grinding wheel parameters are set.

Start grinding and spray coolant.

Check the cone angle and surface quality.

Polishing Process:

The polished electrode is placed in a polishing machine and coated with polishing fluid.

Start polishing, control speed and time.

Check the surface finish.

Craftsmanship details

Grinding wheel selection: The particle size (200~400 mesh) needs to be optimized according to the electrode size.

Coolant management: Maintain low temperatures (<30°C) and high purity.

Polishing parameters: The polishing liquid ratio and speed need to be precisely controlled.

Influencing factors

Equipment Precision: The precision of the grinding wheel and polishing head affects the quality of machining.

Electrode Properties: Hardness and microstructure affect grinding difficulty.

Coolant quality: Affects the grinding effect and surface quality.

Operating specifications: Parameter setting and maintenance level affect the machining effect.

Optimize your strategy

Equipment upgrade: adopt high-precision grinding machine and polishing machine.

Wheel optimization: Use a high-hardness diamond grinding wheel.

Process monitoring: Implement a real-time monitoring system.

Data analysis: Establish a database of processing parameters.

Future trends

Laser-Assisted Grinding: Improves machining accuracy and efficiency.

Intelligent equipment: Optimization of grinding parameters by means of sensors.

Green technology: use of environmentally friendly coolant and low-energy equipment.

New equipment: such as ultrasonic polishing machine, improve surface quality.

6.3.3 Cutting and shaping equipment

How it works:

The cutting equipment cuts the bar to standard length by laser or wire EDM, and the shaping equipment corrects the electrode straightness by means of a fixture.

Cutting principle: laser cutting melts the material through a high-energy beam, and wire cutting corrodes the material through electrical discharge.

Shaping principle: The fixture corrects the electrode shape by mechanical force.

Structural design

Laser Cutting Machine:

Main components: laser, focusing system, mobile platform and control system.

Design Features: The laser delivers a high-energy beam, and the focusing system ensures precision in cutting.

Environmental requirements: Operate in coolant or protective atmosphere.

Shaping Equipment:

Main components: clamps, hydraulic system and control system.

Design Features: The clamp is made of high-strength materials, and the hydraulic system provides uniform pressure.

Environmental requirements: Operate in a clean environment.

Operation process

Cutting Process:

Fix the bar on the cutting machine and set the cutting parameters.

Start the laser or wire cut, control the speed and path.

Check the quality of the cut surface.

Shaping process:

Place the electrode on the fixture and apply a corrective force.

Check for straightness and surface quality.

Craftsmanship details

Cutting parameters: Laser power and cutting speed need to be optimized to avoid heat-affected zones.

Fixture design: The accuracy and rigidity of the fixture affect the correction effect.

Environmental control: Maintain a protective atmosphere and clean environment.

Influencing factors

Equipment Precision: The precision of lasers and fixtures affects the quality of machining.

Material Properties: The hardness and ductility of the electrode affect the difficulty of processing.

Operating specifications: Parameter setting and maintenance level affect the machining effect.

Optimize your strategy

Equipment upgrade: High-precision laser cutting machine and shaping equipment are adopted.

Process monitoring: Implement a real-time monitoring system.

Data analysis: Establish a database of processing parameters.

Environmental management: Equipped with efficient ventilation system.

Future trends

Femtosecond Laser Cutting: Enhancing Cutting Accuracy and Efficiency.
Intelligent equipment: Optimize processing parameters with sensors.
Green technology: development of low-energy cutting equipment.
New equipment: such as electromagnetic shaping machine, improve the correction efficiency.

6.4 Testing and quality control equipment for cerium tungsten electrodes

Inspection and quality control equipment is used to analyze the composition, microstructure, and properties of electrodes to ensure they meet high-performance welding requirements.

6.4.1 Composition Analyzers (ICP-MS, XRF, etc.)

How it works:

Composition analyzers detect tungsten, cerium oxide, and impurity levels in electrodes through spectroscopy or mass spectrometry techniques, ensuring purity and doping uniformity.

ICP-MS principle: Plasma ionization of the sample, mass spectrometer analyzes the ionic quality, and detects ppm-level impurities.
XRF principle: Stimulate the sample by X-ray, analyze the fluorescence spectrum, and quickly detect the component distribution.

Structural design

ICP-MS:

Main components: plasma generator, mass spectrometer, sample introduction system and data analysis system.
Design features: The plasma generator provides a high-temperature ionization environment with high mass spectrometer accuracy (ppb class).
Environmental requirements: Operate in a clean room (ISO level 5).

XRF:

Main components: X-ray tube, detector and data processing system.
Design features: X-ray tubes provide a stable light source and high detector resolution.
Environmental requirements: Operate in a dust-free environment.

Operation process

ICP-MS Process:

The sample is dissolved in an acid solution and introduced into the plasma.
The mass spectrometer analyzes the ion mass and generates compositional data.
Calibrate equipment to ensure inspection accuracy.

XRF Process:

The sample is placed under an X-ray beam and the detector collects the fluorescence signal.
The data processing system analyzes the distribution of components.

Craftsmanship details
Sample preparation: Ensure that the sample surface is clean and free of contamination.
Equipment Calibration: Regularly calibrate standard samples to ensure testing accuracy.
Environmental control: Low humidity and dust-free environment need to be maintained.

Influencing factors
Device accuracy: The resolution of spectrometers and mass spectrometers affects the assay results.
Sample Quality: Surface contamination or inhomogeneity affects analytical accuracy.
Operating Specifications: Calibration and maintenance levels affect equipment performance.

Optimize your strategy
Equipment upgrade: High-resolution ICP-MS and XRF are adopted.
Sample Optimization: Optimize the sample preparation process.
Process monitoring: Implement a real-time data analysis system.
Data analysis: Establish a database of ingredients and optimize detection.

Future trends
High-resolution analysis: Developing equipment suitable for nanoscale impurity detection.
Intelligent Devices: Optimize data analysis through artificial intelligence.
Green technology: development of low-energy analysis equipment.
New equipment: such as synchrotron XRF, for improved accuracy.

6.4.2 Microstructure Detection Equipment (SEM, TEM)
How it works:
Scanning electron microscopy (SEM) and transmission electron microscopy (TEM) analyze the grain size and particle distribution of electrodes through electron beam imaging.

SEM principle: The electron beam scans the sample surface to generate a high-resolution image.
TEM principle: The electron beam penetrates the sample and analyzes the nanoscale structure.

Structural design
WITHOUT:
Main components: electron gun, scanning coil, detector and vacuum system.
Design Features: The electron gun provides a high-energy electron beam, and the vacuum system ensures high resolution.
Environmental requirements: Operate in a high vacuum environment.

HAS:
Main components: electron gun, lens system, sample stage and imaging system.
Design features: The lens system provides high-resolution imaging, and the sample stage supports nanoscale positioning.
Environmental requirements: Operate in an ultra-high vacuum environment.

Operation process

SEM process:

Initiate an electron beam scan to generate a surface image.
Analyze particle distribution and grain size.

TEM Process:

Ultra-thin samples were prepared and placed on the sample stage.
The electron beam is activated to penetrate the sample, producing a nanoscale image.
Analysis of crystal structure and particle distribution.

Craftsmanship details

Sample preparation: SEM needs to be surface polished, TEM needs to be ultra-thin sectioned.
Equipment Calibration: Regularly calibrate the electron beam and detector.
Environmental control: It is necessary to maintain an ultra-high vacuum and vibration-free environment.

Influencing factors

Device Accuracy: The resolution of the electron beam and detector affects the imaging quality.
Sample quality: The quality of the surface or slice affects the analysis results.
Operating Specifications: Calibration and maintenance levels affect equipment performance.

Optimize your strategy

Equipment upgrade: adopt high-resolution SEM and TEM.
Sample Optimization: Optimize the preparation process to improve sample quality.
Process Monitoring: Implement real-time imaging analysis systems.
Data analysis: Establish a microstructure database.

Future trends

High-resolution TEM: Analyze nanoscale structures.
Smart Devices: Optimize imaging analysis with artificial intelligence.
Green technology: development of low-energy microscopes.
New equipment: such as environmental SEM, suitable for dynamic observation.

6.4.3 Performance Test Equipment (Arc Initiation Performance Tester)

How it works:

The arc initiation performance tester evaluates the electrode's performance by simulating the welding environment by measuring the arc voltage, current stability, and arc duration.

Test principle: Arc is initiated by a high-frequency arc initiation device and the electrical parameters are recorded.
Key indicators: arc starting voltage, arc stability, and electrode life.

Structural design

Main components: high-frequency arc initiator, current sensor, gas control system and data acquisition system.

Design features: The high-frequency arc initiator provides a stable arc and the sensor accuracy is high (±0.1 A).

Environmental requirements: Operate in a simulated welding environment.

Operation process

Test Process:

The electrode is mounted on the test device and the argon gas is passed.

Start the high-frequency arc and record the electrical parameters.

Analyze arc initiation performance and arc stability.

Craftsmanship details

Test parameters: current, voltage and gas flow need to be precisely controlled.

Environmental control: Actual welding conditions need to be simulated.

Equipment Calibration: Calibrate the sensors regularly to ensure accuracy.

Influencing factors

Equipment Accuracy: The accuracy of sensors and control systems affects test results.

Electrode quality: Cerium oxide distribution affects arc initiation performance.

Environmental conditions: Gas purity and humidity affect test results.

Optimize your strategy

Equipment upgrade: adopt high-precision tester.

Test Optimization: Optimize test parameters to simulate multiple welding conditions.

Process monitoring: Implement real-time data acquisition systems.

Data analysis: Establish a performance database and optimize testing.

Future trends

Intelligent Testing: Analyze performance data through artificial intelligence.

Multifunctional Testing: Develop comprehensive performance testing equipment.

Green technology: development of low-energy testing equipment.

New equipment: such as dynamic arc tester to improve accuracy.

6.5 Automation and intelligent equipment for cerium tungsten electrodes

Automation and intelligence improve productivity and quality consistency through robotics, sensors, and data analytics.

6.5.1 Industrial robots and automated production lines

How it works:

Industrial robots are programmed to perform tasks such as mixing, pressing, and processing, and automated production lines achieve continuous production through conveyor belts and control systems.

Robot principle: High-precision operation is performed through multi-axis robotic arms.
Production line principle: process integration through conveyor belts and automation equipment.

Structural design

Industrial Robots:

Main components: robotic arm, servo motor, sensor and control system.
Design Features: The robotic arm provides high-precision positioning, and sensors monitor the operation in real time.
Environmental requirements: Operate in a clean environment.

Automated Production Line:

Main components: conveyor belt, automation equipment and central control system.
Design features: The conveyor belt is made of wear-resistant materials, and the control system is integrated with multi-equipment operation.
Environmental requirements: Maintain a dust-free and low-humidity environment.

Operation process

Robot Operation:

Programmed robots to perform tasks such as mixing and pressing.
Sensors monitor the accuracy of the operation and adjust the action.
Check the quality of the finished product.

Production line operation:

Start the conveyor belt and coordinate the operation of each equipment.
The central control system monitors the production status.
Collect the finished product and store it in an airtight container.

Craftsmanship details

Robot programming: Optimize action paths to improve efficiency.
Production line coordination: Equipment needs to be seamlessly connected to ensure continuity.
Environmental control: Maintain a clean and stable environment.

Influencing factors

Equipment Precision: The precision of robots and conveyor belts affects production quality.
Programming quality: The degree of optimization of the program affects efficiency.
Environmental Conditions: Dust and humidity affect equipment performance.

Optimize your strategy

Equipment upgrade: Adopt high-precision robots and conveyor belts.
Programming Optimization: Optimize action paths using artificial intelligence.
Process monitoring: Implement a real-time monitoring system.

Data analysis: Establish a production parameter database.

Future trends

Collaborative robots: Improve human-machine collaboration efficiency.
Intelligent production line: Integrate equipment through the Internet of Things.
Green technology: development of low-energy robots.
New equipment: such as flexible production lines, suitable for multi-variety production.

6.5.2 Online monitoring and data acquisition system

How it works:

The online monitoring system detects production parameters in real time through sensors, and the data acquisition system analyzes the data and optimizes the process.

Monitoring principle: Sensors detect parameters such as temperature, pressure, and gas flow.
Data collection principle: Analyze production data through databases and algorithms.

Structural design

Online monitoring system:

Main components: sensor, data transmission module and display system.
Design features: The sensor has high accuracy, and the data transmission module supports real-time transmission.
Environmental requirements: It needs to be operated in a stable environment.

Data Acquisition System:

Main components: server, database and analysis software.
Design features: The database supports big data storage, and the analysis software integrates artificial intelligence algorithms.
Environment requirements: Operate in a secure network environment.

Operation process

Monitoring Process:

Sensors are installed on production equipment to collect data in real time.
Data is transmitted to the display system to monitor the production status.
Adjust abnormal parameters to ensure stable production.

Data collection process:

Collect production data and store it in a database.
Optimization of process parameters with analysis software.
Generate quality reports to guide production.

Craftsmanship details

Sensor selection: High-precision sensors should be selected according to the type of parameters.
Data analysis: Algorithms need to be optimized to improve analysis efficiency.

Environmental control: Ensure network and power stability.

Influencing factors

Sensor accuracy: Affects data quality.
Algorithm efficiency: affects the results of the analysis.
Network stability: Affects data transmission.

Optimize your strategy

Equipment upgrade: Adopt high-precision sensors and servers.
Algorithm Optimization: Use machine learning to improve analysis accuracy.
Network Optimization: Ensures stable data transmission.
Data analysis: Establish a comprehensive database to optimize the process.

Future trends

Digital twin technology: simulates the optimization parameters of the production process.
Intelligent Monitoring: Dynamically adjust parameters through artificial intelligence.
Green technology: development of low-energy monitoring systems.
New equipment: such as multi-sensor integrated system, improve monitoring efficiency.

CTIA GROUP LTD
Cerium Tungsten Electrode Introduction

1. Overview of Cerium Tungsten Electrode

Cerium Tungsten Electrode (WC20) is a non-radioactive tungsten electrode material composed of high-purity tungsten base doped with 1.8% to 2.2% cerium oxide (CeO_2). Compared to traditional thoriated tungsten electrodes, the cerium tungsten electrode offers superior arc starting performance, lower burn-off rate, and greater arc stability, while being radiation-free and environmentally friendly. It is suitable for both DC (direct current) and AC/DC mixed current welding conditions and is widely used in TIG welding and plasma cutting of materials such as stainless steel, carbon steel, and titanium alloys. This makes it an ideal green substitute in modern industrial welding.

2. Features of Cerium Tungsten Electrode

Excellent Arc Starting: Easy to ignite at low current, with stable and reliable performance.
Low Burn-off Rate: Cerium oxide enhances evaporation resistance at high temperatures, extending electrode life.
High Arc Stability: Focused arc with minimal flicker, suitable for precision welding.
Radiation-Free & Eco-Friendly: A safe and environmentally sound alternative to radioactive thoriated electrodes.

3. Specifications of Cerium Tungsten Electrode

Type	CeO_2 Content	Color Code	Density (g/cm^3)	Length (mm)	Diameter Range (mm)
WC20	1.8% – 2.2%	Grey	19.3	50 – 175	1.0 – 6.4

4. Applications of Cerium Tungsten Electrode

TIG welding of stainless steel, carbon steel, titanium alloys, nickel alloys, etc.
Precision welding and spot welding for medical devices and microelectronic components
Suitable for DC and AC/DC mixed welding conditions
Low-current plasma arc cutting and high-frequency ignition systems

5. Procurement Information

Email: sales@chinatungsten.com
Phone: +86 592 5129595; 592 5129696
Website: www.tungsten.com.cn

Chapter 7 Domestic and Foreign Standards for Cerium and Tungsten Electrodes

As a representative of non-consumable electrodes, the quality and performance of cerium tungsten electrodes directly affect the stability and efficiency of welding and cutting processes. Domestic and foreign standards provide standardized technical guidance for the production, testing and application of cerium tungsten electrodes, ensuring the consistency of product quality and the internationalization level of the industry. This chapter systematically expounds the standardization system of cerium tungsten electrodes from four aspects: international standards, domestic standards, standard comparison and interpretation, and standard update and development trend, and deeply analyzes the background, purpose, scope of application and core content of each standard.

7.1 International standard for cerium tungsten electrode

International standards provide global technical specifications for the production and application of cerium-tungsten electrodes, mainly including standards from the International Organization for Standardization (ISO), the American Welding Society (AWS), and the European Committee for Standardization (EN). These standards provide comprehensive guidance for the quality control of cerium tungsten electrodes, ensuring their applicability and consistency in the global market, from classification, chemical composition, dimensional requirements, performance indicators, to testing methods.

7.1.1 ISO 6848: Classification and requirements for tungsten electrodes

Standard background

ISO 6848 Arc welding and cutting — Nonconsumable tungsten electrodes — Classification was developed by the International Organization for Standardization (ISO) and was first published in 1984 and last revised in 2004. The standard aims to provide uniform classification and performance requirements for non-consumable tungsten electrodes for inert gas shielded arc welding (TIG), plasma welding and cutting, covering pure tungsten electrodes and electrodes doped with oxides such as cerium oxide, thorium oxide, and lanthanum oxide. Cerium-tungsten electrodes are clearly defined as WC20 in standards due to their low radioactivity and excellent arcing performance, and are widely used in high-precision welding scenarios such as aerospace, automobile manufacturing, and energy.

Purpose: Promote international trade and technical exchanges by standardizing the classification, composition, and performance of tungsten electrodes, and ensure the versatility of electrodes in different countries and industries.

Scope of application: Suitable for TIG welding, plasma welding, and cutting, covering a wide range of application scenarios, from low-current precision welding to high-heat input industrial welding.

Revision history: The first edition in 1984 established a basic classification framework, and the 2004 revision added detailed requirements for doped electrodes, reflecting the development of new electrode materials.

Standard content

ISO 6848 details the technical requirements for cerium-tungsten electrodes (WC20), covering the following aspects:

Classification and Identification: Cerium tungsten electrodes are classified as WC20 with a cerium oxide content of 1.8%~2.2% (mass fraction). The standard requires the electrode terminals to be gray marked for easy identification.
Chemical composition: The purity of tungsten matrix should reach more than 99.5%, and the content of cerium oxide as the main doping should be strictly controlled at 1.8%~2.2% to optimize the arc initiation performance and arc stability. The content of impurities (e.g., iron, carbon, silicon) should be kept at a low level to avoid affecting the electrode performance.
Dimensions and tolerances: Electrode diameters range from 0.510 mm to 50175 mm to meet precision manufacturing requirements (e.g., diameter tolerance ±0.05 mm, length tolerance ± 1 mm). The standard also specifies the requirements for the straightness and roundness of the electrode.
Surface quality: The electrode surface is required to be smooth and free from cracks, oxide layers, oil stains, or mechanical damage. Surface finishes need to meet the needs of high-frequency arcing, usually achieved by polishing or chemical cleaning.
Performance requirements: Emphasize the arcing performance, arc stability, and burnout resistance of cerium-tungsten electrodes at low currents. The standard requires the electrode to pass the arc initiation test and the dimensional arc test to verify its performance under different welding conditions.
Detection methods: Inductively coupled plasma mass spectrometry (ICP-MS) or X-ray fluorescence spectroscopy (XRF) is used to detect chemical composition, scanning electron microscopy (SEM) is used to analyze the microstructure, and arc initiation tester is used to evaluate the electrical properties.
Packaging and storage: The electrode packaging is required to be moisture-proof and dust-proof, marking the WC20 model, batch number, and manufacturer information. The packaging materials must comply with international shipping standards, ensuring that the electrodes are not damaged during transportation and storage.
Certification requirements: Manufacturers need to submit samples to ISO certification bodies to obtain a certificate of conformity through composition, dimensions, and performance tests.

Additional Notes

ISO 6848 specifically emphasizes the low radioactivity advantages of cerium-tungsten electrodes, recommending them as an alternative to thorium oxide electrodes to meet the needs of high-security industries such as aerospace. The standard also provides detailed color-coded guidelines, ensuring consistency of WC20 electrodes in the global market. In addition, standard appendices contain recommendations for welding parameters, such as recommended current ranges and shielding gas types (argon or helium), to provide users with application references.

7.1.2 AWS A5.12: Tungsten Electrode Specifications

Standard background

AWS A5.12 "Specification for Tungsten and Oxide Dispersed Tungsten Electrodes for Arc Welding and Cutting" was developed by the American Welding Society (AWS) and was last revised in 2009. This standard provides detailed specifications for the production and application of tungsten electrodes in the North American market, and cerium tungsten electrodes are defined as EWCe-2, which are suitable for TIG welding and plasma welding, and are widely used in aerospace, automotive manufacturing, energy and other industries.

Purpose: To provide uniform specifications for tungsten electrodes in the North American market, ensure product quality and reliability of welding processes, and promote industry standardization.
Scope of application: Suitable for TIG welding, plasma welding, and cutting, with a special emphasis on high-precision and low-current welding scenarios.
Revision history: The first edition in 1998 laid the foundation for classification, and the revised version in 2009 added the performance requirements for doped electrodes to adapt to the development of new welding equipment.

Standard content
AWS A5.12 provides comprehensive specifications for the technical requirements for cerium-tungsten electrodes (EWCe-2), covering the following aspects:

Classification and Identification: Cerium tungsten electrodes are classified as EWCe-2 with a cerium oxide content of 1.8%~2.2%, and the ends are marked with gray, which is consistent with ISO 6848 for international identification.
Chemical composition: The purity of tungsten matrix is required to be ≥ 99.5%, and the content of cerium oxide is strictly controlled at 1.8%~2.2%. The content of impurities (e.g., iron, silicon, aluminum) must be below the specified threshold to ensure the electrical performance of the electrode.
Dimensions and Tolerances: Electrode diameters range from 0.56.4 mm to length ranges from 75300 mm, with tight tolerances (e.g., diameter tolerance ±0.03 mm, length tolerance ±0.5 mm), suitable for high-precision applications.
Surface quality: The electrode surface is required to be free of cracks, oxides, oil stains, or mechanical scratches. The surface needs to be precision polished to meet the needs of low current arcing.
Performance requirements: Emphasize the arc initiation performance and arc stability of EWCe-2 electrodes in direct current (DC) and alternating current (AC) welding, requiring high-frequency arc initiation tests and long-term dimensional arc tests.
Detection methods: It is prescribed to use XRF or atomic absorption spectroscopy (AAS) to detect chemical composition, SEM or light microscopy to analyze the microstructure, and arc testers to evaluate arc initiation and dimensional arc performance.
Packaging and storage: The electrode packaging is required to be moisture-proof and dust-proof, marking the EWCe-2 model, size, and manufacturer information. Packaging must comply with North American shipping standards to prevent mechanical damage during transit.
Certification requirements: Companies need to submit samples to AWS certification bodies to pass composition, size, and performance tests to obtain conformity certification.

Additional Notes
AWS A5.12 pays special attention to uniformity in color coding, and the gray markings of EWCe-

2 are widely adopted in the North American market, ensuring that users can quickly identify electrode types. The standard also provides a detailed welding parameter table, recommending the current range and shielding gas ratio of electrodes of different diameters, making it easier for users to optimize the welding process. In addition, standard appendices contain precautions for electrode storage and handling, such as avoiding high temperatures and humidity to extend electrode life.

7.1.3 EN 26848: European standard for tungsten electrodes

Standard background

EN 26848 "Tungsten electrodes for inert gas shielded arc welding and for plasma cutting and welding" was developed by the European Committee for Standardization (CEN) and was last revised in 1991. This standard provides technical specifications for tungsten electrodes for the European market, and cerium tungsten electrodes are defined as WC20, consistent with ISO 6848, for TIG and plasma welding, and are widely used in aerospace, energy and automotive manufacturing.

Purpose: To unify the specifications of tungsten electrodes in the European market, promote technical exchange and market access, and ensure product quality and safety.
Scope of application: Suitable for TIG welding, plasma welding and cutting, especially suitable for scenarios with high high precision and environmental protection requirements.
Revision history: The 1991 revision harmonized with ISO 6848 and added performance requirements for doped electrodes.

Standard content

EN 26848 details the technical requirements for cerium-tungsten electrodes (WC20) and covers the following aspects:

Classification and Identification: Cerium tungsten electrodes are classified as WC20 with a cerium oxide content of 1.8%~2.2% and gray markings at the ends, which is consistent with ISO 6848.
Chemical composition: The purity of the tungsten matrix is required to be ≥99.5%, the content of cerium oxide is 1.8%~2.2%, and the content of impurity elements (such as iron and carbon) needs to be strictly controlled.
Dimensions and tolerances: Electrode diameters range from 0.510 mm to 50175 mm for lengths with tight tolerance requirements (e.g. diameter tolerance ± 0.05 mm, length tolerance ± 1 mm).
Surface quality: The electrode surface is required to be smooth, free of cracks, oxide layers or contamination, and needs to be polished or chemically cleaned to meet the needs of high-frequency arcing.
Performance requirements: Emphasizing the arc initiation performance and arc stability of WC20 electrodes at low currents, it needs to pass standardized arc initiation and dimension arc tests.
Detection methods: ICP-MS or XRF is used to detect chemical composition, SEM to analyze microstructure, and arc initiation tester to evaluate electrical properties.
Packaging and storage: The electrode packaging is required to be moisture-proof and dust-proof, marked with the WC20 model, batch number, and manufacturer information, and comply with European shipping standards.

Certification requirements: Enterprises need to submit samples to the CEN certification body to pass the composition, size and performance tests to obtain a certificate of conformity.

Additional Notes

EN 26848 is highly harmonized with ISO 6848, emphasizing the low radioactivity and environmental advantages of cerium-tungsten electrodes, which are suitable for the stringent requirements of the European market for safety and sustainability. The standard also provides recommendations for welding processes, such as the recommended use of argon as a shielding gas and the adjustment of the current range according to the electrode diameter. In addition, the standard appendices contain environmental requirements for electrode storage, such as the use of recyclable packaging materials, reflecting Europe's emphasis on green manufacturing.

7.2 Domestic standards for cerium tungsten electrodes

Domestic standards provide specifications for the production and application of cerium tungsten electrodes in the Chinese market, mainly including national standards (GB) and industry standards (JB) to ensure product quality and industry competitiveness. These standards, combined with the technical level and application needs of the Chinese market, provide localized guidance for the production and use of cerium-tungsten electrodes.

7.2.1 GB/T 4192: Technical conditions for tungsten electrodes

Standard background

GB/T 4192 "Tungsten electrodes for inert gas shielded arc welding, plasma welding and cutting" was formulated by the National Standardization Technical Committee, and the latest revised version was in 2015. This standard provides technical specifications for tungsten electrodes in the Chinese market, cerium tungsten electrodes are defined as WC20, suitable for TIG and plasma welding, and are widely used in aerospace, energy, automotive and other industries.

Purpose: To standardize the production, testing and application of domestic tungsten electrodes, improve product quality and industry competitiveness, and promote international market access.
Scope of application: Suitable for TIG welding, plasma welding and cutting, covering scenarios from low-current precision welding to high-heat input industrial welding.
Revision history: The initial 2000 edition established the basic framework, and the 2015 revision harmonized with ISO 6848 to increase performance requirements for doped electrodes.

Standard content

GB/T 4192 comprehensively stipulates the technical requirements for cerium-tungsten electrodes (WC20), covering the following aspects:

Classification and Identification: Cerium tungsten electrodes are classified as WC20, with a cerium oxide content of 1.8%~2.2%, and gray markings are used at the ends, which is consistent with international standards.
Chemical composition: The purity of tungsten matrix is required to be ≥ 99.5%, and the content of cerium oxide is strictly controlled at 1.8%~2.2%. The content of impurity elements (e.g., iron,

Tel: 0086 592 512 9696
CTIAQCD -MA-E/P 2018- 2025V
sales@chinatungsten.com

silicon, carbon) must be below the specified threshold to ensure electrode performance.

Dimensions and tolerances: The electrode diameter range is 0.510 mm, the length range is 50175 mm, and the tolerance requirements are moderate (e.g., diameter tolerance ±0.1 mm, length tolerance ±1.5 mm), suitable for domestic production conditions.

Surface quality: The electrode surface is required to be free of cracks, oxides, or pollution, and the arcing needs need to be met by polishing or cleaning.

Performance requirements: Emphasize the arc initiation performance, arc stability and high temperature resistance of WC20 electrodes, which need to pass the arc initiation test and dimensional arc test.

Detection methods: XRF or AAS is prescribed for chemical composition, SEM or light microscopy for microstructure analysis, and arc initiation tester to evaluate electrical properties.

Packaging and storage: The electrode packaging is required to be moisture-proof and dust-proof, marked with WC20 model, size, and manufacturer information, and comply with domestic transportation standards.

Certification requirements: Enterprises need to submit samples to the national certification body to pass the composition, size and performance tests to obtain a certificate of conformity.

Additional Notes

GB/T 4192 was formulated with the production capacity and cost control needs of the Chinese market in mind, with slightly looser tolerance requirements compared to international standards, but performance requirements consistent with ISO 6848. The standard also provides suggestions for welding parameters, such as the recommended current range and shielding gas type, making it convenient for domestic users to optimize the process. In addition, the standard appendix contains precautions for electrode storage and handling, such as avoiding humid and high-temperature environments to ensure electrode quality.

7.2.2 JB/T 12706: Standard for tungsten electrodes for welding

Standard background

JB/T 12706 "Tungsten Electrode for Welding" was formulated by the China Machinery Industry Federation, and the latest revision was in 2017. This standard provides specifications for the production and application of tungsten electrodes in the machinery industry, cerium tungsten electrodes are defined as WC20, suitable for TIG and plasma welding, and are widely used in machinery manufacturing, shipbuilding, energy and other industries.

Purpose: To standardize the production and use of tungsten electrodes in the machinery industry to ensure product quality and the reliability of welding processes.

Scope of application: Suitable for TIG welding and plasma welding in the field of mechanical manufacturing, especially suitable for scenarios with high requirements for high strength and corrosion resistance.

Revision history: The first edition in 2010 established the basic specifications, and the 2017 revision added performance requirements for doped electrodes.

Standard content

JB/T 12706 specifies in detail the technical requirements for cerium-tungsten electrodes (WC20), covering the following aspects:

Classification and identification: Cerium tungsten electrodes are classified as WC20, with a cerium oxide content of 1.8%~2.2%, and gray markings are used at the ends.
Chemical composition: The purity of tungsten matrix is required to be ≥99.5%, the content of cerium oxide is 1.8%~2.2%, and the content of impurity elements (such as iron and aluminum) needs to be strictly controlled.
Dimensions and tolerances: Electrode diameters range from 0.58 mm to 50150 mm for lengths with moderate tolerance requirements (e.g., diameter tolerances ± 0.1 mm).
Surface quality: The electrode surface is required to be smooth, free of cracks, oxides, or mechanical damage, and needs to be polished to meet welding needs.
Performance requirements: Emphasize the arc initiation performance and arc stability of the WC20 electrode, suitable for high-intensity welding scenarios, and need to be verified by arc testing.
Detection method: AAS or XRF is prescribed to detect chemical composition, optical microscope to analyze microstructure, arc initiation tester to evaluate performance.
Packaging and storage: The electrode packaging is required to be moisture-proof and dust-proof, marked with WC20 model and manufacturer information, and comply with the transportation standards of the machinery industry.
Certification requirements: Companies need to submit samples to industry certification bodies to pass composition, size, and performance tests.

Additional Notes

JB/T 12706 emphasizes the performance of cerium-tungsten electrodes in high heat input and corrosion-resistant environments with relatively flexible tolerance requirements, suitable for the production capacity of domestic small and medium-sized enterprises. The standard also provides guidelines for welding processes, such as the recommended use of argon or argon-helium mixtures to optimize weld quality. In addition, the standard appendices contain precautions for electrode storage, such as avoiding mechanical damage and humid environments.

7.2.3 Other relevant industry standards

Standard background

In addition to GB/T 4192 and JB/T 12706, there are other industry standards in China that deal with cerium tungsten electrodes, such as the Aerospace Industry Standard (HB) and the Energy Industry Standard (NB). These standards are tailored to the application needs of specific industries, supplementing the details of national standards to meet high-demand scenarios such as aerospace and energy.

HB standard: such as HB 7716 "Tungsten electrode for aviation welding", formulated by the China Aviation Industry Standardization Committee, suitable for aerospace high-precision welding.
NB standards: such as NB/T 47018 "Technical Specification for Welding of Pressure Equipment", formulated by the National Energy Administration, involving pipeline and pressure vessel welding

in the energy industry.
Purpose: To provide customized technical specifications for specific industries to ensure that electrode performance meets special requirements.

Standard content
HB 7716:
Classification and identification: Cerium tungsten electrode is defined as WC20, with a cerium oxide content of 1.8%~2.2%, and gray markings are used at the ends.
Chemical composition: The purity of the tungsten matrix is ≥ 99.7%, and the impurity content is extremely low to meet the high reliability needs of aerospace.
Dimensions and tolerances: Electrode diameters range from 0.54 mm to 50150 mm, with tight tolerances (e.g. diameter tolerances ± 0.02 mm).
Surface quality: The surface is required to be free of any defects, and it needs to be met by precision polishing to meet the requirements of low current arcing.
Performance requirements: Emphasizing low-current arcing performance and arc stability, it needs to pass the high-frequency arcing test.
Detection method: ICP-MS was used to detect the components, SEM was used to analyze the microstructure, and the arc initiation tester was used to evaluate the performance.
Packaging and storage: Moisture-proof and dust-proof packaging is required, with the model and batch number indicated, and compliance with air transportation standards.

NB/T 47018:
Classification and identification: Cerium tungsten electrode is defined as WC20, and the content of cerium oxide is 1.8%~2.2%.
Chemical composition: The purity of the tungsten matrix is required to be ≥ 99.5%, and the impurity content is low.
Dimensions and tolerances: Electrode diameters range from 18 mm to 50175 mm for lengths with moderate tolerances.
Surface Quality: Requires a smooth surface with no cracks or oxides.
Performance requirements: Emphasize high temperature resistance and weld strength, and need to pass the arc test.
Detection methods: XRF is used to detect components, optical microscopes are used to analyze structures, and arc initiation testers are used to evaluate performance.
Packaging and storage: Moisture-proof packaging is required, indicating the model number and manufacturer information.

Other standards: such as the Marine Industry Standard (CB) and the Railway Industry Standard (TB), which have similar performance and testing requirements for cerium tungsten electrodes, focusing on corrosion resistance and high-strength welding.

Additional Notes
HB 7716 meets the high precision requirements of the aerospace industry, with stricter tolerances and performance standards, and is suitable for welding thin-walled structures and superalloys. NB/T

Tel: 0086 592 512 9696
CTIAQCD -MA-E/P 2018- 2025V
sales@chinatungsten.com

47018 focuses on high heat input and durability in the energy industry, emphasizing the stability of electrodes during long welding periods. These industry standards, in harmony with GB/T 4192, provide more detailed application guidance to meet the specific needs of specific industries.

7.3 Standard comparison and interpretation of cerium tungsten electrodes

7.3.1 Similarities and differences between domestic and foreign standards

Contrasting background

There are commonalities and differences in domestic and foreign standards in terms of classification, chemical composition, size requirements, performance indicators and testing methods of cerium tungsten electrodes, reflecting the market characteristics, technical level and regulatory requirements of different regions. The following is a detailed comparison of ISO 6848, AWS A5.12, EN 26848, GB/T 4192, and JB/T 12706 from multiple dimensions.

Classification and Identification:

Similarities: ISO 6848, AWS A5.12, EN 26848, GB/T 4192, and JB/T 12706 all define cerium-tungsten electrodes as WC20 (EWCe-5.12 for AWS A2), with a cerium oxide content of 1.8%~2.2%, and gray markings at the ends to ensure global consistency.

Differences: AWS A5.12 emphasizes strict implementation of color coding, and the North American market has higher requirements for EWCe-2 gray marking; domestic standards (such as JB/T 12706) are more flexible in identification, allowing text marks to be the main focus; HB 7716 has stricter marking requirements for the aerospace industry, including lot numbers and manufacturer information.

Chemical composition:

Similarities: All standards require a purity of ≥ 99.5% of the tungsten matrix, a cerium oxide content of 1.8%~2.2%, and the content of impurities (such as iron, carbon, silicon) that needs to be strictly controlled.

Differences: ISO 6848 and EN 26848 have more detailed requirements for the types and thresholds of impurity elements, listing specific elements (e.g. iron < 0.05%); AWS A5.12 has higher requirements for the accuracy of impurity detection; GB/T 4192 and JB/T 12706 consider domestic production costs and have slightly looser impurity control; HB 7716 requires a tungsten matrix purity of ≥99.7%, which is suitable for the high requirements of aerospace.

Dimensions and Tolerances:

Similarities: The diameter range (0.510 mm) and length range (50300 mm) are basically the same, and the tolerance requirements meet precision manufacturing requirements.

Differences: AWS A5.12 and HB 7716 have tighter tolerance requirements (e.g., diameter tolerance ± 0.03 mm), making them suitable for high-precision applications; GB/T 4192 and JB/T 12706 have loose tolerances (such as diameter tolerance ± 0.1 mm) and are suitable for domestic production conditions; EN 26848 tolerances are consistent with ISO 6848, emphasizing uniformity in the European market.

Surface:

Similarities: All standards require a smooth electrode surface with no cracks, oxides, or contamination and need to be polished or chemically cleaned.

Differences: AWS A5.12 and HB 7716 require higher surface finishes and need to meet the requirements of low current arcing; GB/T 4192 and JB/T 12706 have moderate requirements for surface quality, considering production costs; EN 26848 emphasizes environmentally friendly cleaning methods and complies with European regulations.

Performance Requirements:

Similarities: Both emphasize the arc initiation performance, arc stability and high temperature resistance of cerium tungsten electrodes, which need to pass the arc initiation and dimensional arc tests.

Differences: ISO 6848 and EN 26848 focus more on low-current arcing performance and are suitable for precision welding; AWS A5.12 covers the performance requirements of DC and AC soldering; GB/T 4192 and JB/T 12706 focus more on high heat input scenarios; HB 7716 emphasizes high reliability in aerospace.

Detection method:

Similarities: All require chemical composition detection using ICP-MS, XRF, or AAS, SEM or light microscopy for microstructure, and arc initiation tester for electrical performance.

Differences: AWS A5.12 has stricter calibration requirements for inspection equipment, requiring the use of high-precision instruments; GB/T 4192 and JB/T 12706 allow the use of lower-cost testing methods; HB 7716 requires additional microstructure testing to verify nanoscale uniformity.

Packaging and storage:

Similarities: Both require moisture- and dust-proof packaging, indicating the model, size, and manufacturer information.

Differences: AWS A5.12 and EN 26848 have higher environmental requirements for packaging materials; GB/T 4192 and JB/T 12706 pay more attention to the economy of packaging; HB 7716 requires aviation-grade packaging to prevent transportation damage.

Additional Notes

The commonality of domestic and foreign standards is to ensure the performance consistency and market versatility of cerium tungsten electrodes, while the differences reflect the technical level and application needs of the regional market. ISO 6848 and EN 26848 focus more on global harmonization, AWS A5.12 emphasizes high precision requirements in the North American market, GB/T 4192 and JB/T 12706 consider cost-effectiveness in the Chinese market, and HB 7716 targets the high reliability needs of aerospace. The harmonization of these standards facilitates international trade, but the differences also require companies to adjust their production and testing strategies when exporting.

7.3.2 The guiding significance of the standard for production and application

Guidance background

Domestic and foreign standards provide comprehensive technical guidance for the production and application of cerium tungsten electrodes, from raw material selection to welding process optimization, ensuring product quality and process reliability. The following elaborates on the guiding significance of the standard from two aspects: production and application.

Production Guidance:

Raw material selection: All standards require a tungsten matrix purity of ≥99.5% and a cerium oxide content of 1.8%~2.2%, guiding enterprises to choose high-purity tungsten powder and cerium oxide to ensure that the ingredients meet the requirements. HB 7716's higher purity requirements (≥99.7%) prompt aerospace companies to adopt high-purity feedstocks.

Process Control: Dimensional tolerances and surface quality requirements specified by the standard, guiding enterprises to optimize powder metallurgy, pressing, sintering, and processing processes. The tight tolerance requirements of AWS A5.12 drive the use of high-precision equipment, while the moderate tolerances of GB/T 4192 are suitable for the production capacity of small and medium-sized enterprises.

Quality testing: The standard clarifies the testing methods (such as ICP-MS, SEM, arc starting test) and guides enterprises to establish a quality control system to ensure the consistency of electrode performance. The environmental testing requirements of EN 26848 have prompted companies to adopt green cleaning technologies.

Certification Compliance: The standard requires enterprises to pass the test of the certification body and obtain a certificate of conformity to enhance the market competitiveness of the product. International certifications for ISO 6848 and AWS A5.12 are particularly important for easy access to global markets.

Application Guidance:

Welding Parameter Optimization: Standard current range, shielding gas type, and cone angle recommendations guide users to optimize their welding process. For example, ISO 6848 recommends low-current arcing parameters for precision welding; The NB/T 47018 offers high thermal input parameters and is suitable for the energy industry.

Industry Adaptation: The standard provides customized guidance for different industry needs. HB 7716 is suitable for high-precision welding in aerospace, JB/T 12706 is suitable for high-intensity welding in the mechanical industry, and AWS A5.12 covers DC and AC welding scenarios.

Safety and environmental protection: The environmental requirements of EN 26848 and GB/T 4192 guide enterprises to adopt green packaging and low-radioactivity materials to ensure safe use. AWS A5.12's color-coded guides users in quickly selecting electrode types.

Market competitiveness: Electrodes that meet international standards are more likely to enter the North American and European markets, while electrodes that meet domestic standards meet local cost and performance needs, enhancing the competitiveness of enterprises in different markets.

Additional Notes

The guiding significance of the standard is to provide a unified technical framework for production and application, ensuring that the quality and performance of cerium tungsten electrodes meet industry needs. International standards (such as ISO 6848, AWS A5.12) promote global production and trade, while domestic standards (such as GB/T 4192, JB/T 12706) combine the characteristics of the Chinese market to balance performance and cost. Industry standards such as HB 7716 further refine the requirements for special scenarios and support high-precision and high-reliability applications.

7.4 Standard update and development trend of cerium tungsten electrode

7.4.1 Impact of Emerging Technologies on Standards

Background analysis

Emerging technologies (such as nano-doping, intelligent detection, and green production) have put forward new requirements for the performance and production process of cerium-tungsten electrodes, prompting continuous updating of standards to adapt to technological progress and market demands.

Nano-doping technology: To improve the arc-initiating performance and burn-out resistance of electrodes through nano-scale cerium oxide doping, new composition and testing standards need to be formulated.

Intelligent detection technology: AI-assisted detection and online monitoring technology improve testing efficiency and accuracy, and new detection methods and requirements need to be defined in the standard.

Green production technology: low-energy production and waste recycling technology require standards to add environmental protection clauses to reduce the environmental impact in the production process.

Standard content

Composition requirements: Newly added classifications of nano-doped electrodes, such as WC20-N (nanoscale cerium oxide), specify cerium oxide particle size (<100 nm) and distribution uniformity requirements.

Detection Methods: AI-assisted detection standards are introduced, specifying the use of machine learning algorithms to analyze composition, microstructure, and performance data, and define data accuracy and repeatability requirements.

Performance requirements: Added performance indicators suitable for high-precision welding, such as ultra-low current arcing (<10 A) and long-term arc stability (> 10 hours).

Packaging and storage: Requiring the use of recyclable packaging materials and indicating the special properties of nano-doped electrodes to meet green manufacturing needs.

Certification requirements: New certification standards for intelligent testing equipment to ensure the reliability and consistency of test results.

Additional Notes

The introduction of emerging technologies has promoted the modernization of cerium-tungsten electrode standards, such as nano-doping technology requires more stringent microstructure detection, and intelligent detection technology requires standard-defined data processing processes.

These updates make the standard more adaptable to the needs of high-performance electrodes and green production, while providing guidance for companies to upgrade their technology.

7.4.2 Changes in environmental protection and safety requirements

Background analysis

The global emphasis on sustainable development and occupational health has prompted cerium tungsten electrode standards to increase environmental protection and safety requirements, reflecting changes in regulatory trends such as the EU's REACH regulation and China's environmental protection regulations.

Environmental protection requirements: reduce waste gas, waste liquid and solid waste emissions in the production process, and promote green production technology.
Safety requirements: Reduce the radioactivity risk of electrodes and exposure to harmful substances during production, and protect the health of operators.
Regulation-Driven: The EU REACH regulation requires environmental compliance for materials, and China's Environmental Protection Law emphasizes waste disposal and emission control.

Standard content

Waste management: New waste recycling and treatment requirements, stipulating the recovery rate of tungsten powder and cerium oxide waste in the production process (e.g., >90%) to reduce environmental pollution.
Radioactivity control: Strengthen radioactivity detection standards, requiring cerium-tungsten electrodes to have radioactivity levels below safety thresholds (e.g., <1 Bq/g) and verification using gamma ray spectroscopy.
Occupational health: Additional monitoring requirements for dust and harmful gases (such as CO and NOx) are added, and air quality standards in production workshops (such as dust concentration < 0.1 mg/m³) are specified.
Green packaging: Require the use of recyclable or biodegradable packaging materials, reduce the use of plastics, and indicate environmental certification information.
Detection methods: Gas chromatography-mass spectrometry (GC-MS) is used to detect exhaust gases, liquid chromatography (LC) is used to analyze waste liquids, and particle counters are used to monitor dust to ensure environmental compliance.
Certification requirements: Enterprises need to pass environmental protection and safety certification, submit waste treatment and air quality monitoring reports, and obtain green production certification.

Additional Notes

The strengthening of environmental and safety requirements reflects the global trend towards green manufacturing, with cerium tungsten electrode standards guiding companies to adopt green technologies and safety measures through new waste management, radioactivity control, and occupational health provisions. These requirements not only enhance the environmental friendliness of electrodes but also enhance the company's competitiveness in the international market.

Chapter 8 Detection of Cerium Tungsten Electrodes

As a high-performance non-consumable electrode, the quality of cerium tungsten electrode directly affects the stability and efficiency of welding and cutting processes. Testing is a key link to ensure that the performance of cerium tungsten electrodes meets standards, covering chemical composition, physical properties, electrical properties, microstructure, environmental and safety and other aspects. This chapter systematically expounds the detection methods of cerium tungsten electrodes from six aspects: chemical composition testing, physical property testing, electrical performance testing, microstructure testing, environmental and safety testing, and testing equipment and technology, and deeply analyzes the principles, methods, operation processes, influencing factors, optimization strategies and future development trends of each detection.

8.1 Chemical composition detection of cerium tungsten electrodes

Chemical composition testing is used to analyze the cerium oxide content, impurity elements, and compositional uniformity of cerium tungsten electrodes to ensure that the electrodes meet high performance requirements. These detection methods need to be highly accurate and reliable to support the performance optimization of the electrodes.

CTIA GROUP LTD

Cerium Tungsten Electrode Introduction

1. Overview of Cerium Tungsten Electrode

Cerium Tungsten Electrode (WC20) is a non-radioactive tungsten electrode material composed of high-purity tungsten base doped with 1.8% to 2.2% cerium oxide (CeO_2). Compared to traditional thoriated tungsten electrodes, the cerium tungsten electrode offers superior arc starting performance, lower burn-off rate, and greater arc stability, while being radiation-free and environmentally friendly. It is suitable for both DC (direct current) and AC/DC mixed current welding conditions and is widely used in TIG welding and plasma cutting of materials such as stainless steel, carbon steel, and titanium alloys. This makes it an ideal green substitute in modern industrial welding.

2. Features of Cerium Tungsten Electrode

Excellent Arc Starting: Easy to ignite at low current, with stable and reliable performance.

Low Burn-off Rate: Cerium oxide enhances evaporation resistance at high temperatures, extending electrode life.

High Arc Stability: Focused arc with minimal flicker, suitable for precision welding.

Radiation-Free & Eco-Friendly: A safe and environmentally sound alternative to radioactive thoriated electrodes.

3. Specifications of Cerium Tungsten Electrode

Type	CeO_2 Content	Color Code	Density (g/cm³)	Length (mm)	Diameter Range (mm)
WC20	1.8% – 2.2%	Grey	19.3	50 – 175	1.0 – 6.4

4. Applications of Cerium Tungsten Electrode

TIG welding of stainless steel, carbon steel, titanium alloys, nickel alloys, etc.

Precision welding and spot welding for medical devices and microelectronic components

Suitable for DC and AC/DC mixed welding conditions

Low-current plasma arc cutting and high-frequency ignition systems

5. Procurement Information

Email: sales@chinatungsten.com

Phone: +86 592 5129595; 592 5129696

Website: www.tungsten.com.cn

8.1.1 Analysis of cerium oxide content

Detection principle

Cerium oxide content analysis measures the mass percentage of cerium oxide (CeO_2) in the electrode (typically 2%~4%) by spectroscopy or mass spectrometry to verify that the doping ratio meets the standard. Common methods include inductively coupled plasma mass spectrometry (ICP-MS) and X-ray fluorescence spectroscopy (XRF). These technologies quantify the characteristic signal of cerium element and its content, ensuring the arc initiation performance and arc stability of the electrode.

ICP-MS principle: The sample is ionized in a high-temperature plasma (about 6000~10000 K), and the mass spectrometer separates the cerium element by ion mass and detects its concentration (ppb level accuracy).
XRF principle: X-ray excites sample atoms, generates characteristic fluorescence, analyzes the signal intensity of cerium, and quickly determines the content (ppm level accuracy).
Benefits: ICP-MS for trace analysis, XRF for fast, non-destructive testing.

Detection method

ICP-MS Method:

The sample is dissolved in an acid solution (such as nitric or hydrochloric acid) to form a homogeneous solution.
The solution enters the plasma through a sprayer, and the cerium ion signal is analyzed by a mass spectrometer.
The cerium oxide content was calculated by calibrating the standard curve.

XRF Method:

The surface of the sample is polished and placed under an X-ray beam.
The detector collects the fluorescence signal and the analysis software calculates the cerium content.
Calibrate standard samples to ensure accurate results.

Operation process

Sample preparation:

Take samples from the electrodes (such as slices or powders) to ensure representativeness.
Clean the sample surface to remove oxide layers or contaminants.

Device Setup:

ICP-MS: Calibrate plasma power and mass spectrometer resolution, set the detection range (cerium m/z=140).
XRF: Calibrate X-ray tube voltage (30~50 kV) and detector sensitivity.

Testing process:

ICP-MS: Spray the sample solution into the plasma, record the mass spectrometry data, and repeat the measurement three times.
XRF: Place the sample under a beam, record the fluorescence signal, and analyze it multiple times

Tel: 0086 592 512 9696
CTIAQCD -MA-E/P 2018- 2025V
sales@chinatungsten.com

to take an average.

Data analysis:

Analysis software was used to calculate the cerium oxide content to verify compliance with the standard (2%~4%).

Check data consistency and rule out outliers.

Influencing factors

Sample Quality: Oxidation or contamination of the sample surface can lead to biased results.

Device accuracy: The plasma stability of ICP-MS and the detector resolution of XRF affect detection accuracy.

Calibration Standards: The quality of standard samples directly affects calibration accuracy.

Environmental conditions: The cleanliness of the laboratory (ISO level 5, particle concentration <3520 particles/m³) and humidity (<20%) affect the stability of the test.

Operating specifications: The operator's technical level and equipment maintenance affect the reliability of the results.

Optimize your strategy

Sample Optimization: Improve sample surface quality through ultrasonic cleaning and polishing.

Equipment upgrade: High-resolution ICP-MS (resolution <0.01 amu) and XRF (detector sensitivity <0.1 eV).

Calibration optimization: Use high-purity standard samples and calibrate equipment regularly.

Environmental Management: Equipped with high-efficiency filtration systems and constant temperature and humidity devices to ensure a stable testing environment.

Data analysis: Establish a component database and optimize the detection accuracy in combination with statistical analysis.

Future trends

High-throughput analysis: Develop ICP-MS technology for simultaneous detection of multiple elements to improve efficiency.

Intelligent Detection: Optimize data processing through artificial intelligence algorithms to reduce human error.

Green technology: Develop low-energy analytical instruments to reduce the use of acids.

New technologies, such as laser-induced breakdown spectroscopy (LIBS), for fast, non-destructive testing.

8.1.2 Impurity element detection

Detection principle

Impurity element detection is used to identify trace elements (e.g., iron, carbon, oxygen, etc.) in the electrode, ensuring that their levels are below the standard threshold (typically < 100 ppm). Common methods include ICP-MS, atomic absorption spectroscopy (AAS), and glow discharge mass spectrometry (GD-MS). These techniques evaluate the impact of impurity elements on electrode performance by detecting their characteristic signals.

AAS principle: sample atoms absorb specific wavelengths of light, analyze the absorption intensity to determine the impurity content.
GD-MS principle: glow discharge ionization of samples, mass spectrometry analyzes impurity ion signals.
Advantages: GD-MS is suitable for surface analysis, AAS is suitable for high-sensitivity single-element detection.

Detection method
AAS Method:
The sample is dissolved in acid and atomized into the optical path.
The light source emits a specific wavelength of light, and the detector records the absorption signal.
The impurity content is calculated using standard curves.

GD-MS Method:
The sample is placed in a glow discharge chamber and ionized into the mass spectrometer.
Analyze the impurity ion signal and quantify the content.

Operation process
Sample preparation:
Sampling and cleaning to remove surface contaminants.
Dissolved sample (AAS) or polished surface (GD-MS).

Device Setup:
AAS: Calibration of light source wavelength and atomizer parameters.
GD-MS: Set the discharge voltage and mass spectrometer resolution.

Testing process:
AAS: Nebulization of samples, recording of absorption signals, repeated measurements.
GD-MS: Initiate the discharge, record the mass spectrometry data, analyze it multiple times.

Data analysis:
Calculate the impurity content to verify that it is below the standard threshold.
Evaluate data consistency and rule out outliers.

Influencing factors
Sample quality: Surface contamination or inhomogeneity can affect test results.
Device accuracy: Light source stability and mass spectrometer resolution affect detection accuracy.
Calibration Standards: The purity of the standard sample affects the calibration accuracy.
Environmental conditions: Cleanliness and humidity affect the stability of the test.
Operating specifications: The skill level of the operator affects the reliability of the results.

Optimize your strategy
Sample Optimization: Improve sample purity through chemical cleaning.

Equipment upgrade: adopt high-sensitivity AAS and GD-MS.
Calibration optimization: Use multi-element standard samples.
Environmental Management: Equipped with a high-efficiency filtration system.
Data analysis: Establish an impurity database and optimize the detection process.

Future trends

Multi-element detection: Developing techniques for detecting multiple impurities simultaneously.
Intelligent Detection: Optimize impurity analysis with machine learning.
Green technology: development of low-energy testing equipment.
New technologies, such as synchrotron XRF, improve detection accuracy.

8.1.3 Uniformity evaluation

Detection principle

Uniformity evaluation verifies doping uniformity by analyzing the distribution of cerium oxide in the electrode, ensuring arc stability and electrode life. Common methods include X-ray tomography (X-CT) and electron probe microanalysis (EPMA). These techniques evaluate the dispersion of cerium oxide particles through imaging or elemental distribution analysis.

X-CT principle: X-rays penetrate the sample, generate a three-dimensional structural image, and analyze the distribution of cerium oxide.
EPMA principle: Electron beam excites the sample, analyzes characteristic X-rays, and draws elemental distribution maps.
Advantages: X-CT for 3D analysis, EPMA for high-resolution surface analysis.

Detection method

X-CT method:

The sample is placed on a rotating table and the X-ray scan produces a tomographic image.
The analysis software reconstructs the three-dimensional structure and evaluates the cerium oxide distribution.

EPMA Method:

The sample is polished and placed under an electron beam to record the X-ray signal.
Analyze elemental distribution maps to quantify uniformity.

Operation process

Sample preparation:

Slice or polish the sample to ensure a flat surface.
Clean the sample to remove contaminants.

Device Setup:

X-CT: Calibrates X-ray intensity and rotary table speed.
EPMA: Set the electron beam energy (15~20 keV) and detector sensitivity.

Testing process:
X-CT: Scan samples, generate 3D images, analyze distributions.
EPMA: Scan the surface of the sample and map the distribution of elements.

Data analysis:
Evaluate the dispersion of cerium oxide particles and verify uniformity.
Check data consistency and rule out outliers.

Influencing factors
Sample Quality: Surface roughness or contamination affects analytical accuracy.
Device accuracy: X-ray intensity and electron beam resolution affect the results.
Calibration Standards: The uniformity of the standard sample affects the calibration accuracy.
Environmental conditions: cleanliness and vibration affect detection stability.

Optimize your strategy
Sample Optimization: Improve sample quality through polishing and cleaning.
Equipment upgrade: High-resolution X-CT and EPMA are adopted.
Calibration Optimization: Use a uniformity standard sample.
Environmental management: Equipped with anti-vibration and cleanliness systems.
Data analysis: Establish a distributed database to optimize the analysis process.

Future trends
3D high-resolution analysis: Developing nanoscale X-CT technology.
Intelligent Detection: Optimize distribution analysis through artificial intelligence.
Green technology: development of low-energy testing equipment.
New technologies, such as synchrotron X-CT, improve resolution.

8.2 Physical properties of cerium tungsten electrodes

Physical property testing is used to evaluate the density, hardness, dimensional accuracy, surface quality, and thermal properties of electrodes, ensuring they meet mechanical and process requirements.

8.2.1 Density and hardness test

Detection principle

Density tests measure the volumetric density of electrodes by Archimedes' principle, and hardness tests assess deformation resistance by indentation methods such as Vickers hardness. These properties directly impact the durability and welding stability of the electrodes.

Density test principle: Calculate the density (target value is about 19.0~19.3 g/cm³) by measuring the mass and drainage volume of the electrode.
Hardness test principle: The indentation size is measured by applying force to the diamond indenter and the hardness value is calculated (Vickers hardness is about 400~600 HV).

Detection method

Density Test:

Mass and volume are measured using high-precision electronic balances and drainage devices.
Calculate density to verify compliance with standards.

Hardness Test:

Use a Vickers hardness tester to apply a load (e.g. 0.5~1 kg).
Measure the diagonal length of the indentation and calculate the hardness value.

Operation process

Sample preparation:

Polish the sample surface to ensure a flat surface.
Clean the sample to remove contaminants.

Device Setup:

Density Testing: Calibrating balances and drains.
Hardness test: Set load and hold time.

Testing process:

Density test: Measure mass and drainage volume, repeat three times.
Hardness test: Apply a load, measure the indentation size, repeat multiple times.

Data analysis:

Calculate density and hardness values to verify compliance with standards.
Check data consistency.

Influencing factors

Sample Quality: Surface roughness or internal defects affect test results.
Equipment Accuracy: The accuracy of balances and hardness testers affects inspection accuracy.
Environmental conditions: Temperature and humidity affect measurement stability.
Operating specifications: The skill level of the operator affects the reliability of the results.

Optimize your strategy

Sample optimization: Improve surface quality through polishing.
Equipment upgrade: adopt high-precision balance and hardness tester.
Calibration Optimization: Calibrate the equipment using standard samples.
Environmental management: Equipped with constant temperature and humidity system.
Data analysis: Establish a density and hardness database.

Future trends

Non-contact testing: Developing laser density measurement technology.
Intelligent Detection: Optimize data analysis through artificial intelligence.
Green technology: development of low-energy testing equipment.

New technologies: such as ultrasonic hardness testing, to improve efficiency.

8.2.2 Dimensional accuracy and surface quality inspection

Detection principle

Dimensional accuracy checks verify the diameter and cone angle of electrodes through optical or laser measurements, and surface quality checks evaluate surface finish through microscopy or roughness meters. These properties affect arc initiation performance and electrode life.

Dimensional accuracy principle: The laser rangefinder measures the electrode size by beam reflection (accuracy < 0.01 mm).

Surface quality principle: The surface is magnified under a microscope, and the surface parameters (e.g., Ra<0.1 μm) are measured by a roughness meter.

Detection method

Dimensional Accuracy Check:

The electrodes are scanned using a laser rangefinder, recording the diameter and cone angle.

The analysis software calculates the dimensional deviation.

Surface Quality Inspection:

Surface defects are observed using a light microscope.

The roughness meter measures the surface parameters and generates a roughness curve.

Operation process

Sample preparation:

Clean the electrode surface to remove contaminants.

Fix the sample to ensure measurement stability.

Device Setup:

Laser rangefinder: Calibrate the beam and sensor.

Microscope and roughness meter: Set magnification and probe parameters.

Testing process:

Dimensional inspection: Scan the electrode and record the dimensional data.

Surface inspection: Observe the surface and measure the roughness.

Data analysis:

Verify that the dimensions and surface quality meet the standards.

Check data consistency.

Influencing factors

Sample quality: Surface contamination or damage affects the measurement results.

Device Accuracy: The resolution of lasers and microscopes affects inspection accuracy.

Environmental conditions: vibration and light affect measurement stability.

Operating specifications: The skill level of the operator affects the results.

Optimize your strategy
Sample optimization: Improve surface quality through polishing.
Equipment upgrade: adopt high-precision laser rangefinder and microscope.
Calibration Optimization: Calibrate the equipment using standard samples.
Environmental management: equipped with anti-vibration and constant light systems.
Data analysis: Establish a database of dimensions and surfaces.

Future trends
3D scanning technology: improve dimensional measurement accuracy.
Intelligent Inspection: Optimize surface analysis with artificial intelligence.
Green technology: development of low-energy testing equipment.
New technologies: such as white light interferometers, improve the accuracy of surface measurement.

8.2.3 Thermal Performance Test

Detection principle

Thermal performance testing assesses the heat resistance and thermal stability of electrodes by simulating high-temperature environments, ensuring their performance at welding temperatures. Common methods include thermogravimetric analysis (TGA) and high-temperature oxidation testing.

TGA principle: Measure the mass loss of electrodes at high temperatures, evaluate the volatility and stability of cerium oxide.
High-temperature oxidation test: Test the oxidation resistance of the electrode in a high-temperature (>2000°C) atmosphere.

Detection method

TGA Method:
The sample is placed in a thermogravimetric analyzer and heated to the target temperature.
Record mass changes and analyze thermal stability.

High temperature oxidation test:
The sample is placed in a high-temperature furnace and passed through oxygen or air.
Measure the degree of surface oxidation and mass loss.

Operation process

Sample preparation:
Cut the sample and clean the surface.
Ensure consistent sample size.

Device Setup:
TGA: Calibrated heating rate and balance accuracy.
High temperature furnace: Set temperature and atmosphere parameters.

Testing process:
TGA: Heating the sample and recording the change in quality.
High temperature test: Expose the sample to high temperatures to measure the degree of oxidation.

Data analysis:
Analyze thermal stability to verify compliance with standards.
Check data consistency.

Influencing factors
Sample quality: Internal defects affect test results.
Equipment Accuracy: Balance and temperature control accuracy affect detection accuracy.
Environmental conditions: Atmosphere purity and humidity affect oxidation testing.
Operating specifications: Parameter settings affect the reliability of results.

Optimize your strategy
Sample optimization: Improves thermal stability through uniform doping.
Equipment upgrade: adopt high-precision TGA and high-temperature furnace.
Calibration Optimization: Calibrate the equipment using standard samples.
Environmental management: equipped with high-purity atmosphere control system.
Data analysis: Establish a thermal performance database.

Future trends
Dynamic Thermal Testing: Simulates the actual welding environment.
Intelligent Detection: Optimize thermal analysis with artificial intelligence.
Green technology: development of low-energy testing equipment.
New technologies: such as laser thermal testing, improve accuracy.

8.3 Electrical Properties Detection of Cerium Tungsten Electrode

Electrical performance testing is used to evaluate the electrode's electron escape work, arc initiation performance, and burnout rate, ensuring its efficiency and durability in welding.

8.3.1 Electron Escape Power Measurement

Detection principle

Electron escape work measurements evaluate the ability of electrode surfaces to emit electrons by thermionic emission or photoelectric effect method (target value of about 2.5 eV). Common methods include thermionic emission testing and photoelectric effect testing.

Principle of thermionic emission: heat the electrode, measure the emission current, and calculate the escape work.

The principle of photoelectric effect: photons excite electrons, analyze electron energy, and calculate escape work.

Detection method

Thermionic emission method:

The electrode is heated to a high temperature (>1500°C) and the transmitted current is measured. Escape work is calculated by the Richardson equation.

Photoelectric effect method:

The electrode is irradiated with ultraviolet light and the photoelectron energy is recorded. Analyze the photoelectric curve and calculate the escape work.

Operation process

Sample preparation:

Polishing the electrode surface to ensure cleanliness.
Fix the sample in the test device.

Device Setup:

Thermionic Emission: Calibrate heating devices and ammeters.
Photoelectric effect: calibrating the light source and photodetector.

Testing process:

Thermionic emission: heats the electrode and records the current data.
Photoelectric effect: irradiating the beam and recording the optoelectronic signal.

Data analysis:

Calculate electron escape work to verify compliance with standards.
Check data consistency.

Influencing factors

Sample quality: Surface contamination or oxidation affects the escape work.
Equipment accuracy: The accuracy of the heating device and detector affects the results.
Environmental conditions: Vacuum level and temperature affect test stability.
Operating specifications: Parameter settings affect the reliability of results.

Optimize your strategy

Sample Optimization: Improve surface quality through polishing and cleaning.
Equipment upgrade: adopt high-precision thermionic emitter.
Calibration Optimization: Calibrate the equipment using standard samples.
Environmental management: equipped with a high vacuum system.
Data analysis: Establish an escape work database.

Future trends

High-precision measurement: Developing nanoscale escape power testing technology.
Intelligent Detection: Optimize data analysis through artificial intelligence.
Green technology: development of low-energy testing equipment.
New technologies: such as synchrotron radiation photoelectric testing, improve accuracy.

8.3.2 Arc initiation and dimensional arc performance test

Detection principle

Arc initiation and dimensional arc performance testing measures the arc voltage, current stability, and arc duration of the electrode by simulating the welding environment, ensuring its rapid arc start and stability at low currents. The commonly used equipment is a high-frequency arc initiation tester.

Arc Initiation Principle: Arc is triggered by high-frequency pulses, and the arcing voltage and time are recorded.
Dimensional arc principle: Maintain a stable arc, measure current fluctuations and arc length.

Detection method

Arc Initiation Test:

High-frequency pulses are applied under argon protection, recording the arc voltage.
Analysis of arc start time and stability.

Dimensional arc test:

Maintain the arc for several minutes and record current fluctuations.
Analyze arc length and stability.

Operation process

Sample preparation:

Grind the electrode cone angle and clean the surface.
Fix the electrode to the test device.

Device Setup:

Calibrate the high-frequency arc initiator and current sensor.
Set the argon flow rate (5~10 L/min).

Testing process:

Activate high-frequency pulses to record arc initiation data.
Maintain the arc, record current and arc parameters.

Data analysis:

Analyze arc voltage and current stability.
Verify compliance with standards.

Influencing factors
Sample quality: Cone angle and surface mass affect arcing performance.
Equipment Accuracy: The accuracy of high-frequency devices and sensors affects the results.
Environmental Conditions: Gas purity and humidity affect arc stability.
Operating specifications: Parameter settings affect test reliability.

Optimize your strategy
Sample Optimization: Optimize cone angle and surface finish.
Equipment upgrade: adopt high-precision arc starting tester.
Calibration Optimization: Calibrate the equipment using standard electrodes.
Environmental management: equipped with a high-purity gas system.
Data analysis: Establish an arc performance database.

Future trends
Dynamic Testing: Simulates a wide range of welding conditions.
Intelligent Detection: Optimize arc analysis with artificial intelligence.
Green technology: development of low-energy testing equipment.
New technologies: such as multi-parameter arc testers to improve accuracy.

8.3.3 Burnout rate test

Detection principle
The burndown rate test evaluates the mass loss of the electrode through long-term arcing and verifies its high-temperature resistance. The common method is the high-temperature arc test, which records the burn loss of the electrode under the high-temperature arc (>6000 K).

Test principle: Maintain the arc in a simulated welding environment and measure the change in electrode quality.
Key indicators: burnout rate (mass loss/time) and electrode life.

Detection method
High Temperature Arc Test:
Arcing under argon protection for several hours.
Measure the mass before and after the electrode and calculate the burnout rate.

Operation process
Sample preparation:
Grind the electrode cone angle and clean the surface.
Weigh the initial mass and record the data.

Device Setup:
Calibrate the arc device and balance.
Set the argon flow and current parameters.

Testing process:

Start the arc and maintain the target time.

After cooling, the electrode is weighed and the burnout loss is calculated.

Data analysis:

Calculate burnout rate to verify compliance with standards.

Check data consistency.

Influencing factors

Sample quality: Cerium oxide distribution affects burnout rate.

Equipment Precision: The accuracy of the arc device and balance affects the results.

Environmental conditions: Gas purity and temperature affect burnout stability.

Operating specifications: Parameter settings affect test reliability.

Optimize your strategy

Sample optimization: Reduces burnout through uniform doping.

Equipment upgrade: adopt high-precision arc tester.

Calibration Optimization: Calibrate the equipment using standard electrodes.

Environmental management: equipped with a high-purity gas system.

Data analysis: Establish a burnout rate database.

Future trends

Dynamic Burnout Testing: Simulates a wide range of arcing conditions.

Intelligent Detection: Optimize burn loss analysis with artificial intelligence.

Green technology: development of low-energy testing equipment.

New technologies: such as plasma burnout testing to improve accuracy.

8.4 Microstructure detection of cerium tungsten electrode

Microstructure detection is used to analyze the grain size, oxide distribution, and internal defects of the electrode, ensuring the uniformity and integrity of its microstructure.

8.4.1 Grain size and distribution analysis

Detection principle

Grain size and distribution analysis The crystal structure of the electrode is observed by scanning electron microscopy (SEM) or light microscopy to evaluate grain size (typically 1~10 μm) and distribution uniformity.

SEM principle: The electron beam scans the sample surface, generates high-resolution images, and analyzes grain morphology.

Principle of optical microscopy: Observe the grain structure of polished samples through high magnification.

Detection method

SEM Method:
The sample is polished and placed in the SEM vacuum chamber.
The surface of the sample is scanned to generate a grain image.
The analysis software calculates grain size and distribution.

Optical microscopy method:
Polishing and corroding samples to reveal grain boundaries.
Observe the grain structure and measure the size.

Operation process
Sample preparation:
Slice and polish the sample, chemical corrosion reveals grains.
Clean samples to ensure they are free of contaminants.

Device Setup:
SEM: Calibrate the electron beam energy (10~20 keV) and detector.
Optical microscope: Set the magnification (100~1000x).

Testing process:
SEM: Scan the sample and record the grain image.
Optical microscope: Observe grain boundaries and measure dimensions.

Data analysis:
Calculate grain size and distribution to verify uniformity.
Check data consistency.

Influencing factors
Sample quality: Polishing and corrosion quality affect grain reveal.
Device accuracy: Electron beam and microscope resolution affect results.
Environmental conditions: Vibration and cleanliness affect imaging quality.
Operating specifications: The skill level of the operator affects the results.

Optimize your strategy
Sample Optimization: Optimize polishing and corrosion processes.
Equipment upgrade: adopt high-resolution SEM.
Calibration Optimization: Calibrate the equipment using standard samples.
Environmental management: Equipped with anti-vibration and cleanliness systems.
Data analysis: Establish a grain database.

Future trends
Nanoscale analysis: Development of high-resolution TEM analysis techniques.
Intelligent Inspection: Optimize grain analysis with artificial intelligence.
Green technology: development of low-energy microscopes.

New technologies: such as environmental SEM, suitable for dynamic observation.

8.4.2 Check the uniformity of oxide distribution

Detection principle

Oxide distribution uniformity check The distribution of cerium oxide particles is analyzed by electron probe microanalysis (EPMA) or energy dispersive spectrometry (EDS) to verify its uniformity.

EPMA principle: Electron beam excitation sample, analysis of characteristic X-rays, and plotting of cerium oxide distribution.
EDS principle: Combined with SEM to detect X-ray energy and analyze elemental distribution.

Detection method

EPMA Method:

Polished the sample and placed it under the electron beam.
X-ray signals are recorded to generate distribution maps.

EDS Method:

Load the EDS detector in the SEM and scan the sample.
Analyze the cerium element distribution and quantify the uniformity.

Operation process

Sample preparation:

Polishing the sample to ensure a flat surface.
Clean the sample to remove contaminants.

Device Setup:

EPMA: Calibration of electron beam energy and detector.
EDS: Set SEM and EDS parameters.

Testing process:

EPMA: Scan the sample and generate a distribution map.
EDS: Record the cerium element signal and analyze the distribution.

Data analysis:

Evaluate the uniformity of cerium oxide distribution.
Check data consistency.

Influencing factors

Sample quality: surface roughness affects distribution analysis.
Device accuracy: Electron beam and detector resolution affect results.
Environmental conditions: Vibration and cleanliness affect imaging quality.
Operating specifications: The skill level of the operator affects the results.

Optimize your strategy

Sample Optimization: Optimize the polishing process.
Equipment upgrade: adopt high-resolution EPMA and EDS.
Calibration Optimization: Calibrate the equipment using standard samples.
Environmental management: Equipped with anti-vibration and cleanliness systems.
Data analysis: Establish a distribution database.

Future trends

High-resolution analysis: Development of nanoscale EDS technology.
Intelligent Detection: Optimize distribution analysis through artificial intelligence.
Green technology: development of low-energy testing equipment.
New technologies: such as synchrotron EDS, improve accuracy.

8.4.3 Defect Detection (Cracks, Pores, etc.)

Detection principle

Defect Detection Ensures structural integrity by identifying cracks, porosity, and other defects inside the electrode through ultrasonic inspection or X-ray tomography (X-CT).

Ultrasonic Inspection Principle: Ultrasonic reflection identifies internal defects.
X-CT principle: X-rays penetrate the sample, generate a three-dimensional image, and analyze the defect distribution.

Detection method

Ultrasonic Testing:

The electrodes are scanned using an ultrasound probe to record the reflected signal.
Analyze signal strength and locate defects.

X-CT method:

The sample is placed on a rotating table and the X-ray scan generates an image.
The analysis software reconstructs the 3D structure and identifies defects.

Operation process

Sample preparation:

Clean the sample surface to ensure it is free of contaminants.
Fix the sample in the detection device.

Device Setup:

Ultrasonic Detection: Calibrate the probe frequency (5~10 MHz).
X-CT: Set the X-ray intensity and rotation speed.

Testing process:

Ultrasonic testing: Scan the sample and record the reflected signal.
X-CT: Scan the sample to produce a three-dimensional image.

Data analysis:
Identify cracks and pores and assess defect size.
Verify compliance with standards.

Influencing factors
Sample quality: Surface roughness affects the accuracy of the inspection.
Device accuracy: Probe and X-ray resolution affect results.
Environmental conditions: vibration and noise affect detection stability.
Operating specifications: The skill level of the operator affects the results.

Optimize your strategy
Sample optimization: Improve surface quality through polishing.
Equipment upgrade: High-resolution ultrasound and X-CT equipment are adopted.
Calibration Optimization: Calibrate the equipment using standard samples.
Environmental management: equipped with anti-vibration and noise reduction systems.
Data analysis: Establish a defect database.

Future trends
High-resolution detection: Developing nanoscale X-CT technology.
Intelligent Detection: Optimize defect analysis with artificial intelligence.
Green technology: development of low-energy testing equipment.
New technologies: such as phased array ultrasonic detection, improve accuracy.

8.5 Environmental and safety testing of cerium tungsten electrodes

Environmental and safety testing is used to assess the radioactivity, environmental impact, and occupational health and safety of electrodes, ensuring that the production and use process complies with regulations.

8.5.1 Radioactivity Detection

Detection principle

Radioactivity detection measures radioactive isotopes (such as cerium-144) in the electrode by gamma-ray spectrometer, ensuring that it is below the safety threshold (<1 Bq/g). Cerium-tungsten electrodes are usually not significantly radioactive, but need to be tested to rule out raw material contamination.

Principle of gamma ray spectroscopy: detect gamma ray energy and identify radioactive isotopes.
Advantages: High sensitivity for detection of trace amounts of radioactivity.

Detection method

Gamma ray spectrometer method:
The sample is placed near the detector and the gamma-ray signal is recorded.
Analysis software identifies isotopes and strengths.

Operation process

Sample preparation:

Clean the sample to ensure no external contamination.

Fix the sample in the detection device.

Device Setup:

Calibration of gamma-ray detector sensitivity.

Set the detection time (hours).

Testing process:

Gamma-ray signals are recorded and measurements are repeated.

Analysis of radioisotope content.

Data analysis:

Verify that the radioactivity is below the threshold.

Check data consistency.

Influencing factors

Sample quality: Contamination of raw materials affects radioactivity levels.

Device accuracy: detector sensitivity affects the detection results.

Environmental conditions: Background radiation affects the stability of the detection.

Operating specifications: Parameter settings affect the reliability of results.

Optimize your strategy

Sample optimization: Select high-purity raw materials to reduce radioactivity risks.

Equipment upgrade: adopt high-sensitivity gamma ray spectrometer.

Calibration Optimization: Calibrate the equipment using standard samples.

Environmental management: equipped with a shielded chamber to reduce background radiation.

Data analysis: Establish a radioactive database.

Future trends

High-sensitivity detection: Development of ppb-level radioactivity detection technology.

Intelligent Detection: Optimize radioactivity analysis with artificial intelligence.

Green technology: development of low-energy testing equipment.

New technologies, such as neutron activation analysis, improve accuracy.

8.5.2 Environmental impact assessment

Detection principle

Environmental impact assessment assesses the environmental impact of electrode manufacturing by analyzing exhaust gases, waste liquids, and solid waste during production. Common methods include gas chromatography-mass spectrometry (GC-MS) and liquid chromatography (LC).

GC-MS principle: Analyze volatile organic compounds (VOCs) in exhaust gases.

LC principle: Analyze heavy metals or chemicals in waste liquids.

Detection method

GC-MS Method:

Production exhaust gases are collected and injected into the column for separation.

Mass spectrometry analyzes volatile substances.

LC Method:

Waste liquid is collected and chemical components are separated.

The detector analyzes the content of heavy metals or organics.

Operation process

Sample collection:

Use a sampler to collect exhaust gases and waste liquids.

Store samples in airtight containers.

Device Setup:

GC-MS: Calibration column and mass spectrometer.

LC: Set the separation column and detector parameters.

Testing process:

GC-MS: Separation of exhaust gas components and recording of mass spectrometry data.

LC: Separation of waste liquid components and recording signals.

Data analysis:

Analyze pollutant content to verify compliance with environmental standards.

Check data consistency.

Influencing factors

Sample quality: Sampling integrity affects the analysis results.

Device accuracy: The resolution of chromatography and mass spectrometry affects detection accuracy.

Environmental conditions: Temperature and humidity affect sampling stability.

Operating Specifications: Sampling and analysis techniques affect results.

Optimize your strategy

Sample Optimization: Optimize sampling methods for better representativeness.

Equipment upgrade: High-resolution GC-MS and LC are adopted.

Calibration Optimization: Calibrate the equipment using standard samples.

Environmental management: Equipped with constant temperature and humidity sampling system.

Data analysis: Establish a pollutant database.

Future trends

Real-time monitoring: Develop online environmental monitoring technology.

Intelligent Detection: Optimize pollutant analysis through artificial intelligence.

Green technology: development of low-energy testing equipment.

New technologies, such as portable GC-MS, improve the efficiency of on-site inspection.

8.5.3 Occupational health and safety testing

Detection principle

Occupational health and safety testing evaluates the health effects on operators by analyzing hazardous substances (e.g., dust, gases) that may be released during the production process. Common methods include air quality monitoring and toxicity testing.

Air quality monitoring principle: Detect dust and harmful gas concentrations through particle counters and gas analyzers.

Toxicity test principle: Evaluate the toxicity of substances through biological experiments.

Detection method

Air Quality Monitoring:

Dust concentration is measured using a particle counter.

Gas analyzers detect harmful gases (e.g., CO, NOx).

Toxicity Testing:

Production waste is collected and cytotoxicity experiments are conducted.

Assess the potential impact on human health.

Operation process

Sample collection:

Deploy samplers on the production floor to collect air and waste.

Store samples in airtight containers.

Device Setup:

Particle counter: calibrate sensitivity.

Gas analyzer: Set the detection range.

Testing process:

Monitor air quality, record dust and gas concentrations.

Conduct toxicity experiments to assess biological effects.

Data analysis:

Verify compliance with occupational health standards.

Check data consistency.

Influencing factors

Sample quality: Sampling location and time affect results.
Device Accuracy: The sensitivity of counters and analyzers affects detection accuracy.
Environmental conditions: Ventilation and humidity affect sampling stability.
Operating Specifications: Sampling and analysis techniques affect results.

Optimize your strategy

Sample Optimization: Optimize sampling points and timing.
Equipment upgrade: adopt high-sensitivity air quality monitor.
Calibration Optimization: Calibrate the equipment using standard samples.
Environmental management: Equipped with efficient ventilation system.
Data analysis: Establish a health and safety database.

Future trends

Real-time monitoring: Develop an online health and safety monitoring system.
Intelligent Detection: Optimize security analysis with artificial intelligence.
Green technology: develop low-energy monitoring equipment.
New technologies: such as wearable monitoring devices to improve on-site safety.

8.6 Testing equipment and technology of cerium tungsten electrodes

Testing equipment and technology are used to support the above testing methods and provide high-precision and efficient detection methods.

8.6.1 Introduction to common testing instruments

Instrument Overview

Commonly used detection instruments include ICP-MS, XRF, SEM, TEM, X-CT, gamma ray spectrometer, etc., which are used for composition, microstructure, and safety detection, respectively.

ICP-MS: For cerium oxide and impurity content analysis with ppb accuracy.
XRF: For fast, non-destructive component testing, suitable for production lines.
SEM/TEM: For grain and oxide distribution analysis with nanometer resolution.
X-CT: For 3D structural and defect detection, resolution < 1 µm.
Gamma ray spectrometer: for radioactivity detection, sensitivity < 1 Bq/g.

Equipment features:

High Precision: Meets the needs of trace element and nanoscale structure detection.
Versatility: Supports a wide range of inspection tasks.
Environmental Adaptability: Can be used in cleanrooms or production lines.

Operation process

Equipment Selection: Select the instrument according to the detection target.
Calibration: Calibrate the equipment using a standard sample.

Detection: Perform the operation according to the detection method.
Maintenance: Regularly clean and calibrate the equipment.

Influencing factors
Device accuracy: Resolution and sensitivity affect the test results.
Maintenance Level: Regular maintenance affects equipment performance.
Operating specifications: The skill level of the operator affects the results.

Optimize your strategy
Equipment upgrade: adopt the latest model of instrument.
Calibration optimization: Establish a calibration standard system.
Maintenance Optimization: Implement regular maintenance schedules.
Training: Strengthen operator skills training.

Future trends
Multifunctional Instruments: Develop devices that integrate multiple detection functions.
Smart Devices: Optimize instrument performance through artificial intelligence.
Green technology: develop low-energy instruments.
New instruments: such as portable LIBS instruments, improve the efficiency of on-site inspection.

8.6.2 Emerging Detection Technologies (AI-Assisted Detection, etc.)

Technical Overview
Emerging inspection technologies include AI-assisted detection, digital twins, and online monitoring, leveraging artificial intelligence and big data to improve inspection efficiency and accuracy.

AI-Assisted Detection: Analyze inspection data through machine learning to optimize results.
Digital twin: Simulate the detection process through virtual models and predict the results.
Online monitoring: real-time data collection through sensors, dynamic adjustment and detection.

Technical principle
AI-Assisted Detection: Deep learning algorithms analyze images and spectral data to identify features.
Digital twin: Establish a digital model of the electrode to simulate the detection environment.
Online monitoring: Sensors collect composition, structure, and performance data in real time.

Operation process
AI-Assisted Detection:
Collect detection data and feed it into the AI model.
The model analyzes the data and outputs the results.

Digital Twin:
Establish an electrode model to simulate the detection process.

Verify that the simulation results are consistent with the actual data.

Online monitoring:

Deploy sensors to collect data in real time.

Analyze data and adjust detection parameters.

Influencing factors

Algorithm precision: The training quality of the AI model affects the results.

Data quality: Analysis of the impact of sensor data integrity.

Device Integration: Sensor and analytics system compatibility affects efficiency.

Optimize your strategy

Algorithm optimization: Use big data to train AI models.

Sensor upgrade: Adopt high-precision sensors.

Integration optimization: Develop an integrated inspection platform.

Data analysis: Establish a comprehensive testing database.

Future trends

Deep learning detection: Develop high-precision AI models.

Fully automatic detection: realize unmanned inspection process.

Green technology: development of low-energy detection systems.

New technologies, such as quantum computing-assisted detection, to improve the speed of analysis.

Chapter 9 Common Problems and Solutions for Cerium Tungsten Electrode Users

Cerium-tungsten electrodes are widely used in inert gas-shielded arc welding (TIG) and plasma welding due to their low radioactivity, good arc initiation properties, and arc stability. However, users often encounter problems such as unstable arcing, rapid tip burnout, and difficulty in arcing during use, which may stem from the electrode itself, welding parameters, or operating environment. This chapter systematically analyzes the causes of common problems and provides detailed solutions from five aspects: arc instability, tip burnout, cerium content selection, arcing difficulties, and the mixing of cerium tungsten and lanthanum tungsten.

9.1 Possible causes of arc instability of cerium tungsten electrodes

Arc instability is a common problem in the use of cerium tungsten electrodes, manifesting as arc jitter, offset, or interruption, affecting weld quality and process stability. Arc instability can be caused by factors such as electrode tip shape, current setting, shielding gas, or electrode contamination. The following is a detailed analysis of the causes and solutions from four aspects.

9.1.1 Improper shape of the electrode tip

Background of the problem

The shape of the electrode tip directly affects the concentration and stability of the arc. Cerium-tungsten electrodes (WC20) typically need to be ground to a tapered tip to optimize arcing and arc stability. Improper tip shape, such as being too blunt, too pointed, or asymmetrical, can cause arc dispersion or shifting, affecting weld quality.

Cause analysis

Blunt tip: Too large a cone angle (e.g., >60°) can lead to arcs that are too dispersed, making it difficult to form a stable arc column, especially in low-current welding.

Tip is too sharp: The cone angle is too small (such as <20°) to make the arc too concentrated, which can easily cause overheating and burning of the tip, causing arc jitter.

Asymmetrical Shape: Uneven grinding or tip eccentricity can cause the arc to deflect to one side, affecting weld uniformity.

Grinding Marks: Rough grinding surfaces can lead to partial discharges, interfering with arc stability.

solution

Optimize grinding angle: Choose the appropriate cone angle based on the welding current and material, typically 20°40° (low current) or 40°60° (high current). Use a specialized electrode grinder to ensure consistent cone angles.

Ensure symmetry: Keep the electrode aligned with the grinding wheel axis during grinding to avoid eccentricity. Rotating grippers are used to improve grinding accuracy.

Improved Surface Quality: Polishing with a fine-grit grinding wheel (e.g., 400 mesh) reduces surface roughness and ensures a smooth tip surface.

Regular Inspection: Check the tip shape before welding and re-grind immediately if any imperfections are found to ensure compliance with process requirements.

Additional Notes

The choice of tip shape should be adjusted according to the specific welding conditions. For example, when welding thin-walled stainless steel, a smaller cone angle is recommended to concentrate the arc; When welding thick sheet aluminum, a larger cone angle is recommended to improve arc coverage. Users should refer to ISO 6848 or AWS A5.12 for welding parameter recommendations to ensure that the tip shape matches the process.

9.1.2 Current Settings Do Not Match

Background of the problem

The current setting is a critical factor affecting arc stability. Cerium tungsten electrodes are suitable for both direct current (DC) and alternating current (AC) welding, but improper current type, strength, or polarity can lead to arc instability, affecting the welding effect.

Cause analysis

Wrong Current Type: In AC welding, cerium-tungsten electrodes outperform pure tungsten electrodes, but in direct current forward (DCEP), they may cause arc instability due to overheating.

Excessive current intensity: Exceeding the recommended current range for the electrode (e.g., 1.6 mm electrode >150 A) can cause the tip to overheat, causing arc jitter.

Low Current Intensity: Too low a current (e.g., <10 A) can lead to arc initiation difficulties or arc instability, especially in precision welding.

Improper polarity selection: Direct current reverse connection (DCEN) is a common polarity of cerium tungsten electrodes, and if DC is misused, arc stability will decrease.

solution

Choose the right current type: Choose between DC Reverse (DCEN) or AC (AC) depending on the soldering material. DCEN is suitable for stainless steel and carbon steel, and AC is suitable for aluminum and magnesium alloys.

Adjust the current intensity: Select the appropriate current range with reference to the electrode diameter (e.g., 50~100 A is recommended for a 1.6 mm electrode). Avoid exceeding the maximum current capacity of the electrode.

Calibrate Polarity: Ensure DCEN polarity is used to reduce tip overheating. When AC welding, adjust the positive and negative half-wave balance to optimize arc stability.

Use current adjustment equipment: Use welding machines with current stabilization functions to reduce the impact of current fluctuations on arcing.

Additional Notes

The current setting needs to match the electrode diameter and the soldering material. AWS A5.12 provides detailed current range recommendations, allowing users to adjust parameters based on electrode specifications and welding tasks. Additionally, regularly calibrating the welding machine to ensure stable current output is an important measure to address arc instability.

9.1.3 Flow or purity problems of shielding gas

Background of the problem

Shielding gases, such as argon or helium, are used to shield arcs and melt pools to prevent oxidation and contamination. Gas flow or purity issues can lead to unstable arcing, affecting weld quality.

Cause analysis

Low flow rate: Insufficient gas flow rate (e.g., <5 L/min) cannot effectively shield the arc, causing air to enter and causing arc jitter.

Excessive flow rate: Excessive gas flow rate (such as >15 L/min) may cause turbulence and interfere with arc stability.

Insufficient gas purity: Oxygen or moisture (purity <99.99%) mixed into the shielding gas can lead to arc instability or tip oxidation.

Improper gas type: Helium is suitable for high-heat input welding, but it can lead to arc dispersion if used for low-current precision welding.

solution

Adjust gas flow rate: Set the appropriate flow rate based on the electrode diameter and welding conditions, usually 5~12 L/min. Low current welding uses lower flow rates, and high current welding is appropriately increased.

Ensure gas purity: Use high-purity argon gas (≥99.99%) and regularly inspect gas cylinders and lines to avoid contamination.

Choose the right gas: Prefer argon for TIG welding, helium or argon-helium mixtures are suitable

for thick plates or high heat input scenarios.
Check the gas system: Regularly check the gas lines and flow meters to ensure there are no leaks or blockages and maintain a stable gas supply.

Additional Notes

The selection and flow rate of the shielding gas must be matched to the welding process. For example, GB/T 4192 recommends argon as the main shielding gas, and helium for special high heat input scenarios. Users should maintain the gas system regularly to avoid arc instability caused by aging or contamination of pipelines.

9.1.4 Electrode contamination or oxidation

Background of the problem

Electrode contamination or oxidation can alter the surface properties of cerium tungsten electrodes, affecting electron emission and arc stability. Contamination can come from the operating environment, melt pool splashes, or improper storage.

Cause analysis

Melt pool splash: During welding, the melt pool metal splashes onto the tip of the electrode, forming a contamination layer that interferes with electron emissions.
Environmental pollution: Oil, dust, or moisture in the air adheres to the electrode surface, reducing arc stability.
Oxide Layer Formation: When the electrode is exposed to hot air or the shielding gas is insufficient, an oxide layer forms on the surface, hindering electron emission.
Improper storage: The electrodes are stored in humid or contaminated environments, leading to surface contamination or oxidation.

solution

Prevent Meltpool Splashing: Adjust the welding angle and distance to reduce pool splashing. Use a suitable shield electrode for the flow of protective gas.
Clean electrode surfaces: Use specialized cleaning solutions (such as alcohol) or ultrasonic cleaning to remove surface oil and dust.
Prevent oxidation: Ensure sufficient shielding gas to avoid exposing the electrode to hot air. Cool the electrode immediately after welding.
Standardized storage: Store the electrodes in a dry, dust-proof airtight container to avoid moisture and contamination.

Additional Notes

Electrode contamination and oxidation are common causes of arc instability, especially in industrial environments with high humidity or high pollution. ISO 6848 emphasizes the storage and cleaning requirements of electrodes, and users should establish a strict electrode management system to ensure surface quality.

CTIA GROUP LTD
Cerium Tungsten Electrode Introduction

1. Overview of Cerium Tungsten Electrode

Cerium Tungsten Electrode (WC20) is a non-radioactive tungsten electrode material composed of high-purity tungsten base doped with 1.8% to 2.2% cerium oxide (CeO_2). Compared to traditional thoriated tungsten electrodes, the cerium tungsten electrode offers superior arc starting performance, lower burn-off rate, and greater arc stability, while being radiation-free and environmentally friendly. It is suitable for both DC (direct current) and AC/DC mixed current welding conditions and is widely used in TIG welding and plasma cutting of materials such as stainless steel, carbon steel, and titanium alloys. This makes it an ideal green substitute in modern industrial welding.

2. Features of Cerium Tungsten Electrode

Excellent Arc Starting: Easy to ignite at low current, with stable and reliable performance.

Low Burn-off Rate: Cerium oxide enhances evaporation resistance at high temperatures, extending electrode life.

High Arc Stability: Focused arc with minimal flicker, suitable for precision welding.

Radiation-Free & Eco-Friendly: A safe and environmentally sound alternative to radioactive thoriated electrodes.

3. Specifications of Cerium Tungsten Electrode

Type	CeO_2 Content	Color Code	Density (g/cm³)	Length (mm)	Diameter Range (mm)
WC20	1.8% – 2.2%	Grey	19.3	50 – 175	1.0 – 6.4

4. Applications of Cerium Tungsten Electrode

TIG welding of stainless steel, carbon steel, titanium alloys, nickel alloys, etc.

Precision welding and spot welding for medical devices and microelectronic components

Suitable for DC and AC/DC mixed welding conditions

Low-current plasma arc cutting and high-frequency ignition systems

5. Procurement Information

Email: sales@chinatungsten.com

Phone: +86 592 5129595; 592 5129696

Website: www.tungsten.com.cn

9.2 What should I do if the tip of the cerium tungsten electrode burns out too quickly?

Rapid tip burnout is a common problem in the use of cerium tungsten electrodes, which manifests as rapid wear or melting of the electrode tip, shortening the service life. The following analyzes the causes and provides solutions from four aspects: current type, grinding angle, shielding gas and cerium content.

9.2.1 Check the current type and polarity

Background of the problem

The type of current and polarity directly affect the heat load on the electrode tip. Cerium-tungsten electrodes are suitable for direct current reverse (DCEN) and alternating current (AC) soldering, but improper current settings can cause tip overheating and burnout.

Cause analysis

Direct current forward (DCEP) :D CEP subjected the electrode to a higher heat load, causing rapid tip burnout.

AC imbalance: In AC welding, positive and negative half-wave imbalances (such as positive-half-wave being too long) can increase tip heat.

Excessive Current: Exceeding the recommended current range for the electrode can cause the tip to overheat and melt.

Current fluctuations: Unstable welding machine output can cause local overheating of the tip.

solution

Prefer DCEN: Choose DC reverse polarity to reduce electrode heat load, suitable for stainless steel and carbon steel welding.

Optimize AC balance: When AC welding, adjust the ratio of positive and negative half-waves (such as 30%~50% positive half-wave) to reduce the heat at the tip.

Control Current Intensity: Choose the appropriate current range based on the electrode diameter to avoid excessive current.

Calibrate the Welding Machine: Use a welding machine with current stabilization to ensure smooth output.

Additional Notes

AWS A5.12 recommends DCEN as the primary polarity for cerium-tungsten electrodes, and AC welding requires careful adjustment of the balance settings. Users should regularly check the current output stability of the welding machine to avoid tip burnout due to equipment problems.

9.2.2 Optimize the tip grinding angle

Background of the problem

The tip grinding angle affects arc concentration and heat distribution. Improper grinding angle can cause the tip to overheat, accelerating burnout.

Cause analysis

Too small cone angle: A too small cone angle (such as <20°) makes the arc too concentrated, the

Tel: 0086 592 512 9696
CTIAQCD -MA-E/P 2018- 2025V
sales@chinatungsten.com

temperature of the tip rises, and the burnout is accelerated.
Uneven Grinding: The asymmetrical tip shape leads to localized overheating, triggering burnout.
Rough Surface: Grinding marks or rough surfaces increase partial discharge, accelerating tip wear.
Insufficient grinding frequency: If the electrode is not reground for a long time, the tip shape will deteriorate and cause burnout.

solution

Choose the right cone angle: Choose a cone angle of 20°40° (low current) or 40°60° (high current) depending on the current and material to balance arc concentration and heat distribution.
Ensure Uniform Grinding: Use a specialized electrode grinder to ensure symmetrical tips and avoid local overheating.
Polishing the tip: Use a fine-grained grinding wheel to polish the tip to reduce surface roughness.
Regular Regrinding: Depending on the welding time and tip condition, regrind the electrode regularly to maintain optimal shape.

Additional Notes

The choice of tip grinding angle is combined with the welding task. For example, GB/T 4192 recommends using a smaller cone angle for low-current precision welding and a larger cone angle for high-heat input welding. Users should use professional grinding equipment to ensure cutting-edge quality.

9.2.3 Adjust the type and flow rate of the shielding gas

Background of the problem

The type and flow rate of the shielding gas affect the degree of thermal protection and oxidation of the electrode tip. Improper gas settings can cause the tip to burn out too quickly.

Cause analysis

Insufficient Flow Rate: A gas flow rate that is too low (e.g., <5 L/min) cannot effectively shield the tip, leading to oxidation and burnout.
Excessive flow rate: Excessive gas flow rate (e.g., >15 L/min) can cause turbulence, increasing the heat load on the tip.
Improper Gas Type: Helium's high thermal conductivity can lead to overheating tips, especially in low-current welding.
Insufficient gas purity: Oxygen or moisture mixed into the gas will accelerate tip oxidation.

solution

Optimize gas flow: set the flow rate of 5~12 L/min, use a lower flow rate for low-current welding, and increase it appropriately for high-current welding.
Choose argon as the main gas: Prefer to use argon as a shielding gas, helium or argon-helium mixture for high heat input scenarios.
Ensure gas purity: Use high-purity argon gas (≥99.99%) and inspect gas cylinders and lines to avoid contamination.
Maintain the gas system: Regularly check the flow meter and lines to ensure a stable gas supply.

Additional Notes

The choice and flow rate of the shielding gas directly affects tip life. ISO 6848 recommends argon as the main shielding gas for TIG welding, and users should adjust the flow rate according to the welding conditions to ensure that the tip is effectively protected.

9.2.4 Use electrodes with higher cerium content

Background of the problem

The cerium content affects the high temperature resistance and electron emission ability of the electrode. Standard cerium-tungsten electrodes (WC20, cerium oxide 1.8%~2.2%) may burn out quickly in high heat input scenarios.

Cause analysis

Insufficient Cerium Content: Lower cerium levels may not provide sufficient electron emission capabilities, leading to overheating of the tip.

High-temperature environments: High heat input soldering (such as thick plate welding) requires higher burn resistance of the electrode.

Electrode Quality Differences: Cerium distribution is uneven across different batches of electrodes, potentially leading to localized burnout.

Process mismatch: Low cerium content electrodes are used in high-current scenarios, accelerating tip wear.

solution

Choose electrodes with high cerium content: In high heat input scenarios, choose electrodes with a cerium oxide content close to 2.2% to enhance high temperature resistance.

Verify electrode quality: Choose electrodes that comply with ISO 6848 or GB/T 4192 standards to ensure uniform cerium distribution.

Match welding conditions: Choose the appropriate cerium content electrode according to the welding material and current, and avoid using low-cerium electrodes in high-heat scenarios.

Replace electrodes regularly: Monitor tip burnout and replace electrodes promptly to avoid affecting weld quality due to excessive wear.

Additional Notes

High cerium content electrodes improve burn resistance but are more costly. Users need to weigh cost and performance based on the performance requirements of AWS A5.12 and choose the appropriate electrode type.

9.3 How to choose the right cerium content?

Selecting the appropriate cerium content is key to ensuring the performance of cerium-tungsten electrodes, considering welding materials, current types, environmental conditions, and cost factors. The following is an analysis of the selection basis from four aspects.

9.3.1 Selection according to welding material (stainless steel, aluminum, etc.)

Background of the problem

Different welding materials (such as stainless steel, aluminum, carbon steel) have different requirements for the arcing performance and high temperature resistance of the electrode, and the cerium content needs to be matched.

Cause analysis

Stainless steel: requires low current arcing and stable arcing, suitable for standard cerium content (1.8%~2.0%).

Aluminum alloy: High electron emission capacity is required in AC welding, suitable for higher cerium content (2.0%~2.2%).

Carbon steel: High heat input welding requires high burn resistance and is suitable for a cerium content close to 2.2%.

Special alloys: such as titanium alloys, which require extremely high arc stability, and need to choose a high-cerium electrode with uniform doping.

solution

Stainless steel welding: Choose WC20 electrode with a cerium content of 1.8%~2.0% to ensure low current arcing performance.

Aluminum alloy welding: Choose an electrode with a cerium content of 2.0%~2.2% to optimize the arc stability of AC welding.

Carbon Steel Welding: Choose electrodes with a content close to 2.2% cerium to enhance high-temperature resistance.

Special alloy welding: Choose electrodes with high cerium content and stable quality, in accordance with ISO 6848 or HB 7716 standards.

Additional Notes

The choice of welding material directly impacts the demand for cerium content. GB/T 4192 provides recommendations for welding parameters for different materials, and users should choose the appropriate electrode based on material characteristics and process requirements.

9.3.2 Select according to current type and intensity

Background of the problem

The type of current (DC or AC) and intensity affect the heat load and electron emission capacity of the electrode, and the cerium content needs to match the current conditions.

Cause analysis

DC Reverse (DCEN): Low heat load, suitable for standard cerium content (1.8%~2.0%).

Alternating current (AC): positive and negative half-wave switching increases the heat load, and requires a higher cerium content (2.0%~2.2%).

Low current: such as < 50 A, high arcing performance is required, suitable for 1.8%~2.0% cerium content.

High current: e.g. >100 A, which requires high burnout resistance and is suitable for a cerium content close to 2.2%.

solution

DCEN soldering: Choose a WC20 electrode with a cerium content of 1.8%~2.0%, suitable for low heat input scenarios.

AC welding: Select electrodes with cerium content of 2.0%~2.2% to optimize the positive and negative half-wave balance.

Low-current welding: Choose standard cerium-content electrodes to ensure arcing performance.

High-current welding: Choose electrodes with high cerium content to enhance burnout resistance.

Additional Notes

AWS A5.12 provides electrode selection guidelines for current type and intensity, and users should select the appropriate cerium content based on the current output range of the welding machine.

9.3.3 Consider the welding environment and equipment compatibility

Background of the problem

The welding environment (e.g., humidity, temperature) and equipment performance affect the choice of electrode, and the cerium content needs to adapt to these conditions.

Cause analysis

High humidity environment: Moisture may cause electrode oxidation, so choose a corrosion-resistant electrode with high cerium content.

High temperature environment: Increases the risk of tip burnout, and requires the selection of electrodes with high cerium content.

Equipment performance: Older welding machines may have unstable output, so high-performance electrodes need to be selected to compensate.

Protective gas system: Insufficient gas purity or flow rate will affect the electrode performance, so choose an electrode with higher durability.

solution

High humidity environment: Choose an electrode with a cerium content of 2.0%~2.2% to enhance corrosion resistance.

High-temperature environments: Choose electrodes with high cerium content to extend tip life.

Old equipment: choose high-performance WC20 electrodes to compensate for the instability of the equipment.

Optimize gas systems: ensure high-purity gas supply with standard cerium content electrodes.

Additional Notes

The complexity of the welding environment requires users to consider both electrode performance and equipment conditions. EN 26848 emphasizes the adaptability of electrodes in different environments, and users should regularly check the environment and equipment status.

9.3.4 Balance between cost and performance

Background of the problem

High cerium electrodes have excellent performance but high cost, and users need to find a balance between cost and performance.

Cause analysis

High Cerium Content Cost: Electrodes with a cerium oxide content close to 2.2% have higher production costs, making them suitable for high-demand scenarios.

Standard Cerium Content Applicability: 1.8%~2.0% electrode has a lower cost and is suitable for conventional welding.

Lifespan: High cerium content electrodes have a longer lifespan, reducing long-term costs.

Bulk Procurement: Using high cerium content electrodes in large quantities can increase the overall cost.

solution

Conventional welding: Choose WC20 electrode with a cerium content of 1.8%~2.0% to reduce costs.

High demand welding: Choose electrodes with a cerium content of 2.0%~2.2% to ensure performance.

Cost Evaluation: Choose the most cost-effective electrode based on welding frequency and lifespan requirements.

Supplier Selection: Choose suppliers that comply with ISO 6848 or GB/T 4192 standards, ensuring quality and cost balance.

Additional Notes

The balance between cost and performance is determined by the project budget and welding requirements. Users can refer to the annual report of the China Tungsten Industry Association to understand the market price trend and choose the appropriate electrode.

9.4 Countermeasures for the difficulty of arcing of cerium tungsten electrodes

Arcing difficulty is a common problem in the use of cerium tungsten electrodes, manifested by arcing that is difficult to ignite or requires multiple attempts. The following analyzes the causes and provides solutions from four aspects: surface cleanliness, tip geometry, device parameters, and power stability.

9.4.1 Check the cleanliness of the electrode surface

Background of the problem

Electrode surface cleanliness directly affects electron emission capacity, and contamination or oxidation can cause arcing difficulties.

Cause analysis

Surface Contamination: Oil, dust, or melt pool splashes adhere to the electrode surface, hindering electron emission.

Oxide layer: The electrode is exposed to air or insufficient shielding gas, leading to surface oxidation and reduced arcing performance.

Improper storage: The electrodes are stored in a humid environment, leading to contamination or oxide layers forming on the surface.

Operational Contamination: Exposure to contaminants during welding, such as sweaty hands, can affect surface quality.

solution

Clean the electrodes: Wipe the electrode surface with alcohol or a special cleaning solution, and ultrasonic cleaning if necessary.
Prevent oxidation: Ensure sufficient shielding gas to avoid exposing the electrode to hot air.
Regulated storage: Store the electrodes in a dry, dust-proof airtight container.
Operation specifications: Wear gloves to operate the electrodes to avoid hand sweat pollution.

Additional Notes

Electrode surface cleanliness is the basis for arcing performance. ISO 6848 emphasizes the storage and cleaning requirements of electrodes, and users should establish a strict electrode management system.

9.4.2 Optimizing Tip Geometry

Background of the problem

The tip geometry affects the ignition ability of the arc, and improper shape can lead to arcing difficulties.

Cause analysis

Too large cone angle: Too large a cone angle (such as > 60°) disperses the arc and makes it difficult to ignite.
Tip passivation: Prolonged use leads to dullness of the tip, reducing the efficiency of electron emission.
Asymmetrical shape: Uneven grinding leads to arc deflection, increasing arc initiation difficulty.
Rough Surface: Grinding marks or rough surfaces interfere with electron emissions.

solution

Choose the right cone angle: use a 20° 30° cone angle for low-current welding and a 30°50° cone angle for high-current welding.
Regular Grinding: Resharpen the tip according to the time of use, maintaining a sharp shape.
Ensure symmetry: Use specialized grinding machines to ensure the tip is symmetrical.
Polishing tips: Polishing with a fine-grained grinding wheel reduces surface roughness.

Additional Notes

Optimization of tip geometry is key to solving arc initiation difficulties. AWS A5.12 recommends choosing the appropriate cone angle based on current and material, and users should use professional grinding equipment.

9.4.3 Adjusting Welding Equipment Parameters (High Frequency Arc Starting, etc.)

Background of the problem

Welding equipment parameters such as high-frequency arc initiation settings directly affect arcing performance, and improper parameters can lead to arcing difficulties.

Cause analysis

Insufficient arcing at high frequency: The intensity or frequency of high-frequency pulses is too low, making it difficult to ignite the arc.

Current setting too low: The current is below the recommended range of the electrode, and the electron emission is insufficient.

Improper shielding gas: The gas flow rate or type does not match, affecting arc ignition.

Equipment aging: The high-frequency module or power output of the welding machine is unstable.

solution

Optimize High-Frequency Arcing: Adjust the intensity and frequency of high-frequency pulses to ensure rapid ignition arcing.

Set the appropriate current: Choose the appropriate arc current according to the electrode diameter (e.g., 30~50 A is recommended for 1.6 mm electrode).

Adjust the shielding gas: Use argon gas and set the flow rate of 5~10 L/min to ensure the shielding effect.

Maintenance Equipment: Regularly calibrate the welding machine and check the high-frequency module and power supply stability.

Additional Notes

High-frequency arcing is a common arc induction method for cerium tungsten electrodes, and GB/T 4192 provides parameter adjustment suggestions. Users should maintain the equipment regularly to ensure arc starting performance.

9.4.4 Replace the electrode or check the stability of the power supply

Background of the problem

Electrode quality or power supply stability can cause arcing difficulties and need to be resolved by replacing the electrode or checking the power supply.

Cause analysis

Electrode quality issues: Uneven cerium distribution or excessive impurities affect arc initiation performance.

Electrode Aging: Prolonged use leads to tip deterioration, reducing arcing capabilities.

Unstable power supply: The output voltage or current of the welding machine fluctuates, affecting arc ignition.

Connection Issues: Loose or poor contact with electrode grippers, leading to poor current transmission.

solution

Replace the electrode: Choose a WC20 electrode that complies with ISO 6848 or GB/T 4192 standards to ensure quality.

Regular Replacement: Replace the electrodes in a timely manner based on usage time and tip

condition.
Check the Power Supply: Calibrate the welding machine to ensure stable voltage and current output.
Check the Gripper: Ensure the electrode gripper is tight and in good contact.

Additional Notes
Power supply stability and electrode quality are the basis for arcing performance. Users should choose reliable suppliers and regularly inspect welding equipment to avoid difficulty in arcing due to hardware problems.

9.5 Analysis of the problem of mixed use of cerium tungsten and lanthanum tungsten
Cerium tungsten (WC20) and lanthanum tungsten (WL20) electrodes are similar in performance and use, but mixing can lead to reduced performance or management confusion. The following analyzes the mixing problem from four aspects: performance impact, arc stability, identification management, and alternatives.

9.5.1 Performance Effects of Mixing
Background of the problem
Both cerium tungsten and lanthanum tungsten electrodes are suitable for TIG welding, but the difference in doping (cerium oxide and lanthanum oxide) leads to different properties, and mixing may affect the welding effect.

Cause analysis
Electron emission capacity: Cerium oxide of cerium tungsten electrode provides good arcing performance at low current, and lanthanum oxide of lanthanum tungsten electrode is more resistant to burnout at high currents.
Heat load differences: Lanthanum tungsten electrodes are more stable in high heat input scenarios, while cerium tungsten electrodes are suitable for low to moderate currents.
Chemical Composition Differences: Mixing can lead to inconsistent electrode performance, affecting weld quality.
Process adaptability: Different electrodes are suitable for different welding parameters, and mixing may lead to incorrect parameter settings.

solution
Clear usage scenarios: Choose the appropriate electrode according to the welding material and current to avoid mixing.
Store separately: Store cerium tungsten and lanthanum tungsten electrodes separately to avoid confusion.
Adjust Welding Parameters: Adjust the current and gas flow rate based on the electrode type to ensure performance matching.
Quality Verification: Use electrodes that comply with ISO 6848 or AWS A5.12 standards to avoid performance discrepancies.

Additional Notes

The performance differences between cerium tungsten and lanthanum tungsten electrodes need to be selected according to the specific process. AWS A5.12 provides a performance comparison of the two electrodes, and users should choose a single type based on their welding needs.

9.5.2 Arc instability problems that may be caused by mixing

Background of the problem

The mixed use of cerium tungsten and lanthanum tungsten electrodes may lead to arc instability, affecting weld quality and process efficiency.

Cause analysis

Difference in arcing performance: Cerium-tungsten electrodes have better arcing performance than lanthanum tungsten at low currents, and mixing may lead to arcing difficulties.

Arc stability differences: Lanthanum tungsten electrodes are more stable at high currents, and cerium tungsten electrodes may cause arc jitter due to overheating.

Parameter mismatch: When mixing electrodes, the welding parameters may not be suitable for the current electrode type.

Difference in tip shape: The recommended cone angle of the two electrodes is different, and mixing can lead to arc dispersion.

solution

Avoid mixing: Prioritize using a single type of electrode to ensure process consistency.

Optimize parameters: Adjust current, polarity, and gas flow based on electrode type.

Check tip shape: Ensure that the electrode tip grinding meets the recommended cone angle (e.g., cerium tungsten 20°40°, lanthanum tungsten 30°50°).

Regular inspection: Confirm the electrode type before welding to avoid instability caused by mixing.

Additional Notes

Arc instability is a common problem with mixed electrodes. EN 26848 recommends that users strictly differentiate between electrode types to avoid process problems caused by mixing.

9.5.3 Identification and management suggestions when mixing

Background of the problem

Cerium tungsten and lanthanum tungsten electrodes have similar appearances, and their mixing may occur due to unclear marking, affecting welding quality and management efficiency.

Cause analysis

Similar color identification: The end colors of cerium tungsten (gray) and lanthanum tungsten (blue) can be difficult to distinguish in low light.

Storage Mess: The electrodes are not stored separately by type, leading to confusion.

Missing labels: Unclear model identification on packaging or electrodes, increasing the risk of mixing.

Negligent operation: The operator did not carefully check the electrode type and used it directly.

solution

Enhanced color identification: Labeling is strictly in accordance with ISO 6848 or AWS A5.12 color coding (cerium tungsten gray, lanthanum tungsten blue).

Store separately: Store cerium tungsten and lanthanum tungsten electrodes in separate containers or labels to avoid confusion.

Clear labeling: Ensure that the electrode packaging labels the WC20 or WL20 model number, including manufacturer and batch information.

Operation training: Operators are trained to identify the type of electrode and check the identification before use.

Additional Notes

Identification and management are key to avoiding mixing. GB/T 4192 emphasizes the color coding and packaging requirements of electrodes, and users should establish a strict electrode management system.

9.5.4 Recommended Electrode Selection and Alternatives

Background of the problem

To avoid mixing, users need to choose the right electrode for their welding needs and understand alternatives to optimize the process.

Cause analysis

Differences in process requirements: Cerium tungsten is suitable for low to moderate currents, and lanthanum tungsten is suitable for high currents, and mixing may lead to poor performance.

Cost Difference: Lanthanum tungsten electrodes are more expensive, and alternatives need to be evaluated for cost-effectiveness.

Supply Stability: Certain electrodes may be difficult to obtain in some regions, requiring alternative options.

Equipment compatibility: Different electrodes have different parameter requirements for welding equipment, and they need to be matched and selected.

solution

Low-current welding: Prefer cerium-tungsten electrodes (WC20), suitable for stainless steel and sheet welding.

High-current welding: Choose lanthanum tungsten electrode (WL20), suitable for thick plates and superalloy welding.

Alternative: If the supply of cerium tungsten electrodes is insufficient, lanthanum tungsten electrodes can be used instead, but the cone angle and current parameters need to be adjusted.

Supplier Selection: Choose suppliers that comply with ISO 6848 or GB/T 4192 standards to ensure electrode quality.

Additional Notes

Electrode selection requires a comprehensive consideration of process requirements and costs. AWS A5.12 provides a performance comparison between cerium and lanthanum tungsten, allowing users to select the appropriate electrode type for their specific application.

Chapter 10 Future Development Trend of Cerium Tungsten Electrodes

As a key material in inert gas shielded arc welding (TIG) and plasma welding, cerium tungsten electrodes occupy an important position in the global welding industry due to their low radioactivity, excellent arcing properties, and arc stability. With the rapid development of materials science, manufacturing technology, and emerging industries, the technological innovation, application fields, and market environment of cerium-tungsten electrodes are facing profound changes. This chapter systematically discusses the future development trends of cerium tungsten electrodes from three aspects: technological innovation, application expansion, and market and policy, and deeply analyzes the background, development direction, potential impact and application prospects of each trend.

10.1 Technological innovation of cerium tungsten electrodes

Technological innovation is the core driving force for the performance improvement and application expansion of cerium tungsten electrodes. In the future, the research and development of new doped materials, intelligent and green manufacturing, and high-performance electrodes will become the focus of technological development, bringing higher performance, lower cost and more environmentally friendly production methods to cerium tungsten electrodes.

CTIA GROUP LTD
Cerium Tungsten Electrode Introduction

1. Overview of Cerium Tungsten Electrode

Cerium Tungsten Electrode (WC20) is a non-radioactive tungsten electrode material composed of high-purity tungsten base doped with 1.8% to 2.2% cerium oxide (CeO_2). Compared to traditional thoriated tungsten electrodes, the cerium tungsten electrode offers superior arc starting performance, lower burn-off rate, and greater arc stability, while being radiation-free and environmentally friendly. It is suitable for both DC (direct current) and AC/DC mixed current welding conditions and is widely used in TIG welding and plasma cutting of materials such as stainless steel, carbon steel, and titanium alloys. This makes it an ideal green substitute in modern industrial welding.

2. Features of Cerium Tungsten Electrode

Excellent Arc Starting: Easy to ignite at low current, with stable and reliable performance.
Low Burn-off Rate: Cerium oxide enhances evaporation resistance at high temperatures, extending electrode life.
High Arc Stability: Focused arc with minimal flicker, suitable for precision welding.
Radiation-Free & Eco-Friendly: A safe and environmentally sound alternative to radioactive thoriated electrodes.

3. Specifications of Cerium Tungsten Electrode

Type	CeO_2 Content	Color Code	Density (g/cm^3)	Length (mm)	Diameter Range (mm)
WC20	1.8% – 2.2%	Grey	19.3	50 – 175	1.0 – 6.4

4. Applications of Cerium Tungsten Electrode

TIG welding of stainless steel, carbon steel, titanium alloys, nickel alloys, etc.
Precision welding and spot welding for medical devices and microelectronic components
Suitable for DC and AC/DC mixed welding conditions
Low-current plasma arc cutting and high-frequency ignition systems

5. Procurement Information

Email: sales@chinatungsten.com
Phone: +86 592 5129595; 592 5129696
Website: www.tungsten.com.cn

10.1.1 New doped materials and processes

Technical background

The performance of cerium tungsten electrode mainly depends on the synergistic effect between the tungsten matrix and the cerium oxide dopant. The traditional cerium-tungsten electrode (WC20) improves arc initiation performance and arc stability by adding 1.8%~2.2% cerium oxide, but with the increase of high-precision welding and high-temperature environmental requirements, the limitations of single cerium oxide doping gradually emerge. The introduction of new doping materials and advanced manufacturing processes will significantly improve the high temperature resistance, electron emission capability, and service life of electrodes.

Development trend

Composite doping technology: In the future, composite doping electrodes will be developed, such as adding lanthanum oxide, yttrium oxide or zirconia to cerium oxide to form a multi-doping system. Composite doping optimizes electron emission performance and reduces tip burnout rates, making it suitable for high heat input and ultra-precision welding scenarios. For example, cerium-lanthanum composite electrodes are expected to exhibit better arc stability in superalloy welding.

Nanodoping process: Enhance the microstructural stability of the electrode through uniform doping of nanoscale cerium oxide particles (particle size <100 nm). Nanodoping improves the distribution uniformity of cerium oxide, reduces local overheating, and improves the arcing performance of electrodes at low currents, making them particularly suitable for the semiconductor and microelectronics industries.

New Substrate Materials: Explore tungsten-based alloys, such as tungsten-molybdenum alloys or tungsten-rhenium alloys, as substrate materials to improve the mechanical strength and thermal shock resistance of electrodes. These new matrix materials extend the life of electrodes in extreme environments.

Advanced Manufacturing Processes: Plasma sintering, laser cladding, or 3D printing techniques are used to optimize the distribution of doping and the microstructure of the electrodes. Laser cladding allows for precise control of dopings, while 3D printing allows for customized electrode shapes to meet special welding needs.

Surface modification technology: Plasma spraying or chemical vapor deposition (CVD) is used to form a high-temperature resistant coating on the electrode surface, reducing tip oxidation and burnout damage, and improving the stability of the electrode in high-frequency welding.

Potential impact

Performance improvement: Composite doping and nano-doping technologies will significantly improve the arc initiation performance and high temperature resistance of electrodes, meeting high-demand scenarios such as aerospace and nuclear industry.

Cost control: New processes need to balance performance improvement with production costs, and nano-doping and 3D printing may have higher initial costs, but can reduce the frequency of electrode replacement in the long run.

Industry standard updates: New doped materials will drive the revision of standards such as ISO 6848, adding new classification and testing requirements for composite doped electrodes.

Application prospects

New doping materials and processes will make cerium-tungsten electrodes suitable for a wider range of welding scenarios, such as ultra-high temperature alloy welding, micro-device manufacturing, and new energy equipment production. The aerospace industry can use composite doped electrodes to achieve precision welding of titanium alloys, while the semiconductor industry can use nano-doped electrodes to meet the needs of micro-soldering.

10.1.2 Intelligent and green manufacturing

Technical background

Intelligent and green manufacturing are the core direction of manufacturing upgrading. The production of cerium tungsten electrodes involves high-energy processes such as powder metallurgy and high-temperature sintering, and traditional processes have problems of energy waste and environmental pollution. In the future, intelligent production and green manufacturing technologies will optimize the electrode production process, improve efficiency and reduce environmental impact.

Development trend

Intelligent Production: Introduce artificial intelligence (AI) and Industrial Internet of Things (IoT) technologies to optimize the electrode production process. AI predicts electrode quality and automatically adjusts process parameters by monitoring powder doping, sintering temperature, and molding pressure in real time. IoT systems can realize the interconnection of production equipment and improve the automation level of production lines.

Online Quality Inspection: Develop AI-based online inspection systems that use machine vision and spectral analysis to detect electrodes' chemical composition, microstructure, and surface quality in real-time. This will replace traditional manual inspection methods, improving inspection efficiency and consistency.

Green Production Process: Low-energy sintering techniques (such as microwave sintering or plasma sintering) are used to reduce energy consumption. Develop waste recycling technology to recycle tungsten powder and cerium oxide waste in the production process to reduce raw material waste.

Environmentally friendly surface treatment: Replace traditional chemical cleaning methods with plasma cleaning or laser cleaning technology to reduce waste liquid emissions and improve the environmental friendliness of the production process.

Digital twin technology: Construct a digital twin model of the electrode production line, simulate the process flow, optimize production parameters, and reduce test costs and environmental impact.

Potential impact

Improved production efficiency: Intelligent production can shorten the production cycle and improve the consistency and quality stability of electrodes.

Environmentally friendly: Green manufacturing technology will reduce energy consumption and emissions, comply with global environmental regulations, and enhance the competitiveness of enterprises.

Cost optimization: Intelligence and scrap recycling technology can reduce long-term production costs, but the initial equipment investment is higher.

Standard adaptability: Green manufacturing will promote the addition of environmental protection clauses to standards such as GB/T 4192 and standardize the production process.

Application prospects

Intelligent and green manufacturing will make cerium tungsten electrode production more efficient and environmentally friendly, meeting the demand for high-performance electrodes in aerospace, automobile manufacturing and other industries. Intelligent testing systems provide enterprises with quality traceability capabilities, and green processes enhance the competitiveness of electrodes in environmentally strict markets such as Europe.

10.1.3 Research and development of high-performance electrodes

Technical background

With the advancement of welding technology, high-demand fields such as aerospace, semiconductor, and nuclear industry have set higher standards for electrode performance. The performance of traditional cerium-tungsten electrodes in ultra-high current, ultra-low current or extreme environments still needs to be improved, and the research and development of high-performance electrodes has become the focus of the future.

Development trend

Ultra-high current electrodes: Develop cerium-tungsten electrodes suitable for ultra-high currents (>300 A), enhancing burn resistance and arc stability by optimizing doping ratios and matrix materials to meet the needs of thick plate welding.

Ultra-low current electrodes: Develop electrodes suitable for ultra-low current (<10 A), using nano-doping and surface modification techniques to optimize arcing performance and meet micro-welding needs.

Extreme environment resistant electrodes: develop high-temperature and corrosion-resistant electrodes, suitable for special environments such as nuclear industry and marine engineering. For example, adding anti-corrosion coatings or using tungsten-rhenium alloy substrates can improve the stability of the electrode in high-temperature and high-humidity environments.

Long-Life Electrodes: Extend electrode life, reduce replacement frequency, and reduce long-term costs through compound doping and advanced sintering technology.

Customized Electrodes: Utilize 3D printing technology to produce customized electrodes to meet special shape or performance requirements, such as non-standard diameters or complex tip geometries.

Potential impact

Expanded application range: High-performance electrodes will meet the high requirements of emerging industries, driving the application of cerium tungsten electrodes in high-end markets.

Technical barriers: The research and development of high-performance electrodes requires high investment, which may intensify industry competition and form technical barriers.

Standard updates: High-performance electrodes will promote new performance requirements for standards such as AWS A5.12 and promote industry standardization.

Application prospects

High-performance electrodes will be widely used in aerospace (titanium alloy welding), semiconductors (microchip welding), and nuclear industry (superalloy welding). Customized electrodes are available to meet individual needs, such as complex geometric welding in medical device manufacturing.

10.2 Application expansion of cerium tungsten electrodes

The application fields of cerium tungsten electrodes are rapidly expanding, and the demand of emerging industries such as new energy, semiconductors, and micro welding provides new growth points for electrodes. In the future, cerium tungsten electrodes will play a greater role in high-precision and special scenarios.

10.2.1 Demand from Emerging Industries (New Energy, Semiconductors, and Others)

Application Background:

The rapid development of new energy (photovoltaic, wind power, hydrogen) and semiconductor industries has put forward higher requirements for welding technology. Cerium-tungsten electrodes are ideal for these industries due to their low radioactivity and high performance.

Development trend

Photovoltaic industry: Photovoltaic module manufacturing requires high-precision welding, such as silicon wafer joining and cell assembly. The excellent arcing performance of cerium tungsten electrode is suitable for low-current precision welding, and will be widely used in the production of photovoltaic equipment in the future.

Wind Power Industry: Welding of wind power equipment, such as towers and blades, requires high strength and corrosion resistance. Cerium tungsten electrodes can meet the needs of thick plate welding through composite doping, and will support larger-scale wind power projects in the future.

Hydrogen energy industry: The manufacturing of hydrogen fuel cells involves thin-walled metal welding, and the low current performance and arc stability of cerium tungsten electrodes will become the key, and the demand will grow rapidly in the future.

Semiconductor industry: Chip packaging and microelectronics manufacturing require ultra-precision soldering, and the nano-doped version of cerium tungsten electrode can meet micron-level soldering requirements and will play a role in 5G and AI chip manufacturing in the future.

Electric Vehicle Industry: Battery pack and motor manufacturing require high-reliability welding, and high-performance versions of cerium tungsten electrodes will support mass production of electric vehicles.

Potential impact

Market Growth: Demand from emerging industries will drive the market size of cerium tungsten electrodes.

Technological Upgrades: The demand for high-precision welding will accelerate the research and development of high-performance electrodes.

Industry Collaboration: Electrode manufacturers need to collaborate with new energy and semiconductor companies to develop customized solutions.

Application prospects

Cerium tungsten electrodes will play a key role in the new energy and semiconductor industries. For example, the photovoltaic industry can use cerium-tungsten electrodes to achieve efficient silicon wafer welding, and the hydrogen energy industry can improve the manufacturing quality of fuel cells through high-performance electrodes.

10.2.2 Micro welding and ultra-precision welding technology

Application Background:

Micro welding and ultra-precision welding technologies are increasingly in demand in medical devices, microelectronics, aerospace, and other fields. The low-current arcing properties of cerium-tungsten electrodes make them ideal for micro-welding and will be useful in more delicate scenarios in the future.

Development trend

Micro welding electrodes: Develop cerium-tungsten electrodes with a diameter of less than 0.5 mm, suitable for micron-scale welding, such as the manufacture of medical implants. Nanodoping technology will improve the performance of the electrode at ultra-low currents.

Ultra-precision welding: Optimizing electrode tip geometry and surface modification techniques to ensure arc concentration and stability, meeting the needs of semiconductor chip packaging and aerospace microstructures.

Automated Welding System: Combine robotic and laser-assisted welding technology to develop automated electrode systems suitable for micro-welding to improve welding accuracy and efficiency.

Low-temperature welding technology: Research and development of low-temperature resistant electrodes, suitable for micro-welding in low-temperature environments, such as the assembly of spacecraft electronic components.

Multi-Material Welding: Developing electrodes that support the welding of dissimilar materials, such as metals and ceramics, catering to the complex needs of the microelectronics and medical industries.

Potential impact

Technological breakthrough: The research and development of micro-welding electrodes will promote the refined development of welding technology.

Cost Challenge: Ultra-precision electrodes are expensive to produce, requiring process optimization to reduce prices.

Standard development: Microwelding electrodes will promote the addition of microwelding provisions to standards such as ISO 6848.

Application prospects

Cerium tungsten electrodes will shine in the field of micro welding, such as pacemaker welding in the medical industry, chip packaging in the semiconductor industry, and micro sensor manufacturing in the aerospace industry. The introduction of automated welding systems will further improve production efficiency.

10.3 Market and policy of cerium tungsten electrodes

The growth of market demand and changes in the policy environment will profoundly affect the future development of cerium tungsten electrodes. Global market forecasts, environmental policies, and international trade trends will provide new opportunities and challenges for the electrode industry.

10.3.1 Global Market Demand Forecast

Market Background

The market demand for cerium tungsten electrodes is driven by global manufacturing, energy transition, and emerging industry developments. The rapid growth of aerospace, automobile manufacturing, new energy and semiconductor industries will drive the demand for electrodes to continue to rise.

Development trend

Asian market: Manufacturing upgrades and new energy investments in Asian countries such as China and India will drive the demand for cerium tungsten electrodes. As the world's largest tungsten resource country, China will continue to dominate electrode production and exports.

North American Market: The expansion of aerospace and electric vehicle industries will increase the demand for high-performance cerium tungsten electrodes, and stringent enforcement of the AWS A5.12 standard will promote market normalization.

European Market: Environmental regulations and the drive for green manufacturing will increase the demand for low-radioactivity cerium-tungsten electrodes, and updates to the EN 26848 standard will further regulate the market.

Emerging markets: Industrialization in Africa and South America will bring new growth points of demand, especially in the energy and infrastructure sectors.

Industry Segmentation: Demand from new energy (photovoltaic, wind power), semiconductor, and medical industries will drive the market growth for customized electrodes.

Potential impact

Market size expansion: The global cerium tungsten electrode market is expected to maintain an average annual growth rate of 5%~7% in the next ten years.

Regional competition: The cost advantage of Chinese companies and the technological advantages of North American and European companies will intensify market competition.

Supply chain optimization: The regional distribution of market demand will promote the localization of the supply chain.

Application prospects

Cerium tungsten electrodes will maintain an important position in the global manufacturing industry, the Chinese market will benefit from the rapid growth of the new energy and semiconductor industries, and the North American and European markets will focus on the application of high-performance electrodes.

10.3.2 The impact of environmental protection policies on the industry

Policy background

Tel: 0086 592 512 9696
sales@chinatungsten.com

Global environmental regulations (such as the EU REACH regulation and China's Environmental Protection Law) have put forward higher environmental protection and safety requirements for the manufacturing industry. Cerium tungsten electrode production involves tungsten ore mining, powder metallurgy, and chemical processing, and needs to adapt to green manufacturing trends.

Development trend

Waste recycling specifications: The policy will require electrode manufacturers to increase the scrap recycling rate (e.g., >90%), reduce the waste of tungsten and cerium oxide, and reduce environmental pollution.

Low-energy production: Encourage the use of low-energy technologies such as microwave sintering and plasma sintering to reduce carbon emissions in the production process.

Radioactivity Control: Enhance radioactivity detection of electrodes to ensure they fall below safety thresholds and meet safety requirements in the aerospace and medical industries.

Green packaging: Requires the use of recyclable or biodegradable packaging materials, reducing plastic use, and meeting EU environmental standards.

Carbon Footprint Certification: In the future, companies will need to provide carbon footprint reports on the electrode production process and obtain green certification to enter the strict market.

Potential impact

Rising costs: Environmental compliance will increase production costs, and SMEs' ability to adapt may be limited.

Market access: Electrodes that comply with environmental policies are easier to enter the European and North American markets.

Technological Upgrades: Green policies will promote the adoption of low-energy and waste recycling technologies.

Application prospects

Environmental protection policies will promote the transformation of cerium tungsten electrode production to green, and green electrodes will be more widely used in new energy and medical industries. Enterprises need to enhance their market competitiveness through technology upgrades and certification compliance.

10.3.3 International Trade and Supply Chain Trends

Market Background

The international trade of cerium tungsten electrodes is influenced by global tungsten resource distribution, manufacturing demand, and trade policies. China, as the world's largest producer of tungsten, dominates the electrode supply chain, but geopolitical and trade barriers may pose challenges.

Development trend

Supply Chain Diversification: To cope with trade risks, North American and European companies will seek to diversify their supply chains, such as developing tungsten resources in Australia and Canada.

Localized Production: The European and North American markets will drive the localization of electrode production, reducing dependence on Asian imports and improving supply chain stability.
Trade Agreement Impact: Regional trade agreements (e.g., RCEP, CPTPP) will facilitate electrode trade in Asian markets and reduce tariff barriers.
Digital supply chain: Use blockchain technology to track the source of electrode raw materials and production process to improve supply chain transparency and traceability.
Green trade requirements: The EU's Carbon Border Adjustment Mechanism (CBAM) will require imported electrodes to meet carbon emission standards and promote the popularization of green production technologies.

Potential impact

Intensified market competition: Supply chain diversification will increase competition in the global market, and the cost advantage of Chinese companies may weaken.
Trade barriers: Geopolitical and environmental requirements may limit the export of electrodes, which need to be addressed through certification.
Technology Synergy: Digital supply chains will promote global technical cooperation and improve electrode quality.

Application prospects

International trade and supply chain trends will drive the cerium tungsten electrode industry towards globalization, greening, and digitalization. Chinese companies need to maintain their competitive advantage through technology upgrades and green certifications, while North American and European companies can meet market demand through localized production.

Appendix

A. Glossary

Cerium Tungsten Electrode: A non-radioactive electrode doped with 2%~4% cerium oxide based on tungsten and used in TIG welding and other processes.

Electron Escape Work Function: The minimum amount of energy required for electrons to escape from the surface of the material, affecting the arcing performance of the electrode.

Arc Starting Performance: The ability of the electrode to form a stable arc at low currents.

Arc Stability: The arc maintains a continuous and non-jittering characteristic during the welding process.

Burn-off Rate: The mass loss rate of the electrode due to high temperature loss during the welding process.

Powder Metallurgy: A technology for preparing metal materials through powder mixing, pressing, and sintering.

TIG Welding (Tungsten Inert Gas Welding): Tungsten argon arc welding using inert gas protection.

Cerium Oxide (CeO_2): A rare earth oxide additive that improves the performance of tungsten electrodes.

Plasma Arc Welding: A process that uses high-temperature plasma arcs for high-precision welding.

Microstructure: The structural characteristics of the material such as grain and phase distribution observed under a microscope.

ISO 6848: Standard for classification and technical requirements for tungsten electrodes developed by the International Organization for Standardization.

AWS A5.12: A specification standard for tungsten electrodes developed by the American Welding Society.

SEM (Scanning Electron Microscope): A scanning electron microscope used to analyze the surface morphology and microstructure of materials.

ICP-MS (Inductively Coupled Plasma Mass Spectrometry): Inductively coupled plasma mass spectrometry for elemental analysis.

Sintering: The process of heating powder at high temperatures to combine it into a dense material.

B. References

[1] International Organization for Standardization. (2004). ISO 6848: Arc welding and cutting — Nonconsumable tungsten electrodes — Classification. Geneva: ISO. [2] American Welding Society. (2009). AWS A5.12: Specification for Tungsten and Oxide Dispersed Tungsten Electrodes for Arc Welding and Cutting. Miami: AWS.

[3] European Committee for Standardization. (1991). EN 26848: Tungsten electrodes for inert gas shielded arc welding and for plasma cutting and welding. Brussels: CEN.

[4] National Standardization Technical Committee. (2015). GB/T 4192: Tungsten electrodes for arc welding, plasma welding and cutting under inert gas protection. Beijing: China Standard Press.

[5] China Machinery Industry Federation. (2017). JB/T 12706: Tungsten electrode for welding. Beijing: China Standard Press. [6] Zhang Wei, Liu Jun. (2018). Research progress of tungsten electrode materials for TIG welding. Transactions of the Chinese Journal of Materials Science and Engineering, 36(4), 215–223.

[7] Wang Xin, Li Hui. (2020). Application of nano-doping technology in the development of cerium-tungsten electrodes. Welding Technology Review, 42(3), 87–94.

[8] China Tungsten Industry Association. (2022). Annual Report on Tungsten Electrode Production and Market Trends. Beijing: China Tungsten Industry Association.