Encyclopedia of Molybdenum Wire

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

Molybdenum Wire Introduction

1. Overview of Molybdenum Wire

Molybdenum wire is a high-performance metallic filament made from metal molybdenum through hot working, cold drawing, and surface treatment. It features an extremely high melting point, excellent electrical and thermal conductivity, good mechanical strength, and exceptional corrosion resistance. It serves as a core material in various high-temperature and precision application fields.

2. Applications of Molybdenum Wire (Typical)

Application Field	Specific Uses
Lighting Industry	Filament supports, lead wires, halogen lamp electrodes, fluorescent lamp electrodes, LED packaging brackets
Wire-Cut Machining	Electrode wire for EDM, used in mold making and cutting of complex metal parts
Thermal Spraying	Used for surface reinforcement and wear-resistant coatings on automotive, aerospace, and engineering components
Vacuum Coating	Used as evaporation sources and coating materials for optics, solar cells, and semiconductor devices

3. Types of Molybdenum Wire (Typical)

Classification	Type	Description
Surface Condition	Cleaned Molybdenum Wire	Cleaned surface, bright and smooth, suitable for high-precision processing, electronics, coating, and other demanding applications
	Black Molybdenum Wire	Graphite-coated surface, suitable for general industrial processing and cost-effective applications
Use-Based Category	Wire-Cut Molybdenum Wire	For EDM wire-cutting, features high strength, high precision, and excellent durability
	Thermal Spray Molybdenum Wire	Used in thermal spraying processes, requires high density and good melting properties
	Heating Molybdenum Wire	Used as a heating element in high-temperature furnaces, with excellent heat resistance

4. Specifications of Molybdenum Wire from CTIA GROUP LTD

Item	Specification
Purity	≥99.95%
Diameter Range	0.03 mm ~ 3.0 mm (customizable)
Length / Coil Weight	Custom cut lengths (e.g., 200 mm) or continuous winding (e.g., 500g/coil, 2kg/coil)
Diameter Tolerance	±0.002 mm ~ ±0.1 mm
Surface Condition	Cleaned / Black
Packaging Options	Spool, coil, vacuum packaging, customized packaging

5. Procurement Information

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Directory

Chapter 5: Uses of Molybdenum Wire

Chapter 6: Molybdenum Wire Production Equipment

Chapter 1 Introduction

1.1 Definition and overview of molybdenum wire

Molybdenum wire is a kind of filament-like material made of molybdenum metal or its alloy, through powder metallurgy, wire drawing, heat treatment and other processes, usually with a diameter of between 0.03 mm and several mm. Molybdenum (chemical symbol Mo, atomic number 42) is a high melting point, transition metal with excellent physical, chemical and mechanical properties, such as high strength, high temperature resistance, corrosion resistance and good electrical and thermal conductivity. These characteristics make molybdenum wire an irreplaceable role in a variety of industrial fields. Molybdenum wire can be divided into pure molybdenum wire (purity usually ≥ 99.95%) and molybdenum alloy wire (such as lanthanum molybdenum wire, molybdenum-rhenium alloy wire, etc.), which can be divided into black molybdenum wire (without alkali washing, the surface oxide layer is black-gray) and cleaned molybdenum wire (after alkali washing or polishing, the surface is silvery-white) according to the surface state. Molybdenum wire is available in a variety of specifications, from ultra-fine molybdenum wire (diameter < 0.1 mm) to coarse molybdenum wire (diameter > 1.0 mm), to meet the needs of different applications.

The production process of molybdenum wire is complex, involving multiple processes from molybdenum concentrate purification to wire drawing, and its core is to control the grain structure and surface quality to ensure performance stability. Molybdenum wire is used in a wide range of applications, including wire EDM, electric light sources, vacuum coatings, high-temperature furnace components, electronic component manufacturing, and medical and aerospace applications. Molybdenum wire's high melting point (about 2623°C) and low coefficient of thermal expansion make it excellent in high temperatures and extreme environments, while its good conductivity and chemical stability make it an important position in precision machining and electronics industries. In addition, molybdenum wire is also environmentally friendly and recyclable, and waste molybdenum wire can be re-refined through the recycling process, which meets the requirements of modern green manufacturing.

1.2 History and development of molybdenum wire

Molybdenum, as a rare metal, has a history of discovery and application dating back to the end of the 18th century. In 1778, the Swedish chemist Carl Wilhelm Scheele isolated the molybdenum element for the first time and named it "Molybdenum", derived from the Greek word "molybdos", which means "similar to lead", because its ore looks similar to lead ore. In 1790, another Swedish chemist, Peter Jacob Hjelm, prepared molybdenum metal by reducing molybdenum acid, laying the foundation for subsequent applications. However, due to the high melting point and processing difficulty of molybdenum, its application was limited in the early days and was mainly used for laboratory research.

In the late 19th and early 20th centuries, with the growth of metallurgical technology and the demand for high-temperature materials, molybdenum began to enter the industrial field. In the early 1900s, molybdenum was discovered as an alloying element to significantly improve the strength and corrosion resistance of steel, and molybdenum steel began to be used in weapons manufacturing and the machine industry. The development of molybdenum wire is closely related to the rise of the electric light source industry. In 1910, William M. William D. Coolidge developed tungsten filament bulbs at General Electric Company in the United States, and molybdenum wire was used as a support wire and lead material for bulbs because of its similar high-temperature resistance and lower cost to tungsten. Since then, the application of molybdenum wire has gradually expanded to other fields, such as vacuum electronics and high-temperature stoves.

In the middle of the 20th century, the emergence of EDM technology further promoted the development of molybdenum wire. In the 1950s, China began to explore the application of molybdenum wire in wire EDM, and with its high strength and arc erosion resistance, molybdenum wire became an ideal electrode material for wire cutting machine tools. In the 21st century, with the progress of nanotechnology, precision manufacturing and aerospace industry, the preparation process of molybdenum wire has been continuously optimized, and the development of ultra-fine molybdenum wire and alloy molybdenum wire (such as lanthanum molybdenum wire and molybdenum rhenium alloy wire) has significantly improved its performance. For example, Chinatungsten Online reported that in recent years, China's molybdenum wire production technology has reached the international advanced level, and breakthroughs have been made in the drawing technology and doping process of ultra-fine molybdenum wire (diameter <0.02 mm) to meet the needs of microelectronics and medical fields.

1.3 The importance of molybdenum wire in modern industry

Molybdenum wire has an irreplaceable position in modern industry because of its unique combination of properties. First of all, molybdenum wire's high melting point and excellent high-temperature stability make it the material of choice for high-temperature environments. For example, in high-temperature vacuum furnaces, molybdenum wire is used as a heating element and support member, which can operate stably for a long time at temperatures in excess of 2000°C. Secondly, the excellent conductivity and arc erosion resistance of molybdenum wire make it widely used in wire EDM, which can efficiently cut high-hardness materials such as cemented carbide and titanium alloy, and is widely used in precision mold and aerospace parts processing. Chinatungsten Online pointed out that China, as the world's largest producer of molybdenum wire, accounts for more than 70% of the global market share of molybdenum wire for wire cutting.

In the field of electric light sources, molybdenum wire is used as a support wire and lead for light bulbs due to its good thermal compatibility with glass and high temperature resistance, especially in halogen and fluorescent lamps. In addition, molybdenum wire also plays an important role in the field of vacuum coating and thermal spraying. For example, molybdenum wire can be used as an evaporation source material to deposit optical and semiconductor films; In thermal spraying, molybdenum wire spray coating can significantly improve the wear resistance of automotive piston rings and aero engine components. Molybdenum wire is also used in thermocouples, X-ray tubes, and microelectronic wires in the manufacture of electronic components, where its high purity and low impurity content ensure high reliability of the device.

In the medical and aerospace fields, the application of molybdenum wire cannot be ignored. The high strength and biocompatibility of molybdenum wire allow it to be used in the manufacture of X-ray targets and minimally invasive surgical tools; Molybdenum-rhenium alloy wire is widely used in high-temperature structural parts of spacecraft due to its excellent corrosion resistance and high-temperature strength. In addition, the application of molybdenum wire in the field of new energy is also increasing, such as electrode materials and catalyst carriers for solar cells, helping the development of green energy. In summary, the versatility and high performance of molybdenum wire make it a pillar material for modern industry, which is widely used in strategic industries such as machinery manufacturing, electronics, energy, medical and aerospace.

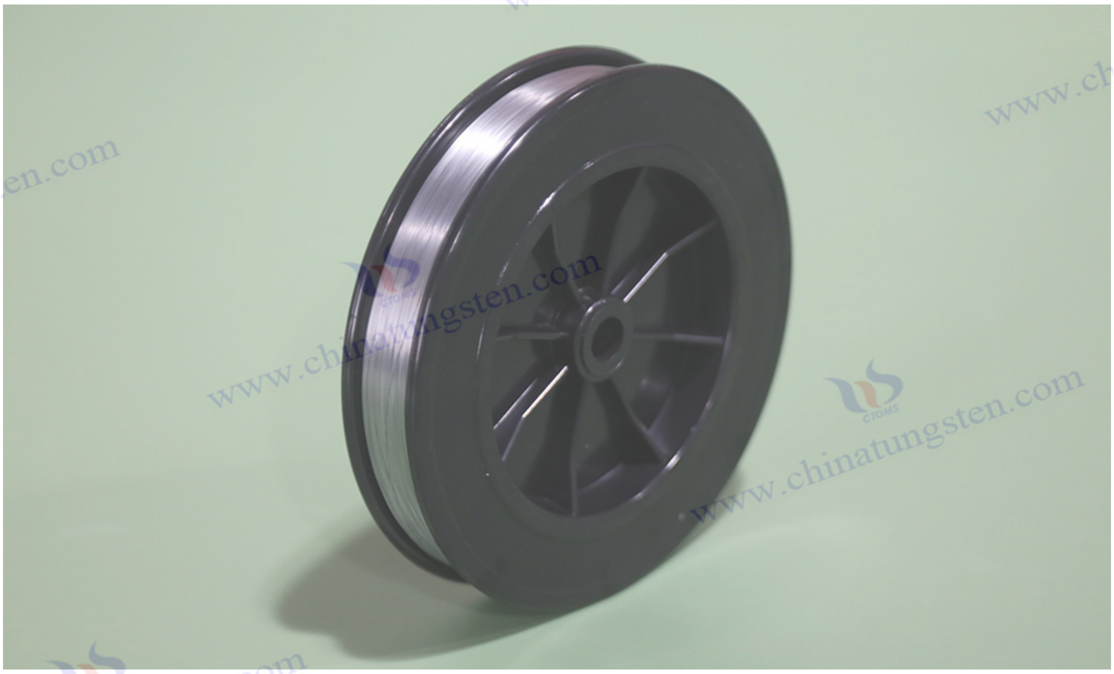
1.4 Current status of research and application of molybdenum wire

At present, the research and application of molybdenum wire is in a stage of rapid development, and a large number of research has been carried out around the material science, process technology and application fields of molybdenum wire worldwide. In materials science, research focuses on improving the strength, toughness, and high-temperature properties of molybdenum wire. For example, molybdenum wire doped with rare earth elements (e.g., lanthanum, yttrium) significantly increases the recrystallization temperature and tensile strength, making it suitable for more demanding high-temperature environments. The development of molybdenum rhenium alloy wire further expands the application of molybdenum wire in extreme environments, such as spacecraft nozzles and high-temperature sensors. According to the research, Chinese scientific research institutions have made breakthroughs in the preparation technology of nanoscale molybdenum wire in recent years, and the tensile strength of ultra-fine molybdenum wire can reach more than 3000 MPa by controlling the grain size and surface defects, which is close to the theoretical limit.

In terms of production process, the preparation technology of molybdenum wire has developed from the traditional powder metallurgy and wire drawing process to the direction of intelligence and green. The application of automatic wire drawing production line and online monitoring system improves production efficiency and product quality stability. At the same time, the introduction of environmentally friendly processes, such as low-energy sintering and wastewater recycling, reduces the environmental impact of molybdenum wire production. In addition, the recycling technology of waste molybdenum wire has also become a research hotspot, and the chemical dissolution method and electrolytic recovery method can efficiently extract molybdenum metal, with a recovery rate of more than 90%.

In terms of application fields, the demand for molybdenum wire in high value-added industries continues to grow. The demand for high-precision molybdenum wire in the field of wire EDM has driven the development of ultra-fine molybdenum wire to meet the requirements of micron processing. In the field of new energy, molybdenum wire is used as an electrode material for solar cells and fuel cells, with an average annual growth rate of more than 10%. The demand for molybdenum-rhenium alloy wire in the aerospace sector is also increasing, especially in high thrust-to-weight ratio engines and deep space exploration equipment. Research in the medical field focuses on the application of molybdenum wire in biosensors and implantable medical devices, taking advantage of its biocompatibility and high strength.

However, the molybdenum wire industry also faces challenges, including fluctuating raw material prices, high production costs, and increased competition in the international market. As a major country in the world's molybdenum resources, China has unique advantages, but it needs to further improve its independent research and development capabilities of high-end molybdenum wire to cope with the competition from European and American companies (such as Plansee and H.C. Starck). In the future, the research direction of molybdenum wire will focus on the development of nanomaterials, intelligent production and multifunctional composite materials to meet the needs of emerging industries.



CTIA GROUP LTD Cleaned Molybdenum Wire

Chapter 2 Classification of Molybdenum Wire

2.1 Classification by chemical composition

The chemical composition of molybdenum wire is the basis for its performance difference, and according to the type and content of added elements, molybdenum wire can be divided into pure molybdenum wire and a variety of alloy molybdenum wire. The difference in chemical composition directly affects the mechanical properties, high-temperature performance and application fields of molybdenum wire. The following is a detailed introduction to the composition, characteristics and application scenarios of various types of molybdenum wire.

2.1.1 Pure molybdenum wire

Pure molybdenum wire refers to molybdenum wire made of high-purity molybdenum (purity is usually ≥ 99.95%) as raw material, which does not contain or only contains trace amounts of other elements. Pure molybdenum wire has a high melting point (about 2623°C), good electrical and thermal conductivity, and excellent corrosion resistance, which is especially suitable for use in high temperature and vacuum environments. Its tensile strength is generally 800-1200 MPa, the elongation is about 2-5%, the grain structure is uniform, and it is suitable for drawing into various specifications. The production process of pure molybdenum wire is relatively simple, mainly prepared by powder metallurgy and multi-pass wire drawing, and the surface can be black molybdenum wire (with oxide layer) or cleaned molybdenum wire (after alkali washing or polishing).

Pure molybdenum wire is widely used in electric light sources, wire cutting and electronic component manufacturing. For example, in the field of electric light sources, pure molybdenum wire is used as a support wire and lead for the bulb, as it is well matched to the coefficient of thermal expansion of the glass and ensures a reliable seal. In wire EDM, pure molybdenum wire has become the preferred electrode wire for small and medium-sized workpiece processing due to its high strength and arc erosion resistance. Pure molybdenum wire accounts for about 60% of the global molybdenum wire market due to its low cost and stable performance. However, pure molybdenum wire is not suitable for extreme high temperature applications due to its low recrystallization temperature (about 1000-1200°C) and its tendency to grain growth in ultra-high temperature environments, resulting in a decrease in strength.

2.1.2 Molybdenum lanthanum wire

Molybdenum lanthanum wire (Lanthanum molybdenum wire) is made by doping a small amount of lanthanum oxide (La_2O_3) in a molybdenum matrix, usually 0.3-1.0 wt%). The addition of lanthanum oxide significantly increased the recrystallization temperature of molybdenum wire (up to 1500-1800°C), and enhanced the creep resistance and tensile strength at high temperature (up to more than 1500 MPa). Molybdenum lanthanum wire has a finer grain structure, ductility and toughness than pure molybdenum wire, and is suitable for use in high-temperature and dynamic loading environments. Its surface is usually cleaned molybdenum wire, which is finely polished to meet high precision requirements.

Molybdenum lanthanum wire is mainly used in high-temperature stoves and aerospace fields. For example, in monocrystalline silicon growth furnaces, molybdenum lanthanum wire is used as a heating element and support member, which can operate above 1700°C for a long time without deformation. In the aerospace sector, molybdenum lanthanum wire is used in the manufacture of high-temperature nozzles and thermocouple protective sleeves. In recent years, China has optimized the doping process of molybdenum lanthanum wire, and further improved the oxidation resistance and mechanical properties of molybdenum wire by controlling the distribution and size of lanthanum oxide particles. The production cost of molybdenum lanthanum wire is higher than that of pure molybdenum wire, but its excellent high-temperature performance gives it a competitive advantage in high-end applications.

2.1.3 Molybdenum rhenium wire

Molybdenum-Rhenium Wire is an alloy molybdenum wire doped with rhenium (Re) elements into a molybdenum matrix, and the rhenium content is usually between 3-41 wt%. The addition of rhenium significantly improves the ductility, toughness and corrosion resistance of molybdenum wire, and at the same time reduces the brittle transition temperature, so that molybdenum rhenium wire still has good machinability at low temperatures. Its tensile strength can reach more than 2000

MPa, the recrystallization temperature is as high as 1800-2000 °C, and the high-temperature oxidation resistance is better than that of pure molybdenum wire and molybdenum lanthanum wire. The production process of molybdenum rhenium wire is complex, and it needs to be sintered and drawn in a vacuum or inert atmosphere to prevent the volatilization of rhenium.

Molybdenum rhenium wire is mainly used in the fields of aerospace, medical and high-temperature sensors. For example, in aerospace engines, molybdenum rhenium wire is used to make high-temperature resistant nozzles and turbine blade coatings; In the medical field, molybdenum rhenium wire is used for X-ray targets and minimally invasive surgical tools due to its biocompatibility and high strength. The International Journal of Materials Science reports that the development of molybdenum-rhenium wire has promoted the progress of superalloy materials, but its high cost (rhenium is a rare precious metal) limits its application in large-scale industry. Chinese companies have developed low-rhenium-molybdenum wires (5-10 wt%) with more cost-effective alloys by optimizing the alloy ratio, which are widely used in the medical and aerospace markets.

2.1.4 Other alloy molybdenum wires

In addition to molybdenum lanthanum wire and molybdenum rhenium wire, other alloy molybdenum wires include yttrium molybdenum wire (Yttrium Molybdenum Wire), silicon-aluminum potassium-molybdenum alloy wire (Si-Al-K Molybdenum Wire), etc. Yttrium-molybdenum wire is doped with yttrium oxide (Y_2O_3, 0.2-0.8 wt%) to improve the tensile strength and oxidation resistance of molybdenum wire, which is suitable for high-temperature furnaces and electronic devices. Silicon-aluminum-potassium-molybdenum alloy wire is mainly used in the electric light source industry, where silicon, aluminum, and potassium elements (total content <1 wt%) are added to enhance sag resistance and high temperature resistance, and are commonly found in the support filaments of halogen lamps and fluorescent lamps. In addition, molybdenum-tungsten alloy wire (Mo-W) and molybdenum-titanium alloy wire (Mo-Ti) are also used in specific fields, such as corrosion-resistant chemical equipment and high-temperature structural parts.

These alloy molybdenum wires have been developed for specific application needs to optimize performance through precise control of doping element ratios and distributions. For example, yttrium-molybdenum wire is superior to molybdenum lanthanum wire in terms of grain refinement and is suitable for the production of ultra-fine molybdenum wire (diameter <0.05 mm). The production of molybdenum wire in other alloys usually adopts powder metallurgy combined with doping technology, which requires strict control of sintering temperature and drawing process to avoid elemental segregation.

2.2 Classification by use

Molybdenum wire is used in a wide range of applications, including electric light sources, precision machining, high-temperature applications, coatings, electronics, medical and aerospace applications. Depending on the application, the composition, specification and surface treatment requirements of molybdenum wire vary. The following is a detailed introduction to the characteristics and application scenarios of molybdenum wire for various purposes.

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Molybdenum Wire Introduction

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2. Applications of Molybdenum Wire (Typical)

Application Field	Specific Uses
Lighting Industry	Filament supports, lead wires, halogen lamp electrodes, fluorescent lamp electrodes, LED packaging brackets
Wire-Cut Machining	Electrode wire for EDM, used in mold making and cutting of complex metal parts
Thermal Spraying	Used for surface reinforcement and wear-resistant coatings on automotive, aerospace, and engineering components
Vacuum Coating	Used as evaporation sources and coating materials for optics, solar cells, and semiconductor devices

3. Types of Molybdenum Wire (Typical)

Classification	Type	Description
Surface Condition	Cleaned Molybdenum Wire	Cleaned surface, bright and smooth, suitable for high-precision processing, electronics, coating, and other demanding applications
	Black Molybdenum Wire	Graphite-coated surface, suitable for general industrial processing and cost-effective applications
Use-Based Category	Wire-Cut Molybdenum Wire	For EDM wire-cutting, features high strength, high precision, and excellent durability
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	Heating Molybdenum Wire	Used as a heating element in high-temperature furnaces, with excellent heat resistance

4. Specifications of Molybdenum Wire from CTIA GROUP LTD

Item	Specification
Purity	≥99.95%
Diameter Range	0.03 mm ~ 3.0 mm (customizable)
Length / Coil Weight	Custom cut lengths (e.g., 200 mm) or continuous winding (e.g., 500g/coil, 2kg/coil)
Diameter Tolerance	±0.002 mm ~ ±0.1 mm
Surface Condition	Cleaned / Black
Packaging Options	Spool, coil, vacuum packaging, customized packaging

5. Procurement Information

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Website: www.molybdenum.com.cn

2.2.1 Molybdenum wire for electric light source

Molybdenum wire for electric light source is mainly used in the manufacture of light bulbs, such as halogen lamps, fluorescent lamps and incandescent lamps, and pure molybdenum wire or silicon-aluminum-potassium-molybdenum alloy wire is commonly used. Its key feature is to match the coefficient of thermal expansion of the glass (approx. 5×10^{-6}/°C) to ensure the reliability of high-temperature sealing; At the same time, the high melting point and oxidation resistance of molybdenum wire ensure its stability at the operating temperature of the bulb (500-1000°C). The typical specification is 0.1-0.5 mm in diameter, and the surface is mostly cleaned molybdenum wire to reduce impurity pollution.

In halogen lamps, molybdenum wire is used as a support and lead for tungsten wire; In fluorescent lamps, the molybdenum wire acts as an electrode lead-out that connects the phosphor coating to the external circuit. Molybdenum wire for electric light source needs to go through a strict surface polishing and cleaning process to avoid trace impurities affecting the life of the bulb. In recent years, with the popularity of LED lamps, the application of molybdenum wire in LED base and electrode connection has gradually increased due to its high conductivity and corrosion resistance.

2.2.2 Molybdenum wire for wire cutting

Molybdenum wire for wire EDM is the core electrode material of wire EDM machine tools, mainly using pure molybdenum wire or molybdenum lanthanum wire, usually with a diameter of 0.1-0.3 mm. Molybdenum wire's high tensile strength (800-1500 MPa) and resistance to arc erosion allow it to withstand high-frequency discharges and is suitable for cutting high-hardness materials such as cemented carbide, titanium alloys and stainless steel. Molybdenum wire for wire EDM needs to have uniform diameter tolerances and a smooth surface to ensure machining accuracy.

According to reports, China is the world's largest producer of wire-cut molybdenum wire, accounting for more than 70% of the market share, which is widely used in mold manufacturing, aerospace parts and precision machining. For example, molybdenum wire can achieve an accuracy of 0.01 mm in the micro-drilling of turbine blades for aero engines. Molybdenum lanthanum wire is gradually replacing pure molybdenum wire for high-speed wire cutting because of its higher strength and wear resistance.

2.2.3 Molybdenum wire for spraying

Molybdenum wire for spraying is used in the thermal spraying process, where molten molybdenum wire is sprayed onto the surface of the substrate through plasma or flame spraying to form a wear-resistant and corrosion-resistant coating. Pure molybdenum wire or molybdenum lanthanum wire is commonly used, the diameter is generally 1.0-3.2 mm, and the surface is mostly black molybdenum wire for easy melting. Molybdenum coatings are available in hardness up to HV 800-1000, significantly improving the wear resistance and life of substrates, and are widely used in automotive piston rings, aero-engine components and industrial molds.

Molybdenum wire for spraying needs to have high purity and uniform chemical composition to ensure coating quality. Spraying the surface oxide layer of molybdenum wire can improve the spraying efficiency, but the degree of oxidation needs to be controlled to avoid coating defects. In recent years, the demand for molybdenum lanthanum wire has increased in high-temperature spraying applications due to its higher melting point and oxidation resistance.

2.2.4 Molybdenum wire for vacuum coating

Molybdenum wire for vacuum coating is used as an evaporation source material for physical vapor deposition (PVD) processes to deposit optical, decorative and functional films. Pure molybdenum wire or molybdenum lanthanum wire is commonly used, with a diameter of 0.1-0.5 mm, and high purity (≥99.99%) and low impurity content are required to ensure film quality. The molybdenum wire is heated to 1500-2000°C in a vacuum environment, and after evaporation, a uniform film is formed on the substrate.

Applications include optical lens coatings, solar cell electrodes, and semiconductor devices. Chinatungsten Online pointed out that molybdenum wire for vacuum coating needs to be annealed and polished several times to reduce surface defects and porosity. Molybdenum lanthanum wire has an advantage in high-power coating equipment due to its higher recrystallization temperature.

2.2.5 Molybdenum wire for heating elements

Molybdenum wire for heating element is mainly used in high-temperature electric furnace and vacuum furnace, and molybdenum lanthanum wire or molybdenum rhenium wire is commonly used, with a diameter of 0.5-2.0 mm. Its high melting point and low vapor pressure ensure stable operation above 2000°C, which is suitable for single crystal growth furnaces, heat treatment furnaces and sintering furnaces. The conductivity of molybdenum wire (about 18% IACS) and low coefficient of thermal expansion make it excellent in high-temperature dynamic environments.

At present, the proportion of molybdenum lanthanum wire in heating elements is increasing year by year, because its creep resistance can extend the life of the stove. Molybdenum wire needs to be used in an inert or vacuum atmosphere to prevent oxidation at high temperatures.

2.2.6 Molybdenum wire for high-temperature furnace components

Molybdenum wire for high-temperature furnace components is used to manufacture furnace supports, leads and shielding components, commonly used molybdenum lanthanum wire or molybdenum rhenium wire, with a diameter of 0.3-1.5 mm. Its high strength and high temperature resistance make it suitable for monocrystalline silicon, sapphire and ceramic sintering furnaces. For example, molybdenum wire, which is used as a seed clamping line for crystal growth furnaces, requires precise control of diameter and surface finish.

International journals have reported that the application of molybdenum rhenium wire in high-temperature furnace components has increased due to its excellent corrosion resistance and toughness. In production, the grain size of molybdenum wire needs to be strictly controlled to avoid high-temperature fracture.

2.2.7 Molybdenum wire for electronic components

Molybdenum wire for electronic components is used for vacuum electronics, thermocouples and microelectronic connections, and pure molybdenum wire or molybdenum lanthanum wire is commonly used, with a diameter of 0.05-0.5 mm. Its high conductivity and low impurity content ensure device reliability. For example, in an X-ray tube, molybdenum wire acts as a cathode lead; In thermocouples, molybdenum wire is used for high-temperature measurements.

Molybdenum wire for electronic components undergoes an ultra-clean cleaning process to remove surface impurities. The demand for ultra-fine molybdenum wire (<0.05 mm diameter) is growing in the field of microelectronics for chip packaging and sensor manufacturing.

2.2.8 Molybdenum wire for medical and aerospace use

Molybdenum wire for medical and aerospace use mainly uses molybdenum rhenium wire or molybdenum lanthanum wire because of its high strength, biocompatibility and corrosion resistance. The diameter range is 0.1-1.0 mm, which requires high purity and precision machining. In the medical field, molybdenum wire is used in X-ray targets, guidewires and minimally invasive surgical tools; In the aerospace field, molybdenum rhenium wire is used in high-temperature nozzles, thruster components and satellite structural parts. The application of molybdenum rhenium wire in the aerospace field is growing rapidly because of its stability in extreme environments such as 3000°C and strong corrosive gases. Medical molybdenum wire is subject to rigorous biocompatibility testing.

2.3 Classification by surface state

The surface state of molybdenum wire has an important impact on its performance and application, and it is divided into black molybdenum wire and cleaned molybdenum wire according to the surface treatment method.

2.3.1 Black molybdenum wire

Black molybdenum wire is a molybdenum wire that has not been caustic washed or polished, and the surface is covered with a layer of molybdenum oxide (MoO_3) film, which is black-gray in color. The oxide layer thickness is typically 0.1-1 μm, which enhances the lubricity of the molybdenum wire and is suitable for thermal spray and some wire EDM applications. Black molybdenum wire has a lower production cost, but there are more surface impurities, which may affect the performance of precision applications.

Black molybdenum wire improves the spraying efficiency due to the easy melting of the oxide layer in thermal spraying; In wire cutting, the oxide layer reduces electrode losses. Black molybdenum wire needs to be strictly controlled for oxide layer uniformity to avoid performance fluctuations.

2.3.2 Cleaned molybdenum wire

Cleaned molybdenum wire is a molybdenum wire that removes the surface oxide layer by alkali washing or electrolytic polishing, which is silvery-white and has a high surface finish. Cleaned molybdenum wire has higher purity and is suitable for applications with high surface quality requirements, such as electric light sources, vacuum coatings, and electronic components. The caustic washing process usually uses a sodium hydroxide solution, which is washed and dried after the oxide layer is removed to prevent secondary oxidation.

Cleaned molybdenum wire is expensive to produce, but its excellent surface quality and low impurity content make it dominant in high-end applications. For example, in semiconductor coatings, cleaned molybdenum wire reduces impurity defects in the film.

2.4 Classification by processing method

The processing method of molybdenum wire affects its microstructure and properties, and is divided into hot-drawn molybdenum wire, cold-drawn molybdenum wire and precision molybdenum wire according to the drawing process and subsequent treatment.

2.4.1 Hot drawn molybdenum wire

Hot-drawn molybdenum wire is made of multi-pass drawing at high temperature (800-1200°C), with coarse grain structure and tensile strength of 700-1000 MPa, which is suitable for the production of coarse molybdenum wire (diameter > 1.0 mm). The hot drawing process can reduce the drawing resistance and reduce the wear of the mold, but the surface quality is poor, and most of them are black molybdenum wires.

Hot drawn molybdenum wire is commonly used in high-temperature furnace components and spray applications because of its low cost and suitability for large diameter machining. Chinatungsten Online reported that the heating temperature needs to be precisely controlled in the hot drawing process to avoid oversized grains.

2.4.2 Cold-drawn molybdenum wire

Cold-drawn molybdenum wire is drawn at room temperature or low temperature (<300 °C), the grain is refined, and the tensile strength can reach 1200-1800 MPa, which is suitable for molybdenum wire with a diameter of 0.05-1.0 mm. The cold drawing process, which requires the use of high-performance lubricants and precision tooling to reduce surface scratches, is commonly used in wire EDM and electronic components.

The surface finish and dimensional accuracy of cold-drawn molybdenum wire are higher than those of hot-drawn molybdenum wire, which is suitable for high-precision processing. International journals have pointed out that the cold drawing process can optimize the toughness of molybdenum wire through multiple passes of annealing.

2.4.3 Precision molybdenum wire

Precision molybdenum wire is made through multiple cold drawing and annealing processes, with well-controlled diameter tolerances and surface roughness, making it suitable for microelectronics, medical and vacuum coatings. The tensile strength of precision molybdenum wire can reach more than 2000 MPa, and high-precision wire drawing machines and online testing equipment are required.

According to public information, Chinese companies have made breakthroughs in the drawing technology of precision molybdenum wire, and ultra-fine precision molybdenum wire (diameter <0.02 mm) has been used in chip manufacturing and biosensors.

2.5 Classification by specification

The specifications of molybdenum wire are mainly distinguished by their diameter, and there are significant differences in performance, production process and application field of molybdenum wire with different diameters. According to the diameter, molybdenum wire can be divided into ultra-fine molybdenum wire (diameter <0.05 mm), standard fine molybdenum wire (0.05–0.3 mm), medium coarse molybdenum wire (0.3–1.0 mm) and coarse molybdenum wire (diameter > 1.0 mm). These specifications reflect the diverse needs of molybdenum wire in precision machining, high-temperature applications, and heavy-duty environments.

2.5.1 Ultra-fine molybdenum wire (diameter <0.05 mm)

Ultra-fine molybdenum wire refers to molybdenum wire with a diameter of less than 0.05 mm, usually in the range of 0.01–0.05 mm, and is the type with the highest precision and the most difficult to manufacture among the specifications of molybdenum wire. The tensile strength of ultra-fine molybdenum wire is extremely high, up to 2000–3500 MPa, which is much higher than that of ordinary metal wires, due to its nanometer grain size and grain refinement achieved by a cold drawing process and multiple annealings. Its extremely low surface roughness and diameter tolerances of ±0.001 mm ensure reliability for high-precision applications. The electrical conductivity (approx. 20% IACS) and thermal conductivity (approx. 130 W/(m·K)) of ultra-fine molybdenum wire are slightly lower than those of coarse molybdenum wire, but its high strength and excellent ductility (elongation of up to 8–12%) give it unique advantages in the field of miniaturization and high precision.

Production process

The production process of ultra-fine molybdenum wire is extremely complex, requiring high-precision cold-drawing technology and multi-stage annealing process. First, starting from the high-purity molybdenum blank (purity ≥99.95%), the fine blank is prepared by powder metallurgy, and then multi-pass drawing is carried out at low temperature (<300°C), using diamond dies to ensure dimensional accuracy. High-performance lubricants (e.g. graphite emulsions) are used during the drawing process to reduce surface scratches, and intermediate annealing (500–800°C, inert atmosphere) is performed after each drawing pass to relieve stress and restore ductility. In addition, surface polishing and ultra-clean cleaning processes, such as ultrasonic cleaning, are necessary steps in the production of ultra-fine molybdenum wire to remove trace impurities and surface defects.

Application scenarios

Ultra-fine molybdenum wire is mainly used in the fields of microelectronics, medical devices and precision wire cutting. In the microelectronics industry, ultra-fine molybdenum wire is used for the connecting wires of chip packages and the wires of miniature sensors, and its high strength and non-magnetic (permeability ≈1) ensure the stability of the device in the electromagnetic environment. For example, a 0.02 mm diameter molybdenum wire can be used for wire bonding of semiconductor chips with nanometer precision. In the medical field, ultra-fine molybdenum wire is used in the manufacture of minimally invasive surgical guidewires and X-ray targets, and its biocompatibility and high strength make it suitable for in vivo implantation or high-precision imaging devices. According to the International Journal of Refractory Metals and Hard Materials, ultrafine molybdenum lanthanum wire performs well in high-temperature miniature sensors due to its higher recrystallization temperature (about 1800°C). In wire EDM, ultra-fine molybdenum wire is used to process micron-sized molds and complex geometries with a cutting accuracy of ±0.5 μm.

2.5.2 Standard fine molybdenum wire (0.05–0.3 mm)

Standard fine molybdenum wire has a diameter range of 0.05–0.3 mm and is the most common specification in molybdenum wire applications and is widely used in wire cutting, electric light sources, and electronic component manufacturing. Standard fine molybdenum wire combines high strength with moderate machinability and is suitable for large-scale industrial production. Pure molybdenum wire and molybdenum lanthanum wire are the main types of this specification, and molybdenum lanthanum wire is advantageous in high-temperature applications due to its higher recrystallization temperature (1500–1800°C).

Production process

Standard fine molybdenum wire is produced using a cold-drawn process, starting with the molybdenum blank and progressively reducing the diameter through multiple passes (typically 10–15 passes). The wire drawing machine is equipped with a carbide or diamond die and the lubricant is an oil-based or water-based solution to reduce friction. Intermediate annealing (600–900°C, argon protection) is used to eliminate work hardening, and annealing time and temperature need to be precisely controlled to balance strength and toughness. In terms of surface treatment, the cleaned molybdenum wire is subjected to alkali washing (sodium hydroxide solution, 80–100°C) to remove the oxide layer, and the black molybdenum wire retains a thin oxide layer to enhance lubricity.

Application scenarios

Standard fine molybdenum wire is the workhorse material for wire EDM and is widely used in mold making, aerospace parts, and precision machining. For example, a 0.18 mm diameter molybdenum wire achieves a machining accuracy of ±3 μm in high-speed wire EDM machines and is suitable for cutting carbide and titanium alloys. In the field of electric light sources, standard fine molybdenum wires (0.1–0.2 mm diameter) are used as support wires and leads for halogen and fluorescent lamps, and their low coefficient of thermal expansion (4.8×10^{-6}/°C) ensures reliable sealing with glass. In electronic components, standard fine molybdenum wire is used for cathode connections between thermocouple leads and vacuum electronics, meeting the requirements of high conductivity (about 20% IACS) and low impurities.

2.5.3 Medium-coarse molybdenum wire (0.3–1.0 mm diameter)

Medium-coarse molybdenum wire is available in diameters ranging from 0.3–1.0 mm, combining high strength with moderate processing difficulty, with tensile strength of 800–1500 MPa and elongation of 3–8%. This grade of molybdenum wire is suitable for applications that require high rigidity and durability, such as high-temperature furnace components, heating elements, and vacuum coatings. The thermal conductivity (about 135 W/(m·K)) and high-temperature stability (can withstand 2000°C) of medium and coarse molybdenum wire make it excellent in high-temperature environments, and molybdenum lanthanum wire and molybdenum rhenium wire are widely used in this specification.

Production process

The production of medium-coarse molybdenum wire combines hot and cold drawing processes. The initial blank is reduced in diameter to 1.5–2.0 mm by hot drawing (800–1200°C) and then further processed to the target size by cold drawing. The hot drawing process reduces mold wear and is suitable for mass production; The cold-drawing process improves dimensional accuracy and surface quality. The annealing process (700–1000°C, inert atmosphere) is used to optimize grain structure and enhance toughness. Surface treatment includes caustic washing or electrolytic polishing to ensure the high finish of the cleaned molybdenum wire.

Application scenarios

Medium coarse molybdenum wire is widely used in high-temperature furnace components and heating elements. In the monocrystalline silicon growth furnace, 0.5 mm diameter molybdenum lanthanum wire is used as a seed clamping line and support member, which can be operated at 1700°C for a long time. In vacuum coating, medium-coarse molybdenum wire (0.4–0.8 mm diameter) acts as an evaporation source to deposit optical and semiconductor films, and its high purity (≥99.99%) ensures film quality. In the field of electronics, medium and coarse molybdenum wire is used for cathode leads and thermocouple protective sleeves for X-ray tubes, which meet the requirements of high temperature and vacuum environments.

2.5.4 Coarse molybdenum wire (diameter > 1.0 mm)

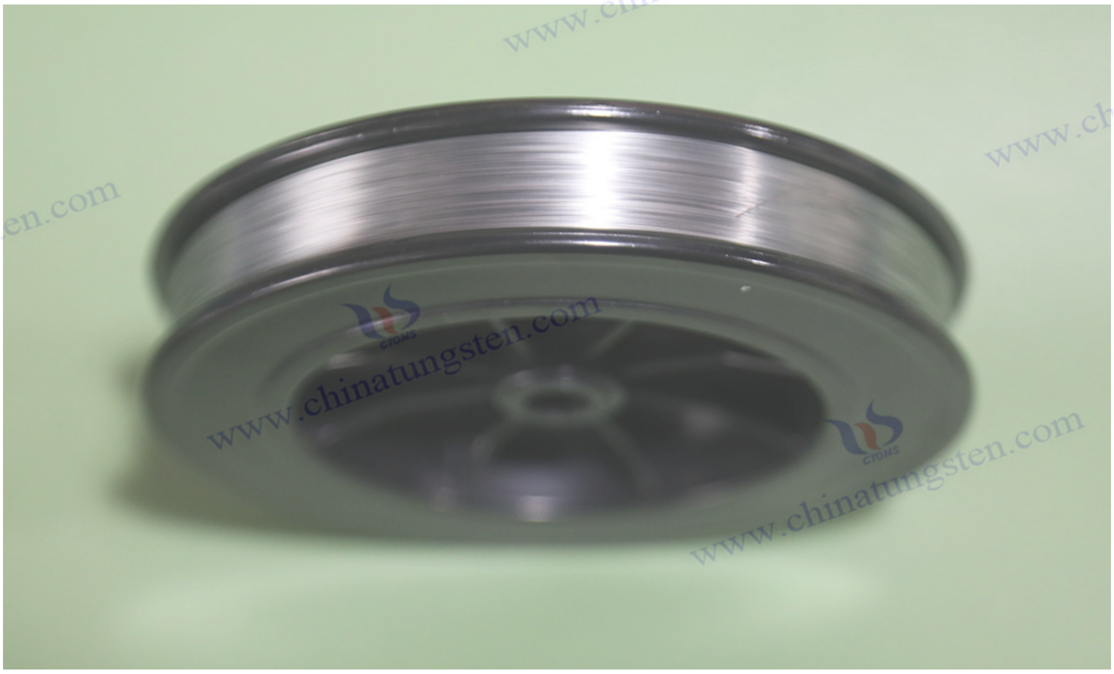
Definition and characteristicsThe diameter of coarse molybdenum wire is greater than 1.0 mm, usually in the range of 1.0–3.2 mm, and is the most rigid and least difficult to process among molybdenum wires. Coarse molybdenum wire is mostly pure molybdenum wire or molybdenum lanthanum wire, which is suitable for heavy-duty and high-temperature applications, such as thermal spraying and high-temperature furnace support members. Its high temperature stability (up to 2000°C) and moderate thermal conductivity (approx. 130 W/(m·K)) make it widely used in industrial applications.

Production process

Coarse molybdenum wire is mainly produced by a hot drawing process, starting from the molybdenum blank (5–10 mm diameter) and drawing through a large diameter die at high temperatures (1000–1200°C) with a single pass diameter reduction of up to 20–30%. The hot drawing process reduces the difficulty of processing and reduces the cost of molds, but the surface quality is poor, and most of them are black molybdenum wires. Some coarse molybdenum wires need to be cold-drawn and polished to make cleaned molybdenum wires to meet the needs of specific applications. The annealing process (800–1100°C, argon protection) is used to eliminate residual stresses and optimize mechanical properties.

Application scenarios

Coarse molybdenum wire is mainly used for thermal spraying and high-temperature furnace components. In thermal spraying, coarse molybdenum wires with a diameter of 1.6–3.2 mm are plasma sprayed to form a wear-resistant coating for surface strengthening of automotive piston rings, aero engine blades, and industrial molds. In high-temperature furnaces, coarse molybdenum wire (diameter 1.0–2.0 mm) is used as support members and leads, such as fixings for sapphire growth furnaces, which can operate stably at 1800°C.



CTIA GROUP LTD Cleaned Molybdenum Wire

Chapter 3 Characteristics of Molybdenum Wire

3.1 Physical properties of molybdenum wire

The physical properties of molybdenum wire are the basis for its wide range of applications in high-temperature, precision machining and electronics, covering key parameters such as melting point, density, coefficient of thermal expansion, electrical conductivity, thermal conductivity and hardness. These properties are determined by the body-centered cubic (BCC) crystal structure of molybdenum and the regulation of doping elements, which give molybdenum wire excellent performance in extreme environments. The following is a detailed analysis of the physical properties of molybdenum wire, including its microscopic mechanism, measurement method and application impact.

3.1.1 Melting point and boiling point of molybdenum wire

With a melting point of 2623 °C (2896 K), molybdenum wire ranks among the highest among all metals, behind tungsten (3422 °C), rhenium (3186 °C) and osmium (3033 °C). This high melting point is due to the strong metallic bonds between molybdenum atoms and the stability of the body-centered cubic structure, which allows the molybdenum wire to maintain its structural integrity without melting in extremely high temperature environments such as 1700–2000°C in a monocrystalline silicon growth furnace. Its high boiling point of 4639 °C (4912 K) corresponds to a very low vapor pressure (approx. 10^{-7} Pa at 2000°C), ensuring minimal material loss of molybdenum wire in vacuum coating and high-temperature furnace applications. Pure molybdenum wire can still maintain mechanical strength at 2000°C, while doped molybdenum lanthanum wire and molybdenum rhenium wire further enhance the high-temperature performance by increasing the recrystallization temperature (up to 1800 °C and 2000°C, respectively).

The melting point is usually measured using high-temperature differential scanning calorimetry (DSC) or optical pyrometers with an accuracy of ±10°C. Boiling point measurements require the use of a thermogravimetric analyzer (TGA) in a vacuum environment to monitor mass loss. In practical applications, the high melting point of molybdenum wire makes it an ideal material for heating elements in high-temperature furnaces, such as in sapphire crystal growth furnaces, where molybdenum wire can withstand circulating heating at 1800°C without deformation. However, molybdenum filaments tend to react with oxygen to form volatile oxides (MoO_3) at high temperatures, so they need to be operated in a vacuum (<10^{-3} Pa) or an inert atmosphere (e.g. argon, helium) to protect their performance. Due to the addition of rhenium, molybdenum rhenium wire can slightly increase the melting point to 2650 °C, and at the same time reduce the high-temperature evaporation rate, which is suitable for aerospace high-temperature components.

3.1.2 Density of molybdenum wire

With a density of 10.28 g/cm³ (20°C), molybdenum wire is between iron (7.87 g/cm³) and tungsten (19.25 g/cm³), which is both lightweight and high-strength. The density decreases slightly with temperature, to 10.15 g/cm³ at 1000°C, with a change of only about 1.3%, reflecting the excellent thermal stability of molybdenum wire. The low density gives molybdenum wire a weight advantage in aerospace and electronics, such as in satellite structural parts, where it reduces overall mass while providing sufficient rigidity.

Density measurements are carried out by the Archimedes drainage method or X-ray densitometer with an accuracy of ±0.01 g/cm³. The density of the molybdenum wire has an important influence on its drawing process: the lower density reduces die wear during the drawing process and facilitates the production of ultra-fine molybdenum wire (diameter <0.05 mm). In the field of electric light sources, the density of molybdenum wire ensures sufficient rigidity when used as a bulb support wire, while avoiding the structural design complication caused by excessive weight. The density of molybdenum lanthanum wire and molybdenum rhenium wire varies slightly (10.3–10.5 g/cm³) due to the influence of doping elements, but still maintains lightweight characteristics and is suitable for high temperature and dynamic loading environments.

3.1.3 Coefficient of thermal expansion of molybdenum wire

The coefficient of thermal expansion of molybdenum wire is $4.8–5.2\times10^{-6}$/°C (20–1000°C), which is highly matched to glass ($4–6\times10^{-6}$/°C) and ceramic ($3–7\times10^{-6}$/°C). It makes it an ideal sealing material for electric light sources and vacuum devices. For example, in halogen lamps and X-ray tubes, molybdenum wire acts as a lead wire to form a reliable connection to the glass seal and avoid cracking during thermal cycling. The coefficient of thermal expansion is measured using a dilatometer or laser interferometry with an accuracy of $\pm0.1\times10^{-6}$/°C.

The low coefficient of thermal expansion ensures high dimensional stability of molybdenum wire in high temperature cycling and reduces deformation caused by thermal stress. In high-temperature furnace applications, the low coefficient of thermal expansion of molybdenum wire allows it to withstand rapid temperature increases (up to 50°C/min) without significant deformation. Molybdenum lanthanum wire can optimize the coefficient of thermal expansion to 4.5×10^{-6}/°C through the pinning effect of lanthanum oxide particles, which is suitable for high-precision high-temperature components. Molybdenum rhenium wire has a slightly higher coefficient of thermal expansion ($5.0–5.5\times10^{-6}$/°C), but its excellent toughness compensates for this difference, making it suitable for use in dynamic aerospace environments.

3.1.4 Conductivity of molybdenum wire

The conductivity of molybdenum wire is 18–20% IACS (international standard for annealed copper, 100% IACS is the conductivity of pure copper), corresponding to a resistivity of 5.2–5.7 μΩ·cm (20°C). Although the conductivity is lower than that of copper (100% IACS) and silver (105% IACS), the conductivity of molybdenum wire is excellent at high temperatures, and the resistivity only increases to about 20 μΩ·cm at 1000°C, which is lower than that of copper (about 50 μΩ·cm). The conductivity was measured using the four-probe method with an accuracy of ±0.1 μΩ·cm. The high-temperature conductivity stability of molybdenum wire makes it excellent in wire-cut wire EDM (WEDM) and high-temperature electric furnaces, and can withstand high-frequency pulse currents (10–100 kHz) without significant thermal damage.

Molybdenum lanthanum wire can increase conductivity up to 22% through grain refinement IACS for high-precision electronic components such as thermocouple leads and microelectronic wires. Cleaned molybdenum wire has an advantage in electric light sources and vacuum devices because the surface oxide layer is removed, and the contact resistance is lower than that of black molybdenum wire (about 10% reduction). In in-line cutting, the conductivity of the molybdenum wire ensures efficient arcing at cutting speeds of up to 10–15 mm²/min. The conductivity of molybdenum rhenium wire is slightly lower than that of pure molybdenum wire (about 16–18% IACS), but its high-temperature stability makes it widely used in aerospace electrical connectors.

3.1.5 Thermal conductivity of molybdenum wire

The thermal conductivity of molybdenum wire is 138 W/(m·K) (20°C), which is the highest level among metals, second only to copper (401 W/(m·K)) and silver (429 W/(m·K)). At 1000°C, the thermal conductivity is reduced to about 100 W/(m·K), which can still effectively conduct heat, which is suitable for high-temperature furnaces and vacuum coating equipment. Thermal conductivity is measured using the laser flash method with an accuracy of ±5 W/(m·K). The high thermal conductivity of molybdenum filament enables rapid heat dissipation in high-power applications and reduces performance degradation caused by localized overheating, such as in electric light sources, where molybdenum filament conducts filament heat to the outside and extends lamp life (up to more than 2000 hours).

In wire cutting, the high thermal conductivity of molybdenum wire reduces the damage to the wire at high arc temperature (>6000°C) and prolongs the service life (up to more than 100 hours). The thermal conductivity of molybdenum lanthanum wire is close to that of pure molybdenum wire, while molybdenum rhenium wire performs well in aerospace high-temperature components such as nozzles by optimizing the rhenium content up to 150 W/(m·K). The surface condition has little effect on the thermal conductivity, but the thermal conductivity efficiency of cleaned molybdenum wire is slightly better than that of black molybdenum wire (about 5% increase) due to its high surface finish.

3.1.6 Mohs hardness of molybdenum wire

Molybdenum wire has a hardness of 5.5–6.0 on the Mohs scale, close to steel (5–6.5), a Vickers hardness (HV) of 200–250, and cold-drawn molybdenum wire up to 300–350 HV. The hardness was measured using a Vickers hardness tester with an applied load of 5–10 kg and an accuracy of ± 5 HV. The hardness of molybdenum wire ensures that it is resistant to wear during wire drawing and processing, while maintaining enough toughness to avoid brittleness. Molybdenum lanthanum wire is doped with lanthanum oxide to increase hardness up to 350–400 HV and molybdenum-rhenium wire up to 400 HV, making it suitable for high wear resistance applications.

In wire EDM, the hardness of molybdenum wire reduces the wear caused by arc erosion, with a wear rate of less than 0.01 mm/h. In thermal spraying, the appropriate hardness ensures that the molybdenum wire remains structurally intact before melting, resulting in a coating hardness of up to HV 800–1000. Hardness is closely related to grain size, and ultra-fine molybdenum wire (<0.05 mm diameter) achieves higher hardness with nanoscale grains (10–50 nm) to meet the needs of the microelectronics and medical fields.

3.2 Chemical properties of molybdenum wire

The chemical properties of molybdenum wire determine its stability in corrosive environments and high temperature conditions, including chemical stability, corrosion resistance, oxidation properties, and chemical reaction behavior. These properties stem from molybdenum's electronic structure and surface properties, which give it unique advantages in chemical, medical, and high-temperature environments.

3.2.1 Chemical stability of molybdenum wire

Molybdenum wire exhibits excellent chemical stability at room temperature and is inert to non-oxidizing acids (e.g., hydrochloric acid, sulfuric acid, phosphoric acid), bases (e.g., sodium hydroxide solution) and organic solvents (e.g., ethanol, acetone). In a solution of 10% hydrochloric acid or 5% sodium hydroxide at 20°C, the corrosion rate of molybdenum wire is less than 0.001 mm/year with almost no mass loss. This stability makes it suitable for use in chemical reactors, electrochemical sensors, and medical devices. For example, in electrochemical sensors, molybdenum wire acts as an electrode for long-term operation in a solution of pH 2–12 without degradation.

The chemical stability was verified by immersion tests and electrochemical corrosion tests, and the corrosion potential (E_corr) measured by a potentiostat was approximately -0.2 V (compared to a standard hydrogen electrode). At high temperatures (>400°C), the chemical stability of molybdenum wire decreases, and it is easy to react with oxygen, nitrogen or halogen, and needs to be operated in a vacuum or inert atmosphere (such as argon, nitrogen) to maintain performance. Molybdenum lanthanum wire forms a protective layer through surface passivation, and its chemical stability is slightly better than that of pure molybdenum wire.

3.2.2 Corrosion resistance of molybdenum wire

Molybdenum wire has excellent corrosion resistance to non-oxidizing acids (e.g., 10% hydrochloric acid, 20% phosphoric acid) and neutral salt solutions (e.g., 3.5% sodium chloride), with a corrosion rate of less than 0.01 mm/year, which is better than that of 316L stainless steel (about 0.05 mm/year). In the seawater environment, the pitting resistance of molybdenum wire is better than that of ordinary steel, which is suitable for marine engineering and chemical equipment. Molybdenum rhenium wire is further enhanced by the addition of rhenium (5–41 wt%), and the corrosion rate is less than 0.005 mm/year in environments containing sulfuric acid or dilute nitric acid, making it suitable for high-temperature chemical reactors.

Molybdenum wire is sensitive to strong oxidizing acids (such as concentrated nitric acid, hot sulfuric acid), and the corrosion rate can reach 0.1 mm/h in concentrated nitric acid at 60°C. The corrosion resistance was tested by salt spray test and electrochemical impedance spectroscopy (EIS), and the impedance value of molybdenum lanthanum wire was higher than that of pure molybdenum wire (about 10^5 Ω·). cm²), indicating that the surface passivation layer is more dense. Surface coatings, such as molybdenum silicide or zirconia, can further reduce the corrosion rate and extend the service life.

3.2.3 Oxidation characteristics of molybdenum wire

Molybdenum filament is prone to oxidation in a high-temperature oxidizing atmosphere to generate volatile molybdenum trioxide (MoO_3), the initial oxidation temperature is about 400°C, and the oxidation rate increases significantly above 600°C. In 800°C air, a yellow oxide layer was rapidly formed on the surface of the molybdenum wire, and the mass loss rate could reach 0.1 mg/cm²·h. The oxidation behavior was measured using a thermogravimetric analyzer (TGA) at different temperatures and atmospheres with an accuracy of ± 0.01 mg. Molybdenum wire avoids oxidation in vacuum (<10^{-3} Pa) or inert atmospheres (e.g. argon, helium, oxygen content <10 ppm) and operates for thousands of hours at 2000°C without significant mass loss.

Molybdenum lanthanum wire increases the initial oxidation temperature to 600–700°C through the pinning effect of lanthanum oxide particles, and molybdenum rhenium wire can reach 800°C. Surface coating technologies, such as molybdenum silicide coatings with a thickness of 5–10 µm, can reduce the oxidation rate to 0.01 mg/cm²·h (in air at 1000°C) and significantly extend the high-temperature life. In high-temperature furnace applications, molybdenum wire is required with a vacuum pump or an inert gas protection system to prevent oxidation.

3.2.4 Valency and chemical reaction of molybdenum wire

Molybdenum is a polyvalent metal with valencies of +2, +3, +4, and +6 that exhibits diversity in chemical reactions. At room temperature, the molybdenum wire does not react with oxygen, nitrogen, water, or common organic solvents, and a thin passivation layer (about 1–2 nm thick) forms on the surface to inhibit further reactions. At high temperature (>700°C), molybdenum wire reacts with oxygen to form MoO_3, with nitrogen to form molybdenum nitride (Mo_2N), and with chlorine to form molybdenum chloride ($MoCl_5$). The volatile nature of these reaction products can lead to material loss and need to be avoided by atmospheric control (e.g. argon protection).

In a highly alkaline high-temperature solution (e.g., molten sodium hydroxide, > 500°C), molybdenum wire dissolves to form molybdate (e.g., Na_2MoO_4) at a dissolution rate of about 0.05 mm/h. The chemical reaction behavior was analyzed by X-ray photoelectron spectroscopy (XPS) and infrared spectroscopy (FTIR) to confirm the composition of the surface compounds. Due to the chemical inertness of rhenium, molybdenum rhenium wire is more resistant to halogens and high-temperature acids, and the corrosion rate is less than 0.01 mm/h in 1000°C chlorine environment, which is suitable for extreme chemical environments.

3.3 Mechanical properties of molybdenum wire

The mechanical properties of molybdenum wire, including tensile strength, ductility, toughness, and fatigue properties, directly affect its performance in processing and application. These properties are optimized through doping, wire drawing processes and heat treatment to meet the needs of different applications.

3.3.1 Tensile strength of molybdenum wire

The tensile strength of molybdenum wire varies depending on the composition and processing process. The tensile strength of pure molybdenum wire is 800–1200 MPa, which can be increased to 1500–1800 MPa in the cold drawing process. The tensile strength of molybdenum lanthanum wire is increased to 1500–2000 MPa by lanthanum oxide doping (0.3–1.0 wt%), the molybdenum rhenium wire (rhenium content 5–41 wt%) can reach 2000–3000 MPa, and the ultra-fine molybdenum wire (diameter <0.05 mm) can be refined to 3500 MPa by nanocrystalline grains. The tensile strength is measured using a universal tensile testing machine with a loading rate of 0.5 mm/min and an accuracy of ± 1 MPa.

The tensile strength decreases with the increase of temperature, and at 1000°C, the strength of pure molybdenum wire decreases to about 500 MPa, and the molybdenum lanthanum wire and molybdenum rhenium wire remain at 1000 MPa and 1500 MPa, respectively. In wire EDM, the high tensile strength (tension 10–20 N) ensures that the molybdenum wire does not break and the cutting accuracy reaches ±3 μm. The high strength of ultra-fine molybdenum wire makes it excellent in microelectronic connection wires and medical guidewires, and can withstand complex stresses without deformation.

3.3.2 Ductility of molybdenum wire

The ductility of molybdenum wire is expressed in terms of elongation, and the elongation of pure molybdenum wire is 2–5%, which can be increased to 8–10% after cold drawing. Molybdenum lanthanum wire and molybdenum rhenium wire are strengthened by grain refinement and doping with elongation of 10–15%, making them suitable for complex shape processing. Ductility was measured using a tensile test that recorded the percentage elongation before fracture with an accuracy of ± 0.1%. At high temperatures (>500°C), the ductility of molybdenum wire is significantly improved, with an elongation of 15–20%, which is convenient for thermal processing.

Molybdenum wire with high ductility can withstand multiple bending and stretching, for example, in electric light sources, molybdenum wire needs to be bent into complex geometries as a support wire; In high-temperature furnaces, molybdenum wire as a lead needs to adapt to the deformation caused by thermal expansion. Molybdenum rhenium wire has excellent low-temperature ductility and can still be processed at -50°C without brittleness, which is suitable for aerospace low-temperature environments.

3.3.3 Toughness of molybdenum wire

The toughness of molybdenum wire reflects its ability to absorb impact energy, and the fracture toughness (K_IC) of pure molybdenum wire is 10–15 MPa·m¹/², because the body-centered cubic structure is prone to brittle transformation at low temperature. Molybdenum lanthanum wire and molybdenum rhenium wire increase the fracture toughness to 20–30 MPa·m¹/² through doping and grain refinement, significantly reducing the risk of brittleness. The toughness was measured using a three-point flexure test or a Charlais impact test with an accuracy of ± 1 MPa·m¹/².

The highly resilient molybdenum wire is suitable for dynamic load environments, such as high-frequency vibrations (10–100 Hz) in wire cutting, or thermal cycling in high-temperature furnaces (50°C/min). Ultra-fine molybdenum wire optimizes toughness through multi-stage annealing to meet the flexibility requirements of minimally invasive surgical guidewires. The toughness of molybdenum rhenium wire is better than that of pure molybdenum wire at low temperature (-50°C) and high temperature (2000°C), which is suitable for aerospace dynamic components.

3.3.4 Fatigue properties of molybdenum wire

The fatigue properties of molybdenum wire refer to its durability under cyclic stress, and the fatigue limit of pure molybdenum wire is 400–600 MPa (10^7 cycles). Molybdenum lanthanum wire and molybdenum rhenium wire are strengthened by grain refinement and doping to fatigue limits of 800–1000 MPa. The fatigue performance was measured by rotational flexural fatigue test with a frequency of 50 Hz and an accuracy of ± 10 MPa. In wire cutting, molybdenum wire is subjected to high-frequency tension cycles (10–20 N), and cleaned molybdenum wire has a fatigue life of about 20% longer than black molybdenum wire due to its high surface finish (Ra<0.2 μm).

Fatigue properties are critical for high-temperature components and wire EDM. The thermal cycle life of molybdenum lanthanum wire in high-temperature furnace can reach more than 5000 times, and the fatigue life of molybdenum rhenium wire in aerospace nozzles can reach 10^8 cycles. Optimization of the drawing die (surface roughness Ra<0.05 μm) and annealing process (700–900 °C, argon protection) further improves fatigue properties and reduces surface microcracks.

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Molybdenum Wire Introduction

1. Overview of Molybdenum Wire

Molybdenum wire is a high-performance metallic filament made from metal molybdenum through hot working, cold drawing, and surface treatment. It features an extremely high melting point, excellent electrical and thermal conductivity, good mechanical strength, and exceptional corrosion resistance. It serves as a core material in various high-temperature and precision application fields.

2. Applications of Molybdenum Wire (Typical)

Application Field	Specific Uses
Lighting Industry	Filament supports, lead wires, halogen lamp electrodes, fluorescent lamp electrodes, LED packaging brackets
Wire-Cut Machining	Electrode wire for EDM, used in mold making and cutting of complex metal parts
Thermal Spraying	Used for surface reinforcement and wear-resistant coatings on automotive, aerospace, and engineering components
Vacuum Coating	Used as evaporation sources and coating materials for optics, solar cells, and semiconductor devices

3. Types of Molybdenum Wire (Typical)

Classification	Type	Description
Surface Condition	Cleaned Molybdenum Wire	Cleaned surface, bright and smooth, suitable for high-precision processing, electronics, coating, and other demanding applications
	Black Molybdenum Wire	Graphite-coated surface, suitable for general industrial processing and cost-effective applications
Use-Based Category	Wire-Cut Molybdenum Wire	For EDM wire-cutting, features high strength, high precision, and excellent durability
	Thermal Spray Molybdenum Wire	Used in thermal spraying processes, requires high density and good melting properties
	Heating Molybdenum Wire	Used as a heating element in high-temperature furnaces, with excellent heat resistance

4. Specifications of Molybdenum Wire from CTIA GROUP LTD

Item	Specification
Purity	≥99.95%
Diameter Range	0.03 mm ~ 3.0 mm (customizable)
Length / Coil Weight	Custom cut lengths (e.g., 200 mm) or continuous winding (e.g., 500g/coil, 2kg/coil)
Diameter Tolerance	±0.002 mm ~ ±0.1 mm
Surface Condition	Cleaned / Black
Packaging Options	Spool, coil, vacuum packaging, customized packaging

5. Procurement Information

Email: sales@chinatungsten.com; Phone: +86 592 5129595; 592 5129696

Website: www.molybdenum.com.cn

3.4 Special properties of molybdenum wire

The special properties of molybdenum wire include high-temperature performance, wear resistance and non-magnetism, which make it uniquely advantageous in specific fields to meet the needs of high-temperature, tribological, and electromagnetically sensitive environments.

3.4.1 High temperature performance of molybdenum wire

The high-temperature performance of molybdenum wire is its most prominent characteristic, pure molybdenum wire maintains structural integrity at 2000°C, and the tensile strength is about 500 MPa. The recrystallization temperature of molybdenum lanthanum wire is up to 1800 °C, and the recrystallization temperature of molybdenum and rhenium wire is up to 2000 °C, which inhibits grain growth through doping, and improves the creep resistance by more than 50%. The high-temperature performance test adopts high-temperature tensile test and creep test, and the temperature control accuracy is ± 5°C. In monocrystalline silicon growth furnaces, molybdenum lanthanum wire can be operated at 1700°C for thousands of hours as a heating element with a deformation rate of less than 0.1%.

Molybdenum rhenium wire exhibits excellent thermal shock resistance in the nozzle of the space engine at 2500°C, and withstands 1000 thermal cycles (heating rate 100°C/s) without cracks. High-temperature performance is affected by the atmosphere and needs to be operated in a vacuum ($<10^{-3}$ Pa) or an inert gas (oxygen content < 10 ppm) to prevent oxidation. Surface coatings, such as zirconia with a thickness of 5–10 μm, extend the high-temperature life to more than 5000 hours.

3.4.2 Abrasion resistance of molybdenum wire

The wear resistance of molybdenum wire is related to its hardness and surface quality, and molybdenum wire with Vickers hardness of 200–400 HV resists arc erosion in wire-EDM with a wear rate of less than 0.01 mm/h. Molybdenum lanthanum wire and molybdenum rhenium wire increase the hardness to 350–400 HV through grain refinement, and increase the wear resistance by 30%. The abrasion resistance is tested using a friction and wear testing machine with a carbide pair and a load of 10 N. In thermal spraying, molybdenum wires form coatings with a hardness of HV 800–1000 and a coefficient of friction of less than 0.3, which significantly improves the wear resistance of substrates such as automotive piston rings.

Due to its high surface finish (Ra<0.1 μm) and wear resistance of cleaned molybdenum wire, cleaned molybdenum wire is suitable for high-frequency vibration environment. Ultrafine molybdenum filaments are further enhanced with nanocrystalline grains (10–50 nm) to meet the needs of microelectronics and medical guidewires. Optimization of the drawing process (e.g. with diamond dies) and surface polishing reduces wear rates to 0.005 mm/h.

3.4.3 Non-magnetic properties of molybdenum wire

Molybdenum wire is a non-magnetic material with a relative permeability close to 1 (the same as vacuum), does not magnetize in a magnetic field, and is suitable for electromagnetically sensitive environments such as nuclear magnetic resonance (MRI) equipment and aerospace navigation systems. The non-magnetic is measured using a vibrating sample magnetometer (VSM) with a

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magnetization of <10^{-6} emu/g. The non-magnetic nature of molybdenum wire stems from its body-centered cubic structure and low impurity content, and doped elements (such as lanthanum and rhenium) do not change this characteristic.

In MRI equipment, molybdenum wire is used as a wire material to avoid magnetic field interference and ensure imaging accuracy (resolution < 1 mm). In aerospace, molybdenum wire is used in satellite sensor connection wires and withstands strong magnetic fields (>1 T) without performance change. The non-magnetic nature also gives molybdenum wire an advantage in precision instruments such as mass spectrometers, where magnetic fields interfere with ion trajectories.

3.5 CTIA GROUP LTD Molybdenum Wire MSDS

The Material Safety Data Sheet (MSDS) provides detailed guidance for the safe use, storage and disposal of Chinatungsten molybdenum wire, covering chemical composition, hazard identification, protective measures, physical and chemical properties, etc., to ensure operational safety and environmental compliance.

1. Product name

name: molybdenum wire
CAS Number: 7439-98-7 (Molybdenum), 7440-15-5 (Rhenium), 1317-33-5 (Lanthanum Oxide)

2. Composition and composition information

Pure molybdenum wire: molybdenum ≥ 99.95%, impurities (C < 0.01%, O < 0.005%, N < 0.003%, Fe < 0.005%)
Molybdenum lanthanum wire: molybdenum ≥ 99.0%, lanthanum oxide (La_2O_3) 0.3–1.0%
Molybdenum rhenium wire: molybdenum 59–95%, rhenium 5–41%
Physical form: silvery-white or black-gray metallic filament, 0.03–3.2 mm diameter
Odor: Odorless

3. Hazard Identification

At room temperature: molybdenum wire is a stable metal, non-toxic, non-radioactive, no significant health hazards, and non-irritating in skin contact.
High temperature (>400°C): Volatile molybdenum oxide (MoO_3) dust may be released, which may cause respiratory irritation (e.g., cough, throat irritation) if inhaled.
Machining: Cutting, grinding, or drawing wire may produce metal dust, which may cause lung irritation if inhaled, and mild pulmonary fibrosis may be caused by long-term exposure.
Fire hazard: Molybdenum wire itself is not flammable, but flammable oxides (MoO_3) are formed in a high-temperature oxidizing atmosphere, which may pose a fire risk.
Environmental hazards: molybdenum wire itself has no significant harm to the environment, and waste molybdenum wire needs to be properly recycled to avoid random discarding.

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4. First aid measures

Inhalation: Move the person to a well-ventilated area to provide fresh air, seek immediate medical attention and provide oxygen support if breathing is difficult.
Skin contact: Rinse contact with soap and plenty of water for at least 15 minutes, consult a dermatologist if redness, swelling or irritation occurs.
Eye contact: Rinse your eyes with plenty of water or saline for at least 15 minutes, open the upper and lower eyelids to make sure they wash thoroughly, and seek medical attention immediately if discomfort persists.
Intake: The possibility of ingesting molybdenum wire by mistake is very low, if it happens, seek medical attention immediately, do not induce vomiting, keep the patient awake and provide MSDS information.

5. Fire protection measures

Fire extinguishing medium: use dry powder, dry sand or carbon dioxide fire extinguishers, and it is forbidden to use water or foam fire extinguishing agents.
Special hazards: Molybdenum oxide fumes are generated at high temperatures, and firefighters need to wear positive pressure breathing apparatus and full-body protective clothing.
Fire precautions: control the source of fire, prevent smoke spread, maintain ventilation, and avoid inhaling toxic gases.

6. Emergency treatment of leakage

Collect scattered molybdenum wires and use anti-static tools to avoid dust flying.
Use a vacuum cleaner (equipped with a HEPA filter) or wet to clean metal dust to prevent inhalation.
The collected waste molybdenum wire is stored in an airtight container and handed over to a professional recycling agency for disposal in accordance with local regulations.
The leak area should be isolated, and protective equipment should be worn to avoid contact by untrained personnel.

7. Handling and Storage

Precautions for handling: Wear protective gloves (nitrile or leather), protective glasses and dust masks (N95 or higher), and use local exhaust equipment (air volume > 500 m^3/h) during machining.
Storage conditions: Store in a dry (humidity < 60%), ventilated (temperature 20–25°C) warehouse, avoid high temperature (>400°C) and humid environment to prevent surface oxidation.
Incompatible substances: Avoid contact with strong oxidizing agents (e.g., concentrated nitric acid, hydrogen peroxide), high-temperature oxygen, and molten alkali.
Packaging requirements: Use moisture-proof plastic bags or metal cans to seal the packaging to prevent physical damage and oxidation.

8. Exposure control and personal protection

Engineering control: Equipped with a local exhaust system (wind speed > 0.5 m/s) and a dust collection device to keep the concentration of molybdenum dust in the air in the workplace below 5 mg/m³.
Personal protective equipment: protective eyewear (according to EN 166), dust mask (according to NIOSH N95), protective gloves and long-sleeved coveralls.
Exposure limits: molybdenum dust OSHA PEL is 5 mg/m³ (respirable particulate), ACGIH TLV is 10 mg/m³ (total dust), and China GBZ 2.1 standard is 6 mg/m³.
Monitoring method: Regularly detect the dust concentration in the workplace with an accuracy of ± 0.1 mg/m³.

9. Physicochemical properties

Appearance: silvery-white (cleaned molybdenum wire) or black-gray (black molybdenum wire) metal filament
Melting Point: 2623°C (pure molybdenum wire), 2650°C (molybdenum rhenium wire)
Boiling Point: 4639 °C
Density: 10.28 g/cm³ (20°C)
Solubility: insoluble in water, dilute acid and alkali, soluble in high temperature concentrated nitric acid or molten sodium hydroxide
Vapor pressure: 10^{-7} Pa (2000°C).
Flash Point: None (non-flammable)
Stability: Stable at room temperature, MoO_3 is easy to form in high temperature (>400°C) oxidizing atmosphere
Coefficient of thermal expansion: 4.8–5.2×10^{-6}/°C (20–1000°C).
Thermal conductivity: 138 W/(m·K)(20°C)
Resistivity: 5.2–5.7 μΩ·cm (20°C)

10. Stability and reactivity

Stability: Chemically stable at room temperature, does not react with water, air or common solvents.
Reactivity: High temperature (>400°C) reacts with oxygen, nitrogen, and halogens to form MoO_3, Mo_2N, or $MoCl_5$.
Avoid conditions: high temperature oxidizing atmosphere, strong oxidizing agent, molten alkali.
Hazardous decomposition products: molybdenum oxide (MoO_3) dust, highly volatile at high temperatures.

11. Toxicological information

Acute toxicity: low toxicity, LD50 (rat, oral) > 2000 mg/kg, LC50 (rat, inhalation) >5 mg/L (4 hours).
Skin irritation: No significant irritation, prolonged exposure may cause slight redness and swelling.
Eye irritation: Dust may cause mechanical irritation and is not chemically corrosive.
Chronic toxicity: long-term inhalation of high concentrations of molybdenum dust (>10 mg/m³)

may cause lung irritation or mild fibrosis, and no systemic toxicity has been observed.
Carcinogenicity: Not classified as carcinogenic by IARC, NTP or OSHA.
Reproductive toxicity: no reproductive or developmental toxicity data.

12. Ecological information

Environmental impact: Molybdenum wire itself has no significant harm to water, soil and atmosphere, and waste molybdenum wire needs to be recycled to avoid environmental accumulation.
Bioaccumulation: There is no significant bioaccumulation, molybdenum is a trace element, and plants and animals can metabolize trace amounts of molybdenum.
Ecotoxicity: No acute toxicity to aquatic organisms (such as fish), LC50 (96 hours) > 100 mg/L.
Persistence and degradability: Molybdenum wire is a non-degradable metal that needs to be recycled.

13. Disposal and Recycling

Disposal method: Waste molybdenum wire is recovered by chemical dissolution (nitric acid or alkali solution) or electrolysis, and the recovery rate can reach 90–95%.
Recycling process: Waste silk is collected→ chemically cleaned→ dissolved and purified→ and molybdenum blanks are re-prepared, which needs to be operated in a professional facility.
Environmental requirements: Do not dispose of it in landfills or water bodies at will, and hand it over to authorized institutions for disposal according to local hazardous waste regulations.
Recycling benefits: About 950 kg of molybdenum can be recovered per ton of waste molybdenum wire, reducing resource waste and environmental pollution.

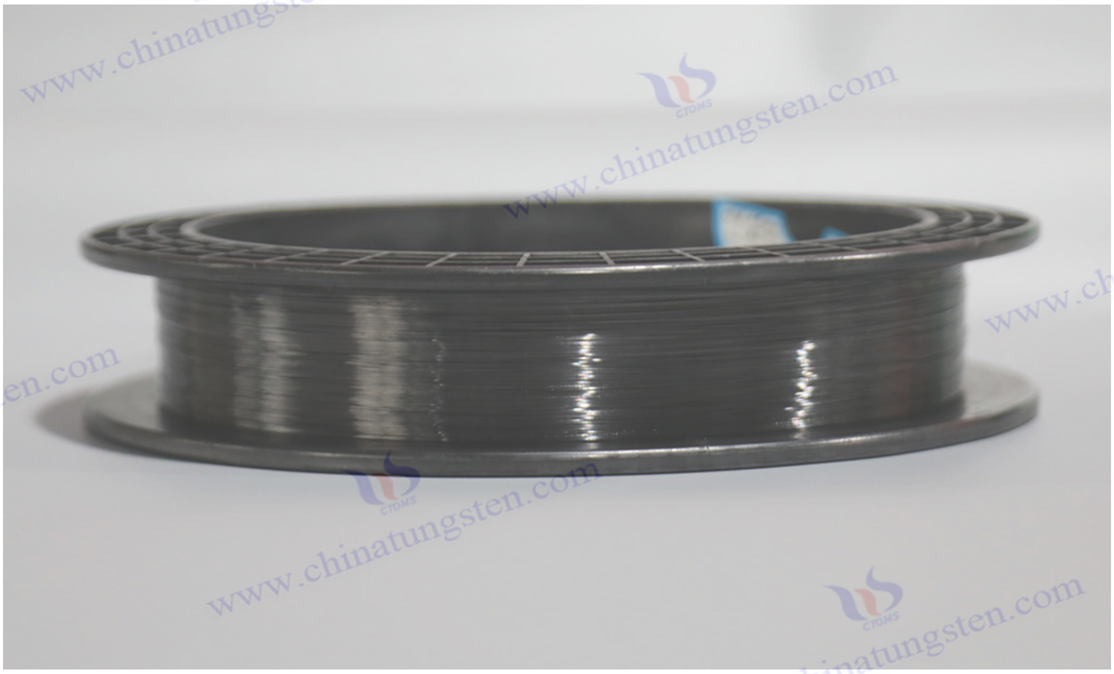
14. Shipping Information

Classification of dangerous goods: non-dangerous goods, transported as ordinary goods.
Transportation requirements: Use moisture-proof and shockproof packaging (such as sealed plastic bags or metal cans) to avoid damage or moisture during transportation.
Transportation identification: marked with "molybdenum wire" and specifications, marked with "moisture-proof" and "handle with care".
International Norms: Complies with IATA, IMDG and ADR transport standards.

15. Regulatory Information

Chinese regulations: comply with GB/T 4182-2003 "Molybdenum Wire" and GBZ 2.1 "Occupational Exposure Limits for Harmful Factors in the Workplace".
International Regulations: Meets ASTM B387 Standard for Molybdenum and Molybdenum Alloy Rods, Strips and Wires, REACH and OSHA Chemical Management requirements.
Environmental regulations: The disposal of waste molybdenum wire shall comply with the Law on the Prevention and Control of Environmental Pollution by Solid Waste and the EU RoHS Directive.
Safety certification: ISO 9001 quality management system and ISO 14001 environmental management system certification.

16. Supplier Information
Supplier: CTIA GROUP LTD
Tel: 0592-5129696/5129595



CTIA GROUP LTD Black Molybdenum Wire

Chapter 4 Preparation and Production Technology of Molybdenum Wire

The preparation of molybdenum wire is a complex multi-step process, involving multiple steps from raw material purification to final molding, including raw material preparation, powder metallurgy, wire drawing processing, surface treatment, heat treatment, and preparation of special alloy molybdenum wire. The technical parameters and equipment selection of each link directly affect the performance, specifications and application range of molybdenum wire. In recent years, the introduction of automation, environmental protection and energy-saving technologies has significantly improved production efficiency and product quality. The following is a detailed analysis of the process links and technical details of molybdenum wire preparation.

4.1 Preparation of raw materials

Raw material preparation is the basis of molybdenum wire production, which involves the beneficiation and purification of molybdenum concentrate, the production of molybdenum powder, and the addition of alloying elements. These steps ensure that the molybdenum wire has a high purity and uniform chemical composition that meets the stringent requirements of precision machining and high-temperature applications.

4.1.1 Beneficiation and purification of molybdenum concentrate

Molybdenum concentrate is mainly extracted from molybdenite (MoS_2), the most common molybdenum mineral found in nature, typically containing 50–60% molybdenum. The beneficiation process separates molybdenite from associated minerals (e.g. copper, iron sulphides) by flotation.

After crushing (particle size < 10 mm) and grinding (particle size < 0.074 mm, accounting for 80%), the molybdenum concentrate was separated in the flotation machine with the addition of collectors (such as xanthate) and foaming agents (such as terpineol oil), and the molybdenum content was increased to 55–58%, and the impurities (such as Si, Fe, Cu) were reduced to <1%.

Purification is carried out by roasting and chemical leaching processes. Roasting takes place in a rotary kiln (temperature 600–700°C, oxygen atmosphere), oxidizes MoS_2 to MoO_3, and the sulfur is released in the form of SO_2, with an exhaust gas treatment unit (desulfurization efficiency >95%). Subsequently, Ammonium molybdate solution is generated by ammonia leaching (NH_4OH concentration 10–15%, temperature 60–80 °C), filtration to remove impurities (Fe, Si, etc.), and then crystallization and thermal decomposition (500–600°C) to produce high-purity MoO_3 (purity > 99.9%). This process ensures that the impurity content of the molybdenum raw material is less than 0.01%, which meets the production needs of high-purity molybdenum wire.

4.1.2 Production of molybdenum powder

Molybdenum powder is prepared by hydrogen reduction by high-purity MoO_3. The reduction process is two-stage: the first stage reduces MoO_3 to MoO_2 at 450–600 °C, and the second stage reduces MoO_2 to metal molybdenum powder at 900–1100 °C. The reduction furnace uses a tube furnace with high-purity hydrogen (purity>99.999% purity, dew point <-40°C) and a controlled gas flow rate (0.5–1.0 m^3/h) to ensure a homogeneous reaction. The obtained molybdenum powder has a particle size of 1–5 μm, a purity ≥ 99.95%, an oxygen content of <0.005%, and a carbon content of <0.01%.

The particle size distribution and morphology of molybdenum powder are detected by laser particle size analyzer and scanning electron microscopy (SEM), and the uniform spherical particles can improve the density and sintering performance of subsequent compression. The reduction temperature and hydrogen purity need to be strictly controlled in production to prevent powder oxidation or particle agglomeration. Ultrafine molybdenum powder (particle size < 1 μm) is used to produce ultrafine molybdenum wire (diameter <0.05 mm), which needs to be further optimized by plasma spheroidization technology.

4.1.3 Alloying element addition

Alloy molybdenum wire (such as molybdenum lanthanum wire, molybdenum rhenium wire) needs to add alloying elements to molybdenum powder to improve performance. Molybdenum lanthanum wire was increased by adding lanthanum oxide (La_2O_3, 0.3–1.0 wt%) to increase the recrystallization temperature and strength, and the wet doping process was adopted: the $La(NO_3)_3$ solution was mixed with molybdenum powder, and a uniform doped powder was formed after spray drying, and the drying temperature was 120–150°C。 Molybdenum rhenium wire enhances toughness and corrosion resistance by adding rhenium powder (Re, 5–41 wt%), and adopts mechanical mixing or plasma melting method with a mixing time of 2–4 hours to ensure uniform distribution of rhenium particles.

The doping process needs to control the uniformity of element distribution and avoid segregation.

X-ray diffraction (XRD) and energy spectroscopy (EDS) were used to detect the content and distribution of doped elements with an accuracy of ±0.01 wt%. Alloying elements are added in an inert atmosphere (argon or nitrogen) to prevent oxidation of the powder. Excessive dosing levels can lead to difficult sintering, and doping ratios need to be optimized to balance performance and cost.

4.2 Powder metallurgy process

Powder metallurgy is the core process of molybdenum wire blank preparation, including molybdenum powder pressing and molding, sintering and billet preparation, ensuring that the blank has a high density and uniform microstructure, providing a basis for subsequent wire drawing.

4.2.1 Molybdenum powder pressing and molding

Molybdenum powder is formed into a rod blank by cold isostatic pressing or compression. Cold isostatic pressing (CIP) is performed at pressures of 200–300 MPa, using rubber molds, pressing times of 5–10 minutes, and billet densities of 6.0–6.5 g/cm³ (60–65% of theoretical density). Molded in steel with a pressure of 100–150 MPa, it is suitable for small batch production. A small amount of binder (e.g. polyvinyl alcohol, 0.5–1.0 wt%) is added during the pressing process to increase the strength of the billet, which needs to be fully volatilized in subsequent sintering.

The dimensions of the pressed blank should be controlled at a diameter of 10–20 mm, a length of 100–500 mm, and a flat surface without cracks. The pressing equipment is equipped with a shaker to reduce powder voids, the density uniformity is verified by ultrasonic testing, and the defect size < 0.1 mm. The pressing process is carried out in a clean room (ISO class 7) to avoid powder contamination.

4.2.2 Sintering process

The pressed billet is densified by high-temperature sintering, and a hydrogen-protected intermediate frequency induction furnace is used, with a sintering temperature of 1800–2000°C, a holding time of 2–4 hours, and a hydrogen gas flow rate of 0.5–1.0 m³/h. Sintering is divided into pre-sintering (800–1000°C, to remove binders and moisture) and high-temperature sintering (1800–2000°C, promoting grain bonding). After sintering, the billet density is 9.8–10.0 g/cm³ (95–98% of theoretical density) and the grain size is 20–50 μm.

During the sintering process, the heating rate (5–10°C/min) should be controlled to avoid thermal stress cracking, and the cooling rate should be controlled at 10–20°C/min to prevent oversized grains. During the sintering of molybdenum lanthanum wire blanks, the distribution of lanthanum oxide particles needs to be additionally controlled to prevent agglomeration. The sintering quality was detected by density meter and metallographic microscope, and the porosity was <2%. The sintering furnace needs to be equipped with an exhaust gas treatment system to recover hydrogen and treat volatile impurities.

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Molybdenum Wire Introduction

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Classification	Type	Description
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Length / Coil Weight	Custom cut lengths (e.g., 200 mm) or continuous winding (e.g., 500g/coil, 2kg/coil)
Diameter Tolerance	±0.002 mm ~ ±0.1 mm
Surface Condition	Cleaned / Black
Packaging Options	Spool, coil, vacuum packaging, customized packaging

5. Procurement Information

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Website: www.molybdenum.com.cn

4.2.3 Blank preparation

The sintered blank is processed into a blank for wire drawing by hot forging or hot rolling. Hot forging is carried out at 1200–1400°C using a hydraulic forging machine with a deformation of 30–50% and a reduction in billet diameter to 5–10 mm. Hot rolling is carried out in a multi-roll mill at a temperature of 1100–1300°C with a deformation of 10–15% per pass, resulting in a bar with a diameter of 2–5 mm. The surface of the blank is turned or ground to remove the oxide layer, and the surface roughness is Ra<1.0 μm.

The microstructure of the blank is analysed by scanning electron microscopy and X-ray diffraction to ensure that the grains are uniform and free of internal defects. Molybdenum rhenium wire blanks need to additionally control the distribution of rhenium elements to prevent volatilization at high temperatures. Blank preparation is carried out in an inert atmosphere to prevent oxidation, and the finished blank is stored in a vacuum-sealed bag to maintain quality.

4.3 Wire drawing

Wire drawing is a key step in processing blanks into molybdenum wire, involving hot drawing, cold drawing, multi-pass wire drawing, lubrication and cooling technology, which directly determines the dimensional accuracy and mechanical properties of molybdenum wire.

4.3.1 Hot wire drawing technology

Hot drawing is used for the production of coarse molybdenum wire (diameter > 1.0 mm) at 800–1200 °C using high-frequency induction heating equipment. The blank is stretched through a carbide die with a diameter reduction of 15–20% per pass and a drawing speed of 2–5 m/s. The heating temperature needs to be precisely controlled (±10°C) to avoid oversized grains or surface oxidation. Hot drawing reduces die wear and extends tool life (up to 1000 m), but the surface quality is poor, and black molybdenum wire is often formed (oxide layer thickness 0.1–1.0 μm).

The thermodrawing machine is equipped with an infrared thermometer and a tension control system (tension 20–50 N) to ensure dimensional stability. The tensile strength of coarse molybdenum wire is 700–1200 MPa, which is suitable for thermal spraying and high-temperature furnace components. Hot wire drawing needs to be carried out under the protection of hydrogen or argon to prevent oxidation at high temperatures.

4.3.2 Cold drawing technology

Cold drawing is used to produce standard fine molybdenum wire (0.05–0.3 mm) and ultra-fine molybdenum wire (<0.05 mm) at room temperature (20–50 °C) or low temperature (<300 °C) using diamond dies (aperture tolerance±0.001 mm). The diameter of each pass is reduced by 5–10% and the drawing speed is 0.5–2 m/s. Cold drawing improves tensile strength (1500–3500 MPa) and surface finish (Ra<0.2 μm) for wire EDM and electronic components.

High-performance lubricants (e.g. graphite emulsions, viscosity 10–20 mPa·s) are required for cold drawing to reduce friction and a tool life of about 500 m. Tension (5–15 N) and temperature (<100°C) are monitored during the drawing process to prevent wire breakage. The cold drawing machine is equipped with a laser caliper to detect diameter tolerances (±0.001 mm) in real time.

4.3.3 Multi-pass drawing

Multi-pass wire drawing is the core process of gradually processing the blank to the target diameter, which requires 5–10 passes for coarse molybdenum wire, 10–20 passes for standard fine molybdenum wire, and 20–30 passes for ultra-fine molybdenum wire. Intermediate annealing (600–900°C, argon protection, incubation for 10–30 minutes) after each pass to eliminate work hardening and restore ductility. The wire drawing machine adopts multi-mode continuous wire drawing equipment, equipped with automatic tension control (accuracy ± 0.1 N) and online defect detection (eddy current flaw detection, detection accuracy 0.01 mm).

The mold design needs to be optimized for multi-pass wire drawing, and the aperture decline rate should be controlled at 5–15% to avoid stress concentration. The drawing of ultra-fine molybdenum wire requires the use of nanoscale diamond dies (aperture < 0.05 mm), which is costly but accurate ± 0.0005 mm. The surface of the molybdenum wire after drawing is inspected by a microscope and a roughness meter to ensure that there are no microcracks or scratches.

4.3.4 Lubrication and cooling technology

Lubrication and cooling are key to the drawing process, affecting die life and molybdenum wire surface quality. The lubricant is a water-based emulsion (containing graphite or MoS_2, viscosity 10–20 mPa·s) or an oil-based lubricant (viscosity 20–50 mPa·s) with a coating thickness of 0.01–0.05 mm and a reduced coefficient of friction to 0.05–0.1. Cooling is carried out by circulating water system (temperature 15–25°C, flow rate 1–2 L/min) or spray cooling to keep the temperature of the mold and molybdenum wire below 100°C.

The lubricant needs to be filtered regularly (1 μm accuracy) to remove impurities and prevent surface scratches. Ultra-fine molybdenum wire drawing requires the use of low-volatile lubricants to reduce residues. The cooling system is equipped with a temperature sensor and a flow meter to ensure uniform cooling. According to Chinatungsten Online data, optimized lubrication and cooling technology can increase the mold life by 30% and reduce the wire breakage rate to 0.05%.

4.4 Surface Treatment

Surface treatments improve the surface quality and performance of molybdenum wire, including caustic washing, polishing, and coating treatments, to meet the needs of different applications, such as electric light sources, wire cutting, and vacuum coating.

4.4.1 Caustic washing process (cleaned molybdenum wire)

The caustic washing process is used to produce cleaned molybdenum wire, remove the surface oxide layer (MoO_3, thickness 0.1–1.0 μm) and improve the surface finish (Ra<0.2 μm). The process uses a sodium hydroxide solution (concentration 10–20%, temperature 80–100 °C) soaked for 1–5 minutes, followed by rinsing with deionized water (conductivity < 1 μS/cm) for 5–10 minutes, and hot air drying (60–80°C). The caustic washing plant is a continuous cleaning line equipped with an ultrasonic cleaning unit (frequency 28–40 kHz) to remove fine particles.

Alkaline washing should control the pH (12–14) and temperature (±2°C) of the solution to avoid excessive corrosion. The low contact resistance (10–15% reduction) and low impurity content (<0.005%) of cleaned molybdenum wire make it suitable for electric light sources and microelectronics applications. The waste liquid needs to be neutralized and precipitated (pH adjusted to 6–8) to meet environmental requirements.

4.4.2 Polishing process

Polishing further improves the surface finish of cleaned molybdenum wire, using electrochemical polishing or mechanical polishing. Electrochemical polishing uses a mixture of phosphoric acid-sulfuric acid electrolyte (ratio 3:1, current density 0.5–1.0 A/cm²) with a polishing time of 30–60 seconds and is performed in a fume hood. Mechanical polishing uses a diamond grinding wheel (grain size 1–5 μm) at 1000–2000 rpm and a polishing time of 1–2 minutes.

After polishing, the surface of the molybdenum wire is inspected by atomic force microscopy (AFM). The polishing process improves the wire cutting accuracy (±2 μm) and the quality of the vacuum-coated film (defect density< 10/cm²). The polishing waste liquid needs to be recycled to prevent heavy metal pollution.

4.4.3 Coating treatment

Coating treatments enhance the oxidation and abrasion resistance of molybdenum wire, and common coatings include molybdenum silicide ($MoSi_2$) and zirconia (ZrO_2). ）。 The molybdenum silicide coating was prepared by chemical vapor deposition (CVD) at a deposition temperature of 1000–1200°C, a coating thickness of 5–10 μm, and an oxidation rate of 0.01 mg/cm²·h in air at 1000°C. The zirconia coating is prepared by plasma spraying with a spraying power of 20–30 kW, a coating thickness of 10–20 μm, and a 50% increase in wear resistance.

The coating quality was detected by scanning electron microscopy and X-ray photoelectron spectroscopy, and the coating adhesion was > 50 MPa. Coated molybdenum wire is used in high-temperature furnaces and aerospace components to extend the life to more than 5000 hours. The coating process requires controlled deposition rates (0.1–0.5 μm/min) and atmospheres (vacuum<10^{-2} Pa) to ensure uniformity.

4.5 Heat treatment and annealing

Heat treatment and annealing optimize the microstructure and mechanical properties of molybdenum wire, eliminate drawing stress, and improve ductility and toughness.

4.5.1 Annealing process parameters

Annealing is carried out under the protection of hydrogen or argon at a temperature of 600–1000°C, a holding time of 10–60 minutes, a heating rate of 5–10°C/min, and a cooling rate of 10–20°C/min. The annealing temperature is 600–800 °C for ultra-fine molybdenum wire (<0.05 mm diameter) and 800–1000°C for coarse molybdenum wire (> 1.0 mm diameter). After annealing, the tensile strength decreases by 10–20% and the elongation increases to 8–15%. Molybdenum lanthanum wire and molybdenum rhenium wire require a higher annealing temperature (800–1200°C) to optimize the doping element distribution.

The annealing process was verified by metallurgical microscopy and tensile test, and the grain size was controlled at 10–50 μm, and the fracture toughness was increased to 20–30 $MPa \cdot m^{1/2}$. Annealing parameters need to be optimized according to the specifications and applications of the molybdenum wire, e.g. molybdenum wire for wire cutting needs to be high strength and the annealing time is short (10–20 minutes).

4.5.2 Heat treatment equipment

Heat treatment is carried out using tubular annealing furnaces or continuous annealing lines with high-purity hydrogen (purity>99.999%) or argon (oxygen content < 10 ppm) protection systems. With a temperature control accuracy of ± 5°C and a furnace length of 1–2 m, the tube furnace is suitable for small batch production. The continuous annealing line is equipped with multi-zone heating (zones 3–5 with a temperature gradient of 10°C/cm) and a drawing speed of 0.5–2 m/min, making it suitable for large-scale production.

The equipment needs to be equipped with an infrared thermometer and an atmosphere analyzer (oxygen content detection accuracy ± 1 ppm) to ensure a stable annealing environment. The exhaust gas is treated by a catalytic combustion device, and the conversion rate is > 99%. The heat treatment equipment is regularly maintained to prevent furnace contamination from affecting the quality of molybdenum wire.

4.6 Preparation of special alloy molybdenum wire

Special alloy molybdenum wire (such as molybdenum lanthanum wire, molybdenum rhenium wire) is prepared by doping and special processes to meet the needs of high temperature and extreme environments.

4.6.1 Doping process of molybdenum lanthanum wire

Molybdenum lanthanum wire is prepared by adding lanthanum oxide (La_2O_3, 0.3–1.0 wt%) to molybdenum powder, which is either wet or dry doped. Wet doping mixes $La(NO_3)_3$ solution with molybdenum powder and spray dried (temperature 120–150°C) to form a homogeneous powder with a particle size of 1–3 μm. Dry doping is done by mixing molybdenum powder and lanthanum oxide powder by a high-speed ball mill (300–500 rpm, 2–4 hours). The doped powder was made into a blank by cold isostatic pressing and sintering (1900–2000°C), and the lanthanum oxide particle size was controlled at 0.1–0.5 μm and the distribution uniformity was >95%.

The drawing and annealing process of molybdenum lanthanum wire needs to be optimized, with an annealing temperature of 800–1000°C, 20–30 wire drawing passes, a tensile strength of 1500–2000 MPa, and a recrystallization temperature of 1800°C. The doping process was verified by X-ray diffraction and transmission electron microscopy (TEM), and the pinning effect of lanthanum oxide particles significantly improved the high-temperature performance.

4.6.2 Production of molybdenum-rhenium alloy wire

Molybdenum rhenium wire is prepared by the addition of rhenium powder (5–41 wt%) using plasma fusion or mechanical mixing processes. Plasma fusion is carried out in argon plasma (power 10–20 kW) at a fusion temperature of 2500–3000 °C with a rhenium distribution uniformity of >98%. Mechanical mixing uses a planetary mill (200–400 rpm, 4–6 hours) to ensure uniform dispersion of rhenium particles (1–5 µm). The mixed powder is made into a blank by cold isostatic pressing (250 MPa) and high-temperature sintering (2000–2200 °C) with a density of > 10.3 g/cm³.

The drawing process of molybdenum rhenium wire is carried out by cold drawing process, the hole diameter tolerance of the die is ± 0.001 mm, and the annealing temperature is 900–1200°C. With a tensile strength of 2000–3000 MPa and a 50% increase in toughness, it is suitable for aerospace and medical applications. The production needs to be carried out in vacuum or argon to prevent rhenium volatilization, and the equipment is equipped with an exhaust gas condensation recovery system.

4.7 Process optimization and technological innovation

Process optimization and technological innovation to improve the production efficiency, quality and environmental performance of molybdenum wire involve automated production and energy-saving processes.

4.7.1 Automated production technology

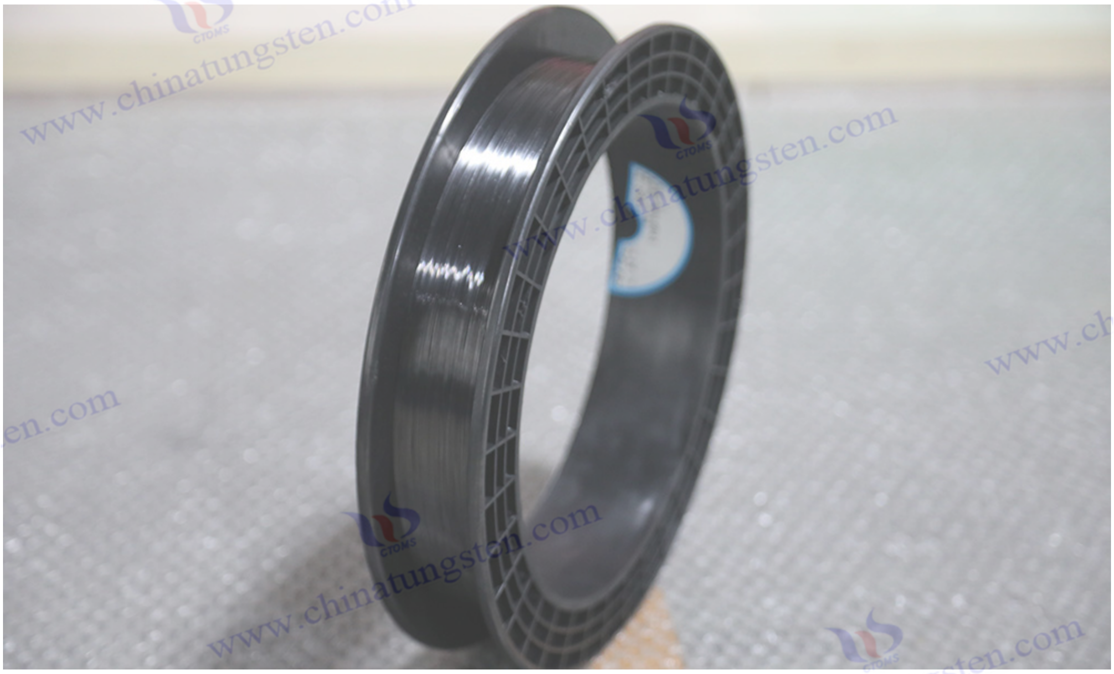
Automation technology is used in wire drawing, annealing and inspection. The wire drawing line is equipped with a multi-axis CNC wire drawing machine, which automatically adjusts the tension (accuracy ± 0.1 N) and speed (0.1–5 m/s), and the wire breakage rate is reduced to 0.05%. On-line inspection uses laser caliper (accuracy ± 0.0005 mm) and eddy current flaw detection (defect detection < 0.01 mm) to monitor the quality of molybdenum wire in real time. The annealing line uses PLC to control the temperature (±2°C) and atmosphere (oxygen content<5 ppm) for continuous production.

The automation system integrates MES (Manufacturing Execution System) to record production data (e.g., drawing speed, annealing time) in real time to improve batch consistency. Automated production will increase the efficiency by 30% and reduce the labor cost by 20%, which is suitable for the large-scale production of ultra-fine molybdenum wire and alloy molybdenum wire.

4.7.2 Environmental protection and energy-saving processes

Environmentally friendly processes include waste gas treatment, waste liquid recovery and energy-saving equipment. The sintering and annealing furnace is equipped with a hydrogen recovery system (recovery rate >90%) and an exhaust gas catalytic combustion unit (conversion rate >99%) to reduce SO_2 and MoO_3 emissions. Molybdate was recovered by neutralization (pH 6–8) and precipitation of the caustic wash waste with a recovery rate of >95%. The drawing lubricant is water-based, environmentally friendly, and reduces volatile organic compound (VOC) emissions by 80%.

Energy-saving technologies include an intermediate frequency induction furnace (15% less energy consumption) and an efficient cooling system (water recycling rate >90%). Green manufacturing complies with ISO 14001 standards and promotes the sustainable development of the molybdenum wire industry.



CTIA GROUP LTD Black Molybdenum Wire

Chapter 5 Uses of Molybdenum Wire

With its excellent high temperature stability, mechanical strength, corrosion resistance and electrical conductivity, molybdenum wire has shown a wide range of application value in the fields of electric light source, wire cutting and spraying. Different applications put forward specific requirements for the specification, purity and surface treatment of molybdenum wire, covering a variety of scenarios from micron-level precision machining to high-temperature and heavy-duty environments. The following is a detailed text description to analyze the specific applications of molybdenum wire in the manufacture of electric light sources, wire EDM and thermal spraying, and explain its performance advantages, process flow and technical challenges.

5.1 Molybdenum wire for electric light source

Molybdenum wire is an indispensable material in the electric light source industry and is widely used in light bulb manufacturing, support structures, leads and connecting parts for halogen, fluorescent and LED lamps. Its low coefficient of thermal expansion is highly matched to glass and ceramic, and its excellent conductivity and high temperature stability enable it to withstand high temperatures and frequent thermal cycling in electric light source devices while ensuring reliability in long-term operation.

5.1.1 Support wires and leads in the manufacture of light bulbs

In the manufacture of traditional light bulbs such as incandescent lamps, molybdenum filaments are used as support wires and leads, which are responsible for holding the high-temperature filaments and introducing current into the bulb. Molybdenum wire can form a tight connection with the glass seal, which can maintain stable sealing performance even at high temperatures, and avoid cracking caused by thermal expansion and cold contraction. As a support filament, the molybdenum wire bears the weight of the filament, preventing it from sagging due to high temperature when lit, ensuring that the filament is positioned accurately, thereby maintaining the uniformity of the light. As a lead, the molybdenum wire connects the external power supply to the filament, conducts current efficiently, reduces energy loss, and extends the life of the bulb.

In the production process, molybdenum wire is usually made of high-purity material, and the fine cold drawing process is used to make fine diameter wire, and then the surface oxide layer is removed by alkali washing to make cleaned molybdenum wire with smooth surface. The surface quality of cleaned molybdenum wire is critical, and trace impurities need to be removed by ultrasonic cleaning to ensure that there are no bubbles or cracks when sealed with glass. In manufacturing, molybdenum wire is annealed under the protection of hydrogen to relieve processing stress, enhance toughness, and facilitate subsequent bending and forming. The technical challenge is to ensure that the surface of the molybdenum wire is free of defects while avoiding oxidation during the high-temperature sealing process, which requires strict control of the cleanliness and atmosphere purity of the production environment.

5.1.2 Electrode materials for halogen and fluorescent lamps

Molybdenum wire is used as an electrode lead wire in halogen and fluorescent lamps to connect the filament or phosphor coating to an external circuit, and is subjected to high temperatures and chemically corrosive environments. In halogen lamps, molybdenum filament is exposed to a highly corrosive atmosphere of halogen gases, and its excellent corrosion resistance ensures that it is not eroded for long-term operation, while supporting the filament to shine stably at high temperatures. In fluorescent lamps, molybdenum wire is used as a cathode lead, which participates in the high-frequency discharge process, and the conductive performance ensures the stability of the arc, thereby improving the luminous efficiency and life of the lamp.

The manufacturing process requires high surface finish and dimensional consistency of molybdenum wire, usually using a cold drawing process, through multiple passes of wire drawing and intermediate annealing, to ensure that the wire is flexible and free of internal stress. The surface is treated by alkali washing and ultra-clean cleaning to remove the oxide layer and particles, and reduce the interference of impurities during electrode discharge. Molybdenum wire is often doped with trace elements (e.g., silicon, aluminum, potassium) to enhance the ability to resist sagging and adapt to the thermal cycle of frequent switching of lamps. The challenge is to control the homogeneity of the doped elements and to avoid oxidation during high-temperature soldering, ensuring a reliable electrode connection.

5.1.3 LED lamp base and connecting material

In LED lamp manufacturing, molybdenum wire is used for base support and electrode connection, fixing the LED chip and conducting current. Its low coefficient of thermal expansion is highly matched to the ceramic substrate to avoid stress cracking caused by thermal cycling. The conductivity and non-magnetic properties of molybdenum wire ensure the current stability and electromagnetic compatibility of high-power LEDs, which are particularly suitable for high-brightness lighting and precision electronic equipment. The surface finish of molybdenum wire has a significant impact on the contact resistance, and it is necessary to ensure low resistance to reduce heat generation and improve the energy efficiency and life of LED lamps.

In production, the molybdenum wire adopts ultra-fine cold drawing process, with polishing and ultra-clean cleaning, to ensure that there are no scratches or impurities on the surface. Laser welding is used to fix the molybdenum wire to the base, requiring the solder joints to be strong and free of impurities. The annealing process optimizes the toughness of the molybdenum wire and allows it to be bent into complex shapes to fit the base design. Technical challenges include achieving micron-level dimensional accuracy and maintaining a vacuum during the welding process to prevent oxidation from affecting conductivity.

5.2 Molybdenum wire for wire cutting

Molybdenum wire is the core electrode material of wire-cut electrical discharge (WEDM) machine tools, and is widely used for cutting metals and manufacturing precision molds due to its high strength, arc resistance and excellent electrical conductivity. Its high toughness and surface quality enable high-precision machining to meet the requirements of complex shapes and micron-level tolerances.

5.2.1 Wire wire for wire EDM machine tools

In wire-EDM machines, molybdenum wire is used as an electrode wire to produce microscopic abodition on the workpiece through high-frequency pulse discharge, enabling high-precision cutting. Molybdenum wire is able to withstand high tension and arc temperatures, maintaining stable discharge performance, ensuring a continuous and efficient cutting process. Its conductivity supports fast current conduction and reduces energy loss, while its high strength prevents the wire from breaking during high-speed operation. Because of its smooth surface and low contact resistance, cleaned molybdenum wire is particularly suitable for high-precision cutting, reducing arc loss and prolonging service life.

The production process adopts cold drawing technology, through multiple passes of wire drawing and intermediate annealing, to ensure that the diameter of the molybdenum wire is uniform and the surface is smooth. Lubricants reduce friction and prevent surface scratches during wire drawing, while in-line inspection equipment monitors wire size and defects to ensure consistent quality. Molybdenum filaments need to be operated in a deionized aqueous medium with a high-precision tension control system to maintain a stable discharge. The challenge was to reduce the risk of wire breakage, to optimize the lubrication and cooling systems, and to ensure that the drawing die was accurate to meet micron tolerances.

5.2.2 Cutting non-ferrous metals, steel and cemented carbide

Molybdenum wire is used to cut non-ferrous metals (such as copper, aluminum), steel, and cemented carbide (such as tungsten-cobalt alloy), and is widely used in machining and mold making. Its high strength and abrasion resistance allow it to cut through high hardness materials while maintaining a stable cut quality. Molybdenum wire withstands high-temperature arc erosion during discharge, excellent thermal conductivity and rapid heat dissipation, reducing wire loss and prolonging service life. Doped molybdenum wire, such as molybdenum lanthanum wire, further improves the efficiency of cutting cemented carbide by enhancing wear resistance and high-temperature stability.

In production, molybdenum wire is prepared by a cold drawing and polishing process to ensure a smooth surface to reduce arc instability. The cutting process is cooled with high-purity deionized water to prevent overheating of the workpiece and wire. Waste silk is recycled through chemical dissolution to reduce resource waste. The technical challenge lies in optimizing the discharge parameters and tension control to balance cutting speed and precision while reducing wire wear in carbide cutting.

5.2.3 Precision molds and complex shape processing

Molybdenum wire achieves micron-level accuracy in precision molds and complex shape processing, and is suitable for the processing of mold steel, titanium alloys and other materials, meeting the needs of the aerospace and automotive industries for complex geometries. Ultra-fine molybdenum wire is capable of cutting fine features such as miniature gear molds or complex curved surfaces, and its high toughness allows for high-speed operation without breaking. Surface finish is critical to cutting accuracy, and cleaned molybdenum wire reduces surface defects through a polishing process to ensure a smooth and burr-free cut.

The manufacturing process includes multiple passes of cold drawing and strict annealing control to ensure that the wire is flexible and free of internal stresses. Multi-axis CNC machines are used to machine complex shapes, and molybdenum wires need to be operated under precise tension control to avoid vibrations. The coolant circulation system maintains process stability and prevents thermal distortion. The challenge is to achieve dimensional consistency and stability when machining complex shapes with ultra-fine molybdenum wires, using high-precision tooling and in-line monitoring technology.

5.3 Molybdenum wire for spraying

Molybdenum wire is used in thermal spraying to form wear-resistant, corrosion-resistant coatings and is widely used in the automotive, mechanical, and aerospace industries for surface strengthening and repair. Its high melting point and mechanical strength ensure excellent performance in extreme environments.

5.3.1 Wear-resistant coatings for automotive parts

Molybdenum wire is sprayed on the surface of automotive parts (such as piston rings, crankshafts) to form a wear-resistant coating, which significantly improves the durability and anti-wear ability of the components. Molybdenum wire is melted by plasma or flame spraying and deposited onto the surface of the substrate to form a dense coating that can withstand high friction and high temperature environments, extending component life. Black molybdenum wire is often used for flame spraying because its surface oxide layer is easy to melt in spraying, with high efficiency and low cost.

In production, molybdenum wire is made into coarser diameter wire using a hot drawing process, and the surface does not need to be polished to retain the oxide layer. The spraying equipment is equipped with a high-powered plasma gun, and the spraying temperature and distance need to be controlled to ensure a uniform coating. The quality of the coating is microscopically inspected to ensure that there are no porosity or cracks. The challenge is to optimize the spray parameters to improve coating adhesion while controlling dust emissions to comply with environmental requirements.

5.3.2 Surface repair and strengthening of mechanical components

Molybdenum wire is used to repair worn mechanical parts (e.g., bearings, shafts) or enhance their surface properties, and is sprayed to form a thick, wear-resistant, corrosion-resistant coating. Molybdenum wire melts in plasma spraying and deposits onto worn surfaces, restoring component size and improving corrosion resistance, making it particularly suitable for components in chemical equipment and offshore engineering. Doped molybdenum wire, such as molybdenum lanthanum wire, extends the service life of repaired parts in high-temperature environments by improving the oxidation resistance of the coating.

The production process includes hot drawing and surface cleaning to ensure that the wire is free of impurities. The spraying process is carried out under the protection of an inert gas (e.g. argon) to prevent oxidation. The coating is verified by wear tests to ensure a low coefficient of friction and high durability. Technical challenges include ensuring the strength of the bond between the coating and the substrate, as well as controlling thermal stresses during the spraying process to avoid deformation of the substrate.

5.3.3 Thermal spraying of aero-engine components

Molybdenum wire is sprayed with high-temperature and wear-resistant coatings on aero-engine components (such as blades and nozzles) to meet the requirements of high temperature, high pressure and corrosive environments. Molybdenum rhenium wire is often used in plasma spraying due to its excellent thermal shock resistance and corrosion resistance, forming a coating that can operate for a long time in high-temperature gas streams. The coating enhances the wear and oxidation resistance of the blades and extends engine maintenance intervals.

In production, molybdenum rhenium wire is prepared by cold drawing and high temperature annealing to ensure the toughness and strength of the wire. Spraying takes place in a vacuum or inert atmosphere and requires precise control of spraying parameters to create a homogeneous coating. The quality of the coating is verified by thermal cycling tests and microscopic analysis to ensure that there are no cracks and peeling. The challenge was to achieve a high-adhesion coating while reducing the material loss and environmental impact of the molybdenum wire during the spraying process.

5.4 Molybdenum wire for vacuum coating

Molybdenum wire is used as a key evaporation source material in the vacuum coating industry for depositing high-performance thin films in a wide range of optical, decorative and functional coatings. Its high melting point, excellent thermal conductivity and chemical stability ensure stable evaporation in a high-temperature vacuum environment, forming a uniform and dense film, meeting the stringent requirements for quality and reliability of precision devices.

5.4.1 Evaporation source materials in thin film deposition

Molybdenum wire is used as an evaporation source material in the physical vapor deposition (PVD) process, where a metal or compound is melted and evaporated by heat to form a thin film on the substrate. Molybdenum wire is able to withstand extremely high temperatures without melting or deformation, making it suitable for long-term operation in a vacuum environment to ensure the stability of thin film deposition. It has excellent thermal conductivity and is able to transfer heat evenly to prevent uneven evaporation caused by local overheating. The chemical stability of the molybdenum wire ensures that no impurities are introduced during the evaporation process, maintaining the high purity and performance of the film.

In production, molybdenum wire is usually made of high-purity materials, and the fine diameter wire is made by cold drawing process, and the surface is polished and ultra-clean cleaned to achieve a very high finish and reduce the impact of porosity or defects on the quality of the film. The evaporation source molybdenum wire needs to be heated by an electron beam or resistance in a vacuum environment, and the heating process needs to be precisely controlled to ensure a stable evaporation rate. The manufacturing process includes multiple passes of wire drawing and annealing to relieve stress and improve toughness, facilitating an evaporation source that is wound into a specific shape. The technical challenge is to ensure that the surface of the molybdenum wire is free of trace contamination and at the same time to avoid premature loss of the wire during the high-temperature evaporation process, which requires ultra-high vacuum equipment and a high-quality cleaning process.

5.4.2 Optical and decorative coatings

Molybdenum wire is used in optical coatings (e.g., lenses, filters) and decorative coatings (e.g., watches, jewelry housings) to deposit oxide or metallic films for high reflectivity or aesthetic needs. Its high-temperature stability supports the deposition of materials with high melting points, such as silica or titanium dioxide, ensuring excellent optical properties and durability of the film. The low vapor pressure of molybdenum wire ensures that no harmful gases are released when evaporating in a vacuum environment, keeping the coating equipment clean and the film pure. Due to its smooth surface and low impurity content, cleaned molybdenum wire is particularly suitable for high-precision optical coatings, reducing light scattering and defects.

The production process requires the molybdenum wire to have an extremely high surface quality, with surface oxides and particulates removed by cold drawing, polishing and ultrasonic cleaning. During the coating process, the molybdenum wire is wound into a spiral or scaphoid structure, which is heated by an electron beam and evaporated in a vacuum chamber. The process requires precise control of the heating power and vacuum level to ensure that the film thickness is uniform and pinhole-free. Technical challenges include achieving film homogeneity and controlling the evaporation rate of molybdenum wires, requiring a high-precision thickness monitoring system and stable heating equipment.

CTIA GROUP LTD

Molybdenum Wire Introduction

1. Overview of Molybdenum Wire

Molybdenum wire is a high-performance metallic filament made from metal molybdenum through hot working, cold drawing, and surface treatment. It features an extremely high melting point, excellent electrical and thermal conductivity, good mechanical strength, and exceptional corrosion resistance. It serves as a core material in various high-temperature and precision application fields.

2. Applications of Molybdenum Wire (Typical)

Application Field	Specific Uses
Lighting Industry	Filament supports, lead wires, halogen lamp electrodes, fluorescent lamp electrodes, LED packaging brackets
Wire-Cut Machining	Electrode wire for EDM, used in mold making and cutting of complex metal parts
Thermal Spraying	Used for surface reinforcement and wear-resistant coatings on automotive, aerospace, and engineering components
Vacuum Coating	Used as evaporation sources and coating materials for optics, solar cells, and semiconductor devices

3. Types of Molybdenum Wire (Typical)

Classification	Type	Description
Surface Condition	Cleaned Molybdenum Wire	Cleaned surface, bright and smooth, suitable for high-precision processing, electronics, coating, and other demanding applications
	Black Molybdenum Wire	Graphite-coated surface, suitable for general industrial processing and cost-effective applications
Use-Based Category	Wire-Cut Molybdenum Wire	For EDM wire-cutting, features high strength, high precision, and excellent durability
	Thermal Spray Molybdenum Wire	Used in thermal spraying processes, requires high density and good melting properties
	Heating Molybdenum Wire	Used as a heating element in high-temperature furnaces, with excellent heat resistance

4. Specifications of Molybdenum Wire from CTIA GROUP LTD

Item	Specification
Purity	≥99.95%
Diameter Range	0.03 mm ~ 3.0 mm (customizable)
Length / Coil Weight	Custom cut lengths (e.g., 200 mm) or continuous winding (e.g., 500g/coil, 2kg/coil)
Diameter Tolerance	±0.002 mm ~ ±0.1 mm
Surface Condition	Cleaned / Black
Packaging Options	Spool, coil, vacuum packaging, customized packaging

5. Procurement Information

Email: sales@chinatungsten.com; Phone: +86 592 5129595; 592 5129696

Website: www.molybdenum.com.cn

5.4.3 Semiconductor and solar cell coatings

Molybdenum wire is used in semiconductor and solar cell coatings to deposit conductive or functional films such as copper, silver, or transparent conductive oxides to meet the high-performance requirements of chips and photovoltaic devices. Its conductivity and high-temperature stability support efficient deposition, ensuring low resistance and good adhesion of the film. Due to its high strength and precise size, ultra-fine molybdenum wire is suitable for thin film deposition with micron thickness, meeting the needs of the semiconductor industry for miniaturization and high precision. The non-magnetic nature of molybdenum wire avoids interference with electromagnetic sensitive devices during the deposition process, and is especially suitable for integrated circuits and photovoltaic electrodes.

In manufacturing, ultra-fine molybdenum wire is prepared by multiple passes of cold drawing and strict annealing process to ensure diameter consistency and surface finish. The surface needs to be cleaned to remove trace impurities to prevent film contamination. The coating equipment uses an ultra-high vacuum system, and the molybdenum wire is heated by a laser or electron beam to deposit the material. The vacuum and deposition rates are tightly controlled to ensure the electrical and optical properties of the film. The technical challenge is to achieve the homogeneity of the ultra-thin film and prevent the micro-evaporation of the molybdenum wire at high temperatures, and the heating method and vacuum environment need to be optimized.

5.5 Molybdenum wire for heating elements

Molybdenum wire is used as a heating element in high-temperature electric furnaces, vacuum furnaces and heat treatment equipment, and with its high melting point and low vapor pressure, it can operate stably at extreme temperatures to meet the needs of industrial heating and material handling. Its excellent thermal conductivity and mechanical strength ensure efficient heat transfer and long-term reliability.

5.5.1 Heating wire for high-temperature electric furnace

Molybdenum wire is used as a heating wire in a high-temperature electric furnace to generate heat directly by electricity, which is used in metal smelting, ceramic sintering and other processes. Its high-temperature stability allows it to operate at temperatures close to the melting point without deformation or melting, making it ideal for applications that require rapid ramp-up and precise temperature control. The conductivity of molybdenum wire supports the passage of large currents, generating a uniform thermal field to ensure that the materials in the furnace are heated consistently. Molybdenum lanthanum wire is doped with lanthanum oxide, which has stronger creep resistance and is suitable for long-term high-temperature operation.

In production, molybdenum wire is made into medium-diameter wire by hot drawing process, and the surface is caustic washed or polished to reduce uneven resistance. The heating wire is wound into a specific shape (e.g. spiral or mesh) and brazed to the furnace body. The manufacturing process includes annealing to relieve stress and ensure that the wire is flexible and easy to form. The technical challenge was to prevent oxidation at high temperatures, to operate under vacuum or inert gas protection, and to optimize the winding design to avoid local overheating.

5.5.2 Heating elements in vacuum furnaces and atmosphere furnaces

In vacuum furnaces and atmosphere furnaces (e.g. argon or nitrogen protection), molybdenum wire acts as a heating element to provide a stable high-temperature environment for processes such as crystal growth, alloy sintering, etc. Its low vapor pressure ensures that no gas is released during operation in a vacuum environment, keeping the furnace clean. Due to its excellent toughness and thermal shock resistance, molybdenum rhenium wire is suitable for furnaces with frequent thermal cycles, and can withstand rapid temperature rise and fall without cracking. The thermal conductivity of molybdenum wire supports efficient heat transfer and reduced energy loss.

The production process uses cold drawing and high temperature annealing to ensure the strength and toughness of the wire. The oxide layer needs to be removed by alkali washing on the surface to reduce the influence of impurities on heating performance. The heating elements are vacuum-brazed or mechanically fixed to ensure a secure connection. Technical challenges include maintaining the ultra-low oxygen content of the vacuum furnace, preventing oxidation of the molybdenum wire, and optimizing the geometry of the heating elements to achieve a uniform thermal field.

5.5.3 Applications in heat treatment equipment

Molybdenum wire is used as a heating element in heat treatment equipment (such as annealing furnaces, quenching furnaces) for heat treatment processes of metals or alloys. Its high-temperature stability and creep resistance ensure that its shape and performance are maintained over long periods of operation, making it suitable for precisely controlled heat treatment processes. Molybdenum wire responds quickly to temperature changes, supports dynamic heat treatment processes, and improves the uniformity of material properties. Due to its low resistance and smooth surface, cleaned molybdenum wire reduces heat loss and prolongs equipment life.

In manufacturing, molybdenum wire is prepared through a multi-pass drawing and annealing process to ensure flexibility and strength. The surface is polished or caustic washed to improve the conductive efficiency. The heating elements are brazed or clamped to the furnace body, and the connection points need to be resistant to high temperatures and mechanical stress. The technical challenge is to ensure the stability of the molybdenum wire during thermal cycling, optimizing the annealing process and furnace atmosphere control to prevent oxidation or deformation.

5.6 Molybdenum wire for high-temperature furnace components

Molybdenum wire is widely used in vacuum furnaces and crystal growth furnaces as supporting, fixing, leading and shielding components in high-temperature furnaces. Its high strength, low coefficient of thermal expansion and high temperature resistance enable it to withstand mechanical and thermal stresses in extreme environments and meet the demands of complex furnace structures.

5.6.1 Supporting and fixing components of high-temperature furnaces

Molybdenum wire is used as a support and fixing member in a high-temperature furnace (such as a monocrystalline silicon growth furnace) to hold seed crystals, crucibles or heating elements to withstand weight and thermal stress at high temperatures. Its high strength and low coefficient of thermal expansion ensure that the components do not relax or deform at high temperatures, maintaining the stability of the furnace structure. Due to its excellent creep resistance, molybdenum lanthanum wire is particularly suitable for furnaces that run for a long time and can withstand repeated thermal cycles without failure.

In production, molybdenum wire is made into a medium-diameter wire by a cold drawing process, and the surface is polished to reduce stress concentration. The components are fixed by laser welding, and the solder joints are subjected to high temperatures and mechanical loads. The manufacturing process includes annealing to improve toughness and facilitate processing into complex shapes. The technical challenge is to ensure the quality of the welds and the dimensional accuracy of the components, using high-precision welding equipment and tight tolerance control.

5.6.2 Leads and shielding parts of vacuum furnaces

Molybdenum wire is used as a lead and shield in a vacuum furnace to conduct current and shield thermal radiation to protect other components in the furnace. Its conductivity and high-temperature stability support the passage of high currents, making it suitable for high-power heating systems. The low vapor pressure of the molybdenum wire ensures that no gas is released in a vacuum environment, keeping the furnace clean. Due to its smooth surface and low impurity content, cleaned molybdenum wire reduces contact resistance and improves the shielding effect.

The production process adopts cold drawing and ultra-clean cleaning to ensure that the surface of the wire is free of impurities. The leads are fixed by vacuum brazing or plasma welding, and the shielding parts need to be processed into a mesh or plate structure to increase the shielding area. The annealing process optimizes the toughness of the wire and prevents cracking during welding. Technical challenges include maintaining the purity of the vacuum environment and ensuring the long-term reliability of the lead connections, requiring ultra-high vacuum systems and high-quality soldering technology.

5.6.3 Structural materials for crystal growth furnaces

Molybdenum wire is used in crystal growth furnaces (e.g., sapphire or monocrystalline silicon furnaces) as seed clamping lines and structural materials to hold seed crystals in place and support furnace internals. Its high strength and high temperature resistance ensure stability at temperatures close to the melting point, making it suitable for long-running crystal growth processes. Due to its high recrystallization temperature, molybdenum lanthanum wire can withstand the thermal shock of rapid ramp and temperature, reducing the risk of deformation or fracture.

In production, molybdenum wire is prepared by a cold drawing and polishing process to ensure a surface finish and dimensional consistency. The components are laser cut and welded, with precise tolerances to accommodate complex furnace shapes. The annealing process improves the flexibility of the wire and facilitates winding or fixing. The technical challenges are to ensure the oxidation resistance and structural stability of the molybdenum wire at high temperatures, to operate in a vacuum or inert gas environment, and to optimize the component design to reduce thermal stress.

5.7 Molybdenum wire for electronic components

Molybdenum wire plays a key role in the manufacture of electronic components and is widely used in vacuum electronics, thermocouples, sensors, and connecting parts for microelectronics and integrated circuits. Its high electrical conductivity, non-magnetism, high-temperature stability, and thermal expansion matching characteristics with ceramics and glass make it irreplaceable in high-precision and high-reliability electronic applications. Molybdenum wire is able to withstand complex electromagnetic environments and high temperature conditions while maintaining stable mechanical and electrical properties, meeting the stringent requirements of precision and durability in the electronics industry.

5.7.1 Vacuum electronics (tubes, X-ray tubes)

Molybdenum wire is used as a cathode lead, support structure, and electrode material in vacuum electronics, such as electron tubes and X-ray tubes, to conduct current and secure critical components. In the electron tube, the molybdenum wire is used as a lead to connect the cathode and the external circuit, which needs to withstand high temperatures and frequent current pulses in a vacuum environment to ensure stable electron emission and signal transmission. Its non-magnetic nature avoids interference with electromagnetic fields, making it particularly suitable for high-frequency tube applications. In X-ray tubes, molybdenum wire is used as a cathode support or lead, which needs to be kept structurally intact under high temperature and high vacuum conditions to prevent failure due to thermal expansion or arc damage. Its conductivity and corrosion resistance ensure stable electrode performance during long-term operation and extend the life of the device.

The production process requires molybdenum wire to have extremely high purity and surface finish, usually using ultra-fine cold drawing process, through multi-pass drawing and annealing to prepare fine diameter wire, the surface through alkali washing and ultrasonic cleaning to remove the oxide layer and particles, to ensure that no impurities interfere with the electrical performance. The molybdenum wire needs to be fixed in the device by vacuum brazing or laser welding, and the solder joints need to be resistant to high temperatures and mechanical stress. Cleaned molybdenum wire is particularly suitable for high-precision devices due to its low contact resistance and smooth surface. The technical challenge is to ensure the oxidation resistance and dimensional stability of the molybdenum wire in a high-temperature vacuum environment, requiring ultra-high vacuum equipment and rigorous surface treatment processes, as well as optimizing the welding technology to avoid the introduction of microcracks or impurities.

5.7.2 Manufacture of thermocouples and sensors

Molybdenum wire is used as a lead or sensing element in the manufacture of high-temperature thermocouples and sensors, and is widely used in temperature measurement in industrial furnaces, aerospace, and scientific research. Its high-temperature stability allows it to operate in extreme temperatures for long periods of time without degradation, making it suitable for measuring accurate data in high-temperature environments. The conductivity of molybdenum wire ensures reliable signal transmission of the sensor, while its low coefficient of thermal expansion is matched to a ceramic or metal substrate to prevent cracking or loosening caused by thermal cycling. Molybdenum lanthanum wire is doped with lanthanum oxide, which has higher creep resistance, which can maintain stability in high-temperature dynamic environments and prolong the life of the sensor.

During the manufacturing process, molybdenum wire is made into a fine diameter through a cold drawing process, which is annealed to eliminate processing stress and improve flexibility for winding or fixing. The surface needs to be polished and cleaned to ensure that no surface defects affect the signal quality. Molybdenum wires are usually held in place in the sensor structure by laser welding or mechanical clamping, and the connection points need to be kept low resistance and high strength. In production, it is necessary to operate in an inert gas or vacuum environment to prevent high-temperature oxidation. Technical challenges include ensuring the chemical stability of molybdenum wire at extreme temperatures and optimizing the joining process to reduce contact resistance, requiring high-precision welding equipment and strict process control.

5.7.3 Connecting materials for microelectronics and integrated circuits

Molybdenum wire is used as a connecting wire or bonding wire in microelectronics and integrated circuits to connect chips with external circuits to meet the needs of miniaturization and high reliability. Its high strength and non-magnetic characteristics ensure that signal transmission is not interfered with in complex electromagnetic environments, making it suitable for high-density integrated circuits and microelectromechanical systems (MEMS). The conductivity of molybdenum wire allows for efficient current transfer, while its surface finish directly affects the bond quality, reducing contact resistance and signal attenuation. Ultra-fine molybdenum wire can adapt to the requirements of micron-level processing to meet the needs of the semiconductor industry for precision connections.

The production process adopts ultra-fine cold drawing technology, and the ultra-fine diameter wire is prepared through multi-pass drawing and intermediate annealing to ensure dimensional consistency and high toughness. The surface is electrochemically polished and cleaned to achieve a mirror-grade finish and prevent particulate or oxide contamination. The molybdenum wire is fixed to the die by ultrasonic bonding or laser soldering to ensure that the bond point is strong and does not damage the chip structure. The technical challenge is to achieve the dimensional accuracy and surface quality of ultra-fine molybdenum wire, using high-precision drawing dies and a cleanroom environment, while optimizing the bonding process to improve connection strength and reliability.

5.8 Molybdenum wire for medical and aerospace use

Molybdenum wire is used in the medical and aerospace fields for high-temperature, corrosion-resistant, and biocompatible components that meet the needs of extreme environments and high-precision applications. Its high strength, corrosion resistance, and high-temperature stability give it a unique advantage in medical devices and spacecraft, especially in scenarios that require long-term reliability and complex machining.

5.8.1 High-temperature components in medical devices (e.g. X-ray targets)

Molybdenum wire is used in medical devices for X-ray targets, heating elements, and support structures, especially in X-ray imaging equipment. Its high-temperature stability allows it to withstand high temperatures and electron bombardment within the X-ray tube, keeping the structure intact and the performance stable. The conductivity and low coefficient of thermal expansion of molybdenum wire ensure that the target does not crack during rapid thermal cycling, making it suitable for high-power imaging equipment. Due to its excellent toughness and corrosion resistance, molybdenum rhenium wire is especially suitable for high-load targets and can operate in corrosive environments for a long time. The biocompatibility of molybdenum wire has been rigorously tested to ensure safe use in medical devices.

In production, molybdenum wire is prepared by cold drawing and polishing processes to ensure a smooth and defect-free surface. The target parts are welded by electron beam and operate in a vacuum to prevent oxidation. The manufacturing process includes annealing to improve toughness and facilitate processing into complex shapes. The technical challenge is to ensure the stability and biocompatibility of the molybdenum wire under high temperature and high vacuum conditions, using ultra-high purity materials and precision welding technology, while ensuring that there are no microcracks or impurities through rigorous quality testing.

5.8.2 High-temperature and corrosion-resistant structural parts of spacecraft

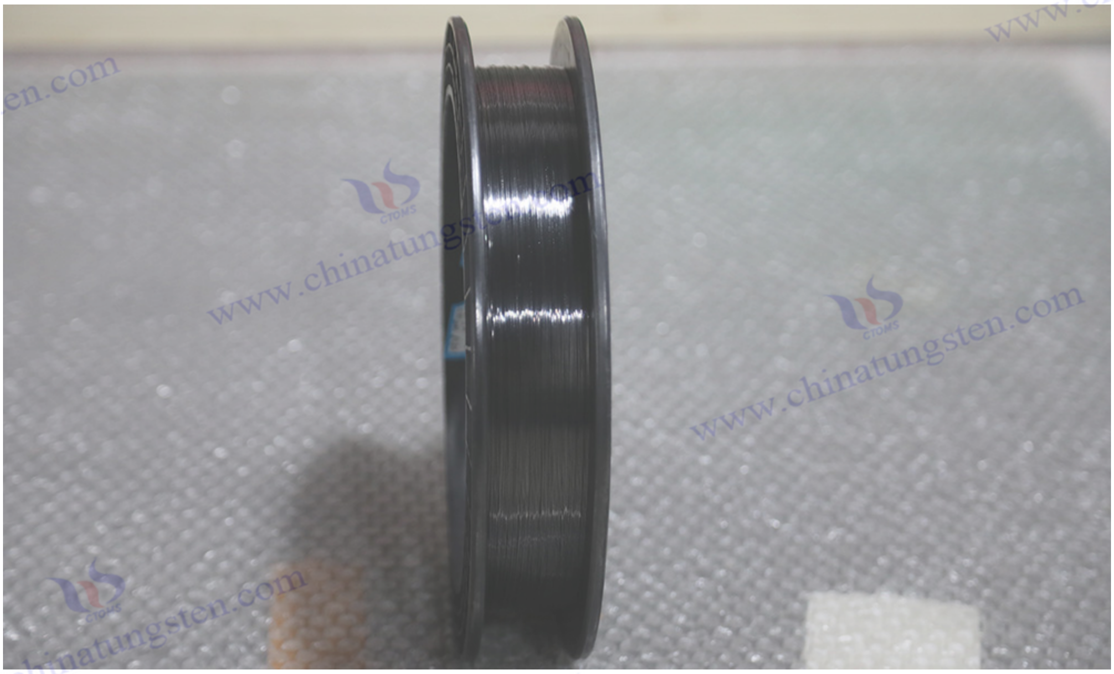
Molybdenum wire is used in spacecraft for high-temperature and corrosion-resistant structural parts such as engine nozzles, thermal shields, and connecting parts to meet the extreme temperature and chemical corrosion requirements of the space environment. Its high melting point and thermal shock resistance allow it to remain stable in high-temperature gas streams, making it suitable for components of rocket engines and reentry spacecraft. Due to the addition of rhenium, molybdenum rhenium wire significantly improves toughness and corrosion resistance, and can operate for a long time in sulfur-containing or acidic environments, prolonging the maintenance interval of spacecraft. Its low coefficient of thermal expansion ensures that the structural parts do not deform during thermal cycling, maintaining the structural integrity of the spacecraft.

The production process uses cold drawing and high-temperature annealing to prepare high-strength wires, and the surface is polished or coated to enhance oxidation resistance. Structural parts are formed by vacuum brazing or plasma welding, and the connection points need to be resistant to high temperatures and vibrations. It is necessary to operate in an inert gas or vacuum environment during manufacturing to prevent oxidation of the material. Technical challenges include optimizing the anti-oxidation coating and welding process of the molybdenum wire to cope with the extreme conditions in the aerospace environment, while ensuring lightweight and high reliability of the components.

5.8.3 Minimally invasive surgical tools and implant materials

Molybdenum wire is used as a key material in minimally invasive surgical tools (e.g., guidewires) and implants (e.g., stents) to meet the precision needs of the medical field due to its high strength, flexibility, and biocompatibility. Ultra-fine molybdenum wire can be processed into very fine diameters and is suitable for guiding catheters through complex vascular structures, and its flexibility allows operation without breaking at a small bend radius. The corrosion resistance of molybdenum wire ensures long-term stability in the internal environment without causing adverse reactions. Due to its excellent toughness and biocompatibility, molybdenum rhenium wire is particularly suitable for manufacturing high-precision implants that can withstand complex mechanical stresses.

In production, ultra-fine molybdenum wire is prepared by multi-pass cold drawing and strict annealing process to ensure dimensional accuracy and surface finish. The surface is electrochemically polished and ultra-clean to meet medical-grade cleanliness standards and prevent particulate contamination. The guidewires are laser-cut and micromachined to ensure smooth edges to avoid tissue damage. The technical challenge was to achieve dimensional consistency and biocompatibility of ultra-fine molybdenum wires, requiring high-precision wire drawing equipment and a rigorous cleanroom environment, while ensuring safety through biocompatibility testing.



CTIA GROUP LTD Black Molybdenum Wire

Chapter 6 Molybdenum Wire Production Equipment

The production of molybdenum wire relies on a range of high-precision equipment, from raw material handling to powder metallurgy to wire drawing, each step of which requires high reliability, precise control and environmental adaptability. These devices ensure the high purity, uniformity and mechanical properties of molybdenum wire to meet the needs of diverse applications such as electric light source, wire cutting, spraying, etc. The following is a detailed text description to analyze the functions, process requirements and operational challenges of raw material handling equipment, powder metallurgy equipment and wire drawing equipment involved in the production of molybdenum wire.

6.1 Raw material handling equipment

The raw material processing equipment is used to extract high-purity molybdenum raw materials from molybdenite and prepare molybdenum powder, which is the basic link in the production of molybdenum wire. Equipment needs to be equipped with efficient separation, precise control and environmental performance to ensure raw material purity and production efficiency, while reducing resource waste and environmental pollution.

6.1.1 Mineral processing equipment

The beneficiation equipment is used to separate molybdenum concentrate from molybdenite, remove associated minerals (such as copper, iron sulfides), and provide high-quality raw materials for subsequent purification. The core equipment includes crushers, ball mills and flotation cells. The crusher crushes the raw ore into small particles to ensure the efficiency of subsequent grinding, and needs to have high wear resistance and large processing capacity, which can handle ore with high hardness. The ball mill further grinds the crushed ore into fine particles, which are suitable for the flotation process, and the equipment needs to be equipped with an efficient grinding medium and precise speed control to avoid uneven particles caused by over-grinding. The flotation machine separates molybdenite and impurities in the liquid medium by adding collector and foaming agent, and needs to have a stable bubble generation and stirring system to ensure high recovery of molybdenum concentrate.

During operation, the beneficiation equipment needs to be combined with an accurate process parameter control system to monitor the slurry concentration and bubble distribution in real time to optimize the separation efficiency. The material of the equipment needs to be corrosion-resistant and adapt to the corrosive environment of chemical reagents. The tailings treatment system is used to recycle waste materials and treat wastewater, reducing environmental pollution. The technical challenge was to improve beneficiation efficiency and purity while reducing energy consumption and chemical reagent usage, and to integrate automated controls and exhaust gas treatment units to meet environmental requirements.

6.1.2 Molybdenum powder production equipment

The molybdenum powder production equipment converts the purified molybdenum concentrate into high-purity molybdenum powder, mainly including roasting furnace and hydrogen reduction furnace. The roaster oxidizes molybdenite to molybdenum oxide, which needs to have high temperature heating capacity and uniform thermal field distribution to ensure that the oxidation reaction is complete and free of residual sulfide. The equipment is equipped with an exhaust gas treatment system to recover sulfur oxides and reduce environmental pollution. The hydrogen reduction furnace converts molybdenum oxide into metal molybdenum powder through a multi-stage reduction process, which needs to be operated in a high-purity hydrogen environment, with precise temperature control and airflow regulation to ensure uniform particle size and low oxygen content of the powder.

In production, the roaster needs to be equipped with high-temperature and corrosion-resistant materials to prevent the furnace body from being damaged during long-term operation. The furnace is protected by an inert atmosphere to prevent the oxidation of molybdenum powder, and is equipped with a high-precision flow meter and gas purification system to maintain hydrogen purity. The automatic monitoring system detects the particle size and chemical composition of the powder in real time to ensure quality consistency. The technical challenge was to control the atmosphere stability and powder morphology during the reduction process, to optimize the gas flow distribution and temperature gradient in the furnace, and to equip the furnace with a dust collection device to improve safety and environmental friendliness.

6.2 Powder metallurgy equipment

Powder metallurgy equipment is used to press and sinter molybdenum powder into high-density blanks, providing a solid foundation for subsequent wire drawing. The equipment needs to be equipped with high pressure, precise control and high reliability to ensure the density uniformity and microstructural stability of the blanks.

6.2.1 Presses

Presses are used to press molybdenum powder into rod or plate blanks, and common types include cold isostatic presses and molding presses. The cold isostatic press exerts uniform pressure through the liquid medium to press the molybdenum powder into high-density blanks, which is suitable for the production of complex shapes of blanks, and the equipment needs to be equipped with high-strength rubber molds and a stable pressure control system to ensure that the blanks have no cracks or voids. The molding machine uses a steel mold to press the molybdenum powder into a regular shape, which is suitable for low-volume production, and requires a highly rigid frame and precise mold alignment to avoid deviations in the pressing process.

During operation, the press needs to be combined with a vibrating table or vacuum extraction device to reduce the air void in the powder and increase the density of the blank. The equipment needs to be operated in a clean environment to prevent powder contamination and affect the quality of subsequent sintering. An automated control system is used to monitor pressure and pressing time to ensure batch consistency. The technical challenge is to achieve a uniform density of the blank and to avoid wear and tear, requiring regular maintenance of the mold and optimization of the pressing process to reduce defects.

6.2.2 Sintering furnaces

The sintering furnace is used to heat the pressed blank to high temperature, so that the molybdenum particles combine to form a high-density billet, and it is commonly used in the medium frequency induction furnace or resistance heating furnace. The sintering furnace needs to have high temperature heating capacity and precise temperature control to ensure that the blank is uniformly densified at high temperatures without cracking. The equipment is protected by hydrogen or inert gas to prevent the oxidation of molybdenum blanks, and needs to be equipped with an efficient gas circulation and purification system to maintain the purity of the atmosphere in the furnace. Sintering furnaces are typically divided into two zones, pre-sintering and high-temperature sintering, to remove binders and promote grain bonding, respectively, and require multi-zone heating to optimize temperature distribution.

In production, the sintering furnace needs to be equipped with high-temperature resistant furnace material to withstand long-term high-temperature operation. The automatic control system monitors the heating and cooling rates to prevent thermal stress from deforming the blank. The exhaust gas treatment device recovers volatile impurities and meets environmental protection standards. The technical challenge is to ensure the microstructural homogeneity and high density of the sintered billet, to optimize the heating profile and atmosphere control, while reducing energy consumption and exhaust emissions.

6.3 Wire drawing equipment

The wire drawing equipment is used to process the sintered blank into fine diameter molybdenum wire, which is a key link in the production of molybdenum wire. The equipment needs to have high precision, stability and efficient lubrication and cooling functions to ensure the dimensional accuracy and surface quality of molybdenum wire and meet the needs of precision applications.

6.3.1 Wire drawing machines

The wire drawing machine is used to gradually stretch the molybdenum blank into a fine wire through the mold, which is divided into hot wire drawing machine and cold wire drawing machine. The hot wire drawing machine is used to produce coarser diameter molybdenum wire, equipped with high-frequency induction heating device, which softens the blank at high temperature and reduces tensile resistance, and is suitable for the production of molybdenum wire for spraying or heating elements. Cold drawing machines are used to produce fine diameter and ultra-fine molybdenum wires, which require high-precision tension control and speed adjustment to ensure that the wire diameter is consistent and unbroken. Modern wire drawing machines are designed with multi-mode continuous wire drawing, which is capable of simultaneous multi-pass stretching and increasing production efficiency.

During operation, the wire drawing machine needs to be equipped with an online monitoring system to detect the diameter and surface defects of the wire in real time to ensure stable quality. The automatic tension control system maintains a constant tensile force to prevent the wire from deforming or breaking. The equipment needs to be calibrated regularly to maintain the accuracy of the mold hole diameter and tensile speed. The technical challenge was to achieve continuous stretching and high-precision control of ultra-fine molybdenum wires, with high-performance servo motors and laser calipers, while optimizing the drawing speed to balance efficiency and quality.

6.3.2 Moulds and lubrication systems

The drawing die and lubrication system are the core components of the wire drawing machine, which directly affect the surface quality and dimensional accuracy of the molybdenum wire. The mold is usually made of cemented carbide or diamond material, the cemented carbide mold is suitable for rough molybdenum wire drawing, and the diamond mold is suitable for the precision machining of ultra-fine molybdenum wire because of its ultra-high hardness and wear resistance. The mold needs to have a high-precision aperture design and a smooth inner wall to reduce friction and surface scratches. The lubrication system provides a water-based or oil-based lubricant that reduces friction between the die and the molybdenum wire, extending the life of the die and improving the surface finish of the wire. The cooling system controls the temperature of the die and wire by circulating water or spray cooling to prevent deformation caused by overheating.

During production, the mold needs to be polished and replaced regularly to maintain the consistency of the hole size. The lubrication system is equipped with a filtration device to remove impurities from the lubricant and prevent scratching the surface of the molybdenum wire. The cooling system needs to maintain a stable water temperature and flow rate to ensure uniform cooling. The technical challenge was to optimize the mold material and lubricant formulation to reduce the risk of wire breakage in the stretching of the ultra-fine molybdenum wire, while at the same time equipping it with an efficient recovery system to reduce lubricant waste and environmental impact.

6.4 Heat Treatment Equipment

Heat treatment equipment is used for annealing and high-temperature treatment of molybdenum wire, relieving processing stress, optimizing microstructure, and improving toughness and ductility to ensure that molybdenum wire meets the needs of precision applications. These devices need to have high-precision temperature control, stable atmosphere protection and efficient thermal field distribution to ensure that the molybdenum wire does not oxidize and performs uniformly at high temperatures.

6.4.1 Annealing furnaces

The annealing furnace is used for the heat treatment of molybdenum wire, which eliminates the stress generated during the drawing process and restores the ductility of the wire through heating and heat preservation, and is suitable for high-precision applications such as wire cutting and electric light source. Annealing furnaces are typically available in tubular or continuous designs and are able to operate under the protection of hydrogen or inert gases such as argon to prevent oxidation of the surface of the molybdenum wire. The equipment is equipped with a multi-zone heating system to ensure a uniform thermal field and avoid uneven grains caused by local overheating. Tubular annealing furnaces are suitable for small batch production, allowing flexible adjustment of annealing parameters, while continuous annealing furnaces enable high-speed processing through conveyor belts or traction systems, making them suitable for large-scale production.

During operation, the annealing furnace needs to precisely control the heating and cooling rates to prevent thermal stress from causing deformation or cracking of the molybdenum wire. The atmosphere inside the furnace needs to be of high purity, and it is equipped with a gas purification and circulation system to remove trace amounts of oxygen and water. The automatic control system monitors the temperature and atmosphere conditions to ensure consistent performance from batch to batch. The technical challenge was to optimize the annealing process to balance toughness and strength while reducing energy and gas consumption, requiring the integration of efficient heat recovery systems and real-time monitoring devices.

6.4.2 Vacuum furnaces

Vacuum furnaces are used for high-temperature heat treatment of molybdenum wire, especially in scenarios where extremely high purity and an oxidation-free environment are required, such as annealing of molybdenum lanthanum wire or molybdenum rhenium wire. The vacuum furnace prevents the oxidation of molybdenum wire at high temperatures through a high vacuum environment, while supporting complex heat treatment processes such as grain refinement and doped element distribution optimization. The equipment is equipped with a high-performance vacuum pump and sealing system to maintain an ultra-low air pressure environment and ensure that the surface of the molybdenum wire is free of impurities. The heating system uses resistance or induction heating, which can quickly heat up and maintain a stable thermal field, and is suitable for processing ultra-fine molybdenum wire or high-performance alloy wire.

In production, vacuum furnaces need to be equipped with high-temperature resistant furnace materials to withstand the heat load of long-term operation. The automatic control system monitors the vacuum degree and temperature in real time to ensure that the process parameters are stable. The exhaust gas treatment device recovers volatile impurities and meets the requirements of environmental protection. The technical challenge is to maintain ultra-high vacuum and prevent micro-leaks, requiring the use of high-precision gauges and sealing technology, while optimizing heating efficiency to reduce energy consumption.

6.5 Surface Treatment Equipment

Surface treatment equipment is used for cleaning, polishing and coating of molybdenum wire, improving surface finish, corrosion resistance and functionality, and meeting the high quality requirements of electric light source, vacuum coating and other applications. The equipment needs to be equipped with efficient cleaning capabilities and precise surface modification functions, while ensuring environmental protection and safety.

6.5.1 Caustic washing equipment

The alkali washing equipment is used to remove the oxide layer and impurities on the surface of molybdenum wire and prepare cleaned molybdenum wire, which is suitable for scenarios with high surface quality requirements such as electric light source and wire cutting. The equipment is usually a continuous cleaning line with a lye bath, an ultrasonic cleaning unit and a deionized water flushing system. The lye bath uses a sodium hydroxide solution to clean the molybdenum wire to remove the molybdenum oxide layer, and needs to be equipped with a heating and agitation system to ensure cleaning efficiency. The ultrasonic cleaning device uses high-frequency vibration to remove fine particles and residues and improve surface cleanliness. The deionized water flushing system completely removes the lye residue and prevents secondary pollution.

During operation, the caustic washing equipment needs to accurately control the concentration and temperature of the solution to ensure uniform cleaning without damaging the surface of the molybdenum wire. The waste liquid treatment system reduces environmental pollution by neutralizing and precipitating the recovery of molybdate. The automatic control system monitors the cleaning time and liquid level to improve production efficiency. The technical challenge was to optimize the cleaning process to avoid excessive corrosion and at the same time to increase the recovery of the effluent, which required high-efficiency filtration and neutralization devices.

6.5.2 Polishing and coating equipment

Polishing and coating equipment is used to improve the surface finish of molybdenum wire or to apply functional coatings, such as molybdenum silicide or zirconia coatings, to enhance wear resistance and oxidation resistance. The polishing equipment includes an electrochemical polishing machine and a mechanical polishing machine, the electrochemical polishing machine uses an acid electrolyte to smooth the surface of the molybdenum wire through an electrochemical reaction, and needs to be equipped with a stable power supply and an electrolytic cell to ensure uniform polishing. Mechanical polishing machines use diamond grinding wheels or polishing belts and are suitable for high-precision polishing in small batches, requiring high rotational speeds and precise feed control. Coating equipment includes chemical vapor deposition (CVD) and plasma spraying equipment, capable of depositing a uniform protective layer on the surface of the molybdenum wire, equipped with a vacuum chamber and gas control system to ensure coating quality.

In production, the polishing equipment needs to be operated in a clean environment to prevent particulate contamination, and the surface quality is microscopically inspected to ensure that there are no scratches. Coating equipment needs to precisely control the deposition rate and atmosphere to prevent uneven or flaking of the coating. The technical challenge was to achieve a high-finish finish and a strong adhesion coating, to optimize the electrolyte formulation and deposition parameters, and to equip the exhaust gas treatment unit to comply with environmental standards.

6.6 Testing and quality control equipment

Inspection and quality control equipment is used to evaluate the dimensional accuracy, surface quality and mechanical properties of molybdenum wire to ensure that products meet standards for applications such as wire EDM, electronic components, and more. These devices need to be highly accurate, responsive, and non-destructive to support efficient production and quality management.

6.6.1 Eddy current flaw detection equipment

Eddy current flaw detection equipment is used to detect microcracks, inclusions and internal defects on the surface of molybdenum wire, and is suitable for in-line inspection in continuous production. Through the principle of electromagnetic induction, the equipment generates eddy currents on the surface of the molybdenum wire to detect the changes in the electrical signal caused by defects, and has high sensitivity and fast scanning ability. Eddy current flaw detectors are typically equipped with multi-channel sensors and automated scanning systems that can analyze the full length of the molybdenum wire in real time to identify minor defects. The equipment needs to be integrated with the drawing line to support high-speed inspection without interrupting production.

During operation, eddy current testing equipment needs to be calibrated to accommodate different diameters of molybdenum wire to ensure detection accuracy. The data processing system records the location and type of defects in real time and generates quality reports. The technical challenge is to improve the detection sensitivity to identify micron-scale defects while avoiding false alarms, and to optimize the sensor design and signal processing algorithms.

6.6.2 Tensile testing machines

Tensile testing machines are used to test the mechanical properties of molybdenum wire, such as strength and ductility, to ensure that the wire meets the needs of the application. The equipment measures the deformation and fracture behavior of molybdenum wire during the stretching process by applying a controlled tensile force, which is suitable for evaluating the performance of coarse molybdenum wire and ultra-fine molybdenum wire. Tensile testing machines are equipped with high-precision grips and force transducers that can accurately grip small diameter molybdenum wires without causing damage. The automatic control system records the tensile curve and analyzes the mechanical properties of the material.

In production, tensile testing machines need to be operated in a constant temperature environment to prevent temperature changes from affecting the test results. The equipment is calibrated regularly to ensure the accuracy of the force sensor and displacement measurements. The technical challenge is to avoid clamping damage when testing ultra-fine molybdenum wires, designing special fixtures and optimizing test parameters to improve repeatability.

6.6.3 Microscopes and spectrometers

Microscopes and spectrometers are used to analyze the microstructure, surface topography and chemical composition of molybdenum wires to ensure consistent product quality and performance. Light microscopy and scanning electron microscopy (SEM) are used to observe scratches, cracks, and grain structures on the surface of molybdenum wires, and are suitable for evaluating drawing and polishing results. Spectrometers (such as X-ray photoelectron spectrometers or energy dispersive analyzers) detect the elemental composition and impurity content of molybdenum wires to ensure high purity and uniform distribution of doped elements. The equipment needs to have high resolution and fast analysis capabilities, and be suitable for batch inspection.

During operation, the microscope needs to be equipped with a high-magnification objective lens and an image processing system to produce clear microscopic images. The spectrometer needs to be operated in a clean environment to prevent sample contamination, and the data analysis software is used to quantitatively assess the chemical composition. The technical challenge is to achieve fast and high-precision analysis, optimizing the illumination system of the microscope and the calibration process of the spectrometer, while ensuring the suitability of the device for ultra-fine molybdenum wires.

6.7 Automation and intelligent equipment

Automation and intelligent equipment improve the efficiency, consistency and traceability of molybdenum wire production, covering wire drawing, inspection and process control. These devices enable efficient production and quality optimization by integrating sensors, control systems, and data analysis technologies.

6.7.1 Automatic wire drawing production line

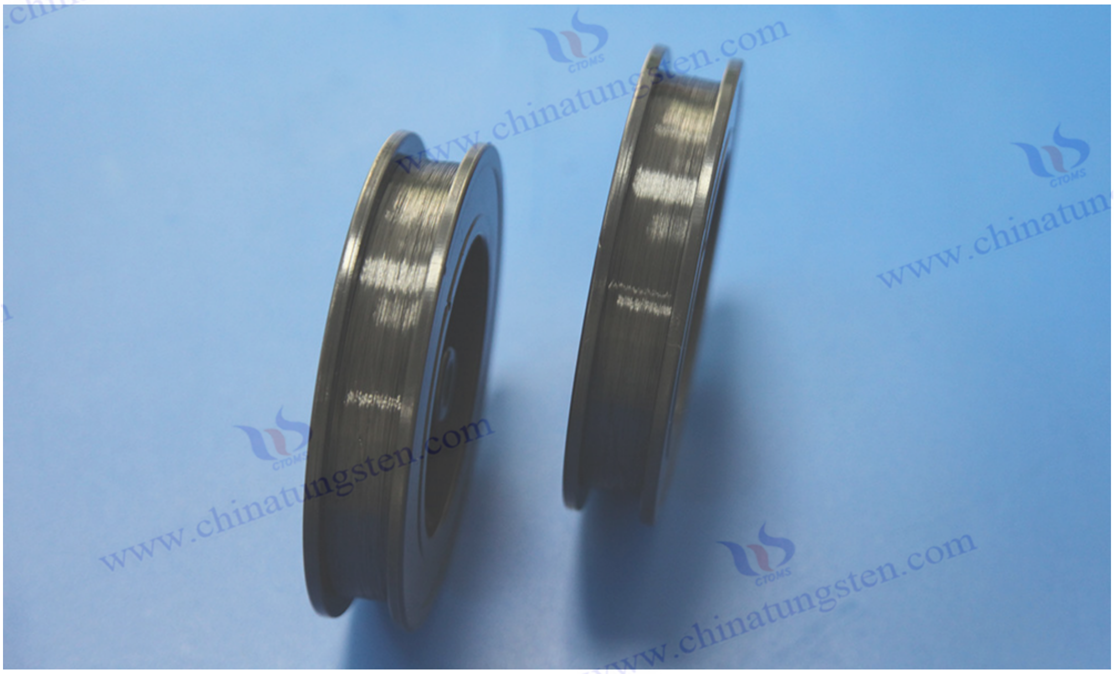
The automatic wire drawing production line integrates a multi-mode wire drawing machine, a tension control system and an online detection device to realize continuous processing from blank to finished molybdenum wire. Through servo motors and PLC control systems, the equipment accurately adjusts the drawing speed and tension to ensure that the wire diameter is consistent and no breakage. The production line is equipped with automatic mold change and lubrication system to reduce manual intervention and improve production efficiency. The continuous annealing device is integrated with the wire drawing machine to relieve processing stress in real time and optimize the toughness of molybdenum wire.

During operation, the production line needs to be equipped with high-precision sensors to monitor the wire diameter and surface quality, and the data is fed back to the control system in real time to adjust the process parameters. The automated production line supports the production of molybdenum wire of various specifications with high flexibility. The technical challenge was to achieve the stability of multiple passes of drawing and the continuous processing of ultra-fine molybdenum wires, optimizing control algorithms and equipment integration, while reducing downtime.

6.7.2 On-line monitoring system

The online monitoring system is used to detect key parameters in the production process of molybdenum wire, such as diameter, surface defects and mechanical properties in real time, to ensure consistent product quality. The system includes a laser caliper, eddy current flaw detector and temperature sensor to collect data in real-time during wire drawing, annealing and surface treatment. The laser caliper detects small changes in the diameter of the molybdenum wire through non-contact measurement, making it suitable for high-speed production environments. The data processing system integrates MES (Manufacturing Execution System) to record production parameters and generate quality reports to support traceability and process optimization.

In production, the online monitoring system needs to be seamlessly integrated with the production line and transmit data to the control center in real time. The system needs to be calibrated regularly to ensure sensor accuracy and data reliability. The technical challenge is to improve the responsiveness and sensitivity of the monitoring system, optimize the sensor layout and data processing algorithms, and ensure the stability of the system in high temperature and high vacuum environments.



CTIA GROUP LTD Black Molybdenum Wire

Chapter 7 Molybdenum Wire Standards

As a high-performance material, the production and application of molybdenum wire are subject to strict standards to ensure quality, performance and consistency. Domestic standards, international standards and industry standards standardize the chemical composition, mechanical properties, dimensional accuracy and surface quality of molybdenum wire from different levels to meet the needs of diversified applications such as electric light source, wire cutting, vacuum coating, etc. These standards provide a unified basis for production, testing and trade through clear technical requirements and testing methods, and at the same time promote the technological progress and international development of the industry. The following is a detailed text description to analyze the domestic, international and industry standards of molybdenum wire, as well as the comparison and applicability of the standards.

7.1 Domestic standard for molybdenum wire

As the world's largest producer of molybdenum wire, China has formulated a series of national standards (GB/T) to regulate the production, testing and application of molybdenum wire and its related products. These standards are issued by the Standardization Administration of the People's Republic of China, covering the material properties, processing requirements and quality control of molybdenum wire, molybdenum bars and molybdenum slabs, and are widely used in domestic molybdenum wire manufacturers and downstream application industries.

7.1.1 GB/T 4182-2003《Molybdenum Wire》

GB/T 4182-2003 is the main national standard for molybdenum wire in China, which is suitable for molybdenum wire in applications such as electric light source, wire cutting and high-temperature furnace. This standard specifies the classification, chemical composition, mechanical properties, dimensional accuracy and surface quality requirements of molybdenum wire, covering pure molybdenum wire and doped molybdenum wire (such as molybdenum lanthanum wire). The standard requires that the molybdenum wire has high purity and uniform microstructure to ensure stability in high temperature and corrosive environments. Inspection methods include chemical analysis, tensile testing, and surface inspection to ensure that the molybdenum wire meets the performance requirements of different applications, such as the tensile strength of wire cutting and the conductivity of electric light sources.

The standard also regulates the production process of molybdenum wire, such as wire drawing, annealing and surface treatment, and requires manufacturers to operate in a clean environment to prevent contamination. Packaging and storage requirements ensure that molybdenum wire is not subject to moisture or oxidation during transportation and maintains surface quality. The technical challenge is to balance high performance requirements with production costs, and to optimize the inspection process to ensure efficient and consistent standard enforcement. This standard provides a unified technical basis for the domestic molybdenum wire industry, and promotes product quality improvement and market competitiveness.

CTIA GROUP LTD

Molybdenum Wire Introduction

1. Overview of Molybdenum Wire

Molybdenum wire is a high-performance metallic filament made from metal molybdenum through hot working, cold drawing, and surface treatment. It features an extremely high melting point, excellent electrical and thermal conductivity, good mechanical strength, and exceptional corrosion resistance. It serves as a core material in various high-temperature and precision application fields.

2. Applications of Molybdenum Wire (Typical)

Application Field	Specific Uses
Lighting Industry	Filament supports, lead wires, halogen lamp electrodes, fluorescent lamp electrodes, LED packaging brackets
Wire-Cut Machining	Electrode wire for EDM, used in mold making and cutting of complex metal parts
Thermal Spraying	Used for surface reinforcement and wear-resistant coatings on automotive, aerospace, and engineering components
Vacuum Coating	Used as evaporation sources and coating materials for optics, solar cells, and semiconductor devices

3. Types of Molybdenum Wire (Typical)

Classification	Type	Description
Surface Condition	Cleaned Molybdenum Wire	Cleaned surface, bright and smooth, suitable for high-precision processing, electronics, coating, and other demanding applications
	Black Molybdenum Wire	Graphite-coated surface, suitable for general industrial processing and cost-effective applications
Use-Based Category	Wire-Cut Molybdenum Wire	For EDM wire-cutting, features high strength, high precision, and excellent durability
	Thermal Spray Molybdenum Wire	Used in thermal spraying processes, requires high density and good melting properties
	Heating Molybdenum Wire	Used as a heating element in high-temperature furnaces, with excellent heat resistance

4. Specifications of Molybdenum Wire from CTIA GROUP LTD

Item	Specification
Purity	≥99.95%
Diameter Range	0.03 mm ~ 3.0 mm (customizable)
Length / Coil Weight	Custom cut lengths (e.g., 200 mm) or continuous winding (e.g., 500g/coil, 2kg/coil)
Diameter Tolerance	±0.002 mm ~ ±0.1 mm
Surface Condition	Cleaned / Black
Packaging Options	Spool, coil, vacuum packaging, customized packaging

5. Procurement Information

Email: sales@chinatungsten.com; Phone: +86 592 5129595; 592 5129696

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7.1.2 GB/T 3462-2007

GB/T 3462-2007 regulates molybdenum bars and molybdenum slabs used in the production of molybdenum wire, which are suitable for raw materials for powder metallurgy and wire drawing processes. The standard specifies in detail the chemical composition, density, surface quality and dimensional tolerances of molybdenum bars and molybdenum slabs, and requires materials with high purity and low impurity content, suitable for subsequent processing into high-performance molybdenum wires. The standard covers the performance requirements of different types of molybdenum bars (e.g., sintered, forged) to ensure that the blank has a uniform microstructure and mechanical strength before drawing.

Production process requirements include powder pressing, sintering, and thermal processing, which need to be carried out in a hydrogen or vacuum environment to prevent oxidation. Testing methods include density measurement, metallographic analysis, and chemical composition testing to ensure that the quality of the blank meets the drawing requirements. The standard also specifies packaging and transportation requirements to protect the blank from moisture or mechanical damage. The technical challenge was to ensure blank uniformity and batch consistency, requiring high-precision pressing and sintering equipment, as well as optimizing the inspection process to improve efficiency. This standard provides specifications for the upstream links of molybdenum wire production and promotes the stability of raw material quality.

7.1.3 Other relevant national standards

In addition to the above standards, China has also formulated a number of national standards related to molybdenum wire, such as GB/T 4197 "Chemical Analysis Methods for Molybdenum and Molybdenum Alloys" and GB/T 3461 "Molybdenum Powder", which are used to standardize the chemical composition analysis and powder preparation of molybdenum materials. These standards detail methods for the detection of impurity elements (e.g., iron, carbon, oxygen) in molybdenum materials and require the use of high-precision spectroscopic analysis and chemical titration techniques to ensure material purity for high-performance applications. Other standards also deal with the packaging, storage and transportation of molybdenum wire, emphasizing measures against moisture, oxidation and mechanical damage, and are applicable to both export and domestic markets.

Together, these standards constitute a complete standard system for molybdenum wire production, covering the whole process from raw materials to finished products. The technical challenge is to harmonize the testing requirements of different standards and to establish a unified quality management system to improve the efficiency of implementation. At the same time, with the expansion of molybdenum wire applications, standards need to be constantly updated to adapt to new technologies and new market needs.

7.2 International standards for molybdenum wire

International standards provide a unified technical basis for the global trade and application of molybdenum wire, which are mainly formulated by the American Society for Testing and Materials (ASTM), the International Organization for Standardization (ISO), and national standards bodies such as Japan (JIS) and Germany (DIN). These standards regulate the performance, processing and testing requirements of molybdenum wire and its alloys, and promote the standardized application of molybdenum wire in the global market.

7.2.1 ASTM B387 Standard for Molybdenum and Molybdenum Alloy Rods, Bars and Wires

ASTM B387 is the most widely used international standard for molybdenum wire, covering rods, bars, and wires of molybdenum and molybdenum alloys (such as molybdenum, lanthanum, molybdenum, rhenium), and is suitable for electric light sources, vacuum coating, high-temperature furnaces, and other industries. This standard specifies the chemical composition, mechanical properties, surface quality and dimensional tolerances of materials, and requires molybdenum wire to have high purity and excellent resistance to high temperatures, suitable for applications in extreme environments. The standard also describes in detail testing methods such as tensile testing, hardness testing, and metallographic analysis to ensure that molybdenum wire meets the mechanical and electrical properties for different applications.

Production process requirements include powder metallurgy, wire drawing, and heat treatment, which need to be operated in a high-purity atmosphere or vacuum to prevent oxidation. The standard emphasizes the importance of surface treatment and requires that the surface of molybdenum wire be free of cracks, scratches or oxide layers, and be suitable for precision applications. Packaging and storage requirements ensure that the quality of the wire is maintained during transportation and storage. The technical challenge is to meet the standards' requirements for high precision and consistency, with advanced production and testing equipment, while optimizing processes to reduce costs. This standard provides a unified technical reference for the global molybdenum wire market and promotes international trade and application.

7.2.2 ISO Standards

The International Organization for Standardization (ISO) has developed standards related to molybdenum and molybdenum alloys, such as ISO 24361, which deals with the properties and testing methods of molybdenum materials and is suitable for the production and application of molybdenum wire. This standard regulates the chemical composition, microstructure and mechanical properties of molybdenum wire, and requires the material to have high purity and uniformity, suitable for high temperature and corrosive environments. Testing methods include chemical analysis, microscopic observation, and mechanical testing to ensure that molybdenum wire meets the quality requirements of the global market. The standard also covers the environmental requirements of the production process, emphasizing the reduction of exhaust gas and waste liquid emissions.

The ISO standard focuses on the international versatility of molybdenum wire and is suitable for multinational applications in the fields of electric light source, wire cutting and medical equipment. High-precision equipment, such as spectrometers and tensile testing machines, is used in production to ensure reliable results. The technical challenge is to reconcile the differences between ISO standards and national standards, establish a global quality control system, and optimize the inspection process to improve efficiency. This standard promotes the international development of the molybdenum wire industry and enhances the global competitiveness of products.

7.2.3 Other international standards (e.g. JIS, DIN)

The Japanese Industrial Standard (JIS) and the German Industrial Standard (DIN) have also developed specifications related to molybdenum wire, such as JIS H 4461 "Molybdenum and molybdenum alloys" and DIN EN 10204 "Inspection Documentation for Metal Products". The JIS standard specifies the chemical composition, mechanical properties and processing requirements of molybdenum wire, and is suitable for electric light source and electronic component applications in the Japanese market, emphasizing high precision and surface quality. The DIN standard focuses on the quality certification and testing documents of molybdenum wire, and requires manufacturers to provide detailed material performance reports to ensure product traceability.

These standards require the production of molybdenum wire using high-purity raw materials and precision machining processes, including spectroscopic analysis and surface inspection, and operating in a clean environment. The technical challenge is to meet the specific requirements of different national standards and to flexibly adapt production and testing processes while ensuring cost-effectiveness. JIS and DIN standards provide technical support for the application of molybdenum wire in specific markets and promote the standardization of regional markets.

7.3 Molybdenum wire industry standard

Industry standards are formulated by professional associations or enterprises, supplementing national and international standards, and providing more detailed specifications for specific links or application scenarios of molybdenum wire production. These standards are usually closer to actual production needs, driving technological innovation and quality improvement.

7.3.1 National Technical Committee for Standardization of Nonferrous Metals (TC243)

The National Technical Committee for Standardization of Nonferrous Metals (TC243) is the main standardization body for China's non-ferrous metals industry, and has formulated a number of industry standards related to molybdenum wire, such as YS/T 369 "Chemical Analysis Methods for Molybdenum Wire". These standards detail the impurity detection, performance testing, and production process requirements of molybdenum wire, and are suitable for applications such as wire cutting, vacuum coating, and high-temperature furnaces. The standard requires molybdenum wire to have high purity and stable mechanical properties, and the detection methods include high-precision spectral analysis and tensile testing to ensure that the product quality meets the needs of the industry.

The industry standard also covers the operating specifications of production equipment, such as the operating parameters of wire drawing machines and sintering furnaces, emphasizing the stability and environmental friendliness of the process. The technical challenge lies in applying standards to diverse production scenarios, coordinating the equipment and process levels of different enterprises, and promoting the updating of standards to adapt to new technologies and applications. The TC243 standard provides technical guidance for China's molybdenum wire industry and promotes standardized management within the industry.

7.3.2 Internal Standards

A leading manufacturer of molybdenum wire, with in-house standards in place to meet specific customer needs and high-end applications. These standards are usually more stringent than national or international standards, with detailed specifications for the performance requirements of ultra-fine molybdenum wire, molybdenum lanthanum wire or molybdenum rhenium wire.

The company's internal standards also regulate the details of the production process, such as the accuracy of the drawing die and the purity of the annealing atmosphere, to ensure that the product meets the needs of high-end markets such as aerospace and medical. The technical challenge is to balance high standards with production costs, to optimize processes and testing equipment, and to ensure that standards match customer needs. These standards promote technological innovation and market competitiveness of enterprises.

7.4 Comparison and analysis of molybdenum wire standards

The comparative analysis of domestic and foreign and industry standards is helpful to understand the differences, applicability and limitations of molybdenum wire specifications, provide guidance for production and application, and promote the optimization and internationalization of the standard system.

7.4.1 Differences between domestic and foreign standards

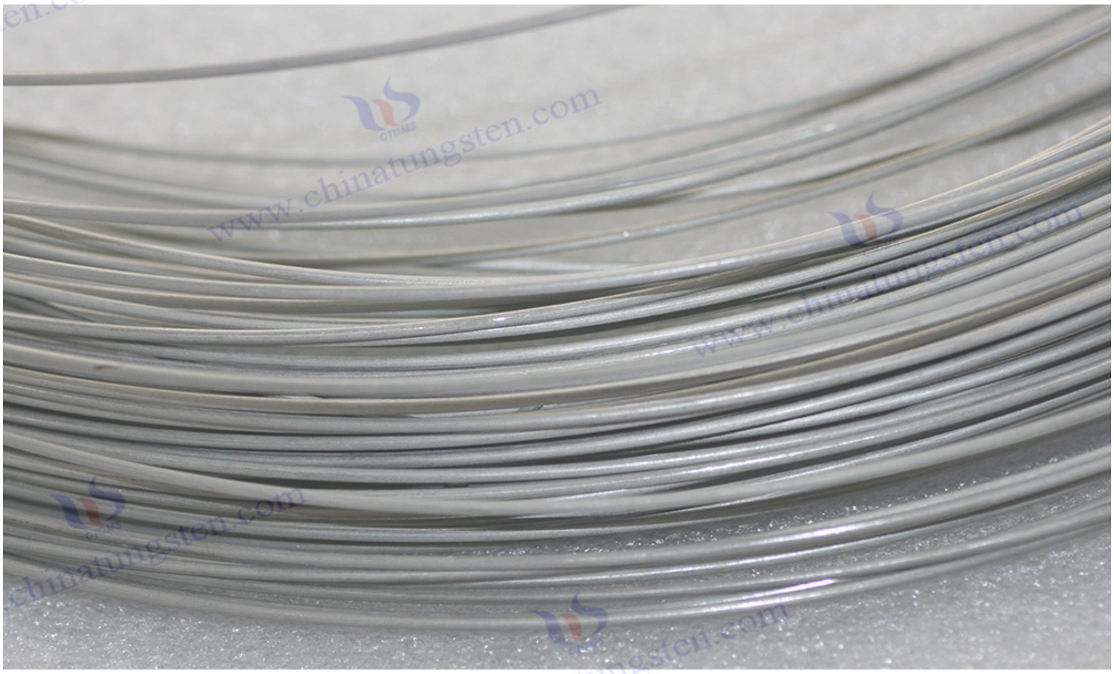
There are differences between domestic standards (such as GB/T 4182-2003) and international standards (such as ASTM B387) in chemical composition, mechanical properties and testing methods. Domestic standards pay more attention to the versatility of molybdenum wire, covering a variety of application scenarios, such as wire cutting and electric light sources, emphasizing production costs and efficiency, and are suitable for large-scale production in the Chinese market. International standards focus more on the performance requirements of high-end applications, such as aerospace and semiconductors, emphasizing high purity and precision testing, and are applicable to the global market. ISO standards focus on international commonality and harmonize national requirements, while JIS and DIN standards focus more on the specific needs of regional markets, such as electronic components in Japan and quality certifications in Germany.

In terms of detection methods, domestic standards mostly use chemical analysis and simple mechanical tests, and the testing equipment requirements are relatively simple, while international standards require high-precision spectrometers and microscopes, and the detection process is more complex. In terms of packaging and storage requirements, international standards are more stringent, emphasizing moisture-proof and anti-oxidation measures, which are suitable for long-distance transportation. The technical challenge is to reconcile these differences, to establish a unified quality certification system, and to promote the mutual recognition of domestic and foreign standards.

7.4.2 Applicability and Limitations of Standards

The suitability of molybdenum wire standards depends on the application scenario and market demand. Domestic standards are suitable for large-scale production and low-end applications, such as wire cutting and ordinary electric light sources, with low implementation costs and easy promotion. International standards are applicable to high-end markets, such as aerospace and medical devices, to meet high performance requirements but are expensive to implement. Industry standards and in-house standards are more application-specific and flexible, but they have a limited scope of application and may not be suitable for cross-industry rollout.

The limitation of the standard is that it is slow to update, and it is difficult to quickly adapt to the needs of new technologies and applications, such as ultra-fine molybdenum wire and new alloy wire. Some standards have insufficient requirements for environmental protection and energy saving, and green manufacturing specifications need to be supplemented. The technical challenge lies in formulating standards that take into account both universality and professionalism, and it is necessary to strengthen international cooperation and industry exchanges to promote the dynamic update and global application of standards.



CTIA GROUP LTD Molybdenum Wire

Chapter 8 Detection Methods of Molybdenum Wire

The performance of molybdenum wire directly affects its application effect in electric light source, wire cutting, vacuum coating and other fields, so it is necessary to evaluate its chemical composition, physical properties and surface quality through accurate detection methods. These detection methods cover a variety of techniques such as spectral analysis, mechanical testing, microscopic observation, etc., to ensure that molybdenum wire meets national standards (e.g., GB/T 4182-2003), international standards (e.g., ASTM B387), and specific industry needs. Inspection equipment needs to be highly accurate, responsive, and non-destructive to support efficient production and quality control. The following is a detailed text description of the methods, process requirements and challenges of chemical composition testing, physical property testing and surface quality testing of molybdenum wire.

8.1 Molybdenum wire chemical composition testing

Chemical composition testing is used to analyze the purity and impurity content of molybdenum wires to ensure that the material meets the requirements of high-performance applications, such as the conductivity of electric light sources and the corrosion resistance of high-temperature furnaces. The detection method needs to have high sensitivity and accuracy, be able to detect trace elements, and adapt to different specifications of molybdenum wire (such as pure molybdenum wire, molybdenum lanthanum wire).

8.1.1 Spectroscopic analysis (ICP-MS, XRF)

Spectroscopy is the main method for detecting the chemical composition of molybdenum filaments, and inductively coupled plasma mass spectrometry (ICP-MS) and X-ray fluorescence spectroscopy (XRF) are commonly used. ICP-MS analyzes the mass spectrum of elements by dissolving the molybdenum wire sample into a solution and ionizing it, which can accurately detect trace impurities (such as iron, carbon, oxygen), and is suitable for the composition analysis of high-purity molybdenum wire. The equipment is equipped with a high-resolution mass spectrometer and purification system to ensure that the test results are not disturbed by the environment, especially for the stringent requirements of molybdenum wire for semiconductors and medical devices. XRF is a non-destructive method that excites the surface of the molybdenum wire by X-rays and analyzes the fluorescence signal to determine the elemental composition, making it suitable for rapid batch detection and widely used in quality control on production lines.

In operation, ICP-MS is performed in an ultra-clean environment, sample preparation includes acid dissolution and dilution, and the purity of the solution needs to be tightly controlled to avoid contamination. XRF equipment needs to be calibrated regularly to ensure the stability and accuracy of the X-ray source. Both methods need to be compared with standards to ensure reliable results. The technical challenge is to increase detection sensitivity to identify ultra-low levels of impurities, while optimizing the sample preparation process to reduce detection time, requiring efficient data processing systems and cleanroom facilities.

8.1.2 Chemical titration

Chemical titration is a traditional chemical composition detection method, which quantitatively analyzes the main elements and some impurities in molybdenum wire through chemical reactions, and is suitable for laboratory and small batch testing. Methods include dissolving a sample of molybdenum wire in an acidic solution, adding a specific reagent to initiate a chemical reaction, and determining the elemental content by the titration endpoint. This method is simple to operate, low cost, suitable for the detection of molybdenum content and common impurities (such as sulfur, phosphorus), and is widely used for quality verification in the early stage of molybdenum wire production.

In operation, chemical titration requires the use of high-purity reagents and precision titration equipment to ensure stable reaction conditions and reproducible results. Sample preparation should be performed in a fume hood to prevent the leakage of harmful gases. The waste liquid needs to be neutralized and precipitated to meet the environmental protection requirements. The technical challenge is to improve the accuracy of titration for the detection of trace impurities, to optimize the reagent formulation and titration process, while reducing manual handling errors, and to be suitable for use in combination with spectroscopy to improve reliability.

8.2 Testing of physical properties of molybdenum wire

Physical property testing evaluates the mechanical properties of molybdenum wire, including tensile strength, elongation, and hardness, to ensure that it meets the mechanical requirements of applications such as wire cutting, heating elements, etc. These methods require the use of high-precision equipment that can accurately measure the performance of molybdenum wire in different states while accommodating the tiny size of ultra-fine molybdenum wire.

8.2.1 Tensile strength test

The tensile strength test is used to measure the breaking strength of molybdenum wire under tensile load, reflecting its mechanical strength and durability, and is suitable for molybdenum wire for wire cutting and high-temperature furnace. The test is carried out by a tensile testing machine, where the molybdenum wire is clamped in a special fixture, a progressively increasing tensile force is applied until it breaks, and the maximum load and deformation behavior are recorded. The equipment needs to be equipped with a high-precision force sensor and displacement control system to ensure stable clamping without damaging the surface of the molybdenum wire, and is suitable for testing coarse molybdenum wire and ultra-fine molybdenum wire.

During operation, the test should be carried out in a constant temperature and humidity environment to prevent environmental factors from affecting the results. The fixture design needs to accommodate different diameters of molybdenum wires to prevent sliding or local stress concentrations. The automatic control system records the tensile curve and analyzes the strength and toughness of the material. The technical challenge was to test the clamping stability of ultra-fine molybdenum wires, to design special micro fixtures, and to optimize the test speed to avoid strain rates affecting the results and to ensure that the data accurately reflected the performance of the molybdenum wires.

8.2.2 Elongation test

The elongation test evaluates the plastic deformation ability of molybdenum wire before tensile fracture, reflecting its ductility and toughness, and is suitable for electric light sources and molybdenum wire for microelectronics. The test is usually performed in conjunction with a tensile strength test, where a tensile testing machine is used to record the elongation of the molybdenum wire during the tensile process and calculate its elongation. The equipment needs to be equipped with a high-precision displacement sensor, which can detect micron-level deformation, which is suitable for the testing of ultra-fine molybdenum wires. The test results are used to evaluate the suitability of the molybdenum wire in the bending or winding process.

During operation, the test needs to ensure that the surface of the molybdenum wire is free of defects to prevent premature fracture from affecting the results. The fixtures need to be precisely aligned to reduce the effects of eccentricity forces. The automated system records the deformation curve and analyzes the plastic behavior of the molybdenum wire. The technical challenge is to achieve high-precision deformation measurements, optimizing sensor sensitivity and fixture design, while ensuring a stable test environment for repeatability.

8.2.3 Hardness test

The hardness test evaluates the deformation resistance of molybdenum wire, reflecting its wear resistance and processability, and is suitable for molybdenum wire for spraying and wire cutting. The Vickers hardness test or microhardness test is commonly used to determine the hardness of the material by applying a specific load to the surface of the molybdenum wire and measuring the indentation size. The equipment needs to be equipped with a high-precision indenter and a microscope, which can perform tests in a small area, and is suitable for the detection of ultra-fine molybdenum wires. The test results are used to evaluate the durability of molybdenum wire in a high-load environment.

During operation, the test needs to be carried out in a clean environment to prevent surface contamination from affecting the indentation measurement. The molybdenum wire needs to be fixed in a special fixture to ensure that the test point is flat. The automated system records the indentation image and calculates the hardness value. The technical challenge was to test the positioning accuracy of ultra-fine molybdenum wires, using high-resolution microscopes and miniature indenters, while optimizing load selection to avoid damaging the wire surface.

8.3 Molybdenum wire surface quality inspection

Surface quality inspection is used to evaluate the surface finish, defects, and roughness of molybdenum wires to ensure that they meet the high requirements of applications such as electric light sources, vacuum coatings, etc. The inspection method needs to be high-resolution and non-destructive, able to quickly identify surface defects and enable in-line inspection.

8.3.1 Microscopic observation

Microscopic observation is used to inspect scratches, cracks and oxide layers on the surface of molybdenum wire, and is suitable for quality control of electric light source and molybdenum wire for wire cutting. Optical microscopes are ideal for quick inspection of surface topography and are equipped with high-magnification objectives to observe micron-sized defects. Scanning electron microscopy (SEM) provides higher resolution and is suitable for analyzing the microstructure and surface defects of ultrafine molybdenum wires, revealing grain boundaries and processing traces. The equipment needs to be equipped with an image processing system that produces clear surface images for easy defect classification and analysis.

During operation, the molybdenum wire needs to be cleaned by ultrasonic to remove surface impurities to prevent interference with observation. Microscopes need to be calibrated regularly to ensure image quality and resolution. The test results are used to evaluate the effectiveness of the drawing and surface treatment processes. The technical challenge was to improve the microscope's imaging accuracy of ultra-fine molybdenum wires, to optimize the illumination system and sample fixation, and to reduce the effects of environmental vibrations.

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Molybdenum Wire Introduction

1. Overview of Molybdenum Wire

Molybdenum wire is a high-performance metallic filament made from metal molybdenum through hot working, cold drawing, and surface treatment. It features an extremely high melting point, excellent electrical and thermal conductivity, good mechanical strength, and exceptional corrosion resistance. It serves as a core material in various high-temperature and precision application fields.

2. Applications of Molybdenum Wire (Typical)

Application Field	Specific Uses
Lighting Industry	Filament supports, lead wires, halogen lamp electrodes, fluorescent lamp electrodes, LED packaging brackets
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Vacuum Coating	Used as evaporation sources and coating materials for optics, solar cells, and semiconductor devices

3. Types of Molybdenum Wire (Typical)

Classification	Type	Description
Surface Condition	Cleaned Molybdenum Wire	Cleaned surface, bright and smooth, suitable for high-precision processing, electronics, coating, and other demanding applications
	Black Molybdenum Wire	Graphite-coated surface, suitable for general industrial processing and cost-effective applications
Use-Based Category	Wire-Cut Molybdenum Wire	For EDM wire-cutting, features high strength, high precision, and excellent durability
	Thermal Spray Molybdenum Wire	Used in thermal spraying processes, requires high density and good melting properties
	Heating Molybdenum Wire	Used as a heating element in high-temperature furnaces, with excellent heat resistance

4. Specifications of Molybdenum Wire from CTIA GROUP LTD

Item	Specification
Purity	≥99.95%
Diameter Range	0.03 mm ~ 3.0 mm (customizable)
Length / Coil Weight	Custom cut lengths (e.g., 200 mm) or continuous winding (e.g., 500g/coil, 2kg/coil)
Diameter Tolerance	±0.002 mm ~ ±0.1 mm
Surface Condition	Cleaned / Black
Packaging Options	Spool, coil, vacuum packaging, customized packaging

5. Procurement Information

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Website: www.molybdenum.com.cn

8.3.2 Eddy current flaw detection

Eddy current flaw testing is used to detect microcracks, inclusions and internal defects on the surface of molybdenum wire, and is suitable for wire cutting and in-line inspection of molybdenum wire for electronic components. Through the principle of electromagnetic induction, the equipment generates eddy currents on the surface of the molybdenum wire to detect the changes in the electrical signal caused by defects, which has the characteristics of non-destructive and high sensitivity. Eddy current flaw detectors are equipped with multi-channel sensors and an automatic scanning system that can quickly detect long molybdenum wires and identify small defects, making them suitable for continuous production environments.

During operation, the equipment needs to be calibrated to accommodate different diameters of molybdenum wires to ensure detection sensitivity. The data processing system records the location and type of defects in real time and generates quality reports. Eddy current testing needs to be integrated with a wire drawing line to support high-speed inspection. The technical challenge is to improve detection accuracy to identify micron-scale defects, optimizing sensor design and signal processing algorithms, while reducing false alarms to improve reliability.

8.3.3 Surface roughness test

The surface roughness test evaluates the smoothness of the surface of a molybdenum wire, affecting its performance in vacuum coatings and electric light sources. The test uses a contact or non-contact roughness tester, and the contact device scans the surface of the molybdenum wire through a probe to measure the change of surface profile, which is suitable for the inspection of coarse molybdenum wire. Non-contact devices use lasers or optical systems and are suitable for the inspection of ultra-fine molybdenum wires to avoid probe damage. The equipment needs to be equipped with high-precision sensors and data analysis systems to generate surface roughness parameters that reflect the finish of the wire.

During operation, the molybdenum wire needs to be cleaned to remove oil from the surface, and the test needs to be carried out in a vibration-free environment to ensure accuracy. The automated system records the profile data and analyzes the surface quality. The technical challenge is to test the positioning accuracy of ultra-fine molybdenum wires, optimizing the sensitivity of the probe or laser system, and ensuring the adaptability of the device to different diameters of molybdenum wires.

8.4 Molybdenum wire size and tolerance testing

Dimensional and tolerance testing is used to evaluate the diameter consistency and geometric accuracy of molybdenum wires to ensure they meet the high accuracy requirements of applications such as wire EDM, electric light sources, and vacuum coatings. The detection method needs to have the characteristics of high resolution, fast response and non-destructiveness, adapt to a variety of specifications from coarse molybdenum wire to ultra-fine molybdenum wire, and meet the strict requirements of national standards (such as GB/T 4182-2003) and international standards (such as ASTM B387).

8.4.1 Laser caliper

Laser caliper is used to detect the diameter and roundness of molybdenum wire online or offline, and is widely used in real-time quality control of wire drawing production lines. The device scans the surface of the molybdenum wire by emitting a laser beam, analyzes the reflected or transmitted light signal, and calculates the diameter and geometric deviation of the wire, which is suitable for high-speed production environments. The laser caliper has the advantage of non-contact measurement, which avoids damage to the surface of the molybdenum wire, and is especially suitable for the detection of ultra-fine molybdenum wire. Its high resolution and fast response capability enable the capture of small dimensional changes in real time, ensuring that the wire meets the needs of precision applications such as micron-level tolerances in wire EDM.

During operation, the laser caliper needs to be operated in a vibration-free environment to prevent external interference from affecting the measurement accuracy. The device is equipped with a multi-axis laser scanning system, which is able to inspect the full circumference of the molybdenum wire and generate a detailed dimensional report. The calibration system uses standard samples to ensure reliable measurement results. The technical challenge was to improve the sensitivity of the inspection system to ultra-fine molybdenum wires, optimize the laser source and signal processing algorithms, and integrate an online monitoring system for real-time feedback and process adjustment.

8.4.2 Micrometers and micromeasurements

Micrometers and micromeasurements are used for off-line inspection of the diameter and surface geometry of molybdenum wires, suitable for laboratory and low-volume quality verification. The micrometer measures the diameter of the molybdenum wire by means of a precision mechanical structure and is equipped with a high-precision probe to detect the dimensional deviation of coarse molybdenum wire and medium diameter wire, and is suitable for spraying or heating element molybdenum wire. Microscopic measurement combined with optical microscope or digital microscope system magnates the surface of molybdenum wire, accurately measures the diameter and roundness, is suitable for the detection of ultra-fine molybdenum wire, and meets the high-precision requirements of microelectronics and medical equipment.

During operation, the micrometer needs to be calibrated regularly to ensure that the probe is flat and wear-free, and the molybdenum wire needs to be gently clamped to avoid deformation. Microscopic measurements require a clean surface of the molybdenum wire, ultrasonic cleaning to remove oil or particles, and testing at a constant temperature to eliminate the effects of thermal expansion. The data processing system records the measurement results and generates a tolerance analysis report. The technical challenge is to ensure that the measurement accuracy is suitable for ultra-fine molybdenum wires, optimizing the magnification of the microscope and the probe design of the micrometer, while reducing operational errors to improve repeatability.

8.5 Other tests of molybdenum wire

Other testing methods evaluate the high-temperature resistance, corrosion resistance, and electrical properties of molybdenum wire, ensuring its reliability in high-temperature furnaces, chemical environments, and electronic components. These methods combine laboratory testing and environmental simulations to verify the performance of molybdenum wire under extreme conditions to meet the needs of high-end applications such as aerospace and medical.

8.5.1 High temperature resistance test

The high-temperature performance test evaluates the stability, creep resistance and oxidation resistance of molybdenum wire in high-temperature environment, and is suitable for high-temperature furnaces and aerospace molybdenum wire. The test simulates the actual use environment through a high-temperature furnace, and places the molybdenum wire in a high-temperature atmosphere (such as hydrogen or vacuum) to observe its deformation, oxide layer formation and mechanical property changes. The equipment is equipped with a high-precision temperature control system and atmosphere conditioning device, which can simulate a variety of high temperature conditions to ensure that the test results reflect the performance of the molybdenum wire in real-world applications. The test also includes a thermal cycling experiment to evaluate the thermal shock resistance of the molybdenum wire under rapid temperature ramps.

During operation, the test needs to be carried out in a high-purity atmosphere or vacuum environment to prevent molybdenum filament oxidation, and the equipment needs to be equipped with an infrared thermometer to monitor the temperature in real time. The specimen fixture ensures that the molybdenum wire is heated evenly, and the surface and microstructure changes are observed through a microscope after the test. The technical challenge was to simulate extreme high temperature conditions while maintaining test accuracy, to optimize the thermal field distribution and atmosphere control in the furnace, and to equip an efficient exhaust gas treatment system to meet environmental requirements.

8.5.2 Corrosion Resistance Test

Corrosion resistance tests evaluate the stability of molybdenum wire in chemical environments such as acids, alkalis, or halogen gases and are suitable for halogen lamps, spray coatings, and molybdenum wire for medical devices. The test observes surface corrosion, mass loss, and performance changes by immersing the molybdenum wire in a corrosive medium such as a salt solution or acid, or by exposing it to a corrosive gas. The equipment includes a corrosion chamber and a gas circulation system capable of simulating a wide range of chemical environments, as well as high-precision balances and microscopes to analyze the degree of corrosion. The test also combines electrochemical methods to measure the corrosion potential and current of the molybdenum wire to evaluate its corrosion resistance mechanism.

In operation, the medium concentration and environmental conditions are tightly controlled to ensure reproducible results. The sample is cleaned by ultrasonic to remove surface impurities, and the corrosion products are detected by spectroscopic analysis after the test. Waste liquids and exhaust gases need to be neutralized and filtered to meet environmental standards. The technical challenge is to simulate the diversity of complex chemical environments, optimizing chamber design and corrosive media formulations, while increasing testing efficiency to support batch inspections.

8.5.3 Electrical performance test

The electrical performance test evaluates the conductivity and resistance characteristics of molybdenum wire, and is suitable for electric light sources, electronic components, and molybdenum wire for wire cutting. The test measures the resistivity and contact resistance of the molybdenum wire by means of a four-probe method or resistance tester to reflect its current conduction efficiency. The equipment is equipped with a high-precision current source and voltmeter, which can detect small changes in resistance, and is suitable for testing ultra-fine molybdenum wires. The test also includes a high-frequency discharge experiment to simulate the arc performance in wire cutting and evaluate the stability of the molybdenum wire under high-frequency currents.

During operation, the test should be carried out in a constant temperature and humidity environment to prevent environmental factors from affecting the resistance measurement. The molybdenum wire needs to be cleaned to remove the oxide layer from the surface, and the test fixture needs to ensure that the contact is stable and does not damage the wire. The data processing system records the resistance curve and analyzes the uniformity of the electrical properties. The technical challenge was to increase the sensitivity of the test to ultra-fine molybdenum wires, optimizing the fixture design and current control, while ensuring that the equipment could be adapted to the inspection needs of different wire diameters.

8.6 Identification method of waste molybdenum wire

The identification method of waste molybdenum wire is used to distinguish waste molybdenum wire from new wire or other metal wires (such as tungsten wire, steel wire), support recycling and reuse, and reduce resource waste. These methods are simple and efficient, suitable for both production and recycling, and combine physical, chemical and mechanical properties.

8.6.1 Burn test

The combustion test observes the reaction characteristics of the waste molybdenum wire by heating it and identifies its material. Molybdenum wire does not melt easily at high temperatures, and yellow molybdenum oxide powder is formed on the surface, while other metals (such as steel wire) may melt or produce oxides of different colors. The test uses a small combustion furnace or blowtorch to heat the molybdenum wire in air and observe its color change and oxidation products. The equipment needs to be equipped with a high-temperature heating device and ventilation system to ensure safe operation.

During operation, the test is carried out in a fume hood to prevent the oxide powder from spreading. The sample is cleaned to avoid impurities, and the oxidation product morphology is observed by microscopy after the test. The technical challenge is to quickly distinguish molybdenum wire from other metals with high melting points (e.g., tungsten wire) and to combine other test methods to improve the accuracy of identification.

8.6.2 Magnetic test

Magnetic testing uses the non-magnetic properties of molybdenum wire to distinguish it from ferromagnetic materials such as steel wire. The test uses a strong magnet or magnetic detector to observe whether the scrap molybdenum wire is magnetized, the molybdenum wire is not attracted due to its non-magnetic nature, and the steel wire usually exhibits significant magnetism. The equipment is simple and portable, suitable for on-site rapid detection, and is widely used for waste sorting.

During operation, the test needs to ensure that the strength of the magnet is sufficient, and the detection environment is free of strong magnetic field interference. The surface of the sample needs to be cleaned to prevent buildup from affecting the results. The technical challenge is to distinguish molybdenum wire from other non-magnetic metals (e.g., tungsten wire) and to combine other methods to improve the reliability of identification.

8.6.3 Concentrated nitric acid test

The concentrated nitric acid test identifies waste molybdenum filament through chemical reaction, and uses the low reactivity of molybdenum filament in concentrated nitric acid. Molybdenum wire reacts slowly in concentrated nitric acid and the surface remains smooth, while other metals, such as copper or steel, may dissolve quickly or produce significant corrosion. The test immersed the spent molybdenum filament in a concentrated nitric acid solution to observe the reaction speed and surface changes, and the equipment includes an acid-resistant container and ventilation system to ensure safe operation.

During operation, the test is carried out in a fume hood to prevent acid gas leakage. The sample should be cleaned to remove oil from the surface, and the corrosion traces should be observed through a microscope after the test. The waste liquid needs to be neutralized and treated to meet the requirements of environmental protection. The technical challenge is to control the nitric acid concentration and reaction time, and the test conditions need to be optimized to distinguish molybdenum wire from other corrosion-resistant metals.

8.6.4 Weight and elasticity checks

The weight and elasticity check are identified by measuring the density and mechanical properties of the scrap molybdenum wire. Molybdenum wire has a high density and elasticity, which is different from other metals such as aluminum or steel. The test uses a precision balance to measure the weight of the molybdenum wire, combined with the length to calculate the density. The elasticity check tests the flexibility and resilience of the molybdenum wire by manual bending or with a special fixture, and the molybdenum wire usually exhibits high toughness and elastic recovery.

In operation, high-precision balances are used to ensure accurate weight measurements. The elasticity test needs to be operated gently to prevent the molybdenum wire from breaking, which is suitable for the identification of coarse molybdenum wire. The technical challenge is to quickly distinguish molybdenum wire from other high-density metals, in combination with combustion or chemical testing to improve accuracy, while optimizing the testing process to support batch identification.

CTIA GROUP LTD Black Molybdenum Wire

Chapter 9 Molybdenum Wire Market and Development Trend

As a high-performance material, molybdenum wire has a wide range of applications in the fields of wire cutting, electric light source, aerospace, new energy and medical, and its market development is affected by global industrial technological progress, resource distribution and downstream demand. The global molybdenum wire market has maintained steady growth, and the Asia-Pacific region, especially China, occupies a dominant position by virtue of its resource advantages and manufacturing capabilities. The domestic market is highly competitive, with large enterprises consolidating their market position through technological innovation and large-scale production, while small and medium-sized enterprises are focusing on market segments. In the future, the molybdenum wire industry will develop in the direction of high performance, intelligence and sustainability, and the application of new materials, new processes and new energy, 5G and medical fields will further expand the market space. The following is an in-depth analysis of the current situation of the global and domestic molybdenum wire market, as well as technological progress and application prospects.

9.1 Overview of the global molybdenum wire market

The global molybdenum wire market is driven by a combination of resource distribution, production capacity, and downstream application demand. The unique properties of molybdenum wire in precision machining, electronic devices and high-temperature environments make it an irreplaceable material, and the market demand is closely related to industrial technology upgrading. Market development is faced with challenges such as fluctuating raw material prices, competition of alternative materials and environmental protection requirements, and it is necessary to ensure product quality and market competitiveness through efficient testing technology and process optimization.

CTIA GROUP LTD

Molybdenum Wire Introduction

1. Overview of Molybdenum Wire

Molybdenum wire is a high-performance metallic filament made from metal molybdenum through hot working, cold drawing, and surface treatment. It features an extremely high melting point, excellent electrical and thermal conductivity, good mechanical strength, and exceptional corrosion resistance. It serves as a core material in various high-temperature and precision application fields.

2. Applications of Molybdenum Wire (Typical)

Application Field	Specific Uses
Lighting Industry	Filament supports, lead wires, halogen lamp electrodes, fluorescent lamp electrodes, LED packaging brackets
Wire-Cut Machining	Electrode wire for EDM, used in mold making and cutting of complex metal parts
Thermal Spraying	Used for surface reinforcement and wear-resistant coatings on automotive, aerospace, and engineering components
Vacuum Coating	Used as evaporation sources and coating materials for optics, solar cells, and semiconductor devices

3. Types of Molybdenum Wire (Typical)

Classification	Type	Description
Surface Condition	Cleaned Molybdenum Wire	Cleaned surface, bright and smooth, suitable for high-precision processing, electronics, coating, and other demanding applications
	Black Molybdenum Wire	Graphite-coated surface, suitable for general industrial processing and cost-effective applications
Use-Based Category	Wire-Cut Molybdenum Wire	For EDM wire-cutting, features high strength, high precision, and excellent durability
	Thermal Spray Molybdenum Wire	Used in thermal spraying processes, requires high density and good melting properties
	Heating Molybdenum Wire	Used as a heating element in high-temperature furnaces, with excellent heat resistance

4. Specifications of Molybdenum Wire from CTIA GROUP LTD

Item	Specification
Purity	≥99.95%
Diameter Range	0.03 mm ~ 3.0 mm (customizable)
Length / Coil Weight	Custom cut lengths (e.g., 200 mm) or continuous winding (e.g., 500g/coil, 2kg/coil)
Diameter Tolerance	±0.002 mm ~ ±0.1 mm
Surface Condition	Cleaned / Black
Packaging Options	Spool, coil, vacuum packaging, customized packaging

5. Procurement Information

Email: sales@chinatungsten.com; Phone: +86 592 5129595; 592 5129696

Website: www.molybdenum.com.cn

9.1.1 Major producing countries

China, the United States, Chile, Peru and Canada are the major producers of molybdenum wire in the world, each of which occupies an important position in the market by virtue of its resource advantages and manufacturing technology. China has the world's largest molybdenum ore reserves, concentrated in Luanchuan, Henan, Jinduicheng, Shaanxi and other places, forming a complete industrial chain from molybdenum mining to molybdenum wire processing. Through large-scale production and advanced wire drawing technology, domestic enterprises supply molybdenum wire for wire cutting, electric light source and high-temperature furnace, and the products are exported to North America, Europe and Southeast Asia. The U.S. focuses on high value-added molybdenum wire, such as ultra-fine molybdenum wire for aerospace and medical use, relying on high-precision production equipment and rigorous testing technologies (such as laser diameter measurement, ICP-MS) to meet the high-end market demand. Chile and Peru use copper-molybdenum associated ore resources to produce molybdenum concentrate and process it into molybdenum wire for export to global markets, especially in South America and Europe. Canada supplies high-purity molybdenum wire through high-efficiency beneficiation and metallurgical technology, mainly serving the North American market.

China focuses on cost control and production scale, the United States and Canada emphasize high performance and precision machining, and Chile and Peru focus on raw material supply. During production, testing methods (e.g., eddy current testing, chemical composition analysis) ensure that the molybdenum wire meets international standards (e.g., ASTM B387). The technical challenge is to reconcile resource development with environmental requirements, to optimize the beneficiation and smelting processes, and to improve product quality through high-precision testing. For example, Chinese companies have significantly improved the dimensional consistency and surface finish of molybdenum wire by automating wire drawing and online monitoring systems.

9.1.2 Market Demand and Supply

The market demand for molybdenum wire mainly comes from wire cutting, electric light source, aerospace and new energy industries. In the field of wire cutting, there is a strong demand for high-strength, fine-diameter molybdenum wire, especially in automotive molds, aerospace parts and precision machining, molybdenum wire needs to have high tensile strength and wear resistance, and the performance is ensured by tensile testing and surface roughness testing. The electric light source industry relies on the high-temperature stability and conductivity of molybdenum wires, which are used in halogen lamps, LED filaments, and X-ray tube leads, and need to be tested for electrical properties to verify their low resistance characteristics. The aerospace industry requires molybdenum wire with excellent creep and corrosion resistance, and is used in engine nozzles and high-temperature supports, where high-temperature performance testing and microscopic observation are required to ensure reliability. The new energy industry, such as thin-film solar cells and wind power equipment, places higher demands on the conductivity and corrosion resistance of molybdenum wires, and verifies the stability of the material through chemical titration and corrosion testing.

On the supply side, global molybdenum wire production is affected by molybdenum mining efficiency and price fluctuations. Manufacturers stabilize the supply of raw materials by optimizing the supply chain and integrating resources. For example, Chinese companies use domestic molybdenum ore resources to ensure the quality of molybdenum powder through high-efficiency mineral processing equipment (such as flotation machines) and powder metallurgy technology. Technical challenges include dealing with raw material price fluctuations and improving production efficiency, as well as reducing costs through smart manufacturing and quality traceability technologies such as online monitoring systems as described in Chapter 8. The market is also facing competition from alternative materials such as tungsten filaments and carbon nanotubes, which require process innovation and detection technologies (such as spectroscopic analysis) to improve the performance advantages of molybdenum wires.

9.2 Domestic molybdenum wire market

China is the world's largest producer and consumer of molybdenum wire, relying on abundant molybdenum resources and a perfect manufacturing system to meet the needs of domestic and foreign markets. The market is highly competitive, with large enterprises dominating through technological innovation and brand advantages, and small and medium-sized enterprises through customized products and regional market competition.

9.2.1 Major manufacturers (e.g CTIA GROUP LTD）

CTIA GROUP LTD is a wholly-owned subsidiary of Chinatungsten Online with independent legal status. It is committed to promoting the intelligent, integrated, and flexible design and manufacturing of tungsten and molybdenum materials in the era of industrial internet. The company possesses a complete industrial chain from molybdenum concentrate refining to high-purity molybdenum wire processing. Its production equipment includes advanced multi-die wire drawing machines and automated annealing furnaces, while its inspection technologies cover laser diameter gauges and eddy current flaw detectors. The products are widely used in wire cutting, electric light sources, and high-temperature furnaces, meeting high precision and high-temperature performance requirements.

9.2.2 Market Share and Competitive Landscape

The domestic molybdenum wire market presents a pattern of high concentration and regional competition. Competitive drivers include technological innovation, inspection accuracy, and production efficiency. Leading companies improve production efficiency and product quality by integrating supply chains and introducing smart manufacturing technologies, such as automated wire drawing lines. Small and medium-sized enterprises (SMEs) are challenged by technology updates and cost pressures, and need to improve their competitiveness through partnerships with large enterprises or technology introduction. The market is also driven by export demand, with Chinese molybdenum wire being exported to Southeast Asia and Europe, where it is required to meet international standards (e.g. ASTM B387). The technical challenge is to balance high performance with low cost, and to cope with domestic and international competition through efficient testing and process optimization.

9.3 Development trend of molybdenum wire

The future development of molybdenum wire is driven by new materials, new processes, intelligent manufacturing and emerging application fields. Advances in inspection technology (such as eddy current flaw detection and laser path measurement as described in Chapter 8) support product quality improvement and new product development, and the market trend is evolving in the direction of high performance, green manufacturing, and intelligence.

9.3.1 Development of new materials and processes

The development of new materials and processes aims to improve the mechanical properties, conductivity and environmental adaptability of molybdenum wire. Doping technology significantly improves the high-temperature creep resistance and ductility of molybdenum wire by adding rare earth elements (such as lanthanum and cerium) or metal elements (such as rhenium). For example, molybdenum lanthanum wire can withstand longer thermal cycles in high-temperature furnaces, extending its service life. The new drawing process uses high-precision molds and environmentally friendly lubricants to produce finer and more uniform molybdenum wires that meet the micron-level requirements of 5G devices and microelectronics. Surface treatment technologies, such as molybdenum silicide coating and zirconia coating, enhance the oxidation and corrosion resistance of molybdenum wire, suitable for aerospace and halogen lamps.

Detection technology is critical in development. For example, microscopic observation is used to analyze the uniformity of the distribution of doped elements, and chemical titration verifies the stability of coating composition. The technical challenge is to balance performance gains with production costs, to reduce energy consumption through efficient testing (e.g. surface roughness testing) and automated equipment, while ensuring that new materials comply with international standards (e.g., ISO 24361).

9.3.2 Intelligent manufacturing and quality traceability technology

Smart manufacturing improves the efficiency and consistency of molybdenum wire production through automation, Internet of Things, and big data technologies. The automatic wire drawing production line integrates servo motors, sensors and PLC control systems to dynamically adjust the drawing speed and tension to reduce wire breakage and defect rate. The quality traceability system uses blockchain and barcode technology to record the chemical composition, processing parameters and test results of molybdenum wire from raw materials to finished products, ensuring that products comply with GB/T 4182 and ASTM B387 standards.

Smart manufacturing also supports real-time quality feedback, eddy current flaw detection and electrical performance test data directly transmitted to the control center to optimize process parameters. Examples include Luoyang Dingding's smart production line, which reduced the scrap rate by 10% through an online monitoring system. The technical challenges are system integration and data security, requiring the development of highly reliable software platforms and network protection measures, as well as the training of technicians to adapt to intelligent devices.

9.3.3 Development of new molybdenum alloy wires

The new molybdenum alloy wire improves performance through doping technology to meet the needs of high-end applications. Molybdenum lanthanum alloy wire is suitable for the supporting components of monocrystalline silicon growth furnace by adding lanthanum oxide to enhance creep resistance and toughness at high temperatures, and can withstand the thermal shock of rapid temperature rise and fall. Molybdenum-rhenium alloy wire meets the needs of 5G base station antennas and medical implantable electrodes by adding rhenium elements to improve electrical conductivity and corrosion resistance. Testing techniques (e.g. ICP-MS, hardness testing) are developed to verify alloy composition and mechanical properties to ensure stable performance.

9.3.4 Development of degradable or alternative materials

Molybdenum wire is difficult to achieve degradable properties as a metal material, but sustainability can be achieved through the recycling of waste molybdenum wire and the development of alternative materials. The waste molybdenum wire recycling technology uses chemical dissolution and electrolysis purification to convert the waste wire into high-purity molybdenum powder for reproduction. Alternative materials such as tungsten filaments, carbon nanotubes, and graphene wires are competitive in some applications. For example, tungsten filament gradually replaces molybdenum filament in high-temperature filament due to its higher melting point, but the cost is higher; Carbon nanotubes have potential in the field of microelectronics due to their light weight and high conductivity, but the production technology is not yet mature.

9.3.5 New application prospects of molybdenum wire in new energy, 5G and medical direction

The application of molybdenum wire in the fields of new energy, 5G and medical has broad prospects, driven by technological progress and market demand. In the field of new energy, molybdenum wire is used in the conductive layer of thin-film solar cells, which improves the efficiency of the cell with high conductivity and corrosion resistance. For example, a solar energy company uses molybdenum wire as the back electrode of a CIGS (copper indium gallium selenide) battery, and verifies its long-term stability through corrosion resistance tests. Wind power equipment uses molybdenum wire to make wear-resistant connectors, which need to pass hardness tests and tensile tests to ensure mechanical properties. The 5G field relies on the ultra-fine diameter and low resistance characteristics of molybdenum wire, which is applied to the RF components of base station antennas. In the medical field, molybdenum wire is used to make minimally invasive surgical guidewires and implantable electrodes, which need to be safed through microscopic observation and biocompatibility testing.

In the future, molybdenum wire will develop in the direction of finer diameter and higher performance to meet the needs of miniaturization and high reliability. For example, ultra-fine molybdenum wire can be used in the manufacture of antennas for 6G devices, where the size and conductivity need to be verified by laser diameter measurement and electrical performance testing. The technical challenge is to develop molybdenum wire for extreme environments, combining advanced inspection technologies (e.g., eddy current testing, high-temperature testing) and material innovation, while optimizing production costs to support large-scale applications.

CTIA GROUP LTD Black Molybdenum Wire

Chapter 10 Molybdenum Wire Environment and Safety

Molybdenum wire production involves complex beneficiation, metallurgy, wire drawing and surface treatment processes, which put forward strict requirements for environmental and safety management. Exhaust gases, wastewater, and solid waste from the production process need to be properly disposed of to comply with environmental regulations, and operators need to follow high temperature and chemical safety practices to reduce risks. The recycling and reuse of waste molybdenum wire reduces resource waste and promotes sustainable development through efficient processes. Environmental and safety management is not only about compliance, but also has a direct impact on the productivity and market competitiveness of enterprises. The following is an in-depth analysis of the environmental impact, safety specifications and recycling process of molybdenum wire production, and the implementation process and challenges through a detailed text description.

10.1 Environmental impact of molybdenum wire production

Molybdenum wire production involves multiple stages from molybdenum mining to finished product processing, which may generate exhaust gases, waste water and solid waste, which has potential environmental impacts. Efficient waste treatment technology and strict environmental protection measures ensure that the production process complies with national and international environmental protection standards (such as GB/T 17196, ISO 14001), reduces damage to the ecosystem, and at the same time enhances the corporate social responsibility image.

10.1.1 Waste gas and wastewater treatment

The waste gas in the production of molybdenum wire mainly comes from the molybdenite roasting and hydrogen reduction process, while the wastewater comes from the beneficiation, alkali washing and surface treatment processes. The roaster produces sulfur-containing waste gas when converting molybdenite into molybdenum oxide, which needs to be captured by a desulfurization device and converted into sulfuric acid or gypsum by-products for use in the building materials or chemical industries.

The wastewater mainly comes from flotation cells and caustic washing equipment, and contains heavy metal ions (e.g., molybdenum, copper) and chemical reagents (e.g., sodium hydroxide). The treatment process includes neutralization, precipitation and filtration, using flocculants to precipitate heavy metal ions into solid compounds, which are then separated by a filter press.

10.1.2 Solid waste management

Solid waste includes beneficiation tailings, sintering residues, and waste from the wire drawing process. The tailings are mainly composed of silica and low-grade molybdenite, and the residual molybdenum resources need to be recovered through stockpile management and re-separation techniques. The sintering residue contains molybdenum oxide and impurities, which need to be chemically purified into reusable molybdenum powder and tested for composition in combination with the chemical titration method in Chapter 8. Wire drawing waste includes broken wires and non-conforming wires, which are sorted and melted for recycling. Solid waste management requires dedicated storage facilities to prevent dust diffusion and rainwater leakage.

10.2 Safety Specifications for Molybdenum Wire Production

Molybdenum wire production involves high-temperature operation and the use of chemicals, which carries the risk of burns, poisoning, and equipment accidents, and requires strict safety practices to protect operators and equipment. Safety management combines national standards (e.g., GB/T 27948) and international norms (e.g., OSHA) to reduce risks through equipment maintenance, personnel training, and emergency measures.

10.2.1 Safety of high-temperature operation

High-temperature operations mainly involve roasters, sintering furnaces and annealing furnaces, which require equipment safety and personnel protection. Roasters and sintering furnaces operate in high-temperature environments, and the furnace body needs to be made of refractory materials and cooling systems to prevent equipment damage caused by overheating. The annealing furnace is protected by hydrogen or inert gas and is equipped with a gas leak detector and an automatic shut-off valve to ensure that the gas supply is quickly stopped in the event of a leak. Operators are required to wear high-temperature protective clothing and heat-insulating gloves, and receive professional training to master equipment operation and emergency handling.

Safety codes require regular inspections of furnace tightness and heating elements to prevent leakage of hot gases. The emergency plan includes fire prevention and evacuation drills, equipped with fire extinguishers and smoke extraction systems. The technical challenge was to balance efficiency and safety in high-temperature operations, optimizing the thermal field distribution and gas circulation system in the furnace, while reducing manual intervention through automated control.

CTIA GROUP LTD

Molybdenum Wire Introduction

1. Overview of Molybdenum Wire

Molybdenum wire is a high-performance metallic filament made from metal molybdenum through hot working, cold drawing, and surface treatment. It features an extremely high melting point, excellent electrical and thermal conductivity, good mechanical strength, and exceptional corrosion resistance. It serves as a core material in various high-temperature and precision application fields.

2. Applications of Molybdenum Wire (Typical)

Application Field	Specific Uses
Lighting Industry	Filament supports, lead wires, halogen lamp electrodes, fluorescent lamp electrodes, LED packaging brackets
Wire-Cut Machining	Electrode wire for EDM, used in mold making and cutting of complex metal parts
Thermal Spraying	Used for surface reinforcement and wear-resistant coatings on automotive, aerospace, and engineering components
Vacuum Coating	Used as evaporation sources and coating materials for optics, solar cells, and semiconductor devices

3. Types of Molybdenum Wire (Typical)

Classification	Type	Description
Surface Condition	Cleaned Molybdenum Wire	Cleaned surface, bright and smooth, suitable for high-precision processing, electronics, coating, and other demanding applications
	Black Molybdenum Wire	Graphite-coated surface, suitable for general industrial processing and cost-effective applications
Use-Based Category	Wire-Cut Molybdenum Wire	For EDM wire-cutting, features high strength, high precision, and excellent durability
	Thermal Spray Molybdenum Wire	Used in thermal spraying processes, requires high density and good melting properties
	Heating Molybdenum Wire	Used as a heating element in high-temperature furnaces, with excellent heat resistance

4. Specifications of Molybdenum Wire from CTIA GROUP LTD

Item	Specification
Purity	≥99.95%
Diameter Range	0.03 mm ~ 3.0 mm (customizable)
Length / Coil Weight	Custom cut lengths (e.g., 200 mm) or continuous winding (e.g., 500g/coil, 2kg/coil)
Diameter Tolerance	±0.002 mm ~ ±0.1 mm
Surface Condition	Cleaned / Black
Packaging Options	Spool, coil, vacuum packaging, customized packaging

5. Procurement Information

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10.2.2 Safe use of chemicals

The use of chemicals involves flotation agents in beneficiation, sodium hydroxide in caustic washes, and acidic electrolytes in surface treatments, which present a risk of corrosion and poisoning. Flotation agents (e.g. xanthate) need to be stored in an airtight container and accurately dosed through an automatic dosing system to reduce volatilization and leakage. The alkali washing equipment uses sodium hydroxide solution, and needs to be equipped with corrosion-resistant pipes and waste liquid collection tanks to prevent the solution from overflowing.

Safety regulations require operators to wear chemical protective suits, protective eyewear and respirators, and to be trained in chemical safety. Warning signs and emergency flushing devices should be installed in the chemical storage area to prevent accidental contact. The waste liquid needs to be neutralized and precipitated, and the composition of the waste liquid is tested in conjunction with the chemical titration method in Chapter 8 to ensure that the discharge standards are met. The technical challenge is to improve the safety of chemical use, to optimize equipment tightness and exhaust gas and liquid treatment efficiency, while reducing manual contact through automated systems.

10.3 Recycling and reuse of waste molybdenum wire

The recycling and reuse of waste molybdenum wire reduces resource waste through efficient processes and promotes a circular economy. The recycling process needs to be combined with the identification methods in Chapter 8 (such as combustion test, concentrated nitric acid test) to ensure the quality of the waste, and at the same time adopt environmental protection technology to reduce secondary pollution and meet the requirements of sustainable development.

10.3.1 Recycling Process

The waste molybdenum wire recycling process includes collection, sorting, purification and reprocessing, and is suitable for wire cutting, electric light source and high-temperature furnace waste wire. In the collection stage, the waste molybdenum wire is separated from other metal scrap (such as steel wire and tungsten wire) by a sorting device, and the non-magnetic molybdenum wire is distinguished by the magnetic test in Chapter 8, the oxidation characteristics are verified by the combustion test, and the corrosion resistance is confirmed by the concentrated nitric acid test. The sorted waste molybdenum wire is cleaned by ultrasonic to remove the surface oil and oxide layer to ensure the purification efficiency. In the purification stage, the waste molybdenum wire is dissolved into molybdate solution by chemical dissolution or electrolysis process, and then converted into high-purity molybdenum powder by electrolysis or reduction.

In the reprocessing stage, the molybdenum powder is pressed into a blank through a powder metallurgy process, and then a new molybdenum wire is made by drawing and annealing. Detection techniques (e.g., ICP-MS, microscopic observation) are used to verify the chemical composition and microstructure of the recovered molybdenum powder to ensure that it meets the GB/T 3462 standard. The recycling equipment needs to be equipped with high-efficiency filtration and waste liquid treatment systems to prevent secondary pollution. The technical challenge is to improve recycling efficiency and product quality, optimize electrolysis parameters and testing processes, and

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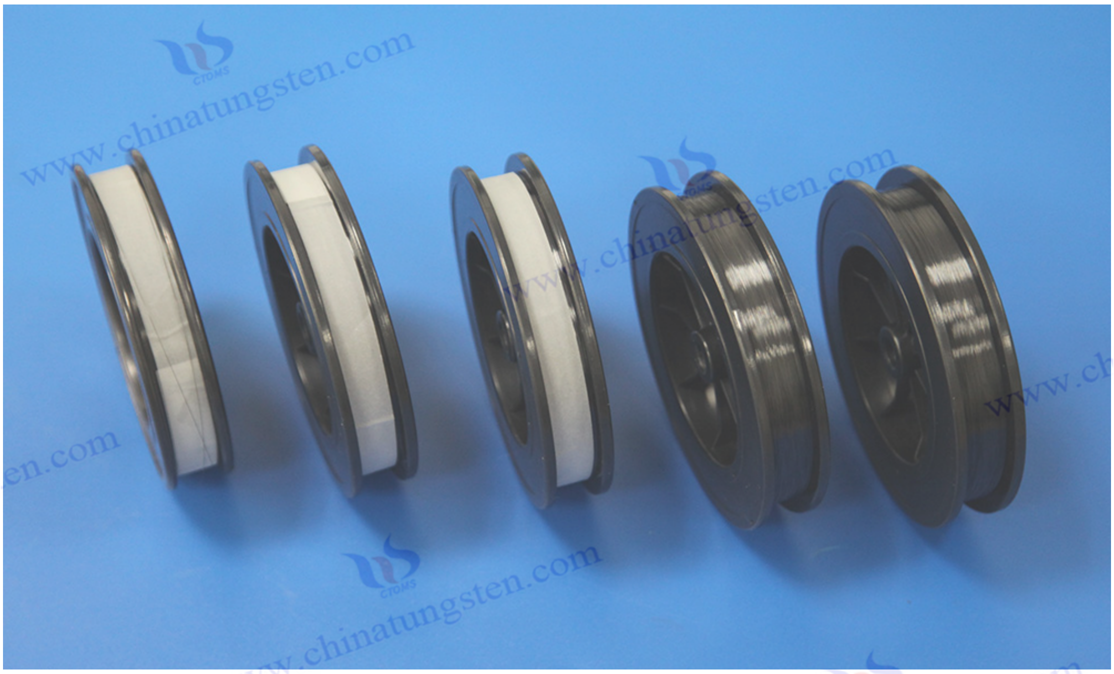
develop automated recycling equipment to support large-scale production.



CTIA GROUP LTD Black Molybdenum Wire

Appendix

A. Glossary

Molybdenum Wire: A fine wire material made from molybdenum or molybdenum alloys.

Pure Molybdenum Wire: Molybdenum wire made from high-purity molybdenum, typically with a purity of ≥99.95%.

Lanthanum Molybdenum Wire: Molybdenum wire doped with rare earth lanthanum, characterized by a high recrystallization temperature.

Yttrium Molybdenum Wire: Molybdenum wire doped with yttrium, known for excellent tensile strength and toughness.

Si-Al-K Molybdenum Alloy Wire: Molybdenum alloy wire containing silicon, aluminum, potassium, etc., mainly used in the lighting industry.

Molybdenum-Rhenium Wire: An alloy wire of molybdenum and rhenium, used in high-temperature and corrosive environments.

Black Molybdenum Wire: Molybdenum wire that has not undergone alkaline cleaning, with a dark gray surface.

White Molybdenum Wire: Molybdenum wire that has been alkaline-cleaned, presenting a silvery-white surface.

Wire Cutting: A machining technique that uses molybdenum wire as an electrode wire for metal cutting via electrical discharge machining (EDM).

Thermal Spraying: A process in which molten molybdenum wire is sprayed onto a substrate surface to enhance wear resistance.

Powder Metallurgy: A process that produces molybdenum billets by compacting and sintering molybdenum powder.

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Wire Drawing: A processing method in which molybdenum billets are drawn into fine wire.
Annealing: A heat treatment process involving heating and cooling to improve the mechanical properties of molybdenum wire.
Eddy Current Testing: A non-destructive testing method used to detect surface defects on molybdenum wire.
Tensile Strength: The maximum stress molybdenum wire can withstand while being stretched.
Recrystallization Temperature: The temperature at which the crystal structure of molybdenum wire is restored during high-temperature exposure.
Electrical Conductivity: The ability of molybdenum wire to conduct electric current.
Thermal Conductivity: The ability of molybdenum wire to conduct heat.
Corrosion Resistance: The stability of molybdenum wire in corrosive environments.
High-Temperature Stability: The ability of molybdenum wire to maintain performance in high-temperature conditions.

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