Complete Guide to Molybdenum Spray 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

TEL: 0086 592 512 9696

sales@chinatungsten.com

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 Spray Wire Introduction

1. Overview of Molybdenum Spray Wire

Molybdenum spray wire is a high-purity molybdenum metal wire that is melted and deposited onto a substrate surface through thermal spray techniques such as flame spraying, plasma spraying, arc spraying, or HVOF (High Velocity Oxy-Fuel). The resulting coating offers excellent resistance to wear, corrosion, and high temperatures. Due to its high melting point and superior performance, molybdenum wire is widely used across various industrial sectors.

2. Characteristics of Molybdenum Spray Wire

High Melting Point: Approximately 2623° C, suitable for high-temperature environments.
Excellent Corrosion Resistance: Resists attack from acids, alkalis, and chemical media.
High Hardness & Wear Resistance: Tough coating that withstands mechanical wear.
Low Friction Coefficient: Reduces component wear and improves efficiency.
Chemical Stability: Maintains performance in harsh environments.
High Thermal Conductivity: Effectively dissipates heat and extends component lifespan.

3. Typical Uses of Molybdenum Spray Wire

Aerospace: Turbine blades, engine parts, thermal barrier coatings.
Automotive Industry: Wear-resistant coatings for piston rings, engine blocks, and brake discs.
Chemical & Energy Sectors: Corrosion-resistant pipelines, heat exchangers, wind power equipment.
Electronics & Semiconductors: Vacuum deposition heating wires, semiconductor leads.
Medical Field: Corrosion-resistant coatings for implants and surgical instruments.
Others: Marine anti-corrosion, wear-resistant construction machinery, high-temperature furnaces.

4. Basic Data of Molybdenum Spray Wire from CTIA GROUP LTD

Purity	≥99.95%
Density	10.2 g/cm³
Diameter Range	1.0-3.0 mm, customizable
Tensile Strength	Moderate to ensure stable wire feeding
Packaging	Customized Packaging

5. Procurement Information

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

Directory

TEL: 0086 592 512 9696

sales@chinatungsten.com

Chapter 1 Introduction

1.1 Definition and concept of molybdenum spray wire

1.1.1 Basic definition of molybdenum spray wire

Molybdenum spray wire is a metal wire material specifically used in the thermal spray process, usually made of high-purity molybdenum (Molybdenum, chemical symbol Mo, atomic number 42). Molybdenum is a transition metal with properties such as high melting point (about 2623°C), high strength, corrosion resistance and excellent thermal conductivity, which makes it one of the important materials in the field of thermal spraying. Thermal spraying is a surface engineering technique that creates a layer of coating with a specific function by spraying molten or semi-melted material onto the surface of a substrate at high velocity. As a raw material for thermal spraying, molybdenum spray wire is usually used in the form of arc spraying or flame spraying, and its main purpose is to form a layer of wear-resistant, high-temperature or corrosion-resistant molybdenum coating on the surface of the substrate.

The typical form of molybdenum spray wire is a slender metal wire, usually between 1.0mm and 3.2mm in diameter, depending on the spraying equipment and process requirements. The molybdenum wire is heated to a molten or semi-molten state by a spray gun during the spraying process, and then accelerated by a compressed gas (such as nitrogen or air) onto the target substrate to form a uniform coating. Such coatings typically have high hardness, low coefficient of friction and good bond strength, which can significantly improve the surface properties of the substrate.

1.1.2 Physical and chemical properties of molybdenum

Molybdenum's unique physical and chemical properties are the basis for its use as a coating material. Molybdenum has a density of 10.28 g/cm³, which is lower than tungsten (19.25 g/cm³) but higher than many common metals, which allows molybdenum coatings to achieve a good balance between weight and performance. Molybdenum has a high melting point of 2623°C, second only to tungsten and rhenium, which allows it to maintain structural stability and mechanical strength at high temperatures. In addition, molybdenum is more resistant to acids, alkalis, and certain corrosive gases than many other metals, especially in non-oxidizing environments.

Molybdenum has a low coefficient of thermal expansion (about 4.8×10^{-6}/K), which means that in environments with drastic temperature changes, there is less thermal stress between the molybdenum coating and the substrate, reducing the risk of cracking or peeling of the coating. Molybdenum also has good electrical and thermal conductivity (thermal conductivity of about 138 W/m·K), which makes the coating formed by molybdenum spray wire advantageous in applications where thermal or electrical conductivity is required. In addition, molybdenum is self-lubricating under certain conditions, especially at high temperatures or in a vacuum, which further expands its application scenarios.

1.1.3 Preparation process of molybdenum spray wire

The preparation of molybdenum spray wire requires multiple processes to ensure its high purity and consistent physical properties. Molybdenum wire is usually prepared by powder metallurgy

TEL: 0086 592 512 9696

sales@chinatungsten.com

technology, and the specific steps include:

Molybdenum concentrate extraction: Molybdenum concentrate is extracted from molybdenum ore (such as molybdenite) to remove impurities through flotation and chemical purification.
Molybdenum powder production: molybdenum concentrate is roasted to produce molybdenum oxide (MoO_3), and then high-purity molybdenum powder is obtained by hydrogen reduction.
Molybdenum billet forming: Molybdenum powder is pressed into a rod or plate blank and sintered at high temperatures to increase density.
Wire drawing: Through hot forging, rolling and multiple wire drawing processes, the molybdenum billet is processed into filaments to achieve the diameter and surface finish required for spraying.
Surface treatment: Molybdenum wire is cleaned, annealed or doped to optimize its mechanical properties and spraying effect.

The purity of molybdenum wire is usually required to reach more than 99.95% to ensure the quality of the spray coating. Some molybdenum spray wires may be doped with small amounts of elements (such as lanthanum, cerium, or potassium) to improve their resistance to high-temperature oxidation or ductility.

1.1.4 The role of molybdenum spray wire in thermal spraying

In the thermal spraying process, the molybdenum wire is fed into the spraying gun by arc spraying or flame spraying equipment, and when heated, it forms molten droplets or semi-molten particles. These particles hit the surface of the substrate under the action of high-velocity air currents, quickly cool and solidify, forming a dense coating. The main functions of molybdenum coating include:

Wear protection: The high hardness of the molybdenum coating (approx. 5.5 on the Mohs scale) makes it effective against mechanical wear.
High Temperature Protection: Molybdenum's high melting point makes it suitable for use in components in high temperature environments, such as aero engine turbine blades.
Corrosion Protection: Molybdenum's corrosion resistance to certain chemicals makes it suitable for use in chemical equipment or marine environments.
Self-lubricating properties: Molybdenum coatings can form molybdenum oxide (MoO_3) at high temperatures or in vacuum environments, and have a low coefficient of friction, making them suitable for use in sliding parts.

1.1.5 Comparison of molybdenum spray wire with other spraying materials

Compared to common spray materials such as nickel-based alloys, tungsten or ceramics, molybdenum spray wire offers the following advantages:

Cost-effective: Molybdenum costs less than tungsten and some precious metals, but has similar performance and is suitable for large-scale industrial applications.
Versatility: Molybdenum coatings are resistant to abrasion, high temperatures, and corrosion, and are suitable for a wide range of applications.
Ease of processing: The ductility of molybdenum wire makes it easy to draw into different

TEL: 0086 592 512 9696
sales@chinatungsten.com

specifications and adapt to a variety of spraying equipment.

However, molybdenum is prone to the formation of volatile oxides (MoO_3) in oxidizing atmospheres, which limits its application in some high-temperature oxidizing environments. In contrast, ceramic coatings may be better in terms of oxidation resistance, but they are more brittle and do not have as strong binding strength as molybdenum coatings.

1.1.6 Specifications and classification of molybdenum spray wire

Molybdenum spray wire can be divided into a variety of specifications according to the use and process requirements, and the common classifications include:

Pure molybdenum wire: ≥ 99.95% purity, used in standard spraying processes.
Doped molybdenum wire: Doped with elements such as lanthanum (La), cerium (Ce) or potassium (K) to improve oxidation resistance or ductility.
Diameter classification: Common diameters include 1.0mm, 1.6mm, 2.0mm, 3.2mm, etc., which are suitable for different spraying equipment.
Surface treatment classification: such as black molybdenum wire (uncleaned, with an oxide layer on the surface) and white molybdenum wire (bright surface after cleaning).

These classifications enable molybdenum spray wire to meet the needs of different industrial applications, such as aerospace, automotive manufacturing, and energy equipment.

1.2 The historical evolution of molybdenum spray wire

1.2.1 Discovery and early application of molybdenum

The discovery of molybdenum dates back to the 18th century. In 1778, the Swedish chemist Carl Wilhelm Scheele first isolated molybdenum oxide from molybdenite and named it "molybdenum" (derived from the Greek word "molybdos", meaning a lead-like substance). In 1781, the Swedish chemist Peter Jacob Hjelm prepared molybdenum metal for the first time by carbon reduction, laying the foundation for the industrial application of molybdenum.

At the end of the 19th century, molybdenum began to be used as an alloying element in the steel industry to improve the strength and corrosion resistance of steel. However, due to the limitations of molybdenum purification and processing technology, its application scope is relatively narrow, mainly limited to the metallurgical field. Until the beginning of the 20th century, with the progress of powder metallurgy and wire drawing technology, the preparation of molybdenum wire became possible, providing conditions for its application in the field of spraying.

1.2.2 Origin of thermal spray technology

Thermal spray technology originated in the early 20th century. In 1910, Swiss engineer Max Ulrich Schoop invented the flame spraying technique, which melted and sprayed metal powder or wire onto the surface of the substrate by burning combustible gas. The emergence of this technology provides the possibility for the application of molybdenum spray wire. In the 1920s, arc spraying technology was introduced, which used an electric arc to heat wire to generate molten droplets, further improving spraying efficiency and coating quality.

Early thermal spraying mainly used meltable metals, such as zinc and aluminum, for anti-corrosion coatings. As a metal with a high melting point, the application of molybdenum in thermal spraying started late, and it was not until the middle of the 20th century, with the development of superalloys and aerospace industry, that the spraying application of molybdenum wire gradually attracted attention.

1.2.3 Early development of molybdenum spray wire

In the 50s of the 20th century, molybdenum spray wire began to emerge in the industrial field. The aerospace industry in the U.S. pioneered the application of molybdenum coatings to turbine blades and combustion chamber components to combat high temperatures and wear issues. Molybdenum's high melting point and wear resistance make it an ideal coating material, especially in gas turbines and jet engines. At the same time, industry in Europe and Japan began to explore the application of molybdenum wire spraying in machine building, such as wear-resistant coatings for piston rings and bearings.

During this period, the preparation technology of molybdenum spray wire was still relatively rough, and the purity and surface quality of molybdenum wire were unstable, resulting in large fluctuations in coating properties. In the 1960s, with advances in vacuum melting and hydrogen reduction technology, the purity of molybdenum wire was significantly improved, and the bonding strength and durability of spray coatings were improved.

1.2.4 Development of modern molybdenum spray wire technology

After the 70s of the 20th century, thermal spraying technology entered a stage of rapid development. The advent of plasma spraying and high-velocity flame spraying (HVOF) has significantly improved the quality of spray coatings, allowing molybdenum coatings to be used in more demanding environments. For example, high-velocity flame spraying can create a denser molybdenum coating, reduce porosity, and improve the bonding strength of the coating to the substrate.

During the same period, a breakthrough was made in the doping technology of molybdenum wire. Molybdenum wire doped with lanthanum or cerium exhibits better oxidation resistance and ductility in high temperature environments, expanding the application field of molybdenum spray wire. In the 1980s, molybdenum spray wire began to be widely used in the automotive industry to make wear-resistant piston rings and synchronizer rings, significantly extending the service life of parts.

1.2.5 The development of molybdenum spray wire in China

China's molybdenum industry started late, but it is developing rapidly. In the 60s of the 20th century, China began to extract molybdenum from molybdenite and gradually established molybdenum wire production capacity. In the 1980s, with the advancement of reform and opening up and industrial modernization, China's molybdenum products enterprises began to introduce foreign advanced wire drawing and spraying equipment, and the production and application of molybdenum spray wire entered a period of rapid development.

In the 1990s, China became the world's largest producer of molybdenum, and the production technology of molybdenum wire gradually matured. Through technological innovation, China's major molybdenum products enterprises have developed high-purity molybdenum wire and doped molybdenum wire to meet the needs of the domestic and foreign spraying markets. After 2000, China's molybdenum spray wire began to be exported to Europe, America and Southeast Asian markets, becoming an important part of the global molybdenum product supply chain.

1.2.6 Milestones in the coating of molybdenum wire

1910: Thermal spraying technology was invented, laying the foundation for the application of molybdenum spray wire.
1950s: Molybdenum wire spraying is first used in the aerospace sector.
1970s: Plasma spraying and high-velocity flame spraying technologies drive improved molybdenum coating performance.
1980s: Development of doped molybdenum wire to improve the oxidation resistance of coatings.
After 2000, China became an important base for global molybdenum wire production and spraying technology.

1.3 Industrial value and application prospect of molybdenum spray wire

1.3.1 Industrial value of molybdenum spray wire

As the core material in thermal spraying technology, the industrial value of molybdenum spray wire is reflected in its unique physical and chemical properties, a wide range of application scenarios, and its contribution to the efficiency and sustainability of modern industry. Molybdenum's high melting point, high hardness, corrosion resistance and self-lubricating properties make it irreplaceable in the field of surface engineering. The following is a detailed analysis of its industrial value from multiple dimensions.

1.3.1.1 Improve the durability and life of components

The coating formed by molybdenum spray wire significantly extends the service life of mechanical components with its high hardness (about 5.5-6.0 on the Mohs scale) and wear resistance. For example, in the automotive industry, piston rings and synchronizer rings are critical components in engines and transmissions that are subjected to high-frequency friction and high-temperature environments for long periods of time. While conventional uncoated piston rings can wear out for thousands of hours under high loads, molybdenum-coated piston rings can extend their life by a factor of 2-3, with some cases showing a service life of more than 100,000 km. This increased durability directly reduces maintenance costs and equipment downtime.

In addition, the stability of molybdenum coatings in high-temperature environments makes them of great value in the aerospace industry. For example, the turbine blades of gas turbines operate in combustion environments in excess of 1000°C, and molybdenum coatings are effective in resisting thermal fatigue and wear, extending blade life. According to industry data, the maintenance interval of molybdenum-coated turbine blades can be extended by 20%-30%, significantly reducing the full

TEL: 0086 592 512 9696

sales@chinatungsten.com

life cycle cost of aero engines.

1.3.1.2 Improve the efficiency of equipment operation

The low coefficient of friction (as low as 0.1-0.2 under certain conditions) of molybdenum coatings makes them self-lubricating, which can significantly reduce frictional losses in mechanical components and thus improve the operating efficiency of equipment. In the automotive industry, the application of molybdenum-coated piston rings can reduce the frictional power consumption inside the engine and improve fuel efficiency by about 1%-2%. Based on the global annual output of 80 million vehicles, if 10% of the engine uses molybdenum-coated piston rings, millions of tons of fuel can be saved every year, and the economic and environmental benefits are significant.

In the aerospace sector, molybdenum coatings are used in the combustion chambers and nozzles of jet engines to reduce material loss at high temperatures and ensure stable thrust. Studies have shown that the thermal efficiency of molybdenum-coated combustion chambers can be improved by about 0.5%, which is important in the aerospace sector, as even small efficiency gains can significantly reduce fuel consumption and operating costs.

1.3.1.3 Reduce production and maintenance costs

Compared with high melting point metal or ceramic coatings such as tungsten and rhenium, molybdenum has a higher cost performance. The global reserves of molybdenum are relatively abundant (about 25 million tons, of which China accounts for more than 50%), and the purification and processing costs are lower than that of tungsten (about 1/2-1/3). The cost of molybdenum spray wire is about $50-$100 per kilogram, while the cost of tungsten wire can reach more than $200. This makes molybdenum coatings more economically advantageous for large-scale industrial applications.

In addition, the restorative properties of molybdenum coatings are one of its important values. Worn molybdenum coatings can be repaired by re-spraying without replacing the entire part. For example, in the bearing repair of heavy machinery, the application of molybdenum coating can reduce repair costs by more than 50% while reducing downtime. This restorative nature is particularly important in the mining, steel, and energy industries, where large equipment replacements are costly and time-consuming.

1.3.1.4 Meet the requirements of environmental protection and sustainable development

Molybdenum is a non-toxic and environmentally friendly metal material that meets the requirements of the EU RoHS directive and REACH regulations. Compared with traditional lead-based or cadmium-based coatings, molybdenum coatings do not release harmful substances during production and use, and are harmless to the environment and human health. In addition, the durability of the molybdenum coating reduces the frequency of parts replacement, thereby reducing resource consumption and waste generation, in line with the concept of green manufacturing.

In terms of energy efficiency, the self-lubricating properties of molybdenum coatings reduce the use of lubricating oils. For example, in automotive engines, molybdenum-coated piston rings can reduce lubricant consumption by about 10 percent, reducing waste oil disposal costs. This is of great significance for the global promotion of a low-carbon economy and a circular economy.

1.3.1.5 Promote industrial intelligence and efficiency

With the advancement of Industry 4.0, the demand for high-performance materials for smart manufacturing is increasing. The precise processing and coating uniformity of the molybdenum spray wire enables it to meet the requirements of precision manufacturing. For example, in robotic joints and high-speed cutting tools, molybdenum coatings can reduce friction and heat accumulation, improving motion accuracy and tool life. Studies have shown that the life of molybdenum-coated cutting tools can be extended by 30%-50%, which has significant advantages in automated production lines.

In addition, the conductivity of the molybdenum coating (resistivity about 5.5×10^{-8} Ω·m) and thermal conductivity (approx. 138 W/m·K) make it unique in electronic and energy devices. For example, in semiconductor manufacturing equipment, molybdenum coatings can be used for electrodes and thermally conductive components to improve the stability and heat dissipation efficiency of the equipment.

1.3.2 Main application areas

The coating of molybdenum spray wire is widely used in many industrial fields due to its versatility, and the following is a detailed analysis of its main application scenarios:

1.3.2.1 Aerospace

Aerospace is one of the most important application areas for molybdenum spray wire. Molybdenum coatings are mainly used for high-temperature components such as turbine blades, combustion chambers, nozzles, and guide vanes. For example, in the turbofan engines of the Boeing 737 and Airbus A320, molybdenum coatings are used to protect turbine blades from wear and maintain stable performance above 1200°C. The coefficient of thermal expansion of the molybdenum coating (about 4.8×10^{-6}/K) is close to that of nickel-based superalloys, reducing coating spalling caused by thermal stress.

In addition, molybdenum coatings are also used in spacecraft thermal protection systems. For example, some parts of SpaceX's Starship are coated with molybdenum to withstand the extreme heat during re-entry. Studies have shown that the self-lubricating properties of molybdenum coatings in a vacuum environment make them particularly suitable for sliding parts of spacecraft, such as satellite antenna drive mechanisms.

1.3.2.2 Automotive industry

The automotive industry is one of the largest markets for molybdenum spray wire, with about 30% of the world's molybdenum spray wire used in the manufacture of automotive parts. Molybdenum coatings are mainly used in components such as piston rings, synchronizer rings, crankshafts and valves. For example, the Volkswagen Group has made extensive use of molybdenum-coated piston rings in its TSI engines to improve fuel efficiency and durability. The data shows that molybdenum-coated piston rings can reduce friction losses by about 15%, significantly improving engine performance.

In addition, molybdenum coating also has potential in the field of new energy vehicles. For example, motor bearings and transmission gears in electric vehicles can be coated with molybdenum to improve wear resistance and thermal conductivity and extend service life. It is estimated that by 2030, the global production of new energy vehicles will exceed 30 million, and the market demand for molybdenum coating will further grow.

1.3.2.3 Energy equipment

In the energy sector, molybdenum coatings are widely used in boilers, heat exchangers, gas turbines, and nuclear power equipment. For example, in the boiler pipes of coal-fired power plants, molybdenum coatings are able to resist high-temperature corrosion and abrasion, extending the life of the pipes by about 2 times. In nuclear power, molybdenum coatings are used in the radiation shielding components of reactors and are effective in absorbing neutron radiation due to their high density (10.28 g/cm^3) and non-toxicity.

Renewable energy equipment is also an important application area for molybdenum coatings. For example, the molybdenum coating on the gear surface of the wind turbine gearbox reduces wear and lubrication and reduces maintenance costs. As the global installed wind power capacity exceeds 1,000 GW by 2024, the demand for molybdenum coatings in wind power equipment continues to grow.

1.3.2.4 Machinery manufacturing

In mechanical engineering, molybdenum coatings are used for surface protection of bearings, gears, molds and cutting tools. For example, in mining equipment, molybdenum-coated drill bits can extend the service life by more than 50% and reduce the frequency of equipment replacement. In injection molds, molybdenum coating can reduce the adhesion of molds to plastics, improve mold release efficiency and product surface quality.

1.3.2.5 Chemical and marine engineering

The corrosion resistance of molybdenum coatings makes it widely used in chemical equipment and offshore engineering. For example, in petrochemical reactors, molybdenum coatings are resistant to acid gases and high-temperature corrosion, extending equipment life. In offshore platforms and marine equipment, molybdenum coatings protect steel structures from seawater corrosion and are particularly suitable for use in pipes and valves on deep-sea drilling platforms.

1.3.2.6 Medical and electronics industries

In the medical field, molybdenum coatings are used in radiation shielding components of X-ray equipment and CT machines due to their non-toxicity and high density. For example, in CT scanners from Siemens Healthineers, molybdenum coatings are used to shield against radiation and ensure image quality and patient safety. In the electronics industry, molybdenum coatings are used in the thermal and electrically conductive parts of semiconductor manufacturing equipment, such as the electrodes of plasma etching machines, and their thermal conductivity can improve the heat dissipation efficiency of the equipment by about 20%.

1.3.3 Application Prospects and Market Trends

1.3.3.1 Potential in the field of new energy

With the global energy transition, the demand for high-performance coatings for new energy equipment is growing rapidly. Molybdenum coatings have a promising future in wind, nuclear power and solar equipment. For example, molybdenum coating on the gear surface of wind turbine gearboxes reduces wear and improves transmission efficiency. In the field of nuclear power, molybdenum coatings can be used in the fuel rod shells of Generation IV nuclear reactors to resist high temperatures and radiation damage. It is estimated that by 2030, the global new energy equipment market will exceed 1.5 trillion US dollars, and the demand for molybdenum coating will grow at an average annual rate of 6%.

1.3.3.2 Smart Manufacturing and Industry 4.0

Industry 4.0 emphasizes intelligence, automation and high efficiency, and the application prospect of molybdenum coating in precision manufacturing is significant. For example, in robot joints, molybdenum coatings reduce friction and heat accumulation, improving motion accuracy and longevity. In 3D printing equipment, molybdenum-coated nozzles are able to resist the wear and tear of high-temperature molten materials and extend their service life. The global smart manufacturing market is expected to reach $500 billion by 2028, and molybdenum coatings will benefit as a key material.

1.3.3.3 Marine engineering and green ships

There is an increasing demand for corrosion-resistant coatings in offshore engineering. Molybdenum coatings are widely used in deep-sea drilling platforms, offshore wind power equipment and green ships. For example, molybdenum coatings can be used to protect the surface of ship propellers, reduce seawater corrosion and biological adhesion, and improve propulsion efficiency. The global offshore market is expected to reach $200 billion by 2030, and molybdenum coatings will be an important solution.

1.3.3.4 Medical and biotechnology

The non-toxicity and biocompatibility of molybdenum coatings give them potential in medical devices. For example, in orthopedic implants, molybdenum coatings can improve the wear and corrosion resistance of the implants and extend their service life. In addition, the use of molybdenum coatings in dental tools and surgical instruments is gradually increasing. The global medical device market is expected to reach $600 billion by 2027, and the demand for molybdenum coatings will continue to grow.

1.3.3.5 Market size and economic benefits

According to industry data, the global molybdenum market size will be about $5 billion in 2024, of which molybdenum spray wire accounts for about 10% of the share. It is expected that by 2030, the molybdenum spray wire market will grow at an average annual rate of 5.5% to reach $800 million.

As the world's largest molybdenum producer, China accounts for more than 50% of the global output, and many Chinese companies have become important suppliers of the global molybdenum spray wire market through technological innovation and large-scale production.

1.3.4 Case Study

1.3.4.1 Aerospace case: GE Aviation

General Electric (GE) Aviation makes extensive use of molybdenum coatings in its GEnx engines for wear protection of turbine blades. GEnx engines are used in the Boeing 787 Dreamliner, and the molybdenum coating keeps the turbine blades stable in high-temperature and high-pressure environments, extending maintenance intervals by 25 percent. This application saves GE Aviation hundreds of millions of dollars in maintenance costs each year.

1.3.4.2 Case for the automotive industry: Volkswagen

Volkswagen uses molybdenum-coated piston rings in its 1.4L TSI engine, which significantly improves fuel efficiency and durability. Tests have shown that molybdenum-coated piston rings reduce friction losses by 15% and extend engine life to more than 150,000 km. This technology has been rolled out to several Volkswagen Group models, with annual production of more than 5 million units worldwide.

1.3.4.3 Energy equipment case: Siemens wind power

Siemens Gamesa uses a molybdenum coating in its offshore wind gearboxes to reduce gear wear and lubricant usage. Tests have shown a 40% longer life and a 30% reduction in maintenance costs for molybdenum-coated gears. This technology has been applied to several offshore wind projects around the world.

1.4 Research and technical status of molybdenum spray wire at home and abroad

1.4.1 Current status of domestic research

As the world's largest molybdenum producer (about 150,000 tons in 2024, accounting for 50% of the world's total), China has significant advantages in the research and development and application of molybdenum spray wire. Domestic research institutions and enterprises have made important progress in the preparation of molybdenum wire, the optimization of spraying process and the improvement of coating performance. The following is a detailed analysis of the current state of research in China:

1.4.1.1 Major research institutions

Institute of Metal Research, Chinese Academy of Sciences: The surface engineering team of the institute focuses on the research of molybdenum-based coatings, and has developed a molybdenum wire preparation technology doped with lanthanum (La) and cerium (Ce). The results show that the oxidation resistance of molybdenum wire doped with 1% lanthanum is increased by 30% and the coating life is extended by 50% in an oxidizing atmosphere at 1000°C. In addition, the institute studied the microstructure of molybdenum coatings and improved the hardness and bonding strength of the coatings by controlling the grain size (10-50nm).

TEL: 0086 592 512 9696

sales@chinatungsten.com

University of Science and Technology Beijing: The School of Materials Science and Engineering at the same university has studied the effects of plasma spraying and high-velocity flame spraying (HVOF) technology on the performance of molybdenum coatings. The experimental results show that the porosity of the molybdenum coating formed by the HVOF process is reduced to less than 1%, and the binding strength reaches 80 MPa, which is significantly better than that of the traditional arc spraying (porosity is about 5%, and the binding strength is about 50 MPa).

Tsinghua University: The Department of Materials at Tsinghua University has developed a cold spray technology for the preparation of molybdenum coatings, which form high-density coatings through ultra-high-velocity particle impact, reducing thermal stress and oxide formation. Cold-spray molybdenum coatings are available up to HV800 hardness for high-precision component applications.

1.4.1.2 Major Enterprises

CTIA GROUP LTD.: As a leading molybdenum products company in China, Chinatungsten Online focuses on the production of high-purity molybdenum wire (purity ≥99.95%), providing molybdenum spray wire with a diameter of 1.0-3.2mm.

1.4.1.3 Research focus

Doping technology: Doping rare earth elements or alkali metals (such as potassium) to improve the high temperature oxidation resistance and mechanical properties of molybdenum wire. For example, molybdenum wire doped with 0.8% cerium reduces the oxidation rate by 40% at 1200°C.

Spraying process optimization: Plasma spraying and HVOF process parameter optimization, such as spraying distance (100-150mm), gas flow rate (50-80 L/min) and current intensity (400-600 A), are studied to reduce coating porosity and improve bonding strength.

Green manufacturing: Develop low-energy spraying equipment and environmentally friendly molybdenum coating process to reduce exhaust emissions and energy consumption in the spraying process. For example, the use of nitrogen instead of argon as a spray gas can reduce costs by about 15%.

1.4.1.4 Application Cases

High-speed rail braking system: CRRC's EMU brake disc adopts molybdenum coating, which improves wear resistance and high temperature resistance by 50%, and extends the life of the brake disc to 10 years.

Petrochemical equipment: Sinopec applied molybdenum coating to the pipeline of the catalytic cracking unit to resist acid gas corrosion, and the pipeline life was extended by 3 times.

1.4.2 Current status of foreign research

The research and application of molybdenum spray wire in foreign countries started earlier, especially in the United States, Germany and Japan, and the related technology is in the leading position in the world. The following is a detailed analysis of the current state of research abroad:

1.4.2.1 Major research institutions and enterprises

Praxair, USA: Praxair, a global leader in thermal spray technology, has developed a plasma spray system capable of producing molybdenum coatings with a porosity of less than 0.5% and a bond strength of up to 100 MPa. The company has investigated molybdenum-based composite coatings to improve the hardness and wear resistance of the coating by adding ceramic particles such as Al_2O_3.

Höganäs, Germany: Höganäs focuses on the development of molybdenum-based composite coatings, researching a hybrid spraying process of molybdenum and nickel-based alloys to form coatings that are both wear-resistant and corrosion-resistant. Its products are widely used in the automotive and energy equipment markets in Europe.

Toshiba of Japan: Toshiba has studied the high-temperature oxidation resistance of molybdenum coatings in the aerospace field, and developed molybdenum wire doped with yttrium (Y), which improves the oxidation resistance by 40% at 1300°C. Toshiba's molybdenum coating is used in the combustion chamber of gas turbines, extending component life by about 30%.

Massachusetts Institute of Technology (MIT): MIT's Materials Science Laboratory has investigated the preparation of nanoscale molybdenum coatings to improve hardness (HV900) and wear resistance by controlling the grain size of the coating (5-20nm). Nano molybdenum coatings are widely used in semiconductor equipment.

1.4.2.2 Research focus

Composite coatings: Research on composite coatings of molybdenum with ceramics (e.g., ZrO_2, Al_2O_3) or metals (e.g., Ni, Cr) to improve the versatility of coatings. For example, molybdenum-Al_2O_3 composite coatings can achieve a hardness of HV1000 and a 50% increase in wear resistance.

Nano coating: Nano-scale molybdenum coating is prepared by cold spraying and laser-assisted spraying technology to reduce porosity and surface roughness ($Ra \leq 0.1 \mu m$) and improve coating performance.

Intelligent spraying: Develop automated spraying equipment that combines artificial intelligence and sensor technology to monitor spraying parameters (e.g., temperature, airflow velocity) in real time to improve coating consistency and production efficiency.

1.4.2.3 Application Cases

Boeing: The turbofan engine of the Boeing 787 uses molybdenum-coated turbine blades, which improves high-temperature performance by 20% and extends maintenance intervals by 25%.

Mitsubishi Heavy Industries: Mitsubishi Heavy Industries applied a molybdenum coating in the combustion chamber of the gas turbine to resist high-temperature corrosion at 1400°C and extend the life of components by 40%.

1.4.3 Technical status and challenges

1.4.3.1 State of the art

At present, the technology of molybdenum spray wire has been relatively mature, and the main technical characteristics include:

High-purity molybdenum wire: The purity of the world's mainstream molybdenum spray wire has reached more than 99.95%, and the oxidation resistance of some doped molybdenum wires has been significantly improved.
Advanced Spraying Processes: Plasma spraying and HVOF processes can form molybdenum coatings with a porosity of less than 1% and a binding strength of 80-100 MPa.
Automated production: The intelligent spraying equipment monitors the spraying parameters through the sensor, and the uniformity of the coating thickness is controlled within ±5µm.

1.4.3.2 Technical challenges

Insufficient oxidation resistance: Molybdenum is prone to form volatile oxides (MoO_3) in high-temperature oxidizing atmospheres, which limits its application in some high-temperature environments.
Coating porosity: Molybdenum coatings with traditional arc spraying have high porosity (3%-5%), which affects durability and corrosion resistance.
Cost control: The production cost of high-purity molybdenum wire is high (about 50-100 US dollars/kg), and the purification and drawing process need to be further optimized.
Adaptability of complex substrates: The uniformity of molybdenum coating is difficult to control on non-flat or complex-shaped substrates, and new spraying equipment needs to be developed.

1.4.4 Future research directions

1.4.4.1 New doping technologies

Develop more efficient doping elements (e.g., yttrium, cerium, zirconium) and doping processes to improve the oxidation resistance and ductility of molybdenum wires. For example, the oxidation rate of molybdenum wire doped with 0.5% zirconium can be reduced by 50% at 1400°C.

1.4.4.2 Advanced spraying technology

Promote cold spray and laser-assisted spraying technology to reduce thermal stress and oxide formation in coatings. Cold-sprayed molybdenum coatings can be used with a porosity as low as 0.2% and a binding strength of up to 120 MPa, making them suitable for high-precision applications.

1.4.4.3 Intelligent and green manufacturing

Develop an intelligent spraying system that uses machine learning to optimize spraying parameters and improve coating consistency. Research into environmentally friendly spraying processes to reduce energy consumption and exhaust emissions. For example, spraying equipment powered by renewable energy can reduce carbon emissions by 20%.

1.4.4.4 Composite and nano-coatings

Research molybdenum-based composite coatings and nanocoatings, combined with ceramics,

TEL: 0086 592 512 9696
CTIAQCD -MA-E/P 2018- 2024V
sales@chinatungsten.com

metals, or other high-performance materials to form multifunctional coatings. For example, molybdenum-ZrO_2 composite coatings can increase wear resistance by up to 60 percent and are suitable for aerospace and energy applications.

1.4.4.5 Interdisciplinary applications

Explore the application of molybdenum coatings in biomedical, new energy and electronics. For example, in flexible electronic devices, molybdenum coatings can be used in the preparation of conductive films; In biological implants, molybdenum coatings improve corrosion resistance and biocompatibility.

CTIA GROUP LTD molybdenum spray wire

CTIA GROUP LTD

Molybdenum Spray Wire Introduction

1. Overview of Molybdenum Spray Wire

Molybdenum spray wire is a high-purity molybdenum metal wire that is melted and deposited onto a substrate surface through thermal spray techniques such as flame spraying, plasma spraying, arc spraying, or HVOF (High Velocity Oxy-Fuel). The resulting coating offers excellent resistance to wear, corrosion, and high temperatures. Due to its high melting point and superior performance, molybdenum wire is widely used across various industrial sectors.

2. Characteristics of Molybdenum Spray Wire

High Melting Point: Approximately 2623° C, suitable for high-temperature environments.
Excellent Corrosion Resistance: Resists attack from acids, alkalis, and chemical media.
High Hardness & Wear Resistance: Tough coating that withstands mechanical wear.
Low Friction Coefficient: Reduces component wear and improves efficiency.
Chemical Stability: Maintains performance in harsh environments.
High Thermal Conductivity: Effectively dissipates heat and extends component lifespan.

3. Typical Uses of Molybdenum Spray Wire

Aerospace: Turbine blades, engine parts, thermal barrier coatings.
Automotive Industry: Wear-resistant coatings for piston rings, engine blocks, and brake discs.
Chemical & Energy Sectors: Corrosion-resistant pipelines, heat exchangers, wind power equipment.
Electronics & Semiconductors: Vacuum deposition heating wires, semiconductor leads.
Medical Field: Corrosion-resistant coatings for implants and surgical instruments.
Others: Marine anti-corrosion, wear-resistant construction machinery, high-temperature furnaces.

4. Basic Data of Molybdenum Spray Wire from CTIA GROUP LTD

Purity	≥99.95%
Density	10.2 g/cm³
Diameter Range	1.0-3.0 mm, customizable
Tensile Strength	Moderate to ensure stable wire feeding
Packaging	Customized Packaging

5. Procurement Information

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

Chapter 2 Characteristics of Molybdenum Spray Wire

2.1 Physical properties of molybdenum spray wire

The physical properties of molybdenum spray wire are the basis for its thermal spraying material, which determines its applicability under high temperature, high pressure and complex working conditions. As a high melting point transition metal, molybdenum has excellent thermal conductivity, low coefficient of thermal expansion and high density, making it widely used in aerospace, automotive industry and energy equipment. The following is a detailed analysis from four aspects: melting point and thermal conductivity, density and hardness, thermal expansion coefficient and thermal stability, conductivity and resistivity.

2.1.1 Melting point and thermal conductivity of molybdenum spray wire

The melting point of molybdenum is 2623 °C (4753 °F), which is second only to tungsten (3422 °C) and rhenium (3186 °C) among common metals, and much higher than iron (1538 °C) and nickel (1455 °C). This high melting point allows molybdenum spray wire to remain structurally stable in extremely high-temperature environments, making it particularly suitable for surface coating of high-temperature components such as aero-engine turbine blades, gas turbine combustion chambers, and petrochemical reactors. For example, the coating formed by molybdenum spray wire can withstand transient high temperatures of up to 1400°C in gas turbines without melting or significantly softening.

In the thermal spraying process, the molybdenum wire is heated to a molten or semi-molten state by an electric arc or flame. The high melting point means that the spraying equipment requires a high energy input (e.g. plasma spraying can reach temperatures of up to 15,000°C), but it also ensures that the molten molybdenum particles maintain a high viscosity during the spraying process, resulting in a dense coating. The results show that the melting point properties of molybdenum coatings allow them to maintain a certain degree of stability in high-temperature oxidizing atmospheres, although the oxidation resistance needs to be further improved by doping or composite coatings.

Thermal conductivity: The thermal conductivity of molybdenum is 138 W/m·K (at 20°C), which is higher than that of steel (about 50 W/m·K) but lower than that of copper (about 400 W/m·K). This property gives molybdenum coatings an advantage in scenarios where fast heat dissipation is required. For example, in plasma etching machines for semiconductor manufacturing equipment, molybdenum-coated electrodes can effectively conduct heat, prevent equipment from overheating, and improve operational stability. Thermal conductivity also affects the cooling rate of the droplets during spraying, and a higher thermal conductivity helps the droplets solidify quickly on the surface of the substrate, reducing thermal stress and porosity in the coating.

In practice, the thermal conductivity of the molybdenum coating decreases slightly at high temperatures. For example, at 1000°C, the thermal conductivity of molybdenum drops to about 110 W/m·K, but is still sufficient for most industrial needs. In contrast, ceramic coatings (e.g., zirconia, with a thermal conductivity of about 2 W/m·K) have poor thermal conductivity and are prone to

TEL: 0086 592 512 9696
sales@chinatungsten.com

heat accumulation, while molybdenum coatings have more advantages in the balance of thermal conductivity and mechanical strength.

2.1.2 Density and hardness of molybdenum spray wire

Density molybdenum has a density of 10.28 g/cm³, which is lower than tungsten (19.25 g/cm³) but higher than nickel (8.91 g/cm³) and iron (7.87 g/cm³). This medium density provides a good balance between weight and performance, making it particularly suitable for components in the aerospace and automotive industries where lightweight is required. For example, in automotive piston rings, molybdenum coatings provide excellent wear resistance without significantly increasing weight.

The density of molybdenum coating directly affects its spraying quality. The lower density helps the droplets maintain good flow during the spraying process, reducing spatter losses during the spraying process. The results show that the density of the coating formed by arc molybdenum spray wire can reach 9.8-10.0 g/cm³, which is close to the theoretical value, indicating that the coating has high compactness.

The hardness of molybdenum is 5.5-6.0 on the Mohs scale (about 200-250 on the Vickers scale), and the hardness of the molybdenum coating formed by spraying is usually between HV300-500, depending on the spraying process and post-treatment. For example, the high-velocity flame spraying (HVOF) process can form molybdenum coatings with a hardness of up to HV450, while plasma spraying coatings are typically around HV350. The high hardness of the molybdenum coating makes it resistant to mechanical wear and is particularly suitable for high-friction components such as piston rings, bearings and cutting tools.

Hardness is also closely related to the microstructure of the coating. The grain size of molybdenum coatings is typically 10-50μm, and the smaller grain size helps to improve hardness and wear resistance. By doping with rare earth elements such as lanthanum or cerium, the grain can be further refined and the hardness can be increased to HV550. For example, research by the Institute of Metal Research of the Chinese Academy of Sciences showed that molybdenum coatings doped with 1% lanthanum increased their hardness by 15% and their wear resistance by 20%.

2.1.3 Thermal expansion coefficient and thermal stability of molybdenum spray wire

The coefficient of thermal expansion of molybdenum is 4.8×10^{-6}/K (20-1000°C), which is much lower than that of steel (about 12×10^{-6}/K) and aluminum (about 23×10^{-6}/K), and close to that of nickel-base superalloys (about 5.0×10^{-6}/K). The low coefficient of thermal expansion allows molybdenum coatings to reduce thermal stress in environments with drastic temperature changes, reducing the risk of coating cracking or peeling. For example, in aero engines, the molybdenum coating is well matched to the thermal expansion of the nickel-based alloy substrate, ensuring the stability of the coating during hot and cold cycles.

During thermal spraying, the coefficient of thermal expansion affects the quality of the bonding of the coating to the substrate. If the difference in the coefficient of thermal expansion between the substrate and the coating is too large, a large residual stress will be generated when the coating is cooled after spraying at high temperatures, causing the coating to peel off. The low coefficient of thermal expansion of molybdenum coatings makes them suitable for a wide range of metal substrates such as stainless steels, titanium alloys, and superalloys.

Thermal stabilityThe thermal stability of molybdenum coatings is due to their high melting point and low volatility. In non-oxidizing atmospheres such as nitrogen or vacuum, molybdenum coatings are stable above 1600°C and are suitable for use in vacuum furnaces, electrodes, and spacecraft components. However, in an oxidizing atmosphere, molybdenum generates volatile oxides (MoO_3) above 500°C, resulting in a decrease in coating quality. To solve this problem, researchers have developed doped molybdenum wires (such as doped potassium or cerium) and composite coatings (such as molybdenum-Al_2O_3) to improve thermal stability. For example, a molybdenum coating doped with 0.8% cerium can extend its life by 30% in an oxidizing atmosphere at 1000°C.

2.1.4 Conductivity and resistivity of molybdenum spray wire

Conductivity: The conductivity of molybdenum is about 1.8×10^7 S/m (20°C), which is lower than that of copper (5.9×10^7 S/m) but higher than that of stainless steel (about 1.4×10^6 S/m). This property gives molybdenum coatings an advantage in applications where electrical conductivity is required, such as electrodes in semiconductor manufacturing equipment and conductive layers for electronic components. The high conductivity of the molybdenum coating also reduces the arc resistance during spraying, helping to stabilize the arc spraying process.

ResistivityThe resistivity of molybdenum is 5.5×10^{-8} Ω·m (20 °C) with a slight increase in temperature (about 2.0×10^{-7} Ω··) at 1000 °C m）。 The low resistivity allows the molybdenum coating to maintain good conductivity in high-temperature environments, making it suitable for high-temperature electrodes and resistive heating elements. For example, in the electrodes of a glass furnace, the molybdenum coating is able to stably conduct electricity at 1400°C, extending the electrode life by about 40%.

In the thermal spraying process, the resistivity of the molybdenum wire affects the energy efficiency of arc spraying. Lower resistivity means lower power loss, making it suitable for large-scale industrial production. Studies have shown that optimizing arc spraying parameters (e.g., currents 400-600 A) can increase energy utilization by up to 15%.

2.2 Chemical properties of molybdenum spray wire

The chemical properties of molybdenum spray wire determine its performance in corrosive environments and high-temperature oxidation conditions. Molybdenum's chemical inertness, corrosion resistance, and oxidation resistance (under certain conditions) make it widely used in chemical, offshore, and energy equipment. The following is analyzed from three aspects: corrosion resistance, oxidation resistance, chemical inertness and reactivity.

2.2.1 Corrosion resistance of molybdenum spray wire

Molybdenum has excellent corrosion resistance to non-oxidizing acids (e.g., hydrochloric acid, sulfuric acid) and alkaline solutions. For example, in hydrochloric acid at a concentration of 10%, molybdenum has a corrosion rate of only 0.01 mm/year, which is much lower than stainless steel (about 0.1 mm/year). This property makes molybdenum coatings important for applications in petrochemical reactors, chemical pipelines, and marine equipment. In seawater, molybdenum coatings are more corrosion-resistant than zinc coatings, resistant to chloride ions, and are suitable for steel structure protection on offshore platforms.

However, molybdenum is less resistant to corrosion in oxidizing acids such as nitric acid and is prone to rapid dissolution. To solve this problem, researchers have developed molybdenum-based composite coatings that improve corrosion resistance by adding nickel or chromium. For example, molybdenum-Ni composite coatings reduce the corrosion rate by 50% in nitric acid environments.

2.2.2 Oxidation resistance of molybdenum spray wire

Molybdenum has good oxidation resistance at low temperature (<500°C), but volatile oxides (MoO_3) are easy to form in high temperature oxidizing atmosphere (>500°C), resulting in the deterioration of coating quality. For example, in air at 800°C, pure molybdenum coatings can oxidize at a rate of up to 0.1 mm/h, limiting their application in high-temperature oxidizing environments.

To improve antioxidant activity, the researchers employed:

Doping technology: Doping rare earth elements (e.g., lanthanum, cerium) or alkali metals (e.g., potassium) can form a stable oxide protective layer. For example, a molybdenum coating doped with 1% lanthanum reduces the oxidation rate by 40% at 1000°C.
Composite coating: Creates an antioxidant barrier by adding ceramic materials (e.g. Al_2O_3, ZrO_2). For example, molybdenum-Al_2O_3 composite coatings have a 50% increase in oxidation resistance at 1200°C.
Protective atmosphere: Molybdenum coatings are significantly more resistant to oxidation when protected by nitrogen or argon, making them suitable for use in vacuum furnaces and spacecraft components.

2.2.3 Chemical inertness and reactivity of molybdenum spray wire

Molybdenum is chemically inert at room temperature and does not react with most non-metallic elements (e.g., oxygen, nitrogen) or react significantly with water or steam. This property gives molybdenum coatings an advantage in scenarios where chemical stability is critical, such as electrodes in glass furnaces and lining in chemical reactors.

However, at high temperatures, molybdenum has certain reactivity with oxygen, chlorine, and fluorine. For example, above 600°C, molybdenum reacts with oxygen to form MoO_3, resulting in coating loss. In order to reduce the reactivity, the researchers have developed surface modification techniques, such as siliconization to form a protective layer of $MoSi_2$, which significantly improves chemical stability.

2.3 Mechanical properties of molybdenum spray wire

The mechanical properties of molybdenum spray wire determine its performance in high load, high friction and complex stress environments. Molybdenum's high strength, ductility, and wear resistance enable its coatings to meet the needs of aerospace, automotive, and mechanical engineering applications. The following is analyzed from three aspects: tensile strength and yield strength, ductility and fracture toughness, wear resistance and fatigue performance.

2.3.1 Tensile strength and yield strength of molybdenum spray wire

Tensile strengthThe tensile strength of molybdenum wire is about 800-1000 MPa at 20°C, which is much higher than aluminum (about 200 MPa) but lower than tungsten (about 1500 MPa). The tensile strength of the molybdenum coating formed by spraying is usually between 500-700 MPa due to changes in microstructure such as grain refinement and porosity. The high-velocity flame spraying (HVOF) process increases the tensile strength of the coating to about 800 MPa, as it forms a denser coating.

Yield StrengthThe yield strength of molybdenum is about 600-800 MPa, and the yield strength of spray coatings is usually between 400-600 MPa. The yield strength directly affects the deformation resistance of the coating. For example, in automotive piston rings, the high yield strength of molybdenum coatings is able to resist high-frequency vibrations and thermal stresses, preventing cracking of the coating.

2.3.2 Ductility and fracture toughness of molybdenum spray wire

Malleable molybdenum wire has good ductility, and the elongation at break is about 10%-15%. Doping with rare earth elements such as lanthanum can further improve ductility, e.g. molybdenum wire doped with 1% lanthanum can reach an elongation at break of up to 20%. The ductility of the spray coating is slightly lower than that of the molybdenum wire body, which is about 5%-10%, but it is sufficient for most industrial applications. For example, in the turbine blades of aero engines, the ductility of molybdenum coatings is able to accommodate thermal expansion and mechanical vibrations, reducing coating peeling.

Fracture toughnessThe fracture toughness (K_{IC}) of molybdenum coatings is typically between 10-15 $MPa \cdot m^{1/2}$, which is lower than that of ceramic coatings (e.g., zirconia, about 5 $MPa \cdot m^{1/2}$) but higher than that of nickel-based coatings (about 8 $MPa \cdot m^{1/2}$). The high fracture toughness allows the molybdenum coating to resist crack propagation and is suitable for use in components with high shock loads, such as mining bits and forging dies.

2.3.3 Wear resistance and fatigue properties of molybdenum spray wire

Abrasion resistance The wear resistance of molybdenum coatings is due to their high hardness and low coefficient of friction (about 0.1-0.2). Under sliding friction conditions, the wear rate of molybdenum coating is only 0.01-0.05 $mm^3/N \cdot m$, which is significantly lower than that of steel (about 0.1 $mm^3/N \cdot m$). For example, in automotive synchronizer rings, the wear resistance of the molybdenum coating extends component life by a factor of 3.

Fatigue PropertiesThe fatigue life of molybdenum coatings performs well in the High Cycle Fatigue (HCF) test. For example, the fatigue strength of molybdenum coatings is about 400 MPa under stress of 10^7 cycles, making it suitable for rotating parts of aero engines. Studies have shown that optimizing the spraying process, such as reducing porosity, can increase fatigue life by up to 20%.

2.4 Spray coating performance

The coating properties formed by molybdenum spray wire directly affect its effectiveness in industrial applications. Adhesion, porosity, high temperature resistance and surface properties of coatings are key indicators to evaluate their quality. The following is analyzed from four aspects.

2.4.1 Coating adhesion and bond strength

The adhesion of molybdenum coatings is typically measured by a tensile test (ASTM C633) with a bonding strength between 50-100 MPa. The high-velocity flame spraying (HVOF) process can form coatings with a bond strength of up to 100 MPa, while arc spraying typically has a bond strength of 50-70 MPa. The strength of the bond depends on the coating parameters (e.g. 100-150 mm spray distance, gas flow 50-80 L/min) and the substrate surface treatment (e.g. blasting roughening).

2.4.2 Coating porosity and uniformity

The porosity of molybdenum coatings is typically between 0.5%-5%, depending on the spraying process. The porosity of the HVOF process can be as low as 0.5%, while the porosity of arc spraying is about 3%-5%. The low porosity helps to improve the corrosion and abrasion resistance of the coating. The uniformity of the coating thickness is controlled within ±5μm, which is suitable for high-precision applications.

2.4.3 Coating resistance to high temperature and thermal shock

Molybdenum coatings can withstand more than 1600°C in non-oxidizing atmospheres, but have limited resistance to high temperatures (about 500°C) in oxidizing atmospheres. Doped or composite coatings can improve high temperature resistance, such as cerium-doped molybdenum coatings that operate stably at 1000°C. The thermal shock resistance was evaluated by hot and cold cycling tests, and the molybdenum coating was stable from 1000°C to room temperature for up to 500 cycles.

2.4.4 Surface roughness and microstructure of coatings

The surface roughness (Ra) of molybdenum coatings is typically between 0.2-2.0 μm, and the HVOF process can achieve a mirror effect of Ra ≤ 0.2 μm. The microstructure shows that the molybdenum coating consists of layered stacked flat particles with a grain size of 10-50 μm. The fine grain size contributes to increased hardness and wear resistance.

2.5 CTIA GROUP LTD molybdenum spray wire MSDS

A Material Safety Data Sheet (MSDS), now commonly known as a Safety Data Sheet (SDS), is a comprehensive technical document that meets the requirements of the International Organization for Standardization (ISO 11014) and the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) to provide information on the physical and chemical properties, potential hazards, safe use, storage, transportation, emergency treatment and related regulations of a chemical or material. As a high-purity metal material, molybdenum spray wire is widely used in thermal spraying processes, and its MSDS is designed to provide comprehensive safety guidance for manufacturers, users, transportation personnel and emergency responders to ensure compliance with occupational health and safety standards in the workplace and during transportation.

Part 1: Chemical and business identification
Chemical Name: Molybdenum Wire
CAS number: 7439-98-7
Recommended use: It is used in thermal spraying processes (such as arc spraying, flame spraying) to form wear-resistant and high-temperature resistant coatings, suitable for aerospace, automotive industry, energy equipment, etc.
Restrictions on use: Not recommended for use in high-temperature oxidizing atmospheres (>500°C) unless antioxidant measures are taken.

Part 2: Overview of Hazards
GHS classification: Molybdenum spray wire is a non-hazardous chemical and does not fall within the scope of GHS hazard classification.
Hazard Category: There is no specific hazard classification, but molybdenum dust or fumes may be generated during processing or spraying, which is a potential inhalation hazard.
Health hazards: Long-term inhalation of molybdenum dust may cause respiratory irritation, and short-term exposure has no significant health hazards.
Physical hazards: Solid molybdenum wire is not flammable or explosive, but it may cause a fire risk when it melts at high temperatures during the spraying process.
Environmental hazards: There is no significant environmental harm, molybdenum is a non-toxic metal, and the waste can be recycled.
Warning: Caution

Hazard Statement:
H335: May cause respiratory irritation (dust from processing or spraying).
H315: Minor irritation may occur with prolonged skin contact.

Precautionary Statement:
P261: Avoid inhaling dust or fumes.
P280: Wear protective gloves/protective glasses/respiratory protective equipment when operating.
P305+P351+P338: In case of contact in eyes, rinse with water for several minutes, if contact lenses are easy to remove, remove and continue to rinse.

Part 3: Composition/composition information
Chemical Composition: Molybdenum (Mo), Purity≥ 99.95%
Impurities: May contain trace amounts of iron (Fe<0.01%), nickel (Ni<0.005%), carbon (C<0.01%), etc.
Doping elements (optional): Some molybdenum spray wires may be doped with lanthanum (La<1%), cerium (Ce<1%) or potassium (K<0.1%) for improved oxidation resistance or ductility.
Form: Solid metal wire, diameter 1.0-3.2mm, smooth surface or with trace oxide layer (black

molybdenum wire).

Part 4: First Aid Measures

Skin contact: If molybdenum filament or dust comes into contact with the skin, rinse with soapy water and water without special treatment. If irritation occurs, seek medical attention promptly.

Eye contact: If molybdenum dust gets into the eye, lift the eyelid and rinse with running water or saline for at least 15 minutes. If discomfort persists, seek medical attention immediately.

Inhalation: If molybdenum dust or spray fumes are inhaled, immediately transfer to fresh air to keep the respiratory tract open. If you have trouble breathing, give oxygen and seek medical attention.

Accidental ingestion: Molybdenum wire is a solid metal, and the possibility of accidental ingestion is extremely low. If it happens, seek medical attention immediately and do not induce vomiting.

First aid personnel protection: First aid personnel should wear protective gloves and masks to avoid inhaling dust.

Part 5: Fire Protection Measures

Fire extinguishing method: Molybdenum wire itself is non-flammable, but high-temperature melting during the spraying process may cause fire. Use dry powder, foam or carbon dioxide fire extinguishers to extinguish fires, and use water is prohibited (which may cause metal dust explosions).

Special hazards: Molybdenum oxide (MoO_3) fumes may be produced at high temperatures, which are irritating, and respiratory protective equipment is required.

Fire precautions: Firefighters should wear full-body protective clothing and positive airway pressure respirators to prevent inhaling toxic fumes.

Part 6: Emergency Treatment of Spills

Emergency measures: Molybdenum wire is a solid material, no risk of liquid leakage. If molybdenum dust is generated by processing or spraying, immediately isolate the contaminated area to prevent the dust from spreading.

Collection method: Use an explosion-proof vacuum cleaner or wet sweep to collect dust and avoid dust. The collected dust should be sealed in a container and handed over to a professional organization for recycling.

Environmental protection: Molybdenum dust has less impact on the environment, but it should be avoided from entering water bodies or soil.

Personal protection: Handlers should wear protective eyewear, masks, and gloves to avoid inhalation or exposure to dust.

Part 7: Handling, Handling and Storage

Precautions:

Operate in a well-ventilated environment to avoid dust accumulation.

Use specialized spraying equipment, such as arc spraying guns, to ensure that the equipment is grounded to prevent static sparks.

Avoid direct use in high-temperature oxidizing atmospheres (>500°C) unless antioxidant measures are taken.

Equipped with a dust capture system to prevent dust diffusion during the spraying process.

Precautions for storage:
Store in a dry, ventilated warehouse away from humidity (to prevent oxidation of surfaces).
The storage temperature is controlled at 5-30°C and the humidity is below 60%.
Keep away from strong oxidizing agents (e.g. nitric acid, chlorine) and acidic substances.
The packaging is sealed in a plastic bag or metal container to prevent mechanical damage.

Part 8: Exposure Control/Personal Protection
Engineering controls: Use local exhaust systems or dust collection equipment to keep the concentration of molybdenum dust in the workplace air below OSHA PEL (15 mg/m³, total dust).
Personal Protection:
Respiratory protection: Wear a NIOSH-certified N95 or P100 dust mask at high dust concentrations.
Eye protection: Wear chemical safety glasses to prevent dust from entering your eyes.
Skin protection: Wear protective gloves and overalls to avoid long-term contact.
Other protection: Spraying operators should wear high-temperature protective clothing to prevent high-temperature droplet burns.

Occupational Exposure Limits:
China GBZ 2.1-2019: Molybdenum dust TLV-TWA is 10 mg/m³ (total dust).
OSHA PEL: 15 mg/m³ (total dust), 5 mg/m³ (respirable dust).
ACGIH TLV: 10 mg/m³ (respirable dust), 3 mg/m³ (respirable dust).

Part 9: Physicochemical properties
Appearance and properties: silver-white metal wire, smooth surface or with trace oxide layer (black molybdenum wire).
Melting Point: 2623 °C
Boiling Point: 4639 °C
Density: 10.28 g/cm³ (20°C)
Thermal conductivity: 138 W/m·K (20°C)
Coefficient of thermal expansion: 4.8×10^{-6}/K (20-1000°C).
Resistivity: 5.5×10^{-8} Ω·m（20°C）
Hardness: Mohs hardness 5.5-6.0, Vickers hardness HV200-250
Solubility: insoluble in water, acid or alkali, soluble in hot concentrated nitric acid or aqua regia.
Volatility: Non-volatile, but volatile MoO_3 can be generated in a high-temperature oxidizing atmosphere.

Part 10: Stability and Reactivity
Stability: Stable at room temperature, MoO_3 may be formed in a high-temperature oxidizing atmosphere (>500°C).
Reactivity: Reacts with strong oxidizing agents (e.g., nitric acid, chlorine) to produce oxides or halides. Avoid contact with strong acids and alkalis.
Prohibited substances: strong oxidants, halogen gases, acidic substances.

Decomposition products: May decompose into MoO_3 smoke at high temperatures, which is irritating.

Part 11: Toxicological information

Acute toxicity: No significant acute toxicity, LD50 (oral, rat) > 2000 mg/kg.

Chronic toxicity: Long-term inhalation of high concentrations of molybdenum dust may cause respiratory irritation or lung inflammation with no evidence of carcinogenicity (not classified as a carcinogen in IARC).

Skin irritation: Long-term exposure may cause mild irritation and is non-sensitizing.

Eye irritation: Molybdenum dust may cause mechanical irritation and is non-corrosive.

Reproductive toxicity: No data on reproductive toxicity or teratogenicity.

Others: Molybdenum is an essential trace element for the human body, and excessive inhalation may lead to an increase in blood molybdenum concentration, but there is no significant health hazard.

Part 12: Ecological Information

Environmental impact: Molybdenum wire is a solid metal and has no significant harm to the environment. Waste can be recycled and disposed of to avoid entering water bodies or soil.

Bioaccumulative: No bioaccumulative.

Ecotoxicity: No significant toxicity to aquatic organisms, LC50 (fish, 96 hours) > 100 mg/L.

Persistence and degradability: Not applicable, molybdenum is a non-degradable metal.

Part 13: Disposal

Disposal method: Waste molybdenum wire should be sealed and collected, handed over to a professional recycling institution for disposal, and it is forbidden to discard it at will.

Recycling: Molybdenum is a recyclable metal that is recommended for reuse through smelting or chemical purification.

Regulatory requirements: In accordance with China's Law on the Prevention and Control of Environmental Pollution by Solid Waste and the EU RoHS directive, it is forbidden to discharge waste into the environment.

SECTION 14: SHIPPING INFORMATION

UN Number: None (non-hazmat).

Shipping Name: Molybdenum Wire.

Transport Hazard Category: Non-dangerous goods, in accordance with the International Maritime Dangerous Goods Code (IMDG) and International Air Transport Association (IATA) requirements.

Packaging requirements: Use sealed plastic bags or metal containers to prevent mechanical damage.

Precautions for transportation: Keep it dry during transportation and avoid mixing with strong oxidants.

Part 15: Regulatory Information

Regulations in China:

Comply with the "Labeling and General Rules for Hazardous Chemicals" (GB/T 15258-2009).

Comply with the Occupational Exposure Limits for Hazardous Factors in Occupational Workplaces (GBZ 2.1-2019).

International Regulations:
In accordance with the EU REACH regulation (EC No 1907/2006), molybdenum does not belong to SVHC (Substances of Very High Concern).
Meets OSHA hazard communication standards (29 CFR 1910.1200).
Meets Canadian WHMIS (Hazardous Materials Information System for the Workplace) requirements.
Others: The production and use of molybdenum wire is subject to ISO 14001 environmental management system and ISO 9001 quality management system.

SECTION 16: ADDITIONAL INFORMATION
Supplier: CTIA GROUP LTD
Tel: 0592-5129696/5129595

CTIA GROUP LTD molybdenum spray wire

CTIA GROUP LTD
Molybdenum Spray Wire Introduction

1. Overview of Molybdenum Spray Wire

Molybdenum spray wire is a high-purity molybdenum metal wire that is melted and deposited onto a substrate surface through thermal spray techniques such as flame spraying, plasma spraying, arc spraying, or HVOF (High Velocity Oxy-Fuel). The resulting coating offers excellent resistance to wear, corrosion, and high temperatures. Due to its high melting point and superior performance, molybdenum wire is widely used across various industrial sectors.

2. Characteristics of Molybdenum Spray Wire

High Melting Point: Approximately 2623° C, suitable for high-temperature environments.
Excellent Corrosion Resistance: Resists attack from acids, alkalis, and chemical media.
High Hardness & Wear Resistance: Tough coating that withstands mechanical wear.
Low Friction Coefficient: Reduces component wear and improves efficiency.
Chemical Stability: Maintains performance in harsh environments.
High Thermal Conductivity: Effectively dissipates heat and extends component lifespan.

3. Typical Uses of Molybdenum Spray Wire

Aerospace: Turbine blades, engine parts, thermal barrier coatings.
Automotive Industry: Wear-resistant coatings for piston rings, engine blocks, and brake discs.
Chemical & Energy Sectors: Corrosion-resistant pipelines, heat exchangers, wind power equipment.
Electronics & Semiconductors: Vacuum deposition heating wires, semiconductor leads.
Medical Field: Corrosion-resistant coatings for implants and surgical instruments.
Others: Marine anti-corrosion, wear-resistant construction machinery, high-temperature furnaces.

4. Basic Data of Molybdenum Spray Wire from CTIA GROUP LTD

Purity	≥99.95%
Density	10.2 g/cm³
Diameter Range	1.0-3.0 mm, customizable
Tensile Strength	Moderate to ensure stable wire feeding
Packaging	Customized Packaging

5. Procurement Information

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

Chapter 3 Preparation and Production Process of Molybdenum Spray Wire

3.1 Preparation of raw materials for molybdenum spray wire

The preparation of molybdenum spray wire begins with the selection and processing of raw materials, and the high-quality preparation process of molybdenum, as a high melting point and corrosion-resistant transition metal, directly determines the performance of the final product. Raw material preparation involves the extraction of high-purity molybdenum compounds from molybdenum ore, which in turn are processed into high-purity molybdenum powders suitable for molding. This process is not only technology-intensive, but also requires sophisticated process control to ensure material consistency and reliability. This section will discuss in detail the beneficiation and purification technology of molybdenum ore, the production process of high-purity molybdenum powder, and the quality control and testing of molybdenum powder.

3.1.1 Molybdenum ore beneficiation and purification technology

Molybdenum is found in nature mainly in the form of molybdenite (MoS_2), a dark gray, metallic sulphide mineral that is often associated with metallic minerals such as copper, tungsten, and iron. The distribution of molybdenum ore resources in the world is relatively concentrated, with China, the United States, Chile and Peru being the main producing areas, among which China dominates with its rich reserves and production. China's molybdenum ore is mainly distributed in Luanchuan in Henan, Jinduicheng in Shaanxi and Daheishan in Jilin, and the molybdenum ore produced in these mining areas is of good quality, but often contains a variety of impurities, which need to be separated through complex beneficiation and purification processes.

The first step in the beneficiation process is the physical crushing of the raw ore. The mined molybdenum ore is large and usually needs to be crushed into smaller particles by jaw crushers and cone crushers. This process may seem simple, but it requires precise control of the parameters of the crushing plant to avoid mineral loss or dust contamination due to over-crushing. The crushed ore particles are fed into grinding equipment, such as ball mills or rod mills, where they are further ground into fine powders. The purpose of grinding is to liberate molybdenite particles from the associated minerals and create conditions for subsequent separation. At this stage, special attention needs to be paid to the uniformity of the grinding grain size, as too coarse particles will reduce the processing efficiency, while too fine particles may increase the cost of treatment.

The core process of mineral processing is flotation technology, which is a method of separating minerals using differences in surface properties. During flotation, the finely ground ore is mixed with water to form a slurry and specific chemicals are added, including collectors, foaming agents, and conditioners. Collectors (such as xanthate or terpineol) selectively adsorb on the surface of molybdenite particles, making them hydrophobic; The foaming agent produces a stable foam in the slurry, the hydrophobic molybdenite particles attach to the bubbles and float to the surface with the foam, while the hydrophilic impurity minerals sink to the bottom of the slurry. The flotation process usually requires multiple cycles, and the grade of molybdenite is gradually increased through roughing, selection and sweeping, and finally a high-purity molybdenum concentrate is obtained. This concentrate has a dark grey color with a greasy sheen, making it an ideal raw material for subsequent purification.

The purification process of molybdenum concentrate is designed to convert molybdenite into a compound that can be used in the production of molybdenum metal, typically molybdenum oxide (MoO_3). The first step in purification is roasting, where the molybdenum concentrate is fed into a large rotary kiln or multi-chamber furnace where it reacts with oxygen at high temperatures. During the roasting process, the sulfur in molybdenite is oxidized to sulfur dioxide gas and released, while molybdenum is converted to molybdenum oxide. This process requires precise control of temperature and oxygen supply to ensure complete removal of sulfur while avoiding loss of molybdenum oxide volatilization. Molybdenum oxide after roasting is a yellow or white powder, but may still contain trace amounts of copper, iron, or other impurities that require further chemical purification.

Chemical purification is usually done using an ammonia leaching process. Molybdenum oxide is dissolved in ammonia to form ammonium molybdate solution, while insoluble impurities are filtered and separated. Subsequently, high-purity ammonium molybdate is precipitated from the solution by evaporation crystallization or acid precipitation. This compound is an ideal precursor for the production of high-purity molybdenum powder, and its purity has a direct impact on the success of the subsequent process. The entire beneficiation and purification process reflects the complexity of modern metallurgical technology, from extensive ore crushing to fine chemical separation, each step of which needs to be carefully designed to ensure the quality of the final product.

3.1.2 Production process of high-purity molybdenum powder

High-purity molybdenum powder is the base material for molybdenum spray wire, and its production process is centered on hydrogen reduction, which aims to convert molybdenum oxide into metal molybdenum while maintaining extremely high purity and appropriate particle properties. This process requires not only advanced equipment support, but also a deep understanding of the chemical reactions and material properties to ensure that the molybdenum powder meets the stringent requirements for molybdenum spray wire.

The production of high-purity molybdenum powder begins with the refining of molybdenum oxide. The molybdenum oxide obtained from roasting may contain trace impurities that need to be further purified by chemical methods. Ammonia leaching is a commonly used refining method, which can effectively remove impurities such as iron, copper, and silicon by controlling the pH and temperature of the solution. The refined molybdenum oxide is dried and ground into fine particles in preparation for the subsequent reduction process. Each process at this stage needs to be carried out in a clean environment to avoid the introduction of external contaminants.

Hydrogen reduction is the core process of molybdenum powder production and is usually carried out in two stages. The first stage is the reduction of molybdenum oxide to molybdenum dioxide (MoO_2). This reaction takes place in a tube furnace or pusher furnace, where the molybdenum oxide powder is placed in a high-temperature boat dish and slowly passed through the heating zone. Under the protection of a hydrogen atmosphere, molybdenum oxide reacts with hydrogen to release water vapor and form molybdenum dioxide. This process requires precise control of the furnace temperature and hydrogen flow to ensure that the reaction is complete and that the particles do not agglomerate. Molybdenum dioxide is dark brown in color and loose in particles, which is an intermediate product of the second stage of reduction.

The second stage is the further reduction of molybdenum dioxide to metal molybdenum powder. This process needs to take place at higher temperatures, and hydrogen continues to act as a reducing agent, reacting with molybdenum dioxide to form molybdenum metal and water vapor. The design of the reduction furnace is crucial, often employing multiple heating zones to achieve a gradual increase in temperature. High-temperature reduction not only requires a pure atmosphere in the furnace, but also requires the growth rate of the particles to be controlled to avoid the formation of oversized grains. The final molybdenum powder is silvery-gray, the particles are fine and uniform, and it has good fluidity and compressibility.

The reduced molybdenum powder needs to be sieved and graded to ensure that the particle size and distribution meet the demands of the drawing process. Airflow classifiers or vibrating screens are used to separate powders of different particle sizes, with the fine particles being used for high-precision applications and the larger particles being reprocessed. The entire production process is carried out in a clean room or controlled environment to prevent dust contamination or oxidation. The preparation of molybdenum powder is not only a combination of chemistry and engineering, but also the ultimate pursuit of detail and quality.

3.1.3 Quality control and testing of molybdenum powder

The quality of molybdenum powder directly determines the performance of molybdenum spray wire, so quality control and testing are the key links in the preparation of raw materials. This process involves a thorough evaluation of the chemical composition, physical properties, and microstructure of the molybdenum powder to ensure that it meets stringent industry standards. Quality control is not only the use of technical means, but also the systematic management of the production process, which runs through every link from raw materials to finished products.

The detection of chemical components is the primary task of quality control. The purity of molybdenum powder is extremely high, and any trace impurities can affect the performance of subsequent processes or final coatings. Commonly used detection methods include Inductively Coupled Plasma Emission Spectroscopy (ICP-OES), which enables rapid and accurate analysis of the elemental content of molybdenum powders such as iron, nickel, carbon, and oxygen. Oxygen content control is particularly important, as too much oxygen can cause molybdenum powder to oxidize at high temperatures, affecting the drawing or spraying effect. The inert gas melting method is the standard method for measuring oxygen content, which is precisely determined by heating a sample and analyzing the released gas.

Physical properties are tested including particle size distribution, topography, and flowability. Particle size distribution affects the behavior of molybdenum powder during pressing and sintering, and laser particle size analyzers are widely used to measure the size and distribution of particles.

The ideal molybdenum powder should have a uniform particle size, with particles that are too large can cause molding defects and particles that are too fine can reduce flowability. Scanning electron microscopy (SEM) is used to observe the morphology of molybdenum powder and check whether the particles are regularly spherical or if there is any agglomeration. The flow test is performed by a Hall flow meter to evaluate the flow velocity of the powder in the funnel, which is critical for the stability of the powder metallurgy process.

Quality control also includes strict process management. Each batch of molybdenum powder requires detailed documentation, including raw material origin, production parameters, and test results, for full traceability. This traceability mechanism not only helps to identify potential problems, but also provides data support for process optimization. International quality management system standards, such as ISO 9001, provide a normative framework for molybdenum powder production, ensuring that every step of the operation meets the established requirements. Through these measures, manufacturers are able to produce molybdenum powders with consistent quality and excellent performance, laying a solid foundation for the preparation of coated molybdenum wires.

3.2 Molybdenum wire forming process

Converting high-purity molybdenum powder into molybdenum wire for spraying is a complex process that involves multi-stage processing from powder to filament. Molybdenum's hard and brittle properties make the forming process challenging, requiring sophisticated equipment and process control to ensure the strength, uniformity and surface quality of the wire. This section will discuss in detail powder metallurgy molding technology, molybdenum wire drawing process, annealing and stress relief, and surface cleaning and polishing.

3.2.1 Powder metallurgy molding technology

Powder metallurgy is the basic process of molybdenum wire forming, which provides raw materials for subsequent wire drawing by pressing and sintering molybdenum powder into a dense blank. This process, which combines physical compression and high-temperature treatment, makes it possible to effectively utilize the properties of molybdenum powder to produce high-strength molybdenum blanks.

The first step in powder metallurgy is press molding. The high-purity molybdenum powder is packed into a special steel mold and a hydraulic press applies high pressure to tightly compact the powder particles to form a so-called "green billet". The green form has low strength and is maintained only by mechanical fitting between the particles, so extra care is required when handling and processing. The pressing process requires controlling the magnitude and distribution of pressure to avoid cracks or uneven density inside the blank. Some advanced pressing equipment adopts cold isostatic pressing technology, which further improves the density and uniformity of the green billet by applying uniform pressure through the liquid medium.

This is followed by the sintering process, in which the green billets are fed into a high-temperature furnace for heat treatment. Sintering is usually carried out in a hydrogen or vacuum environment to prevent molybdenum oxidation at high temperatures. The temperature of the sintering furnace is precisely controlled below the melting point of molybdenum, which causes the powder particles to bond by diffusion to form a strong metal structure. The sintering process not only increases the density of the blank, but also improves its mechanical properties, allowing it to withstand subsequent machining. The sintered molybdenum blank has a silver-gray color, a smooth surface and a dense internal structure, which is an ideal starting point for the wire drawing process.

Sintered molybdenum billets often require further hot working, such as hot forging or hot rolling, to adjust their size and shape. Hot forging deforms the blank by hammering or extrusion, refining the grain structure and improving the strength. Hot rolling prepares the wire drawing process by rolling the blank into slender molybdenum rods through a series of rolls. These hot working steps need to be performed at high temperatures to enhance the ductility of molybdenum while avoiding brittle fracture caused by cold working. The success of powder metallurgy technology lies in its transformation of loose powder into a tough metal blank, which lays the foundation for the forming of molybdenum wire.

3.2.2 Molybdenum wire drawing process

Molybdenum wire drawing is a critical step in processing molybdenum rods into filaments, which need to overcome the hard and brittle characteristics of molybdenum to ensure that the wire has a uniform diameter and a smooth surface. The drawing process is divided into two methods: single-mode wire drawing and multi-mode continuous wire drawing, each with its own application scenarios and characteristics.

3.2.2.1 Single-die wire drawing

Single-die wire drawing is a high-precision processing method suitable for low-volume production or scenarios with extremely high wire size requirements. In single-die wire drawing, the molybdenum rod is preheated to improve its ductility and subsequently pulled through a carbide or diamond die by a wire drawing machine. The aperture of the mold is slightly smaller than the diameter of the molybdenum rod, and the molybdenum rod is deformed by tensile force to gradually reduce its cross-section. After each drawing, the diameter of the molybdenum wire decreases slightly, and it takes several pulls to reach the target size.

The advantage of single-die wire drawing lies in its high precision and flexibility. The mould and process parameters can be individually adjusted for each drawing to ensure the size and surface quality of the wire. Lubricants play a key role in the wire drawing process, and commonly used lubricants include graphite emulsion or molybdenum disulfide, which can reduce friction between the die and the molybdenum wire, extend the life of the die and improve the surface finish of the wire. The disadvantage of single-die wire drawing is that the efficiency is low, and it needs to be manually operated to replace the mold or adjust the equipment after each drawing, which is suitable for aerospace and other fields with extremely high quality requirements.

CTIA GROUP LTD
Molybdenum Spray Wire Introduction

1. Overview of Molybdenum Spray Wire

Molybdenum spray wire is a high-purity molybdenum metal wire that is melted and deposited onto a substrate surface through thermal spray techniques such as flame spraying, plasma spraying, arc spraying, or HVOF (High Velocity Oxy-Fuel). The resulting coating offers excellent resistance to wear, corrosion, and high temperatures. Due to its high melting point and superior performance, molybdenum wire is widely used across various industrial sectors.

2. Characteristics of Molybdenum Spray Wire

High Melting Point: Approximately 2623° C, suitable for high-temperature environments.
Excellent Corrosion Resistance: Resists attack from acids, alkalis, and chemical media.
High Hardness & Wear Resistance: Tough coating that withstands mechanical wear.
Low Friction Coefficient: Reduces component wear and improves efficiency.
Chemical Stability: Maintains performance in harsh environments.
High Thermal Conductivity: Effectively dissipates heat and extends component lifespan.

3. Typical Uses of Molybdenum Spray Wire

Aerospace: Turbine blades, engine parts, thermal barrier coatings.
Automotive Industry: Wear-resistant coatings for piston rings, engine blocks, and brake discs.
Chemical & Energy Sectors: Corrosion-resistant pipelines, heat exchangers, wind power equipment.
Electronics & Semiconductors: Vacuum deposition heating wires, semiconductor leads.
Medical Field: Corrosion-resistant coatings for implants and surgical instruments.
Others: Marine anti-corrosion, wear-resistant construction machinery, high-temperature furnaces.

4. Basic Data of Molybdenum Spray Wire from CTIA GROUP LTD

Purity	≥99.95%
Density	10.2 g/cm³
Diameter Range	1.0-3.0 mm, customizable
Tensile Strength	Moderate to ensure stable wire feeding
Packaging	Customized Packaging

5. Procurement Information

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

3.2.2.2 Multi-mode continuous wire drawing

Multi-mode continuous wire drawing is an efficient industrial production method suitable for high-volume production of molybdenum spray wire. In this process, the molybdenum rod is continuously pulled through a series of molds, each with a gradual decrease in pore diameter. The wire drawing machine is equipped with multiple die bases and traction devices, and the molybdenum wire enters the next die immediately after passing through one die to achieve continuous processing. The multi-mode drawing has a high degree of automation, and ensures the uniformity and stability of the wire through precise tension control and cooling system.

The key to multi-mode drawing lies in the design of the die sequence and the coordination of process parameters. The decreasing pore size of the die requires scientific planning to avoid wire breakage or defects during the drawing process. The cooling system is usually water-cooled or air-cooled to prevent the molybdenum wire from being embrittled due to excessive temperature during the drawing process. A continuous supply of lubricant is also crucial, often spraying lubricant onto the die and wire surfaces via a recirculating system. The production efficiency of multi-mode continuous wire drawing is much higher than that of single-mode wire drawing, which is suitable for scenarios that require large-scale supply, such as the automotive industry or energy equipment.

3.2.3 Molybdenum wire annealing and stress relief

The drawing process introduces residual stresses inside the molybdenum wire that can cause cracks or fractures in subsequent processing or use. Annealing and stress relief are essential steps to restore the crystal structure of molybdenum wire through heat treatment, improving its ductility and toughness.

Annealing is usually carried out in a vacuum or hydrogen-protected furnace to prevent oxidation of the surface of the molybdenum wire. Molybdenum wire is slowly heated to a specific temperature, held for a period of time and then gradually cooled. This process rearranges the grains, eliminating dislocations and stress concentrations that form during the drawing process. The choice of annealing temperature is crucial, too high a temperature may cause the grain to be too large and reduce the strength of the wire, while too low a temperature will not be effective in relieving the stress. Some advanced annealing processes use staged heating to gradually adjust the microstructure of the wire through multiple temperature stages to optimize its properties.

Hydrogen annealing is a commonly used method that not only provides a protective atmosphere, but also reacts with trace oxides on the surface to further clean the surface of the molybdenum wire. Vacuum annealing is more suitable for high-precision applications, as it is free of any gaseous impurities and ensures the purity of the wire. The annealed molybdenum wire has significantly improved flexibility and better surface gloss, which can meet the demanding requirements of the spraying process for the performance of the wire.

3.2.4 Surface cleaning and polishing

After drawing and annealing, lubricants, oxides, or other contaminants may remain on the surface of molybdenum wire, which can affect the stability of the spraying process and the quality of the coating. Surface cleaning and polishing is the final step in the forming of molybdenum wire, which aims to create a smooth, flawless wire surface.

The cleaning process typically includes chemical cleaning and ultrasonic cleaning. Chemical cleaning uses mild acidic or alkaline solutions, such as dilute hydrochloric acid or sodium hydroxide, to remove oxide layers and organic residues from the surface. After cleaning, the molybdenum wire needs to be thoroughly rinsed with deionized water to avoid chemical residues. Ultrasonic cleaning uses high-frequency sound waves to create tiny bubbles in a liquid that pop with an impact force that effectively removes micron-sized particles and oil. Ultrasonic cleaning is particularly suitable for complex shapes of wires, ensuring that every inch of the surface is clean and flawless.

Polishing is a critical step in improving the surface quality of molybdenum wire and can be achieved by mechanical or electrochemical polishing. Mechanical polishing uses fine abrasives, such as alumina or diamond powder, to polish the surface of the wire with a rotating brush or abrasive belt to achieve a mirror effect. Electrochemical polishing places the molybdenum wire in an electrolyte, which acts as an anode, and the microscopic protrusions on the surface are preferentially dissolved, resulting in a smooth surface. The polished molybdenum wire not only has a bright appearance, but also reduces the spatter of molten droplets during the spraying process and improves the uniformity of the coating.

3.3 Special processing for molybdenum spray wire

Molybdenum spray wire requires specialized processing to meet the unique needs of the thermal spray process. These treatments include surface activation, specification customization, and surface modification to optimize the performance of the wire during the spraying process, ensuring coating quality and production efficiency.

3.3.1 Molybdenum wire surface activation treatment

Surface activation treatment is designed to improve the chemical activity and physical properties of the surface of the molybdenum wire, making it easier to melt and form uniform droplets during the spraying process. Activation can be achieved by chemical, plasma, or mechanical methods, each with its own unique advantages.

Chemical activation typically uses dilute acids or lyes to soak molybdenum wire to remove surface oxides and increase surface roughness. This treatment makes the surface of the molybdenum wire more hydrophilic, which aids in the formation and ejection of molten droplets. Plasma activation uses low-temperature plasma to bombard the surface of the wire, introduce active functional groups, and improve the chemical reactivity of the surface. This method is particularly suitable for high-precision spraying, as it does not alter the dimensions or mechanical properties of the wire. Mechanical activation increases the surface roughness and enhances the adhesion of the molten droplets by microblasting or frosting.

The activation process needs to choose the appropriate method according to the spraying equipment and application scenario. For example, spraying in the aerospace sector requires extremely high coating quality, often with plasma activation to ensure that the filament surface is clean and highly active. The activated molybdenum wire can significantly improve the spraying efficiency and coating bonding strength.

3.3.2 Specification customization of molybdenum wire for spraying

The diversity of spraying equipment requires molybdenum wire with customized specifications, including diameter, length, and composition. Specification customization is a reflection of the manufacturer's close collaboration with the customer to ensure that the filament is perfectly matched to the spraying system.

The diameter of the molybdenum wire directly affects the wire feeding speed and melting behavior. Thinner filaments are suitable for high-precision spraying and can form a thin and uniform coating; Coarser filaments are suitable for high-efficiency spraying and can quickly cover large areas of substrates. Wire is typically supplied in reels with lengths tailored to the needs of the equipment, ensuring uninterrupted spraying. The packaging is made of vacuum-sealed plastic bags or metal containers to prevent the wire from being damp or oxidized.

Ingredient customization is another important aspect. Some spray applications require molybdenum wire doped with rare earth elements such as lanthanum or cerium to improve oxidation resistance or ductility. The doping process is completed prior to wire drawing and is achieved by adjusting the molybdenum powder formulation. Customized specifications not only improve spraying results, but also extend the life of equipment and reduce maintenance costs.

3.3.3 Molybdenum wire surface modification technology

Surface modification technology further optimizes the coating performance of molybdenum wire by changing its chemical or physical properties. These technologies include siliconization, doping modification, and pre-coating treatments for issues such as high-temperature oxidation or droplet instability in spraying.

The siliconization process takes place in a high-temperature silicon atmosphere to form a protective layer of molybdenum silicide ($MoSi_2$). This protective layer is effective against high-temperature oxidation and extends the service life of the wire during the spraying process. Doping modification refines the grain structure and improves high-temperature stability by introducing rare earth or alkali metal elements into the surface of the wire. In the pre-coating process, a thin film, such as alumina or zirconia, is applied to the surface of the wire to reduce the formation of oxides during the spraying process.

These modification technologies need to be tightly integrated with the spraying process to ensure that the modified layer does not affect the wire feeding or melting behavior of the wire. Through surface modification, molybdenum wire can perform well in harsh spraying environments, meeting the demanding requirements of aviation, energy and other fields.

TEL: 0086 592 512 9696
CTIAQCD -MA-E/P 2018- 2024V
sales@chinatungsten.com

CTIA GROUP LTD
Molybdenum Spray Wire Introduction

1. Overview of Molybdenum Spray Wire

Molybdenum spray wire is a high-purity molybdenum metal wire that is melted and deposited onto a substrate surface through thermal spray techniques such as flame spraying, plasma spraying, arc spraying, or HVOF (High Velocity Oxy-Fuel). The resulting coating offers excellent resistance to wear, corrosion, and high temperatures. Due to its high melting point and superior performance, molybdenum wire is widely used across various industrial sectors.

2. Characteristics of Molybdenum Spray Wire

High Melting Point: Approximately 2623° C, suitable for high-temperature environments.
Excellent Corrosion Resistance: Resists attack from acids, alkalis, and chemical media.
High Hardness & Wear Resistance: Tough coating that withstands mechanical wear.
Low Friction Coefficient: Reduces component wear and improves efficiency.
Chemical Stability: Maintains performance in harsh environments.
High Thermal Conductivity: Effectively dissipates heat and extends component lifespan.

3. Typical Uses of Molybdenum Spray Wire

Aerospace: Turbine blades, engine parts, thermal barrier coatings.
Automotive Industry: Wear-resistant coatings for piston rings, engine blocks, and brake discs.
Chemical & Energy Sectors: Corrosion-resistant pipelines, heat exchangers, wind power equipment.
Electronics & Semiconductors: Vacuum deposition heating wires, semiconductor leads.
Medical Field: Corrosion-resistant coatings for implants and surgical instruments.
Others: Marine anti-corrosion, wear-resistant construction machinery, high-temperature furnaces.

4. Basic Data of Molybdenum Spray Wire from CTIA GROUP LTD

Purity	≥99.95%
Density	10.2 g/cm³
Diameter Range	1.0-3.0 mm, customizable
Tensile Strength	Moderate to ensure stable wire feeding
Packaging	Customized Packaging

5. Procurement Information

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

3.4 Spraying process

The spraying process is the core process of melting and depositing molybdenum wire onto the surface of the substrate, involving three stages: substrate pretreatment, thermal spraying technology and post-treatment. Each stage plays a decisive role in the quality and performance of the coating.

3.4.1 Surface pretreatment of substrates

The condition of the substrate surface has a direct impact on the adhesion and durability of the coating. Pre-treatment uses mechanical, chemical and ultrasonic methods to clean and optimize the surface of the substrate and create ideal conditions for spraying.

3.4.1.1 Mechanical sandblasting

Mechanical blasting uses high-velocity jetting of abrasives, such as alumina or silicon carbide, to impact the surface of the substrate, increasing roughness and removing impurities such as oxides, old coatings, and more. The blasting process requires precise control of abrasive type, jet pressure, and angle to avoid substrate damage. The rough surface enhances the mechanical adhesion of the coating to the substrate and improves adhesion. Sandblasting is suitable for hard substrates such as steel and nickel-based alloys, and is a common method of spraying pretreatment.

3.4.1.2 Chemical cleaning

Chemical cleaning uses solvents or alkaline solutions to remove oil, lubricants, and other organics from the surface of the substrate. Commonly used cleaning agents include ethanol, acetone, or sodium hydroxide solutions, which are rinsed with deionized water after cleaning to ensure that there is no residue. Chemical cleaning is suitable for substrates with complex shapes, and is able to penetrate deep into crevices and holes to ensure a thoroughly clean surface. This process requires attention to the selection of cleaning agents to avoid corrosion of the substrate.

3.4.1.3 Ultrasonic cleaning

Ultrasonic cleaning uses high-frequency sound waves to create tiny bubbles in the liquid, which pop with an impact force that peels off tiny particles and residues from the surface of the substrate. Ultrasonic cleaning is particularly suitable for delicate components such as aero engine blades or semiconductor equipment parts. The cleaning solution is usually deionized water or mild cleaning agent, and the cleaning time and frequency need to be adjusted according to the characteristics of the substrate to ensure cleaning results without damaging the surface.

3.4.2 Thermal spray technology

Thermal spraying technology melts and sprays molybdenum wire onto the surface of the substrate at high temperatures to form a protective coating. Commonly used thermal spray methods include flame spraying, plasma spraying, arc spraying, and high-velocity oxygen-fueled spraying (HVOF).

3.4.2.1 Flame spraying process

Flame spraying uses an oxygen-acetylene flame to heat the molybdenum wire to melt or semi-melt it, which is then sprayed onto the surface of the substrate by compressed air. The flame spraying equipment is simple and flexible to operate, which is suitable for on-site construction or spraying of large components. However, due to the lower flame temperature, the coating porosity is higher, and the adhesion is relatively weak, which is suitable for scenarios with low performance requirements, such as mechanical parts repair.

3.4.2.2 Plasma spraying process

Plasma spraying generates a high-temperature plasma (up to 15,000°C) through an electric arc that rapidly melts the molybdenum wire and sprays it onto the surface of the substrate at high velocity. Plasma spraying creates a dense, adhesive coating for high-performance applications such as aerospace and energy equipment. Precise control of process parameters is key, including plasma gas type, current intensity, and spray distance.

3.4.2.3 Arc spraying process

Arc spraying utilizes arc heating between two molybdenum wires to melt the wire and spray it through compressed air onto the substrate. Arc spraying has a high deposition efficiency and is suitable for large-area spraying, such as bridge steel structures or ship components. Coating quality depends on the coordination of arc stability and wire feed speed, and proper process tuning can significantly improve coating performance.

3.4.2.4 High velocity oxy-fuel spraying (HVOF)

HVOF spraying produces a high-velocity flame through the combustion of oxygen and fuel (e.g., kerosene), which injects molten molybdenum wire onto the substrate at supersonic speed. HVOF coatings have extremely low porosity, high hardness and adhesion, making them the first choice for high-end applications such as aero engines and gas turbines. The process complexity is high, but its superior coating properties make it indispensable in critical areas.

3.4.3 Post-spraying treatment

Post-spray treatment is designed to optimize the performance of coatings, including heat treatment, polishing, and sealing treatments.

3.4.3.1 Heat treatment and annealing

Heat treatment improves the microstructure by heating the coating in a vacuum or protective atmosphere, eliminating residual stresses. The annealing process strengthens the adhesion of the coating to the substrate and improves thermal shock resistance. The heat treatment temperature and holding time need to be adjusted according to the coating thickness and substrate characteristics to avoid performance degradation due to overheating.

3.4.3.2 Coating polishing and finishing

Polishing smooths the surface of the coating by mechanical or electrochemical methods, reducing roughness and friction. Mechanical polishing uses diamond abrasives, while electrochemical polishing uses electrolysis to achieve a mirror effect. The polished coating performs better in sliding parts such as piston rings and significantly extends the service life.

3.4.3.3 Coating sealing treatment

Sealing treatments use organic (e.g., epoxy) or inorganic (e.g., silica) sealants to fill the pores of the coating and prevent the penetration of corrosive media. Sealing treatments are particularly suitable for coatings in marine or chemical environments and can greatly improve durability. The choice of sealant is based on compatibility with the coating to ensure long-term stability.

3.5 Optimization of the production process of molybdenum spray wire

Process optimization is the key to improving the quality and efficiency of molybdenum spray wire, involving parameter control, quality assurance and green manufacturing.

3.5.1 Optimization and control of process parameters

Process optimization improves product consistency and performance by adjusting parameters in wire drawing, spraying, and more. For example, during the drawing process, it is necessary to balance the drawing speed and tension to ensure that the wire is uniform; During the spraying process, it is necessary to optimize the spraying distance and gas flow to improve the coating quality. The real-time monitoring system ensures stable parameters and improves production efficiency through sensors and feedback mechanisms.

3.5.2 Quality Assurance System

The quality assurance system covers the whole process from raw materials to finished products, following the ISO 9001 standard. Including raw material purity testing, wire size inspection and coating performance testing. The batch traceability mechanism ensures that problems can be traced back and the process is continuously improved. Quality assurance is not only a technical requirement, but also a reflection of corporate reputation.

3.5.3 Green manufacturing and energy-saving technologies

Green manufacturing focuses on energy conservation, emission reduction and resource recycling. Efficient equipment is used to reduce energy consumption, recover sprayed molybdenum particles, and reduce waste. Reduce carbon emissions by using renewable energy to power production equipment. Green manufacturing not only meets the requirements of environmental protection, but also enhances the market competitiveness of enterprises.

3.6 Key Technical Points

The production technology of molybdenum spray wire is a high-end manufacturing process that integrates material science, mechanical engineering and surface treatment technology, the core of which is to ensure the high purity of molybdenum wire, the excellent performance of the coating, and the efficiency and consistency of the coating process. This section will take an in-depth look at the three key technical points of high-purity molybdenum wire preparation, spray coating quality control, and spray efficiency and consistency, revealing how these technologies play a vital role in the production of molybdenum spray wire.

3.6.1 Preparation technology of high-purity molybdenum wire

High-purity molybdenum wire is the basis of the spraying process, and its preparation technology directly determines the physical properties, chemical stability and spraying effect of the wire. As a high-melting, corrosion-resistant transition metal, molybdenum needs to overcome its hard and brittle properties and high sensitivity to oxygen in order to produce wire with high purity and stable performance.

The preparation of high-purity molybdenum wire begins with the processing of high-purity molybdenum powder. As mentioned earlier, molybdenum powder is obtained by reducing molybdenum oxide by hydrogen, but its purity and particle properties must be further optimized to meet the needs of the wire drawing process. During the preparation process, molybdenum powder needs to be strictly screened and graded to remove oversized or undersized particles to ensure uniform particle distribution. This uniformity is essential for subsequent pressing and sintering, as any uneven grain can lead to internal defects in the billet, which in turn can affect the strength and ductility of the wire.

The pressing of molybdenum powder adopts cold isostatic pressing technology, and the powder is compacted into green billet by applying uniform pressure through a liquid medium. This method significantly improves the density and structural consistency of the blank compared to traditional unidirectional pressing. The pressed green billets are fed into a high-temperature sintering furnace where they are heated to close to the melting point of molybdenum in a hydrogen or vacuum environment. The sintering process not only binds the powder particles into a strong metal structure, but also eliminates internal porosity through the recombination and diffusion of the grains. The design of the sintering furnace should take into account the purity of the atmosphere and the uniformity of the temperature to prevent oxidation or abnormal grain growth.

The sintered molybdenum billet needs to be processed into slender molybdenum rods by hot forging or hot rolling in preparation for the wire drawing process. Hot forging makes the grain structure of the blank denser and improves its ductility through repeated hammering or extrusion. Hot rolling uses a series of rolls to gradually reduce the diameter of the billet to produce molybdenum rods suitable for wire drawing. The entire thermal process needs to be carried out at high temperatures to reduce the brittleness of molybdenum, but too high temperatures may lead to surface oxidation, so it needs to be operated in a protective atmosphere.

Wire drawing is the core link of high-purity molybdenum wire preparation, and the molybdenum rod is processed into filament through single-mode or multi-mode wire drawing process. Single-die drawing is suitable for low-volume, high-precision wire production, and the die and lubricant need to be carefully adjusted for each drawing to ensure that the wire surface is smooth and crack-free. Multi-mode continuous wire drawing is more suitable for large-scale production, and efficient processing can be achieved by automated equipment. In the drawing process, the selection of lubricants and the control of wire feeding speed are particularly important, and commonly used lubricants such as graphite emulsion or molybdenum disulfide can effectively reduce die wear and improve wire quality. The drawn molybdenum wire needs to be annealed to eliminate internal stress and restore the stability of the crystal structure, so as to ensure that it has good mechanical properties during the spraying process.

The preparation technology of high-purity molybdenum wire requires not only the precision of the process, but also the comprehensive control of raw materials, equipment and environment. For example, the production hall needs to be kept clean to prevent dust or impurities from contaminating the wire; The wire drawing equipment needs to be calibrated regularly to ensure the accuracy of the die hole diameter. Together, these details determine the quality of molybdenum wire, allowing it to meet the needs of high-end applications such as aerospace and automotive industries.

3.6.2 Quality control of spray coatings

The quality of spraying coating is an important indicator to measure the technical level of molybdenum spray wire production. High-quality coatings require excellent adhesion, uniform thickness and good wear and corrosion resistance. Coating quality control is present at every step of the spraying process, from substrate pre-treatment to coating parameter adjustment to coating inspection, ensuring that the final product meets stringent industry standards.

Substrate pretreatment is the starting point for coating quality control. The cleanliness and roughness of the substrate surface directly affect the adhesion of the coating, so it is necessary to thoroughly remove oil, oxides and other impurities through methods such as mechanical blasting, chemical cleaning and ultrasonic cleaning. Sandblasting increases the roughness of the surface of the substrate by jetting an abrasive (such as alumina) at high speed, creating a microscopic concave-convex structure that facilitates the mechanical mating of the coating to the substrate. Chemical cleaning uses mild solvents or lyes to remove organic contaminants, while ultrasonic cleaning uses the burst effect of tiny bubbles created by high-frequency sound waves to remove tiny particles that are difficult to reach. These pre-treatment steps need to be individually designed according to the material and shape of the substrate to ensure an ideal surface condition.

Parameter control in the spraying process is at the heart of quality management. The operating parameters of spraying equipment, such as arc spray guns or plasma spraying systems, including spray distance, gas flow, current intensity, and wire feed speed, must be precisely coordinated. For example, spraying too close together can cause the coating to overheat and cause cracks, while spraying too far away can cause the droplets to cool too quickly and reduce adhesion. The regulation of gas flow affects the injection rate and deposition efficiency of molten droplets, while the selection of current intensity determines the melting degree of molybdenum wire. Modern spraying equipment is often equipped with a real-time monitoring system that captures data such as temperature, pressure, and speed through sensors, and adjusts parameters in time to maintain process stability.

Coating quality testing is the last line of defense for quality control. Commonly used inspection methods include microstructural analysis, adhesion testing, and abrasion resistance assessment. Scanning electron microscopy (SEM) is used to observe the microscopic topography of coatings and check for the presence of pores, cracks, or unmelted particles. Adhesion testing evaluates the strength of a coating to a substrate through a tensile or shear test, commonly used to standard ASTM C633. The abrasion resistance test simulates the wear of the coating in actual use, and the durability of the coating is measured by a friction testing machine. In addition, the thickness and uniformity of the coating are evaluated by ultrasonic thickness gauge or X-ray fluorescence analysis to ensure compliance with design requirements.

Coating quality control also requires the establishment of a comprehensive quality management system. Each production batch needs to be documented in detail, including raw material information, process parameters, and test results, for full traceability. International standards such as ISO 9001 provide a normative framework for quality management, ensuring the stability of the production process and the consistency of products through regular audits and continuous improvement. This systematic approach to quality control enables coatings of molybdenum spray wire to meet the needs of demanding applications, such as wear-resistant coatings for gas turbine blades or automotive piston rings.

3.6.3 Spraying efficiency and consistency

Spraying efficiency and consistency are key considerations in production technology, directly impacting production costs and product quality. An efficient spraying process enables large areas of coating to be deposited in a short period of time, while consistency ensures consistent coating performance for each component and avoids defects caused by process fluctuations.

The improvement of spraying efficiency depends on the optimization of equipment and the improvement of processes. Modern spraying systems use a high-power heat source, such as plasma or HVOF, to quickly melt the molybdenum wire and form a high-velocity melt drip stream, resulting in higher deposition rates. The introduction of an automated wire feeding system has significantly improved efficiency, as it is able to feed molybdenum wire at a constant speed and angle compared to manual wire feeding, reducing the error of human operation. Efficiency is further enhanced by the use of spraying robots, which are able to precisely move the gun along a preset path to cover the surface of complexly shaped substrates for fast and uniform coating deposition.

Achieving consistency requires a number of approaches. First of all, the quality of the molybdenum wire must be stable, including the uniformity of diameter, surface finish, and chemical composition. Any wire inconsistencies can lead to fluctuations in droplet size or jet velocity, affecting coating quality. Secondly, the stability of the spraying equipment is crucial. The plant's power supply, gas supply system, and cooling system require regular maintenance to prevent process deviations due to aging or malfunctioning equipment. In addition, the control of environmental factors should not be ignored, and the spray shop needs to maintain a constant temperature and humidity to avoid the influence of external conditions on the deposition of melt droplets.

Standardization of process parameters is an important means of ensuring consistency. By establishing detailed operating procedures (SOPs) that define the range and adjustment method for each parameter, operators are able to maintain consistent process conditions from batch to batch. Data-driven process management is a development trend in recent years, through IoT technology and big data analysis, the key data in the spraying process is collected in real time, potential problems are predicted and intervened in advance. For example, some advanced spraying systems are able to use machine learning algorithms to optimize parameter combinations to significantly improve coating consistency.

Balancing spray efficiency and consistency requires a combination of production needs and cost factors. An overemphasis on efficiency can lead to a decrease in coating quality, while an overemphasis on consistency can increase production time and costs. Therefore, manufacturers need to find the best balance in process design to achieve efficient and high-quality production through technological innovation and process optimization.

3.7 Application of advanced technology

With the rapid development of materials science and manufacturing technology, the production technology of molybdenum spray wire is constantly incorporating cutting-edge technology to meet the needs of higher performance and more complex applications. This session will discuss the application of nanoscale spraying technology, laser-assisted spraying technology, cold spraying technology, and intelligent and automated spraying systems, and show how these advanced technologies can drive technological innovation in the molybdenum spray wire industry.

3.7.1 Nanoscale spraying technology

Nanoscale spraying technology is an advanced method to improve performance by controlling the microstructure of a coating down to the nanoscale. While the grain size of conventional spray coatings is usually in the micron range, nanoscale spraying reduces the grain size of the coating to the nanometer scale by optimizing the coating parameters and material properties. This fine grain structure significantly improves the hardness, toughness and wear resistance of the coating, making it excellent in extreme environments.

In the application of molybdenum spray wire, nanoscale spraying technology is achieved by adjusting the heat source and droplet deposition behavior during the thermal spraying process. Plasma spraying and HVOF spraying are commonly used technology platforms that generate finer melt droplets by precisely controlling the composition of the plasma gas, spray power, and injection speed. These droplets solidify rapidly on the surface of the substrate to form nanoscale grain structures. To further optimize the results, nano-scale molybdenum powders or dopants (such as zirconia or alumina nanoparticles) are introduced in some processes, which are co-deposited with the molybdenum wire during the spraying process to form a composite coating.

The advantage of nanoscale spraying technology is that it can significantly improve the performance of coatings. For example, the application of nanoscale molybdenum coating on aero engine turbine blades can effectively resist high-temperature oxidation and mechanical wear, and prolong the service life of components. In addition, the nano-coating has a smoother surface and a lower coefficient of friction, making it suitable for high-precision sliding parts such as automotive piston rings or hydraulic system seals. However, nanoscale spraying technology is extremely demanding on process control, and even the slightest deviation in any parameter can lead to inconsistencies in grain size, requiring advanced monitoring equipment and technical technical support.

TEL: 0086 592 512 9696
CTIAQCD -MA-E/P 2018- 2024V
sales@chinatungsten.com

3.7.2 Laser-assisted spraying technology

Laser-assisted spraying technology combines the high energy density of lasers with the flexibility of thermal spraying to revolutionize the production of spray-coated molybdenum wires. In traditional thermal spraying, molybdenum wire is melted by flame, plasma, or arc, while laser-assisted coating uses a laser beam as an auxiliary heat source or post-processing tool, significantly improving the quality and precision of the coating.

In laser-assisted spraying, the laser beam can work synchronously with a spray heat source, such as plasma or arc, to preheat the surface of the substrate or assist in melting the molybdenum wire. The high focus of the laser results in a more concentrated heat input, reducing the heat-affected zone and reducing the risk of thermal distortion of the substrate. In addition, the laser is able to precisely control the temperature and deposition path of the molten droplets, resulting in a more uniform coating and lower porosity. Some advanced systems even use lasers to remelt the sprayed coating, which refines the microstructure of the coating by quickly melting and solidifying, further improving its compactness and bonding strength.

Laser-assisted spraying technology can be used in a wide range of applications. In the aerospace sector, laser-assisted spraying enables the preparation of high-performance molybdenum coatings on titanium or nickel-based alloy substrates for the protection of turbine blades or combustion chambers. In the energy industry, laser-assisted spraying is used to create coatings that are resistant to high-temperature corrosion and extend the life of gas turbine or boiler components. The introduction of laser technology has also increased process flexibility, enabling the processing of substrates with complex shapes, such as curved surfaces or porous structures. However, the cost of laser equipment is high and the operation is complex, requiring highly qualified technicians and a complete maintenance system.

3.7.3 Cold spray technology

Cold spray technology is an emerging technology that disrupts traditional thermal spraying, and its core is to spray solid particles onto the surface of the substrate through high-velocity airflow, rather than relying on high-temperature melting. For the application of molybdenum spray wire, cold spray technology achieves coating deposition at low temperatures by processing the molybdenum wire into micron-sized particles or directly using molybdenum powder. This technology is unique in that it avoids oxidation, phase transition, or thermal stress issues associated with high temperatures, making it particularly suitable for heat-sensitive substrates.

During the cold spray process, the molybdenum particles are accelerated to supersonic speeds (usually driven by helium or nitrogen) to hit the surface of the substrate with extremely high kinetic energy. The particles undergo violent plastic deformation at the moment of impact, forming a mechanical or metallurgical bond with the substrate to form a dense coating. The cold-sprayed coating has very low porosity and excellent adhesion, while retaining the original chemical composition and crystal structure of molybdenum. This property makes cold spray particularly suitable for the preparation of high-purity, corrosion-resistant molybdenum coatings for use in offshore or chemical equipment.

TEL: 0086 592 512 9696
sales@chinatungsten.com

The challenge of cold spray technology lies in its high requirements for particle properties and equipment performance. The size, morphology, and fluidity of molybdenum particles need to be precisely controlled to ensure the stability of the spray and the uniformity of the coating. In addition, cold spray equipment requires a high-pressure gas system and a sophisticated nozzle design, which increases production costs. Nevertheless, the low-temperature nature of cold spraying makes it promising for aerospace, electronics, and medical applications, such as the preparation of functional coatings for aluminum alloys or polymer substrates.

3.7.4 Intelligent and automated spraying systems

The introduction of intelligent and automated spraying system marks the arrival of molybdenum spray wire production technology towards the era of Industry 4.0. By integrating sensors, robotics, artificial intelligence, and big data analytics, these systems have made the spraying process automated, intelligent, and efficient, significantly improving production efficiency and product quality.

The automated spraying system is equipped with high-precision spraying guns and wire feeding devices with industrial robots as the core, which can complete the spraying of complex substrates according to the preset path. Through visual recognition and path planning technology, the robot adapts to substrates of different shapes and sizes, reducing manual intervention. The sensor monitors spraying parameters such as temperature, pressure and droplet velocity in real time and automatically adjusts through a feedback system to ensure process stability. Some advanced systems also integrate in-line inspection capabilities to check the thickness and defects of coatings through laser scanning or infrared imaging, and identify problems in a timely manner.

Intelligent spraying systems go one step further, using artificial intelligence and machine learning algorithms to optimize the process. For example, AI systems are able to analyze historical spray data to predict the best combination of parameters and reduce the cost of testing. Cloud computing technology enables the data of multiple production bases to be shared, form a unified process database, and improve the technical management ability of the enterprise. In addition, the intelligent system also supports remote monitoring and maintenance, and operators can view the equipment status in real time through mobile devices and quickly respond to faults.

The application of intelligent and automated spraying system has significantly improved the production efficiency of molybdenum spray wire. In the automotive industry, for example, automated spraying lines are capable of continuously processing thousands of piston rings with a coating consistency of more than 99%. In the aerospace sector, intelligent systems provide customized coating solutions for parts with complex geometries and shorten production cycles. The wide application of these technologies has not only enhanced the competitiveness of the industry, but also promoted the development of spraying technology in a more efficient and intelligent direction.

3.8 Technical Challenges and Solutions

Although significant progress has been made in the production technology of molybdenum spray wire, there are still a number of technical challenges, including coating peeling and cracking, high-temperature oxidation and performance degradation, balancing production costs and efficiency, and the adaptability of complex substrates. This section will analyze the causes of these challenges and propose practical solutions.

3.8.1 Coating peeling and cracking

Coating peeling and cracking is a common problem in molybdenum spray wire applications and is often caused by insufficient adhesion of the coating to the substrate, thermal stress accumulation, or defects within the coating. Spalling can cause the coating to fail, while cracking can trigger further corrosion or wear, shortening component life.

The main cause of coating peeling is insufficient surface preparation of the substrate or improper spraying parameters. Oil, oxides, or uneven roughness on the surface of the substrate can weaken the adhesion of the coating to the substrate. Solving this problem requires enhanced substrate pre-treatment, multi-stage cleaning and sandblasting processes to ensure that the surface is clean and has the right roughness. In addition, optimizing spray parameters, such as lowering the spray temperature or adjusting the spray distance, can reduce the rapid cooling of the melt droplets and improve the adhesion of the coating.

Cracking is usually caused by thermal or mechanical stress. During the spraying process, the difference in the coefficient of thermal expansion between the molybdenum coating and the substrate can lead to stress accumulation, especially during high-temperature cooling. Solutions include the use of gradient coating techniques to smooth out differences in the coefficient of thermal expansion by introducing a transition layer (e.g., nickel-based alloys) between the substrate and the molybdenum coating. Heat treatment and annealing are also effective methods to eliminate residual stresses and enhance the toughness of the coating through slow cooling. In addition, improved spraying processes, such as cold spraying with low heat input, can significantly reduce cracking caused by thermal stress.

3.8.2 High-temperature oxidation and performance degradation

The oxidation of molybdenum coatings at high temperatures is another major challenge. Molybdenum reacts easily with oxygen at high temperatures to form volatile molybdenum oxide (MoO_3), which leads to degradation or even failure of the coating. This problem is especially acute in high-temperature applications such as aero engines and gas turbines.

Solutions for high-temperature oxidation include the application of surface modifications and protective coatings. Siliconization is an effective method to significantly improve oxidation resistance by forming a protective layer of $MoSi_2$ on the surface of the molybdenum wire or coating. Another method is to dope rare earth elements such as lanthanum or cerium to enhance the high-temperature stability of the coating by refining the grains and forming a stable oxide layer. In addition, pre-coating technologies, such as alumina or zirconia coatings, reduce oxide formation during the spraying process and extend coating life.

TEL: 0086 592 512 9696

sales@chinatungsten.com

Process optimization is also an important means to deal with high-temperature oxidation. For example, the use of an inert gas (e.g. argon) as the spray atmosphere can effectively isolate oxygen and reduce oxidation reactions. The application of cold spray technology avoids high-temperature melting and radically reduces the risk of oxidation. By combining these methods, molybdenum coatings are able to maintain long-term performance stability at high temperatures.

3.8.3 Balance between production cost and efficiency

The production cost of molybdenum spray wire is high, mainly due to the consumption of raw materials, equipment and energy. How to improve production efficiency and reduce costs while maintaining high quality is an important challenge faced by the industry.

The control of raw material cost needs to start from the preparation of molybdenum powder. By optimizing the beneficiation and purification process, the recovery rate of molybdenum concentrate can be improved and production costs can be reduced. In addition, the recycling of spatter particles and waste from the spraying process significantly reduces raw material waste. The reduction of equipment costs depends on the promotion of modular design and localization technology. For example, the cost of localized plasma spraying equipment is 30%-50% lower than that of imported equipment, and its performance is gradually approaching the international level.

Efficiency gains need to be achieved through automation and intelligent technologies. Automated spray lines reduce manual operations and increase production speeds, while intelligent systems optimize process parameters through data analysis to reduce unnecessary testing and scrap rates. In addition, improving energy efficiency is also key to reducing costs. The use of high-efficiency heat sources and energy-saving cooling systems can reduce energy consumption while meeting the requirements of green manufacturing.

3.8.4 Adaptability of spraying complex substrates

The coating of complex substrates, such as curved surfaces, porous structures, or odd-shaped parts, is a technical challenge, and it is difficult to achieve uniform coating deposition with traditional coating methods, especially in high-precision parts in the aerospace and medical sectors.

One solution is to use robotic spraying systems that adapt to complex substrate geometries through multi-axis motion and path planning. The introduction of visual recognition technology enables the robot to adjust the spraying angle and distance in real time to ensure the uniformity of the coating. Laser-assisted spraying is also an effective means of coating complex surfaces with a highly focused heat source that allows precise control of droplet deposition.

The application of cold spray technology on complex substrates is promising. Due to its low-temperature nature, cold spraying is able to handle heat-sensitive substrates, such as polymers or composites, without causing deformation or degradation of performance. In addition, the development of customized spraying fixtures and auxiliary tools can further improve the coating adaptability of complex substrates, ensuring comprehensive and consistent coating coverage.

TEL: 0086 592 512 9696
CTIAQCD -MA-E/P 2018- 2024V
sales@chinatungsten.com


CTIA GROUP LTD molybdenum spray wire

Chapter 4 Classification of Molybdenum Spray Wire

As an important material for thermal spraying technology, the performance and application range of molybdenum spray wire are diversified due to different production processes, chemical compositions and use scenarios. In order to better understand and select suitable molybdenum spray wires, it is necessary to classify them scientifically. This section will classify the molybdenum spray wire in detail from the three dimensions of purity, use and spraying process, and discuss the characteristics, preparation methods and application scenarios of various types of molybdenum wire.

4.1 Classification by purity

The purity of molybdenum spray wire is the core index of its performance, which directly affects the chemical stability, mechanical properties and corrosion resistance of the coating. According to the difference of molybdenum content and doped elements in molybdenum wire, it can be divided into two categories: high-purity molybdenum wire and doped molybdenum wire.

4.1.1 High-purity molybdenum wire

High-purity molybdenum wire refers to molybdenum wire with a molybdenum content of 99.95% or higher, with very low impurities (such as iron, nickel, carbon, oxygen), and usually meets the requirements of national standards (such as GB/T 4181-2017) or international standards (such as ASTM B387-18). High-purity molybdenum wire is prepared through a multi-stage purification process, including ammonia leaching, hydrogen reduction and vacuum smelting, to ensure that trace impurities are effectively removed.

TEL: 0086 592 512 9696
CTIAQCD -MA-E/P 2018- 2024V
sales@chinatungsten.com

CTIA GROUP LTD
Molybdenum Spray Wire Introduction

1. Overview of Molybdenum Spray Wire

Molybdenum spray wire is a high-purity molybdenum metal wire that is melted and deposited onto a substrate surface through thermal spray techniques such as flame spraying, plasma spraying, arc spraying, or HVOF (High Velocity Oxy-Fuel). The resulting coating offers excellent resistance to wear, corrosion, and high temperatures. Due to its high melting point and superior performance, molybdenum wire is widely used across various industrial sectors.

2. Characteristics of Molybdenum Spray Wire

High Melting Point: Approximately 2623° C, suitable for high-temperature environments.
Excellent Corrosion Resistance: Resists attack from acids, alkalis, and chemical media.
High Hardness & Wear Resistance: Tough coating that withstands mechanical wear.
Low Friction Coefficient: Reduces component wear and improves efficiency.
Chemical Stability: Maintains performance in harsh environments.
High Thermal Conductivity: Effectively dissipates heat and extends component lifespan.

3. Typical Uses of Molybdenum Spray Wire

Aerospace: Turbine blades, engine parts, thermal barrier coatings.
Automotive Industry: Wear-resistant coatings for piston rings, engine blocks, and brake discs.
Chemical & Energy Sectors: Corrosion-resistant pipelines, heat exchangers, wind power equipment.
Electronics & Semiconductors: Vacuum deposition heating wires, semiconductor leads.
Medical Field: Corrosion-resistant coatings for implants and surgical instruments.
Others: Marine anti-corrosion, wear-resistant construction machinery, high-temperature furnaces.

4. Basic Data of Molybdenum Spray Wire from CTIA GROUP LTD

Purity	≥99.95%
Density	10.2 g/cm³
Diameter Range	1.0-3.0 mm, customizable
Tensile Strength	Moderate to ensure stable wire feeding
Packaging	Customized Packaging

5. Procurement Information

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

Peculiarity:
High chemical stability: High purity molybdenum wire exhibits excellent oxidation and chemical resistance in high temperature and corrosive environments, making it suitable for demanding applications.
Excellent thermal conductivity: High purity reduces the scattering of impurities at grain boundaries and enhances thermal conductivity, making it suitable for coatings that require efficient thermal management.
Uniform microstructure: The grain of high-purity molybdenum wire is fine and evenly distributed, the coating density is high, and the porosity is low.
High cost: Due to the complex purification process, the production cost of high-purity molybdenum wire is high, which is suitable for the high-end market.

Preparation process: The production of high-purity molybdenum wire starts with high-purity molybdenum powder. Molybdenum powder is prepared in a tightly controlled reducing atmosphere by a hydrogen reduction furnace and then pressed into a molybdenum billet using a powder metallurgy process. The molybdenum billet undergoes high-temperature sintering, hot rolling and multi-wire drawing processes to gradually reduce the diameter and finally form a filament. High-precision molds and graphite emulsion lubricants are used during the drawing process to ensure that the surface of the wire is smooth and defect-free. The annealing process is carried out under vacuum or hydrogen protection, which relieves internal stresses and optimizes mechanical properties. Surface cleaning uses chemical or ultrasonic methods to remove residual lubricants and oxides, ensuring a high level of filament cleanliness.

Application scenario: High-purity molybdenum wire is widely used in fields with extremely high requirements for coating performance. For example, in the aerospace sector, coatings prepared with high-purity molybdenum wire are used in turbine blades and combustion chambers to resist high-temperature oxidation and mechanical wear; In the semiconductor industry, high-purity molybdenum wire is used for vacuum coating heating wire to ensure that there is no impurity contamination during the coating process; In the chemical industry, high-purity molybdenum coatings protect reactors and pipelines against the erosion of acidic media.

4.1.2 Doped molybdenum wire

Doped molybdenum wire is a molybdenum wire that adds trace elements such as rare earth elements, ceramic particles or other metals to the molybdenum matrix to improve specific properties. Common doped elements include lanthanum oxide (La_2O_3), yttrium oxide (Y_2O_3), potassium (K), or silicon carbide (SiC). The doping amount is usually controlled between 0.1%-2% to balance performance improvement and cost control.

Peculiarity:
Enhanced high-temperature performance: Molybdenum wire doped with rare earth elements (e.g., lanthanum oxide doping) forms a stable oxide protective layer at high temperatures, significantly improving oxidation resistance.
Improved mechanical properties: Doped elements refine grains, enhance tensile strength and

toughness, and reduce the risk of broken filaments during the spraying process.

Customized features: Doped molybdenum wire can be adapted to the application requirements, such as increasing wear resistance or decreasing the coefficient of friction.

Moderate cost: Compared with high-purity molybdenum wire, the production cost of doped molybdenum wire is slightly lower, which is suitable for large-scale industrial applications.

Preparation process: The preparation of doped molybdenum wire introduces doped elements in the production stage of molybdenum powder. For example, lanthanum oxide-doped molybdenum wire is produced by mixing a lanthanum oxide solution with ammonium molybdate to produce doped molybdenum powder, which is subsequently reduced. Doped molybdenum powder is made into molybdenum wire by pressing, sintering and drawing process. During the sintering process, the temperature and atmosphere need to be precisely controlled to ensure that the doping elements are evenly distributed and not volatile. The drawing and annealing process is similar to that of high-purity molybdenum wire, but the parameters need to be adjusted to accommodate the effect of doping elements on the hardness of the material. Special attention should be paid to the surface treatment to avoid the loss of doping elements during the cleaning process.

Application scenarios: Doped molybdenum wire is widely used in specific industrial scenarios due to its targeted performance optimization. For example, lanthanum oxide doped molybdenum wire is used for high-temperature resistant coating of gas turbine blades to extend component life; Because of its high toughness, potassium-doped molybdenum wire is suitable for wear-resistant coating of automobile piston rings; Molybdenum wire doped with silicon carbide is used in offshore equipment to provide excellent wear and corrosion resistance. The diversification of doped molybdenum wire allows it to strike a balance between cost and performance, and is particularly suitable for the mid-to-high-end market.

4.2 Classification by use

Molybdenum spray wire can be divided into two categories: molybdenum wire for industrial spraying and molybdenum wire for functional coating according to its end use. This classification reflects the performance requirements and coating design of molybdenum wire in different application scenarios.

4.2.1 Molybdenum wire for industrial spraying

Molybdenum wire for industrial spraying is mainly used to prepare protective coatings, which are designed to improve the wear resistance, corrosion resistance and high temperature resistance of the substrate. This type of molybdenum wire is widely used in large-scale industrial production, emphasizing the reliability and cost-effectiveness of the coating.

Peculiarity:

High durability: Industrial spray coatings need to withstand mechanical abrasion, chemical attack, or high-temperature impact, and molybdenum wire needs to have stable mechanical and chemical properties.

High deposition efficiency: Industrial spraying focuses on production efficiency, and molybdenum wire needs to be adapted to an automatic wire feeding system to ensure a continuous and stable spraying process.

Versatility: Molybdenum wire for industrial spraying is usually in standard specifications and is suitable for a variety of substrates (e.g. steel, aluminum, ceramics).

Economy: The coating performance and cost need to be balanced, and the molybdenum wire for industrial spraying is mostly high-purity or lightly doped molybdenum wire.

Preparation and application process: The preparation process of molybdenum wire for industrial spraying is relatively standardized, using high-purity molybdenum powder or lightly doped molybdenum powder, made by powder metallurgy, wire drawing and annealing. The spraying process is mainly flame spraying and arc spraying, which is suitable for large-area coating deposition due to its simple equipment and low cost. During the spraying process, the molybdenum wire enters the spray gun at a constant speed through the wire feeding device, and after melting, it forms molten droplets, which are sprayed onto the surface of the substrate. Post-coating treatments, such as polishing or heat treatment, can further optimize performance.

Application scenario: Molybdenum wire for industrial spraying is widely used in the following fields:

Automotive industry: wear-resistant, high-temperature coatings for piston rings, cylinder blocks and exhaust systems to improve engine efficiency and longevity.

Energy industry: Protects boiler pipes, heat exchangers and wind turbine components against corrosion and wear.

Marine & Offshore: Provides anti-corrosion coatings for propellers and hulls to extend the life of marine equipment.

Construction machinery: Excavator buckets and heavy equipment surface coatings for improved wear and impact resistance.

4.2.2 Molybdenum wire for functional coating

Molybdenum wire for functional coatings is used to prepare coatings with specific functions, such as self-lubricating, electrically conductive, thermal barrier or biocompatible coatings. These molybdenum wires are typically targeted at high-end applications and require customized properties to meet specific technical requirements.

Peculiarity:

Special functionality: Functional coatings are designed for specific applications, such as low friction, electrical conductivity, or thermal shock resistance.

High precision requirements: The coating needs to have a precise thickness and microstructure, and the size and surface quality of the molybdenum wire are extremely high.

Complex process: Advanced spraying technology (such as plasma spraying, HVOF) is often used for functional coatings, which have strict requirements on the melting behavior and deposition efficiency of molybdenum wire.

High added value: molybdenum wire for functional coating is mostly used in high-tech fields, with high market value but high production cost.

TEL: 0086 592 512 9696
sales@chinatungsten.com

Preparation and application process: The preparation of molybdenum wire for functional coating needs to be customized according to the coating function. For example, molybdenum wire for self-lubricating coatings may be doped with molybdenum disulfide or graphite, and molybdenum wire for thermal barrier coatings may be compounded with ceramic particles. The preparation process includes high-precision wire drawing and multi-stage annealing to ensure the uniformity and stability of the wire. The spraying process is mainly plasma spraying, HVOF or cold spraying, which enables precise control of the microstructure and properties of the coating. Fine pre-treatment of the substrate (e.g. sandblasting or ultrasonic cleaning) is required prior to spraying to ensure coating adhesion. Post-coating treatment may include laser remelting or sealing to optimize functional properties.

Application scenario: Molybdenum wire for functional coating has a wide range of applications in the following fields:
Aerospace: Thermal barrier coatings are used on turbine blades to protect components from high temperatures and oxidation; Conductive coatings are used for spacecraft electrical contact parts.
Electronics & Semiconductors: Molybdenum coating is used to heat wires in vacuum coating equipment to ensure high-purity coating; Self-lubricating coatings are used to slide electronic components at high speeds.
Medical: biocompatible molybdenum coatings are used in artificial joints and implants to reduce corrosion of body fluids; Antimicrobial coatings are used for surgical tools.
Additive manufacturing: The molybdenum coating protects the 3D printing nozzle against the wear and tear of the high-temperature molten material.

4.3 Classification according to spraying process

According to the applicable spraying process, molybdenum wire can be divided into molybdenum wire for flame spraying, molybdenum wire for arc spraying, molybdenum wire for plasma spraying, molybdenum wire for high-speed oxygen fuel spraying (HVOF) and molybdenum wire for cold spraying. This classification reflects the performance requirements and process characteristics of molybdenum wire in different spraying technologies.

4.3.1 Molybdenum wire for flame spraying

Flame spraying is a traditional spraying process that uses an oxy-acetylene flame to heat the molybdenum wire, melt it and spray it onto the surface of the substrate. Molybdenum wire for flame spraying needs to have stable melting behavior and moderate mechanical properties.

Peculiarity:
Simple process: Flame spraying equipment has low cost, easy operation, and is suitable for on-site construction.
Moderate coating properties: The coating has high porosity and medium adhesion, making it suitable for general industrial applications.
The requirements for molybdenum wire are low: the diameter is usually 1.6-3.0 mm, the surface needs to be smooth, but the purity requirements are relatively loose.

TEL: 0086 592 512 9696

sales@chinatungsten.com

Preparation and application process: Molybdenum wire for flame spraying is mostly made of high-purity or lightly doped molybdenum wire, which is prepared by standard wire drawing process. During the spraying process, the molybdenum wire enters the spray gun through the wire feeding device, the oxy-acetylene flame melts it, and the compressed air sprays the molten droplets onto the substrate. After coating, it needs to be polished or sealed to reduce porosity.

Application Scenarios:
Repair of automotive parts (e.g. crankshafts, pistons).
Abrasion resistant coatings for construction machinery (e.g. excavator buckets).
Anti-corrosion coating for bridge steel structure.

4.3.2 Molybdenum wire for arc spraying

Arc spraying uses an arc heat formed between two molybdenum wires to melt the wire and spray it onto the surface of the substrate. Molybdenum wire for arc spraying needs to have high conductivity and stable wire feeding performance.

Peculiarity:
High deposition efficiency: The arc spraying speed is fast, and it is suitable for large-area coatings.
Higher coating quality: Coating has lower porosity and stronger adhesion than flame spraying.
Double-wire design: two molybdenum wires need to be fed synchronously, and the consistency of wire diameter is required to be high.

Preparation and application process: Molybdenum wire for arc spraying is usually high-purity molybdenum wire with a diameter of 1.6-2.0 mm. The preparation process focuses on the dimensional accuracy and surface finish of the wire to ensure the stability of the arc. The spraying equipment is equipped with a dual wire feeding system to precisely control the wire feed rate.

Application Scenarios:
Anti-corrosion coatings for ships (e.g. hulls, decks).
Wear-resistant coating for wind turbine blades.
Protective coating for steel bridges.

4.3.3 Molybdenum wire for plasma spraying

Plasma spraying uses high-temperature plasma (up to 15,000°C) to melt molybdenum wire to form a high-performance coating. Molybdenum wire for plasma spraying requires high purity and precision.

Peculiarity:
High coating quality: dense coating, low porosity, strong adhesion.
Complex process: High equipment costs and precise control of plasma parameters.
High requirements for molybdenum wire: high purity and no defects on the surface are required.

Preparation and application process: The molybdenum wire for plasma spraying is made of high-purity molybdenum wire with a diameter of 1.0-2.0 mm, and the surface is electrochemically polished. Plasma is generated by an inert gas (e.g. argon) in the spraying equipment, and the molybdenum wire is melted in a high-temperature plasma stream to form a highly dense coating after deposition.

Application Scenarios:
Thermal barrier coating for aero engine turbine blades.
Conductive coatings for semiconductor devices.
Corrosion-resistant coating for high-temperature reactors.

4.3.4 Molybdenum wire for high-speed oxy-fuel spraying (HVOF).

HVOF spraying deposits a molybdenum coating through a supersonic flame, which has high hardness and strong adhesion. Molybdenum wire for HVOF needs to be resistant to high temperature and high pressure injection.

Peculiarity:
Ultra-high coating performance: The coating porosity is extremely low, and the hardness is close to that of ceramic coatings.
High equipment requirements: high-pressure fuel and precise control systems are required.
Molybdenum wire has strong stability: it needs to withstand the impact of high-speed jetting.

Preparation and application process: Most of the molybdenum wires for HVOF are high-purity or doped molybdenum wires, and the preparation process optimizes the toughness and surface quality of the wires. Spraying equipment uses oxygen and fuel, such as kerosene, to create a supersonic flame, where the molybdenum wire melts at high temperatures and deposits at high speeds.

Application Scenarios:
Wear-resistant coating for gas turbine blades.
High hardness coating for aerospace hydraulic parts.
Pressure-resistant coating for deep-sea equipment.

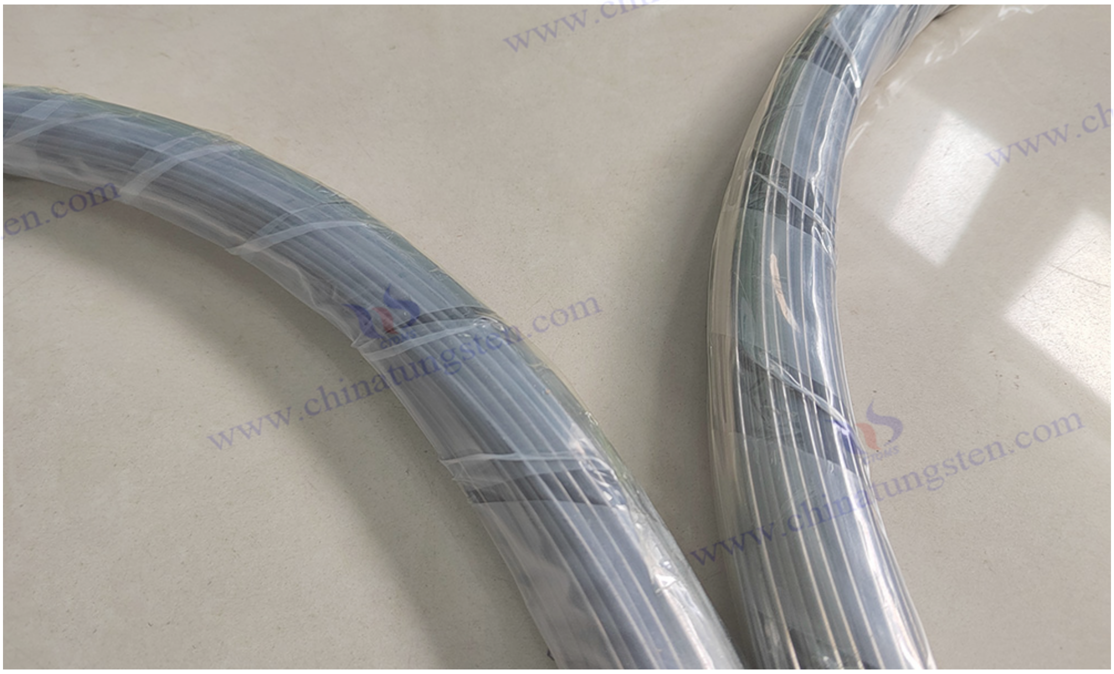
4.3.5 Molybdenum wire for cold spraying

Cold spraying accelerates the deposition of molybdenum particles through ultra-high-velocity gases to form a coating at low temperatures. Molybdenum wire for cold spraying needs to be fine and uniform.

Peculiarity:
Low-temperature process: avoids oxidation and is suitable for heat-sensitive substrates.
Strong environmental protection: no exhaust gas, in line with green manufacturing.
Special requirements for molybdenum wire: fine particles or powder form are required.

Preparation and application process: Molybdenum for cold spraying needs to be prepared by special grinding or gas atomization, and the particle size is controlled at the micron level. Spraying equipment uses high-pressure gases, such as nitrogen, to accelerate particles that are deposited on the surface of the substrate to form a dense coating.

Application Scenarios:
Thermally conductive coatings for electronic components.
Aluminum alloy substrate repair.
Biocompatible coatings for medical devices.



CTIA GROUP LTD molybdenum spray wire

Chapter 5 Uses of Molybdenum Spray Wire

Molybdenum spray wire plays an irreplaceable role in many industrial fields due to its high melting point, corrosion resistance and excellent mechanical properties. Molybdenum coatings are deposited on the surface of substrates through thermal spraying techniques such as flame spraying, plasma spraying, arc spraying, and high-velocity oxy-fuel spraying, which can significantly improve the wear resistance, high temperature resistance, and corrosion resistance of components. This chapter will discuss in detail the wide range of applications of molybdenum spray wire in aerospace, automotive, chemical and energy, electronics and semiconductors, medical and bioengineering, and other fields, demonstrating its diverse value in modern industry.

5.1 Aerospace field

The aerospace industry has extremely demanding requirements for material properties, and components need to operate stably at high temperatures, high pressures, and in highly corrosive environments. Due to its excellent high-temperature performance and oxidation resistance, molybdenum spray wire is widely used in the preparation of coatings for key components of aero engines and spacecraft. This section will discuss the specific applications of molybdenum spray wire in turbine blades and engine components, high-temperature structural parts and thermal barrier coatings, and wear-resistant and anti-corrosion coatings for spacecraft.

5.1.1 Turbine blades and engine components

The turbine blades of an aero engine are the core components of an aero engine and are subjected to extremely high temperatures, pressures and mechanical stresses. The molybdenum coating prepared by molybdenum spray wire has become an ideal choice for surface protection of turbine blades due to its high hardness and wear resistance. Molybdenum coatings are deposited on the surface of nickel-based alloys or titanium blades by plasma spraying or high-velocity oxy-fuel spraying (HVOF) to form a tough protective layer that can effectively resist the erosion of high-temperature gas streams and particulate wear.

In the operating environment of turbine blades, the temperature can exceed 1000°C, and with high-speed rotation and vibration, ordinary materials can hardly withstand such harsh conditions. The excellent thermal conductivity and thermal shock resistance of the molybdenum coating enable it to effectively disperse heat and reduce the thermal stress concentration on the blade surface. In addition, the high hardness of the molybdenum coating resists the impact of solid particles such as sand or combustion residues, extending the service life of the blades. In practical applications, molybdenum coatings are often combined with other materials, such as zirconia thermal barrier coatings, to form a composite coating that further improves the high temperature resistance of blades.

Molybdenum spray wire is also widely used in other engine components such as combustion chambers and nozzles. Extreme heat and chemical corrosion inside the combustion chamber require materials with excellent oxidation resistance, and molybdenum coatings protect the substrate from erosion by forming a stable oxide layer. The flexibility of the spraying process allows the molybdenum coating to adapt to complex geometries, ensuring full protection of the combustion chamber and nozzles. The application of this coating technology significantly improves the reliability and maintenance intervals of aero engines, providing important support for the efficiency and safety of the aerospace industry.

5.1.2 High-temperature structural parts and thermal barrier coatings

High-temperature structural components in aerospace vehicles, such as rocket engine nozzles, hot-end components, and re-entry spacecraft enclosures, require structural integrity to be maintained at extreme temperatures. Coatings prepared by molybdenum spray wire are ideal protective materials for these components due to their high melting point and thermal shock resistance. The molybdenum coating is deposited on the surface of superalloy or ceramic matrix composites by plasma spraying technology to form a dense protective layer, which can effectively resist high-temperature oxidation and thermal cycle stress.

Thermal barrier coatings (TBC) are an important technology in the aerospace industry to reduce the surface temperature of substrates and extend component life. Molybdenum coatings are often used as a binder layer in thermal barrier coating systems to connect the substrate to the top layer of ceramics (e.g., zirconia). The coefficient of thermal expansion of molybdenum coating is between that of metal substrate and ceramic coating, which can effectively alleviate the stress caused by thermal expansion mismatch and prevent the coating from peeling. In addition, the high thermal conductivity of the molybdenum coating helps to conduct heat from the ceramic layer to the substrate, optimizing the performance of the thermal barrier system.

In the hot-end components of space shuttles or hypersonic vehicles, molybdenum coatings also act as anti-ablation. Ablation refers to the gradual loss of materials under the impact of high-temperature air streams, and molybdenum coatings can slow the rate of ablation and protect critical components through their high melting point and chemical stability. The application of this coating technology enables spacecraft to perform longer missions in extreme environments, providing technical support for deep space exploration and high-speed flight.

5.1.3 Wear-resistant and anti-corrosion coating for spacecraft

Spacecraft face complex environmental challenges during launch, operation, and recovery, including atmospheric friction, chemical corrosion, and mechanical wear. Abrasion-resistant and anti-corrosion coatings prepared by molybdenum spray wire are widely used in the external structure and key components of spacecraft, such as satellite antennas, propulsion system components and landing devices. These coatings are deposited by arc spraying or HVOF technology, which can significantly improve the durability and reliability of components.

On the exterior of spacecraft, the molybdenum coating is resistant to atmospheric oxygen and moisture corrosion, especially in the launch site environment in oceanic climates. The high hardness and low coefficient of friction of the molybdenum coating make it resistant to impact wear by tiny particles, such as dust or ice particles encountered during high-speed flight. In addition, the chemical inertness of the molybdenum coating allows it to remain stable when exposed to chemical fuels or oxidizers, protecting critical components of the spacecraft from erosion.

The low-friction properties of molybdenum coatings are particularly important in the moving parts of satellites, such as solar wing hinges or antenna drive mechanisms. These components require high-precision movement in a vacuum environment, and any friction or wear can lead to functional failure. The coating prepared by molybdenum spray wire ensures the long-term stable operation of these components through its smooth surface and excellent wear resistance. Advances in spacecraft coating technology have not only improved equipment performance, but also provided more reliable material support for future deep space exploration missions.

5.2 Automotive industry

The automotive industry is an important application area for molybdenum spray wire, which is widely used to improve the performance of engine, exhaust system and brake system components due to its wear resistance, high temperature resistance and low friction characteristics. This section examines the specific applications of molybdenum spray wire in engine piston and cylinder block coatings, exhaust system high-temperature coatings, and brake system wear coatings.

5.2.1 Engine piston and block coating

The pistons and cylinder blocks of automobile engines are the core components of automobiles, which need to operate in high-temperature, high-pressure, and high-speed friction environments. The molybdenum coating prepared by molybdenum spray wire becomes an ideal protective layer for the piston and cylinder surface due to its high hardness and low coefficient of friction. Molybdenum coatings are typically deposited on the surface of aluminum alloy or cast iron substrates by arc spraying or flame spraying techniques to form a tough protective layer that significantly reduces frictional wear and improves engine efficiency and life.

In the application of piston rings, molybdenum coating can effectively reduce the friction with the cylinder wall, reducing energy loss and fuel consumption. The porous structure of the molybdenum coating also has a certain oil storage capacity, which is able to maintain lubrication during operation and prevent burns caused by dry friction. In addition, the high-temperature resistance of the molybdenum coating allows it to remain stable in the high-temperature environment of the combustion chamber and resist the corrosion of combustion products. The application of this coating technology allows modern automotive engines to operate at higher compression ratios and power outputs while maintaining low maintenance costs.

The molybdenum coating on the inside of the cylinder block is equally important. The surface of the cylinder block needs to withstand the repeated friction of the piston ring and the impact of high-temperature gas, and it is difficult for ordinary materials to maintain performance for a long time. Molybdenum coating can effectively protect the surface of the cylinder block and prolong its service life through its high hardness and thermal shock resistance. In some high-performance vehicles, molybdenum coatings are used in combination with other materials, such as ceramic or carbon-based coatings, to form a composite coating that further enhances performance. The widespread use of this technology has pushed the automotive industry towards a more efficient and environmentally friendly development.

5.2.2 High temperature resistant coating for exhaust system

Automotive exhaust systems operate in high-temperature and corrosive gas environments and require excellent heat and corrosion resistance. Due to its high melting point and chemical stability, molybdenum coatings prepared by molybdenum spray wire are widely used in the surface protection of exhaust pipes, catalytic converters and mufflers. These coatings are deposited by plasma spraying or HVOF technology and are resistant to erosion and oxidation by high-temperature exhaust gases.

The operating temperature of the exhaust system can be as high as more than 800°C, especially in turbocharged engines, where the exhaust gas temperature is even higher. Molybdenum coatings prevent substrates, such as stainless steel or mild steel, from oxidizing or embrittlement at high temperatures by forming a stable oxide layer. In addition, the thermal shock resistance of the molybdenum coating allows it to withstand frequent hot and cold cycles, avoiding cracks or spalling caused by temperature changes. In catalytic converters, the molybdenum coating also protects the precious metal catalyst inside, extending its service life and improving the efficiency of exhaust gas treatment.

The low-friction properties of molybdenum coatings also play an important role in certain parts of the exhaust system, such as valves or connections. These components need to maintain flexible movement at high temperatures, and the application of molybdenum coatings can reduce frictional wear and improve system reliability. Through the molybdenum spray wire technology, the automobile exhaust system can maintain long-term stable performance in harsh environments, providing important support for the environmental performance and durability of the vehicle.

5.2.3 Wear-resistant coating for brake system

The braking system is at the heart of automotive safety, and brake discs and pads are subjected to high levels of friction and thermal loads. The molybdenum coating prepared by molybdenum spray wire is widely used on the surface of brake discs due to its high hardness and wear resistance, enhancing its ability to resist wear and thermal decay. Molybdenum coatings are deposited by HVOF or arc spraying technology to form a tough protective layer that significantly improves the performance and life of the braking system.

During braking, the high-speed friction between the brake disc and the brake pads generates a lot of heat, resulting in a sharp increase in surface temperature. The high thermal conductivity and thermal shock resistance of the molybdenum coating can effectively disperse the heat and prevent the brake disc from overheating and deforming or cracking. In addition, the low coefficient of friction of the molybdenum coating helps to reduce energy loss during braking and improve braking efficiency. In high-performance sports cars or heavy-duty commercial vehicles, molybdenum coatings also resist wear and tear caused by frequent braking, extending the life of brake discs.

The application of molybdenum coating for brake pads is equally important. Molybdenum coating can improve the wear resistance and high temperature resistance of brake pads, reduce the generation of wear particles, and reduce the environmental impact of brake dust. In the field of electric vehicles, the application of molybdenum coatings is particularly prominent, because the braking system of electric vehicles requires higher durability to adapt to the working mode of regenerative braking. Through the spraying of molybdenum wire technology, the performance of the brake system has been significantly improved, providing a guarantee for the safety and environmental protection of the car.

5.3 Chemical and energy industries

The chemical and energy industries involve a variety of extreme environments, including highly corrosive chemicals, high temperatures and high pressures, and coatings prepared by molybdenum spray wire have become important materials in these fields due to their corrosion resistance and high temperature resistance. This section examines the application of spray-coated molybdenum wire in corrosion-resistant coatings for pipes and valves, reactors and heat exchangers, and solar and wind equipment.

5.3.1 Corrosion-resistant pipes and valves

Pipes and valves in the chemical industry are often exposed to strong acids, alkalis or other corrosive media, and ordinary materials are difficult to withstand this erosion for a long time. Molybdenum coatings prepared by molybdenum spray wire are widely used in the surface protection of pipelines and valves due to their excellent chemical stability and corrosion resistance. These coatings are deposited by plasma spray or cold spray technology to form a dense protective layer that effectively isolates corrosive media.

In the petrochemical industry, pipes and valves need to withstand sulfur-containing compounds, chlorides, and other corrosive gases. The chemical inertness of molybdenum coatings allows them to remain stable in these environments, preventing corrosion and pitting of substrates such as carbon steel or stainless steel. In addition, the high hardness of the molybdenum coating resists the erosion and wear of solid particles in the flowing medium, extending the service life of pipes and valves. In offshore oil and gas platforms, the application of molybdenum coatings is particularly important because it can resist the corrosion of seawater and salt spray, ensuring the reliability of equipment in harsh environments.

The moving parts of valves, such as spools and seats, require low friction and high wear resistance, and the application of molybdenum coatings can significantly improve the performance of these components. The smooth surface of the molybdenum coating and the low coefficient of friction reduce the resistance during valve operation, improving the flexibility and tightness of the switch. With the use of molybdenum wire spraying technology, maintenance intervals for chemical pipes and valves are extended, reducing operating costs and downtime.

5.3.2 Reactor and heat exchanger coatings

Chemical reactors and heat exchangers are the core equipment in chemical production, which need to operate in high-temperature, high-pressure and corrosive environments. The molybdenum coating prepared by molybdenum spray wire is an ideal protective material for these devices due to its high temperature resistance and corrosion resistance. The molybdenum coating is deposited by HVOF or plasma spraying technology, which is able to form a tough protective layer that protects the internal surfaces of reactors and heat exchangers.

Reactors often involve complex chemical reactions, resulting in high-temperature gases and corrosive liquids that place extremely high demands on the materials. The high melting point and chemical stability of molybdenum coatings allow them to resist attack by acidic or alkaline media while maintaining structural integrity at high temperatures. In heat exchangers, the excellent thermal conductivity of molybdenum coatings helps improve heat exchange efficiency, while its thermal shock resistance can withstand frequent temperature changes and prevent cracking or peeling of the coating.

In the nuclear industry, molybdenum coatings are used to protect the tube bundles of heat exchangers against corrosion of radioactive media. The low neutron absorption cross section of the molybdenum coating gives it a unique advantage in the nuclear reaction environment, providing protection without compromising the efficiency of the reaction. Through the spraying of molybdenum wire technology, the performance and safety of reactors and heat exchangers have been significantly improved, which provides a guarantee for the stable operation of the chemical and energy industries.

CTIA GROUP LTD
Molybdenum Spray Wire Introduction

1. Overview of Molybdenum Spray Wire

Molybdenum spray wire is a high-purity molybdenum metal wire that is melted and deposited onto a substrate surface through thermal spray techniques such as flame spraying, plasma spraying, arc spraying, or HVOF (High Velocity Oxy-Fuel). The resulting coating offers excellent resistance to wear, corrosion, and high temperatures. Due to its high melting point and superior performance, molybdenum wire is widely used across various industrial sectors.

2. Characteristics of Molybdenum Spray Wire

High Melting Point: Approximately 2623° C, suitable for high-temperature environments.
Excellent Corrosion Resistance: Resists attack from acids, alkalis, and chemical media.
High Hardness & Wear Resistance: Tough coating that withstands mechanical wear.
Low Friction Coefficient: Reduces component wear and improves efficiency.
Chemical Stability: Maintains performance in harsh environments.
High Thermal Conductivity: Effectively dissipates heat and extends component lifespan.

3. Typical Uses of Molybdenum Spray Wire

Aerospace: Turbine blades, engine parts, thermal barrier coatings.
Automotive Industry: Wear-resistant coatings for piston rings, engine blocks, and brake discs.
Chemical & Energy Sectors: Corrosion-resistant pipelines, heat exchangers, wind power equipment.
Electronics & Semiconductors: Vacuum deposition heating wires, semiconductor leads.
Medical Field: Corrosion-resistant coatings for implants and surgical instruments.
Others: Marine anti-corrosion, wear-resistant construction machinery, high-temperature furnaces.

4. Basic Data of Molybdenum Spray Wire from CTIA GROUP LTD

Purity	≥99.95%
Density	10.2 g/cm³
Diameter Range	1.0-3.0 mm, customizable
Tensile Strength	Moderate to ensure stable wire feeding
Packaging	Customized Packaging

5. Procurement Information

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

5.3.3 Coatings for solar and wind energy equipment

The rapid development of renewable energy equipment has put forward new requirements for material properties, and coatings prepared by molybdenum spray wire have played an important role in solar and wind energy equipment. These coatings increase the efficiency and longevity of equipment through their abrasion resistance, corrosion resistance, and high thermal conductivity.

In solar thermal power generation systems, molybdenum coatings are applied to the surface protection of collector tubes. The high thermal conductivity and thermal shock resistance of the molybdenum coating ensures efficient heat transfer while preventing damage caused by high-temperature oxidation and thermal cycling. In wind energy equipment, molybdenum coatings are used to protect blades and bearings in wind turbines. Wind turbines operate in a volatile natural environment that is subject to sand, moisture and salt spray, and the wear and corrosion resistance of molybdenum coatings can effectively extend the service life of blades and bearings.

The low-friction properties of molybdenum coatings are particularly important in the transmission system of wind turbines, reducing wear on gears and bearings and improving energy conversion efficiency. Cold spray technology is also increasingly used in renewable energy equipment, and its low-temperature properties are suitable for the preparation of molybdenum coatings for composite or light alloy substrates to avoid thermal damage. The reliability and efficiency of solar and wind energy equipment have been significantly improved through the application of molybdenum wire spraying technology, which provides technical support for the popularization of renewable energy.

5.4 Electronics and semiconductor industry

The electronics and semiconductor industry has extremely high requirements for the purity, conductivity and thermal stability of materials, and molybdenum spray wire has become an important material in this field due to its high purity and excellent physical properties. This section will discuss the application of spray-coated molybdenum wire in heating wire for vacuum coating, semiconductor leads and electrodes, and molybdenum wire coating for thin film deposition.

5.4.1 Heating wire for vacuum coating

Vacuum coating is a thin-film preparation technique commonly used in the electronics and semiconductor industries to produce devices such as displays, sensors, and integrated circuits. Molybdenum spray wire is widely used as a heating wire for vacuum coating equipment due to its high melting point and good electrical conductivity. Molybdenum wire is heated by resistance to create high temperatures, vaporizing evaporated materials such as aluminum or copper and depositing them on the surface of the substrate to form a uniform film.

The high purity and chemical stability of molybdenum wire allow it to operate in a vacuum environment for long periods of time and avoid contamination due to oxidation or volatilization of impurities. Molybdenum spray wire further improves oxidation resistance through surface modification (e.g., siliconization) and prolongs the service life of the heating wire. In addition, the mechanical strength and thermal shock resistance of molybdenum wire allow it to withstand frequent heating and cooling cycles and maintain stable performance. In high-precision coating equipment, the uniformity and surface finish of the molybdenum wire are critical to the quality of the film, and the spraying process ensures these properties of the wire.

5.4.2 Semiconductor leads and electrodes

Leads and electrodes in semiconductor devices require high conductivity and high temperature resistance, and molybdenum coatings prepared by molybdenum spray wires are widely used for these components due to their excellent electrical and mechanical properties. The molybdenum coating is deposited on the lead frame or electrode surface by plasma spray or cold spray technology to form a highly conductive and corrosion-resistant protective layer.

In semiconductor packaging, the lead frame is subjected to high-temperature soldering and chemical cleaning, and the chemical inertness and high hardness of the molybdenum coating protect the frame from damage. In power semiconductor devices, molybdenum coatings are used on the surface of electrodes to enhance their conductivity and wear resistance, and ensure stable operation of the device at high currents and voltages. The low coefficient of thermal expansion of the molybdenum coating gives it a good match to silicon-based materials, reducing cracking caused by thermal stress.

5.4.3 Molybdenum wire coating for thin film deposition

Thin film deposition is a key technology in the semiconductor industry for the preparation of functional thin films such as conductive layers, insulating layers, and barrier layers. Due to its high purity and uniformity, spray-coated molybdenum wire is used as a target or auxiliary material for thin film deposition. The molybdenum coating is deposited on the surface of the substrate by cold spray or plasma spray technology to form a highly dense film suitable for physical vapor deposition (PVD) or chemical vapor deposition (CVD) processes.

The excellent electrical conductivity and chemical stability of the molybdenum coating allows it to provide stable performance in thin film deposition, preventing degradation of the target material in high temperatures or reactive gases. In display manufacturing, molybdenum coatings are used to create transparent conductive films (such as the back electrode of indium tin oxide) to improve the conductivity and durability of the film. The efficiency and quality of thin film deposition have been significantly improved through molybdenum spray wire technology, supporting innovation in the electronics and semiconductor industries.

5.5 Medical and bioengineering

The medical and bioengineering fields have extremely high requirements for the biocompatibility, corrosion resistance and high temperature performance of materials, and the molybdenum coating prepared by molybdenum spray wire is widely used in medical devices and bioengineering equipment with its excellent performance. This section will explore the application of molybdenum spray wire in the coating of medical device heating elements and corrosion-resistant medical devices.

5.5.1 Heating elements for medical devices

Heating elements in medical devices, such as scalpel heaters, dental equipment, and laboratory analytical instruments, need to be stable and reliable at high temperatures. Spray-coated molybdenum wire, with its high melting point and good electrical conductivity, is used as a material for these heating elements. Molybdenum wire is heated by resistance to generate high temperatures and is used to cut, cauterize, or heat samples, and its high purity and chemical stability ensure safety in medical environments.

In dental equipment, molybdenum wire is used as a heating element in a high-temperature sintering furnace to make ceramic crowns or implants. The high-temperature stability and oxidation resistance of molybdenum wire allow it to maintain its performance over multiple heating cycles, avoiding contamination caused by material degradation. In laboratory analytical instruments, molybdenum wire is used as a heating element in mass spectrometers or thermal analysis equipment to ensure accurate heating of samples and reliable analysis results.

5.5.2 Corrosion-resistant coatings for medical devices

Medical devices, such as surgical tools, implants, and diagnostic devices, need to remain corrosion-resistant in the presence of bodily fluids or disinfectants. Molybdenum coatings prepared by molybdenum spray wire are widely used for surface protection of these devices due to their chemical inertness and high hardness. Molybdenum coatings are deposited by cold spray or plasma spray technology to form a dense protective layer that prevents corrosion or wear on the surface of the equipment.

In orthopedic implants, such as artificial joints or bone nails, molybdenum coatings can improve the corrosion resistance and biocompatibility of substrates such as titanium alloys, reducing inflammation caused by implant reactions to body fluids. In surgical tools, the low friction and high hardness of molybdenum coating can reduce resistance during cutting, improving tool durability and precision. Through the spraying of molybdenum wire technology, the performance and safety of medical devices have been significantly improved, providing a guarantee for the treatment of patients.

5.6 Other areas of application

The use of molybdenum spray wire is not limited to the main areas mentioned above, but also plays an important role in marine and offshore engineering, construction machinery and heavy equipment, and high-temperature stoves and heat treatment equipment. This section will explore specific applications in these areas.

5.6.1 Anti-corrosion coatings for ships and offshore engineering

Corrosion is a major challenge for ships and offshore equipment that operate in seawater, salt spray and humid environments. The molybdenum coating prepared by molybdenum spray wire is widely used in the pipeline protection of ship propellers, rudder shafts and offshore platforms due to its excellent corrosion resistance and high hardness. The molybdenum coating is deposited by HVOF or arc spraying technology, which can effectively resist the galvanic corrosion of seawater and the erosion and wear of solid particles.

In offshore platforms, molybdenum coatings are used to protect drilling pipes and valves, extending their service life in harsh environments. The low-friction properties of the molybdenum coating also improve the performance of moving parts, such as hydraulic systems, reducing the need for maintenance. The reliability and safety of marine and offshore equipment have been significantly improved through the application of molybdenum wire spraying technology.

5.6.2 Wear-resistant coatings for construction machinery and heavy equipment

Construction machinery and heavy equipment, such as excavator buckets, bulldozer blades, and crusher hammers, are subjected to high levels of wear and impact. The molybdenum coating prepared by molybdenum spray wire is an ideal protective material for these components due to its high hardness and wear resistance. The molybdenum coating is deposited through HVOF technology to form a tough protective layer against the impact of sand, rock and other abrasives.

In heavy equipment, the low-friction properties of molybdenum coatings reduce component-to-component wear and improve mechanical efficiency. For example, the molybdenum coating of an excavator bucket extends its life in rocky soils, reducing replacement frequency and maintenance costs. Through the application of molybdenum wire technology, the performance and durability of construction machinery have been significantly improved, supporting the efficiency of engineering projects.

5.6.3 High-temperature stoves and heat treatment equipment

High-temperature stoves and heat treatment equipment need to operate at extremely high temperatures, and materials need to have excellent resistance to high temperatures and oxidation. Due to its high melting point and chemical stability, spray-coated molybdenum wire is used as a heating element and protective coating for high-temperature stoves. Molybdenum wire is heated by resistance to generate high temperatures and is used in metal heat treatment, ceramic sintering and glass melting, and its high purity and oxidation resistance ensure long-term stable performance.

In heat treatment equipment, molybdenum coatings are used to protect the inner walls and support structures of furnaces against high-temperature oxidation and chemical attack. The high thermal conductivity and thermal shock resistance of the molybdenum coating allows it to withstand frequent temperature changes and avoid cracks or spalling. Through the molybdenum spray wire technology, the performance and life of high-temperature stoves have been significantly improved, which provides a guarantee for the stability and efficiency of industrial production.


CTIA GROUP LTD molybdenum spray wire

Chapter 6 Production Equipment for Molybdenum Spray Wire

The production process of molybdenum spray wire involves many complex steps, from raw material processing to final coating deposition, each of which requires specialized equipment to ensure process accuracy and product quality stability. This chapter will discuss in detail the various types of equipment required for the production of molybdenum spray wire, including raw material processing equipment, molybdenum wire production equipment, spraying equipment, auxiliary and post-processing equipment, and automation and intelligent equipment. Together, these machines form the technical basis for the production of coated molybdenum wires and provide reliable support for applications in the aerospace, automotive industry, chemical and energy sectors.

6.1 Raw material processing equipment

Raw material processing is the first step in the production of molybdenum spray wire, which involves a complex conversion process from molybdenum ore to high-purity molybdenum powder. The equipment at this stage needs to have high precision and strict environmental control capabilities to ensure the high purity and consistency of the molybdenum powder. This section will discuss molybdenum powder preparation and reduction equipment as well as sintering furnace and forging equipment.

6.1.1 Molybdenum powder preparation and reduction equipment

Molybdenum powder preparation and reduction equipment is the core of raw material processing, which is used to convert molybdenum oxide (MoO_3) after molybdenum ore purification into high-purity metal molybdenum powder. These include crushers, mills, flotation equipment and hydrogen reduction furnaces, each of which plays a specific role in the process chain.

Crushers and mills are used to process molybdenum ore from large pieces of ore into fine particles. Jaw crushers and cone crushers are commonly used primary crushing equipment that are capable of crushing ore into smaller particles and are suitable for subsequent grinding treatment. The grinding machine (such as a ball mill or rod mill) further grinds the ore into a fine powder through the grinding medium in the rotating cylinder, which is float = "; System: Select Separation to prepare. These equipment need to be equipped with efficient dust collection systems to reduce dust contamination while ensuring uniform particle size.

Flotation equipment is the key to the beneficiation process and is used to separate molybdenite (MoS_2) from the finely ground ore. The flotation cell usually consists of multiple flotation tanks, which are filled with slurry and air, which are combined with collectors and foaming agents to form foam and separate molybdenite particles from impurities. Modern flotation equipment adopts an automatic control system, which can adjust the amount of agent added and bubble flow in real time, and improve the beneficiation efficiency and concentrate purity. The flotation molybdenum concentrate is filtered and dried in preparation for subsequent roasting.

The roaster is used to convert molybdenite into molybdenum oxide and is an important step in the preparation of molybdenum powder. Rotary kilns and multi-chamber furnaces are commonly used roasting equipment to remove sulfur from molybdenite through high-temperature oxidation to produce molybdenum oxide powder. These stoves need to be equipped with precise temperature control systems and exhaust gas treatment units to ensure complete removal of sulphur and reduce sulphur dioxide emissions. The roasted molybdenum oxide is further purified by ammonia leaching equipment to remove trace impurities and form a high-purity ammonium molybdate solution.

The hydrogen reduction furnace is the core equipment for the production of molybdenum powder, which is used to reduce molybdenum oxide or ammonium molybdate to metal molybdenum powder. The reduction process is usually divided into two stages: the first stage reduces molybdenum oxide to molybdenum dioxide (MoO_2) at lower temperatures, and the second stage further reduces molybdenum metal to metal at higher temperatures. These furnaces are available in a tubular or push-boat design, equipped with a high-purity hydrogen supply system and precise temperature control to ensure the stability of the reduction process. The furnace body material is usually molybdenum alloy or quartz that is resistant to high temperatures to prevent contamination. The reduced molybdenum powder is sorted by air classifier or vibrating screen to ensure that the particle size and distribution meet the needs of the wire drawing process.

The coordinated operation of these equipment requires a highly clean production environment to avoid external contamination of molybdenum powder. Modern molybdenum powder preparation equipment also integrates an online monitoring system, which can detect the chemical composition and particle size distribution of the powder in real time to ensure the consistency of product quality.

CTIA GROUP LTD
Molybdenum Spray Wire Introduction

1. Overview of Molybdenum Spray Wire

Molybdenum spray wire is a high-purity molybdenum metal wire that is melted and deposited onto a substrate surface through thermal spray techniques such as flame spraying, plasma spraying, arc spraying, or HVOF (High Velocity Oxy-Fuel). The resulting coating offers excellent resistance to wear, corrosion, and high temperatures. Due to its high melting point and superior performance, molybdenum wire is widely used across various industrial sectors.

2. Characteristics of Molybdenum Spray Wire

High Melting Point: Approximately 2623° C, suitable for high-temperature environments.
Excellent Corrosion Resistance: Resists attack from acids, alkalis, and chemical media.
High Hardness & Wear Resistance: Tough coating that withstands mechanical wear.
Low Friction Coefficient: Reduces component wear and improves efficiency.
Chemical Stability: Maintains performance in harsh environments.
High Thermal Conductivity: Effectively dissipates heat and extends component lifespan.

3. Typical Uses of Molybdenum Spray Wire

Aerospace: Turbine blades, engine parts, thermal barrier coatings.
Automotive Industry: Wear-resistant coatings for piston rings, engine blocks, and brake discs.
Chemical & Energy Sectors: Corrosion-resistant pipelines, heat exchangers, wind power equipment.
Electronics & Semiconductors: Vacuum deposition heating wires, semiconductor leads.
Medical Field: Corrosion-resistant coatings for implants and surgical instruments.
Others: Marine anti-corrosion, wear-resistant construction machinery, high-temperature furnaces.

4. Basic Data of Molybdenum Spray Wire from CTIA GROUP LTD

Purity	≥99.95%
Density	10.2 g/cm³
Diameter Range	1.0-3.0 mm, customizable
Tensile Strength	Moderate to ensure stable wire feeding
Packaging	Customized Packaging

5. Procurement Information

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

6.1.2 Sintering furnaces and forging equipment

Sintering furnaces and forging equipment are used to press molybdenum powder into a dense blank and further process it into molybdenum rods suitable for wire drawing. The sintering furnace is the core equipment of the powder metallurgy process, and the molybdenum powder particles are combined into a strong metal structure through high-temperature treatment. Forging equipment optimizes the microstructure of the blank through mechanical deformation to improve its strength and ductility.

Sintering furnaces usually use vacuum or hydrogen to protect the atmosphere from oxidizing molybdenum at high temperatures. Vacuum sintering furnaces are suitable for the production of high-purity molybdenum blanks by vacuuming to remove oxygen and moisture from the furnace. The hydrogen sintering furnace creates a reducing atmosphere by continuously supplying high-purity hydrogen, which not only prevents oxidation, but also cleans trace oxides on the surface of the blank. Modern sintering furnaces are equipped with multi-stage heating zones and precise temperature control systems, which are able to adjust the sintering temperature and holding time according to the characteristics of the molybdenum powder, and optimize the density and grain structure of the blank. Some advanced sintering furnaces also integrate automated loading and unloading systems to improve production efficiency.

The forging equipment includes a hot forging machine and a hot rolling mill for processing the sintered molybdenum billet into an elongated molybdenum bar. The hot forging machine uses hydraulic or mechanical hammering to deform the blank at high temperatures, refine the grains and eliminate internal defects. The hot rolling mill gradually reduces the diameter of the billet through a series of rolls to produce a uniform molybdenum rod. These devices need to be equipped with high-temperature heating to maintain the ductility of molybdenum, as well as a protective atmosphere system to prevent oxidation. The forging and rolling process requires precise control of the deformation rate and temperature to avoid cracking of the blank or surface defects.

The synergy between the sintering furnace and the forging equipment provides a high-quality raw material for the production of molybdenum wire. Through digital control and real-time monitoring, modern equipment can significantly improve production efficiency and product consistency, laying a solid foundation for the subsequent drawing process.

6.2 Molybdenum wire production equipment

Molybdenum wire production is a critical stage in processing molybdenum rods into filaments, involving processes such as wire drawing, annealing, and surface treatment. These processes require high-precision equipment to overcome the hard and brittle properties of molybdenum, ensuring dimensional accuracy and surface quality of the wire. This section will discuss wire drawing machines and dies, annealing furnaces and heat treatment equipment, and surface cleaning and polishing equipment.

6.2.1 Wire drawing machines and dies

The wire drawing machine is the core equipment for molybdenum wire production, which is used to stretch the molybdenum rod into a filament through a mold. The wire drawing machine is divided into single-mode wire drawing machine and multi-mode continuous wire drawing machine, each with its own applicable scenarios. The single-die wire drawing machine is suitable for low-volume, high-precision production, equipped with a single mold, and each drawing is completed by manual or semi-automatic operation. The multi-mode continuous drawing machine is suitable for large-scale production, equipped with multiple dies and a traction device, which can continuously stretch the molybdenum rod, significantly improving efficiency.

The core component of the wire drawing machine is the die, which is usually made of tungsten carbide or polycrystalline diamond, which has extremely high hardness and wear resistance. The aperture design of the die needs to accurately match the drawing requirements, and the aperture decreasing sequence is scientifically calculated to ensure the uniform deformation of the wire. The lubrication system is an important part of the wire drawing machine, by spraying graphite emulsion or molybdenum disulfide lubricant, the friction between the mold and the molybdenum wire is reduced, the die life is extended and the surface quality of the wire is improved. Modern wire drawing machines are also equipped with a tension control system and cooling to prevent the wire from breaking or overheating during the drawing process.

The manufacture and maintenance of the mold is the key to the drawing process. High-quality molds need to be polished and inspected regularly to ensure the accuracy of the aperture and the surface finish. Some advanced wire drawing machines integrate an in-line inspection system, which is able to monitor wire diameter and surface defects in real time, and adjust the drawing parameters in time. This high-precision equipment design ensures the dimensional consistency and mechanical properties of the molybdenum wire, providing a high-quality wire for the spraying process.

6.2.2 Annealing furnaces and heat treatment equipment

Annealing furnaces and heat treatment equipment are used to eliminate the internal stresses introduced during the wire drawing process, restore the crystal structure of molybdenum wire, and improve its ductility and toughness. These devices need to be operated in a vacuum or protective atmosphere to prevent oxidation of the surface of the molybdenum wire.

Vacuum annealing furnaces are suitable for the production of high-purity molybdenum wire by vacuuming to remove oxygen from the furnace. The furnace is equipped with a high-temperature heating element (e.g. molybdenum or tungsten heating wire) that enables precise control of the temperature and ramp-up rate. The hydrogen annealing furnace uses high-purity hydrogen to create a reducing atmosphere, which not only prevents oxidation, but also cleans trace oxides on the surface of the wire. Modern annealing furnaces use a multi-stage heating design to optimize the microstructure of the molybdenum wire through progressive heating to avoid oversized grains or stress carryover.

The heat treatment equipment also includes a cooling system to control the cooling rate after annealing. Rapid cooling can lead to stress re-accumulation, while too slow cooling can affect productivity. Some advanced annealing furnaces are equipped with automated loading and unloading systems, which are capable of continuously processing multiple rolls of molybdenum wire, improving production efficiency. The annealing furnace was also designed with energy efficiency in mind, reducing heat loss through efficient insulation and recovery systems, in line with the requirements of green manufacturing.

6.2.3 Surface cleaning and polishing equipment

Surface cleaning and polishing equipment is used to remove lubricants, oxides, and other contaminants from the surface of molybdenum wire, ensuring excellent surface quality during the coating process. These include chemical cleaning tanks, ultrasonic cleaners, and polishing units.

Chemical cleaning baths use mild acidic or alkaline solutions, such as dilute hydrochloric acid or sodium hydroxide, to remove oxide layers and organic residues from the surface of molybdenum wires. The cleaning tank is usually equipped with a circulating filtration system to ensure the purity of the cleaning solution and prevent secondary contamination. After cleaning, the molybdenum wire is thoroughly cleaned through the deionized water rinsing tank to avoid chemical residues affecting the spraying effect.

Ultrasonic cleaners use high-frequency sound waves to create tiny bubbles in liquids, and remove micron-sized particles and oil stains through the impact of bubble bursting. This machine is particularly suitable for handling small molybdenum wires and is able to penetrate into the microscopic depressions of the filament surface to ensure complete cleaning. The frequency and power of the ultrasonic cleaner need to be adjusted according to the size of the wire to avoid damaging the surface.

Polishing equipment includes mechanical polishing machine and electrochemical polishing device. Mechanical polishing machines use fine abrasives, such as alumina or diamond powder, to polish the surface of molybdenum wire by rotating brushes or abrasive belts to achieve a mirror effect. The electrochemical polishing device selectively dissolves the microscopic protrusions on the surface of the wire through electrolysis to form a smooth surface. These devices can significantly improve the surface finish of molybdenum wire, reduce the spatter of molten droplets during the spraying process, and improve the quality of the coating.

6.3 Spraying equipment

Spraying equipment is the heart of molybdenum spray wire production, which is used to melt and deposit molybdenum wire onto the surface of the substrate to form a protective coating. These include flame spraying systems, plasma spraying equipment, arc spraying units, and high-velocity oxy-fuel spraying (HVOF) equipment, each for different applications and coating requirements.

6.3.1 Flame spraying systems

The flame spraying system is one of the earliest thermal spray technologies, utilizing an oxygen-acetylene flame to heat the molybdenum wire, causing it to melt or semi-melt and spray it onto the surface of the substrate by compressed air. The flame spraying system consists of a spray gun, a wire feeding device, a gas supply system and a control unit.

The spray gun is the core component of the flame spraying system, equipped with a combustion chamber and nozzles that create a high-temperature flame and control the direction of the droplets. The wire feeding device feeds the molybdenum wire into the spray gun at a constant speed through precise motor control, ensuring the stability of the melting process. The gas supply system provides oxygen and acetylene, and the mixing ratio is adjusted by a flow meter to optimize flame temperature and stability. The control unit adjusts the spraying parameters such as wire feed speed, flame intensity and spraying distance via a digital interface.

The flame spraying system has a simple structure and is suitable for on-site construction and large-area coating deposition, and is widely used in automotive parts repair and industrial machinery protection. However, the flame temperature is lower and the coating porosity is high, which needs to be optimized in conjunction with post-treatment equipment. Modern flame spraying systems integrate automated control and online monitoring to improve spraying efficiency and consistency.

6.3.2 Plasma spraying equipment

Plasma spraying equipment uses high-temperature plasma (up to 15,000°C) to melt molybdenum wires to form a high-velocity stream of molten trickles that are deposited on the surface of the substrate to form a dense coating. This equipment includes a plasma spray gun, a power supply system, a gas supply system and a cooling unit.

The plasma spray gun converts an inert gas (such as argon or nitrogen) into a high-temperature plasma by means of an electric arc, and the molybdenum wire is fed into the plasma stream to melt rapidly. The nozzle design of the spray gun needs to ensure the stability and directionality of the plasma flow to improve the quality of the coating. The power supply system provides high-voltage direct current, which controls the strength and stability of the arc. The gas supply system precisely regulates the flow and composition of the plasma gas to optimize the melting effect. The cooling device prevents the gun from overheating by means of water cooling or air cooling, extending the life of the equipment.

Plasma spray equipment is capable of producing high-hardness, low-porosity molybdenum coatings for high-performance applications in the aerospace and energy sectors. Its high accuracy and flexibility enable it to handle substrates with complex geometries, but the equipment costs are high, the operation is complex, and professional technical support is required.

6.3.3 Arc spraying device

The arc spraying device uses arc heating between two molybdenum wires to melt the wire and spray it onto the surface of the substrate through compressed air. Such a device includes an arc spray gun, a wire feeding system, a power supply system, and an air compressor.

The arc spray gun creates a stable arc by precisely controlling the contact of two molybdenum wires, melting the end of the wire. The wire feeding system is driven by two motors to ensure that the two molybdenum wires are fed into the spray gun at the same speed to maintain the stability of the arc.

TEL: 0086 592 512 9696
sales@chinatungsten.com

The power supply system provides DC or AC power, regulating the intensity and duration of the arc. The air compressor creates a high-pressure airstream that atomizes and sprays molten molybdenum droplets onto the substrate to form a uniform coating.

The arc spraying unit has a high deposition efficiency and is suitable for spraying large areas, such as bridge steel structures or ship component protection. Its coating quality is between flame spraying and plasma spraying, and the cost is low, making it suitable for industrial production. Modern arc spraying units integrate an automated control system to improve spraying consistency and productivity.

6.3.4 High-velocity oxy-fuel spraying (HVOF) equipment

High-velocity oxy-fuel spraying (HVOF) equipment uses high-pressure combustion of oxygen and fuel, such as kerosene or propane, to produce a supersonic flame that melts molybdenum wire and sprays it onto the surface of the substrate at extremely high speeds. This equipment includes HVOF spray guns, fuel supply systems, oxygen supply systems and cooling units.

The HVOF spray gun ignites the mixture of fuel and oxygen through the combustion chamber and nozzle design, forming a flame flow with high temperature and high pressure. The molybdenum wire is fed into a flame stream to melt rapidly and is sprayed onto the substrate at supersonic speeds to form a dense, low-porosity coating. The fuel and oxygen supply system optimizes combustion efficiency and flame velocity through precise flow control. The cooling unit protects the lance from high temperature damage by means of a water cooling system.

HVOF equipment is capable of producing molybdenum coatings with high hardness and high adhesion, which are suitable for high-end applications such as aero engines and gas turbines. Its high speed and low temperature characteristics reduce oxidation and thermal stress of the coating, but the equipment complexity and cost are high. Modern HVOF equipment is equipped with a digital control system and online monitoring function, which is able to adjust the spraying parameters in real time and improve the coating quality.

6.4 Auxiliary and post-treatment equipment

Ancillary and post-processing equipment is used to support substrate preparation, coating finishing, and quality inspection in the spraying process to ensure the performance and reliability of the final product. This section will discuss substrate pre-treatment equipment, coating post-processing equipment, and in-line inspection and monitoring equipment.

6.4.1 Substrate pretreatment equipment

Substrate pretreatment equipment is used to clean and optimize the substrate surface and improve coating adhesion. These include sandblasting machines, chemical cleaning tanks, and ultrasonic cleaners.

The sandblasting machine increases the roughness of the surface of the substrate by jetting abrasives such as alumina or silicon carbide at high speed, removing oxides and old coatings. Modern abrasive blasting machines are equipped with automated jetting systems and recovery devices, which can control the abrasive flow and spray angle, improving treatment efficiency and environmental friendliness. Chemical cleaning baths use alkaline or acidic solutions to remove oil and organic contaminants, and are equipped with a circulating filtration system to ensure the purity of the cleaning fluid. Ultrasonic cleaners use high-frequency sound waves to create tiny bubbles to remove micron-sized particles from the surface of the substrate and are suitable for parts with complex geometries.

These machines require process parameters that are tailored to the substrate material and shape. For example, aluminum alloy substrates require gentle blasting and cleaning conditions, while stainless steel substrates can withstand increased processing strength. The synergy of the pretreatment equipment provides an ideal substrate surface for the spraying process.

6.4.2 Coating post-treatment equipment

Coating post-treatment equipment is used to optimize the performance of coatings, including heat treatment furnaces, polishing machines, and seal treatment units. The heat treatment furnace is heated by vacuum or protective atmosphere to eliminate residual stresses in the coating and improve the microstructure. Modern heat treatment furnaces are equipped with a multi-stage heating and cooling system that enables precise control of the temperature profile to avoid cracking of the coating.

Polishing machines include mechanical polishing and electrochemical polishing equipment. Mechanical polishing machines grind the surface of the coating through abrasives, reducing roughness and improving the finish. The electrochemical polishing unit smooths the coated surface by electrolysis and is suitable for high-precision applications. Seal treatment devices improve corrosion resistance by spraying or impregnating organic/inorganic sealants to fill the pores of the coating. These devices significantly improve the durability and functionality of coatings.

6.4.3 Online detection and monitoring equipment

In-line inspection and monitoring equipment, including laser thickness gauges, thermal imaging cameras, and ultrasonic detectors, is used to evaluate the coating process and coating quality in real time. Laser thickness gauges accurately inspect coating thickness and uniformity through non-contact measurements. Thermal imaging cameras monitor the temperature distribution of substrates and coatings to prevent overheating or uneven cooling. Ultrasonic detectors are used to detect pores or cracks inside coatings to ensure quality.

These devices are integrated with data acquisition systems to record process parameters and test results in real-time to provide data support for quality management and process optimization. Modern inspection equipment also supports remote monitoring, allowing operators to analyze equipment status through a cloud-based platform to improve productivity and reliability.

6.5 Automation and intelligent equipment

Automation and intelligent equipment represent the future direction of molybdenum spray wire production technology, through the integration of robots, sensors and artificial intelligence technology to achieve efficient and accurate production. This section will discuss automated spraying lines, intelligent control and data acquisition systems, and robotic spraying systems.

6.5.1 Automatic spraying production line

The automated spraying line integrates spraying equipment, wire feeding systems and conveyors to achieve continuous production from substrate pretreatment to coating post-treatment. The production line is equipped with an automatic control system, which coordinates the work of each equipment through PLC (programmable logic controller) to ensure the stability of process parameters. Conveyors, such as conveyor belts or robotic arms, move the substrate from the pretreatment station to the spraying station and then to the post-treatment station, reducing manual intervention.

The advantage of an automated spraying line is its high efficiency and consistency. For example, an automotive parts spraying line is capable of continuously processing thousands of piston rings with a coating quality deviation of less than 1%. The production line is also equipped with a waste recycling system to reduce molybdenum wire splash waste and meet the requirements of green manufacturing.

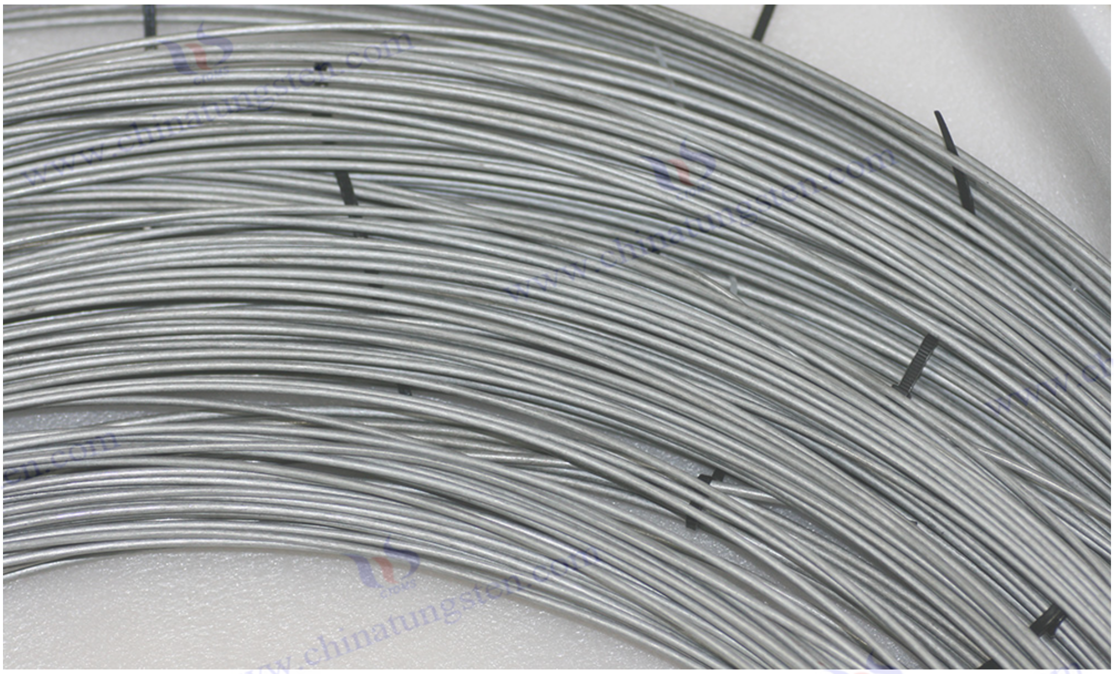
6.5.2 Intelligent control and data acquisition systems

The Intelligent Control and Data Acquisition System (SCADA) uses sensors and IoT technology to monitor key parameters in the spraying process, such as temperature, pressure, and wire feed speed, in real time. These systems, combined with artificial intelligence algorithms, are able to predict process deviations and automatically adjust parameters. For example, machine learning models can improve coating quality by optimizing spray distances and gas flow rates based on historical data.
The SCADA system also supports data visualization and remote management, allowing operators to view real-time production status via mobile devices. The cloud-based database consolidates operational data from multiple production lines to support process optimization and equipment maintenance. This intelligent system significantly improves production efficiency and product quality, and drives the digital transformation of coating technology.

6.5.3 Robotic spraying systems

The robotic coating system uses multi-axis industrial robots to achieve precise coating of complex substrates. The robot is equipped with visual recognition and path planning technology, which can adapt to different shapes and sizes of substrates, and automatically adjust the gun angle and movement path. The spraying robot is integrated with an online inspection system to provide real-time feedback on coating quality and dynamically optimize coating parameters.

The use of robotic spraying systems has significantly increased production flexibility. For example, in the aerospace sector, robots are able to prepare a uniform molybdenum coating for the curved surface of turbine blades; In the automotive industry, robots can quickly switch between spraying programs for different parts, reducing cycle times. The wide application of these systems has promoted the development of molybdenum spray wire production in the direction of intelligence and flexibility.



CTIA GROUP LTD molybdenum spray wire

Chapter 7 Domestic and Foreign Standards for Molybdenum Spray Wire

As a high-performance material, the production and application of molybdenum spray wire needs to follow strict standards to ensure product quality, process consistency and application safety. A number of standards have been formulated for molybdenum wire and thermal spraying materials at home and abroad, covering raw materials, processing technology, performance testing and application specifications. This chapter will systematically discuss the domestic standards, international standards, industry standards and enterprise specifications of molybdenum spray wire, and conduct an in-depth analysis of the differences and applicability of these standards, so as to provide reference for producers and users.

7.1 Domestic standards for molybdenum spray wire

As the world's largest producer and consumer of molybdenum resources, China has formulated a series of national standards (GB/T) related to molybdenum wire and thermal spray materials, which provide specifications for the production, testing and application of molybdenum spray wire. These standards are issued by the Standardization Administration of the People's Republic of China and are widely used in the domestic molybdenum processing and thermal spraying industries. This section will introduce in detail the national standards directly related to molybdenum spray wire, including GB/T 4181-2017 "Molybdenum Wire", GB/T 3462-2017 "Molybdenum Bar and Molybdenum Blank", GB/T 4197-2011 "Metal Wire for Spraying" and other relevant standards.

7.1.1 GB/T 4181-2017 "Molybdenum Wire" and related requirements

GB/T 4181-2017 "Molybdenum Wire" is a national standard for the preparation and performance of molybdenum wire in China, which is suitable for molybdenum wire for various purposes,

TEL: 0086 592 512 9696
CTIAQCD -MA-E/P 2018- 2024V
sales@chinatungsten.com

including molybdenum wire for spraying. The standard specifies in detail the chemical composition, dimensional tolerance, mechanical properties, surface quality and testing methods of molybdenum wire, which provides a technical basis for the production of molybdenum spray wire.

The standard has extremely strict requirements for the chemical composition of molybdenum wire, stipulating that the purity of molybdenum must reach more than 99.95%, and limiting the content of impurities such as iron, nickel, carbon, and oxygen. These requirements ensure that the molybdenum wire has a stable melting behavior and excellent coating properties during the spraying process. The standard also stipulates the diameter range and tolerance of molybdenum wire, which is usually 0.02 mm to 3.0 mm, and the molybdenum wire for spraying is mostly concentrated in the range of 1.0 mm to 2.0 mm to meet the needs of different spraying equipment.

In terms of mechanical properties, the standard requires that molybdenum wire has appropriate tensile strength and ductility to ensure that it is not easy to break during wire drawing and wire feeding. Surface quality is another key criterion, and molybdenum filament for spraying needs to have a smooth, crack-free, oxide-free surface to reduce droplet spatter during the spraying process. Inspection methods include chemical analysis (using inductively coupled plasma emission spectrometry), dimensional measurement (using a high-precision micrometer or laser caliper), and surface inspection (using microscopy or visual inspection).

GB/T 4181-2017 covers the aerospace, automotive industry and electronics fields, and provides the basis for the standardized production of molybdenum spray wire. The standard also emphasizes packaging and transportation requirements, stipulating that molybdenum wire must be vacuum-sealed or inert gas protected packaging to prevent moisture or oxidation.

7.1.2 GB/T 3462-2017

GB/T 3462-2017 "Molybdenum Bar and Molybdenum Billet" is a national standard for raw materials in the pre-production stage of molybdenum wire, which is applicable to molybdenum bars and molybdenum billets prepared by powder metallurgy process. These materials are the starting point of the wire drawing process, and their quality directly affects the performance of the molybdenum spray wire.

This standard specifies the chemical composition, size, density, and surface quality of molybdenum bars and molybdenum blanks. The chemical composition requirements are consistent with GB/T 4181-2017, and the purity of molybdenum should reach 99.95%, and the impurity content should be limited to ensure the stability of subsequent processing. In terms of size, the standard covers a wide range of molybdenum bars and blanks, typically with diameters ranging from 5 mm to 100 mm, and lengths tailored to user needs. Density is an important indicator of molybdenum billet, which needs to be close to the theoretical density (10.2 g/cm³) to ensure that there are no internal defects during the wire drawing process.

The surface quality requires that the surface of molybdenum bars and molybdenum blanks is free of cracks, oxide scale or inclusions, and the finish requirements need to be turned or ground to meet the requirements of finish. Inspection methods include ultrasonic flaw detection (checking for internal defects), chemical analysis, and microstructural observation (assessing grain size and uniformity). The standard also specifies heat treatment process parameters, such as sintering and forging temperatures, to optimize the microstructure of the molybdenum billet.

For the production of molybdenum spray wire, GB/T 3462-2017 provides specifications for high-quality raw materials to ensure that molybdenum bars and molybdenum blanks can meet the demanding requirements of wire drawing and spraying. This standard is widely used in domestic molybdenum processing enterprises, such as Jinduicheng Molybdenum and Luoyang Molybdenum.

7.1.3 GB/T 4197-2011

GB/T 4197-2011 "Metallic Wire for Spraying" is a special standard for metallic wire for thermal spraying in China, covering a variety of metallic wire materials including molybdenum wire. This standard provides specific guidance on the performance, specification and testing of molybdenum spray wire, and is particularly applicable to flame spraying and arc spraying processes.

The standard specifies the chemical composition, dimensional tolerances, surface condition and packaging requirements of molybdenum wire for spraying. The chemical purity of molybdenum wire should meet the requirements of GB/T 4181-2017, and the surface should be smooth, oil-free and oxide-free to ensure the uniformity of melt droplets and the quality of the coating during the spraying process. The dimensional tolerance requirements are strict, and the diameter deviation of the molybdenum wire for spraying needs to be controlled within ±0.02 mm to meet the needs of the automatic wire feeding system.

In terms of performance testing, the standard requires tensile testing, surface roughness testing and spraying testing of molybdenum wires. The tensile test evaluates the tensile strength and ductility of the wire to ensure that it is not easy to break during wire feeding. The surface roughness test is measured by a profilometer to ensure that the surface finish of the wire meets the spraying requirements. The spraying test evaluates the adhesion, porosity and uniformity of the coating through actual spraying operations, using internationally accepted test methods such as ASTM C633 as a reference.

The formulation of GB/T 4197-2011 fills the gap in the standardization of metal wire for spraying in China, and provides technical support for the application of molybdenum spray wire in the fields of automotive, energy and shipbuilding. The standard also emphasizes environmental protection requirements, stipulating that waste gas and waste emissions need to be reduced in the production process, in line with the trend of green manufacturing.

7.1.4 Other relevant national standards

In addition to the above-mentioned core standards, China has also formulated a number of national standards related to the production and application of molybdenum spray wire, covering raw materials, processing technology and coating properties. For example:

TEL: 0086 592 512 9696

sales@chinatungsten.com

GB/T 15258-2009 "General Principles of Chemical Analysis Methods": provides general methods for the chemical composition analysis of molybdenum wires and coatings, including inductively coupled plasma emission spectrometry (ICP-OES) and atomic absorption spectrometry (AAS), to ensure accurate detection of impurity content.

GB/T 4325-2013 "Chemical Analysis Methods for Molybdenum and Molybdenum Alloys": Specifically for molybdenum materials, the analysis methods of iron, nickel, carbon, oxygen and other elements are specified, which provides a technical basis for the detection of raw materials and finished products of molybdenum spray wire.

GB/T 17733-2008 "Quality Requirements for Thermal Spray Coatings": It specifies the performance requirements of thermal spray coatings, including adhesion, hardness, porosity and corrosion resistance, and is suitable for coatings prepared by molybdenum spray wires.

GB/T 14842-2007 "Test Methods for Mechanical Properties of Molybdenum and Molybdenum Alloys": It provides specifications for the tensile strength, ductility and hardness testing of molybdenum wire to ensure that it meets the mechanical property requirements of the spraying process.

Together, these standards constitute a complete specification system for the production and application of molybdenum spray wire, covering every link from raw materials to finished products. When domestic enterprises produce molybdenum spray wire, they usually need to comply with a number of standards at the same time to meet the needs of different industries and customers.

7.2 International standards for molybdenum spray wire

International standards provide a unified framework for global trade and technical exchange of molybdenum spray wire, which are mainly formulated by the American Society for Testing and Materials (ASTM), the International Organization for Standardization (ISO) and other institutions. These standards are highly authoritative in terms of chemical composition, performance testing and application specifications, and are widely used in the molybdenum processing and thermal spraying industries in Europe, America and Asia. This section will focus on ASTM B387-18 Molybdenum and Molybdenum Alloy Rods, Bars, and Wires, ISO 20407 Specification for Thermal Spray Materials, ISO 14919 Wire for Thermal Spraying, and other relevant international standards.

7.2.1 ASTM B387-18 Molybdenum and Molybdenum Alloy Rods, Bars and Wires

ASTM B387-18 is an American standard for molybdenum and molybdenum alloy materials, which is suitable for various forms of molybdenum materials such as rods, strips, and wires, including molybdenum wire for spraying. This standard was developed by ASTM International and is widely used in the aerospace, electronics, and energy sectors.

The standard specifies the chemical composition, mechanical properties, dimensional tolerances and surface quality of molybdenum wire. The purity requirements of molybdenum are divided into several grades, the highest grade (Type 361) requires a molybdenum content of 99.97%, and the

TEL: 0086 592 512 9696
CTIAQCD -MA-E/P 2018- 2024V
sales@chinatungsten.com

content of impurities (such as carbon, oxygen, iron) is strictly limited. Molybdenum wire for spraying is usually selected in a high purity grade to ensure the chemical stability and performance of the coating. The dimensional tolerance requires that the diameter deviation of the molybdenum wire be controlled within ±0.01 mm, and the surface must be free of cracks, oxides or other defects.

Mechanical property tests include tensile strength, elongation, and hardness, and the standard provides detailed test methods such as tensile tests (see ASTM E8) and hardness tests (see ASTM E18). Surface quality checks are carried out using visual and microscopic observation to ensure that the filaments are suitable for the high demands of thermal spraying. The standard also stipulates the packaging and labeling requirements for molybdenum wire, which shall be packaged in a moisture-proof and oxidation-proof manner, and marked with the batch number, specification and manufacturer information.

ASTM B387-18 is highly internationalized, and many Chinese companies are required to comply with this standard when exporting spray-coated molybdenum wire. The high precision requirements of the standard make it particularly suitable for applications in the aerospace and semiconductor industries, such as turbine blade coatings and vacuum-coated heating wires.

7.2.2 ISO 20407 Specification for Thermal Spray Materials

ISO 20407 is a general specification for thermal spray materials developed by the International Organization for Standardization, covering a variety of material forms such as wire, powder, and rod, including molybdenum spray wire. This standard provides a framework for the performance, testing, and application of thermal spray materials for processes such as flame spraying, plasma spraying, and arc spraying.

The standard sets out the requirements for the chemical composition, size and surface condition of the molybdenum spray wire. The purity of molybdenum wire needs to reach more than 99.95%, and the surface needs to be smooth, oil-free and oxide-free to ensure the stability and coating quality during the spraying process. The dimensional tolerance requirements are similar to those of ASTM B387-18, and the diameter deviation should be controlled within ±0.02 mm. The standard also specifies the packaging and storage conditions for the wire, which must be vacuum-sealed or inert gas protected against environmental factors.

In terms of performance testing, ISO 20407 provides a number of test methods, including chemical analysis (using spectroscopy), surface roughness testing (with reference to ISO 4287), and spray performance testing. The spray performance test evaluates the adhesion, porosity, and microstructure of coatings using internationally accepted test standards such as ASTM C633 (adhesion test) and ISO 6507 (hardness test). The standard also emphasizes a quality management system that requires manufacturers to establish traceable records to ensure consistent performance from batch to batch.

The versatility of ISO 20407 makes it suitable for the global thermal spray industry, especially in the European and Asian markets. The standard provides a technical basis for the international trade of molybdenum spray wire, and promotes cross-border cooperation and technical exchanges.

7.2.3 ISO 14919 Wire for Thermal Spraying

ISO 14919 is a standard specific to wire for thermal spraying and is applicable to a wide range of wire materials, including molybdenum wire. This standard specifies in detail the specifications, properties, and test methods for spraying wires, and provides specifications for flame spraying and arc spraying processes.

The standard requires that the molybdenum spray wire has high purity and uniform chemical composition, the molybdenum content needs to reach 99.95%, and the impurity content needs to be strictly controlled. In terms of dimensions, the standard specifies a common diameter range (1.0 mm to 3.2 mm) with tolerances in accordance with ISO 286. The surface quality requires that the wire has no cracks, no oxides, no lubricant residues, and needs to be chemically cleaned or polished to achieve the finish standard.

Test methods include tensile tests (to evaluate tensile strength and ductility), surface quality checks (using microscopes or profilers), and spray tests (to evaluate coating properties). The standard also provides packaging and shipping specifications that require the wire to be packaged in a moisture- and oxidation-resistant manner, with detailed identification information such as material type, lot number, and date of manufacture.

The specificity of ISO 14919 makes it an important reference standard for the thermal spray industry, especially for coating applications in the automotive, marine and energy sectors. The standard complements ISO 20407 and together forms a complete system of thermal spray material specifications.

7.2.4 Other international standards

In addition to the above core standards, there are a number of international standards related to the coating of molybdenum wire, covering materials, processes and coating properties. For example:

ASTM E8/E8M-21 "Tensile Test Methods for Metallic Materials": Provides a general method for testing the tensile strength and elongation of molybdenum wire, which is suitable for testing the mechanical properties of ASTM B387-18.

ASTM C633-13 Test Method for Adhesion of Thermal Spray Coatings: Specifies an adhesion test method for thermal spray coatings, which is widely used to evaluate the quality of coatings prepared by molybdenum spray wire.

ISO 4287 Surface Texture Parameters: Provides a specification for surface roughness measurement of molybdenum wires and coatings, ensuring that the surface quality of wires and coatings meets the requirements of coating.

ISO 6507 Vickers Hardness Test for Metallic Materials: Provides a method for hardness testing of

TEL: 0086 592 512 9696

sales@chinatungsten.com

molybdenum coatings and is suitable for evaluating the wear resistance and mechanical properties of coatings.

These standards provide comprehensive technical support for the production and application of molybdenum spray wire, which is of great significance especially in the international market. Many multinational companies need to comply with multiple international standards when producing molybdenum spray wire to meet the requirements of different countries and industries.

7.3 Industry standards and enterprise specifications for molybdenum spray wire

In addition to national and international standards, the production and application of molybdenum spray wire also needs to follow industry standards and internal corporate specifications. These specifications are often developed by industry associations or leading companies to provide more detailed guidance for specific application scenarios or technical requirements. This section will explore industry standards for non-ferrous metals, thermal spray industry standards, and internal quality control practices.

7.3.1 Non-ferrous metal industry standards

The China Nonferrous Metals Industry Association (CNIA) has formulated a number of industry standards related to molybdenum materials, supplementing the deficiencies of national standards. These standards are drafted by the Institute of Nonferrous Metals Technology and Economics and other institutions, and are widely used in domestic molybdenum processing enterprises.

YS/T 357-2014 "High Purity Molybdenum and Molybdenum Alloys": It stipulates the chemical composition, properties and testing methods of high-purity molybdenum wire, molybdenum bar and other molybdenum alloy materials, which is suitable for raw materials and semi-finished products of molybdenum spray wire. This standard requires molybdenum to be 99.99% pure, making it particularly suitable for applications in the aerospace and semiconductor industries.

YS/T 616-2012 "Inspection Methods for Molybdenum and Molybdenum Alloy Processed Products": It provides detailed inspection methods for the size, surface quality and mechanical properties of molybdenum wires and molybdenum bars, including ultrasonic flaw detection, microstructure analysis and hardness testing.

YS/T 358-2011 "Molybdenum Powder": It stipulates the particle size distribution, chemical composition and physical properties of molybdenum powder, and provides specifications for the preparation of raw materials for molybdenum spray wire.

These industry standards provide more specific technical requirements for the production and processing of molybdenum materials, complementing the GB/T standards. The standards are formulated by leading domestic enterprises (such as Jinduicheng Molybdenum and Luoyang Molybdenum), reflecting the actual needs and technical level of the industry.

CTIA GROUP LTD
Molybdenum Spray Wire Introduction

1. Overview of Molybdenum Spray Wire

Molybdenum spray wire is a high-purity molybdenum metal wire that is melted and deposited onto a substrate surface through thermal spray techniques such as flame spraying, plasma spraying, arc spraying, or HVOF (High Velocity Oxy-Fuel). The resulting coating offers excellent resistance to wear, corrosion, and high temperatures. Due to its high melting point and superior performance, molybdenum wire is widely used across various industrial sectors.

2. Characteristics of Molybdenum Spray Wire

High Melting Point: Approximately 2623° C, suitable for high-temperature environments.
Excellent Corrosion Resistance: Resists attack from acids, alkalis, and chemical media.
High Hardness & Wear Resistance: Tough coating that withstands mechanical wear.
Low Friction Coefficient: Reduces component wear and improves efficiency.
Chemical Stability: Maintains performance in harsh environments.
High Thermal Conductivity: Effectively dissipates heat and extends component lifespan.

3. Typical Uses of Molybdenum Spray Wire

Aerospace: Turbine blades, engine parts, thermal barrier coatings.
Automotive Industry: Wear-resistant coatings for piston rings, engine blocks, and brake discs.
Chemical & Energy Sectors: Corrosion-resistant pipelines, heat exchangers, wind power equipment.
Electronics & Semiconductors: Vacuum deposition heating wires, semiconductor leads.
Medical Field: Corrosion-resistant coatings for implants and surgical instruments.
Others: Marine anti-corrosion, wear-resistant construction machinery, high-temperature furnaces.

4. Basic Data of Molybdenum Spray Wire from CTIA GROUP LTD

Purity	≥99.95%
Density	10.2 g/cm³
Diameter Range	1.0-3.0 mm, customizable
Tensile Strength	Moderate to ensure stable wire feeding
Packaging	Customized Packaging

5. Procurement Information

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

7.3.2 Thermal spraying industry standards

Developed by the China National Thermal Spray Group (CNTSG) and other international organizations such as the American Thermal Spray Society (ASM TSS), the Thermal Spray Industry Standard provides guidance on the coating process, material, and coating performance.

JB/T 7702-2012 "Technical Specification for Thermal Spraying": A standard issued by the China Machinery Industry Federation, which specifies the general requirements for the thermal spraying process, including the preparation of molybdenum spray wire, spraying parameters and coating testing. This standard applies to flame spraying, arc spraying, and plasma spraying processes.

AWS C2.25/C2.25M: 2012 Specification for Thermal Spray Materials: A standard developed by the American Welding Society (AWS) that covers wire and powders for spraying, including molybdenum wire. This standard provides detailed specifications for the performance and testing of spray materials and is applicable to the North American market.

EN 15311 Quality Requirements for Thermal Spraying: A European standard that specifies quality control methods for thermal spray coatings, including adhesion, porosity and surface roughness testing, for coatings prepared by molybdenum spray wire.

These industry standards provide more granular technical guidance than national standards for the specific needs of thermal spray processes. The standards are developed by industry experts and companies and reflect the latest trends in thermal spray technology.

7.3.3 Internal quality control specifications

Many leading molybdenum processing and thermal spraying companies have developed internal quality control specifications to meet the needs of specific customers or applications. These specifications are often based on national and industry standards, but add more stringent requirements or customized test methods.

The strength of a corporate specification lies in its flexibility and relevance, as well as its ability to respond quickly to market changes and customer needs. These specifications are often combined with ISO 9001 (Quality Management System) and ISO 14001 (Environmental Management System) to ensure compliance and sustainability in the production process.

7.4 Standard comparison and applicability analysis of molybdenum spray wire

Domestic and foreign standards and industry specifications provide multi-level guidance for the production and application of molybdenum spray wire, but there are differences in its content and requirements. Understanding these differences and choosing the right standard is essential to optimize production processes and meet market demands. This section will analyze the differences between domestic and foreign standards, and discuss their application scenarios and selection basis.

7.4.1 Differences in domestic and foreign standards

There are the following main differences between domestic and foreign standards in terms of chemical composition, performance requirements, test methods and application scope:

Chemical composition: Domestic standards (e.g., GB/T 4181-2017) require molybdenum wire purity of 99.95%, while international standards (e.g., ASTM B387-18) offer multiple purity grades up to 99.97%. International standards have stricter limits on certain impurities (e.g., oxygen, nitrogen) and are suitable for high-precision applications.

Dimensional tolerances: International standards (e.g., ISO 14919) require stricter dimensional tolerances, and diameter deviations need to be controlled within ±0.01 mm, while domestic standards (e.g., GB/T 4197-2011) allow deviations of ±.02 mm. This reflects the demand for high-precision wire in the international market.

Test methods: Domestic standards favor the use of traditional spectral analysis and mechanical test methods, while international standards (such as ASTM C633) introduce more advanced detection techniques, such as SEM analysis and ultrasonic flaw detection, with higher detection accuracy.

Scope of application: Domestic standards (such as GB/T 4197-2011) focus more on general applications in the automotive and energy fields, while international standards (such as ISO 20407) cover high-end fields such as aerospace and semiconductors, emphasizing the special properties of coatings.

Environmental requirements: Domestic standards have added environmental protection provisions in recent years (e.g., GB/T 4197-2011 requires the reduction of exhaust emissions), while international standards (e.g., ISO 20407) have incorporated green manufacturing concepts earlier, emphasizing the sustainability of the production process.

These differences reflect the different needs and technical levels of domestic and foreign markets. Domestic standards pay more attention to practicality and cost-effectiveness, and are suitable for large-scale industrial applications; International standards place more emphasis on high precision and high performance, which are suitable for the high-end market.

7.4.2 Standard Application Scenarios and Selection

The selection of suitable molybdenum spray wire standards should be comprehensively considered according to the application scenario, customer requirements and market positioning. The following are the recommended criteria for the main application scenarios:

Aerospace: ASTM B387-18 and ISO 20407 are recommended due to their stringent requirements for high purity and coating properties for high-performance applications such as turbine blades and thermal barrier coatings. This can also be supplemented by internal company specifications, such as Plansee's standards.

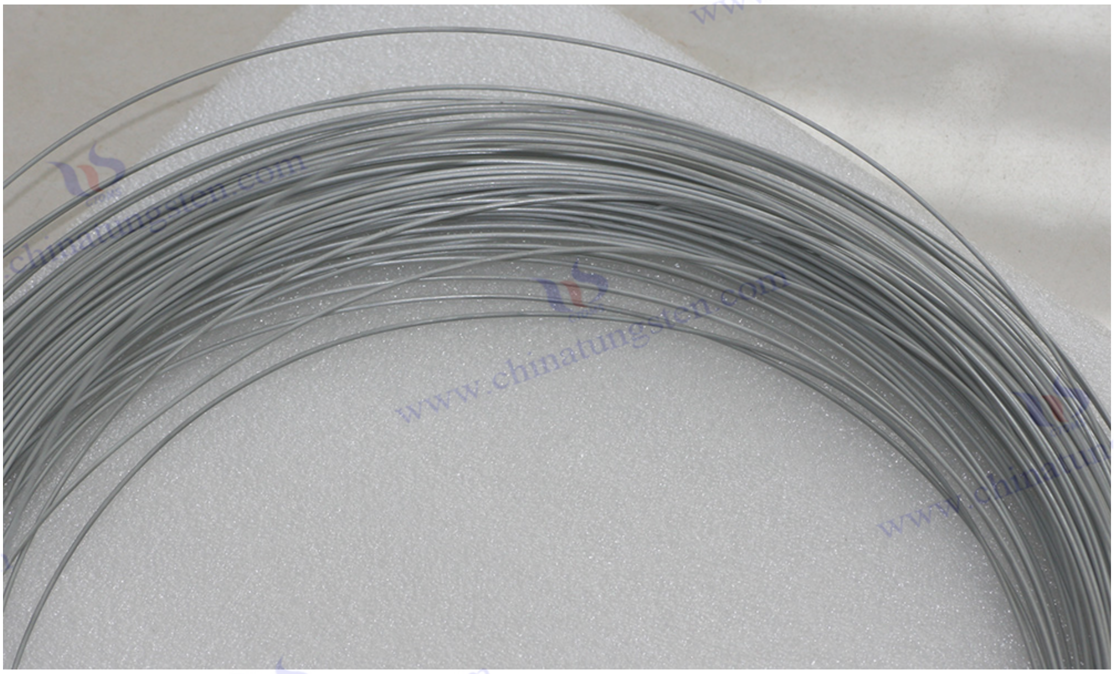
Automotive: GB/T 4197-2011 and ISO 14919 are ideal for general purpose coating applications such as piston rings, exhaust systems, etc. These standards are cost-effective, have simple detection methods, and are suitable for large-scale production.

Chemical & Energy Industry: GB/T 17733-2008 and AWS C2.25 are recommended for corrosion-resistant pipe and heat exchanger coatings. These standards specify in detail the corrosion resistance and durability of coatings.

Electronics & Semiconductor Industry: ASTM B387-18 and YS/T 357-2014 are suitable for the preparation of high-purity molybdenum wires to meet the demanding requirements of vacuum coatings and semiconductor leads.

Export markets: Priority is required to meet international standards (e.g., ISO 14919, ASTM B387-18) and industry norms in target markets (e.g., EN 15311) to meet customer requirements and trade compliance.

In practice, companies often have to comply with several standards at the same time. For example, companies exporting spray-coated molybdenum wire for aerospace use may need to comply with GB/T 4181-2017 (domestic production), ASTM B387-18 (international market) and internal specifications (customer-specific requirements). By establishing a standardized quality management system, enterprises can flexibly respond to the requirements of different standards and improve market competitiveness.



CTIA GROUP LTD molybdenum spray wire

Chapter 8 Testing and Quality Control of Molybdenum Spray Wire

The production and application of molybdenum spray wire has extremely high quality requirements, and its performance directly affects the durability, adhesion and service life of the coating. Testing and quality control is a key part of ensuring that molybdenum spray wire and its coating meet industry standards and customer needs, covering every stage of production, from raw materials to finished products. This chapter will systematically discuss the raw material testing, molybdenum wire quality testing, spraying coating testing, testing technology and equipment, and quality management system of molybdenum spray wire, and reveal how to achieve high-quality production through scientific testing methods and strict management processes.

8.1 Raw material testing

The quality of raw materials is the basis for the production of molybdenum spray wire, especially the chemical composition, particle size and impurity content of high-purity molybdenum powder, which directly affects the subsequent processing and coating performance. Raw material testing requires high-precision analytical methods to ensure that molybdenum powder meets stringent standards. This section will introduce the chemical composition analysis, particle size and morphology testing, and impurity content testing of molybdenum powder in detail.

8.1.1 Analysis of chemical composition of molybdenum powder

The chemical composition of molybdenum powder is the core indicator of its quality, which directly determines the performance of molybdenum wire and coating. Molybdenum powder for spraying usually requires the molybdenum content to reach more than 99.95%, and the content of impurities such as iron, nickel, carbon, and oxygen needs to be strictly controlled to avoid adverse reactions or reduce the quality of the coating during the high-temperature spraying process.

Inductively coupled plasma optical emission spectrometry (ICP-OES) and atomic absorption spectroscopy (AAS) were used for chemical composition analysis. ICP-OES is suitable for the detection of metal impurities such as iron, nickel, and silicon by excitation of molybdenum powder samples to generate characteristic spectra and analyze the types and contents of elements, and has the advantages of high sensitivity and simultaneous analysis of multiple elements. AAS accurately determines the content of a single element by absorbing light at a specific wavelength by atoms, and is commonly used to detect trace amounts of carbon or sulfur in molybdenum powder. The content of oxygen and nitrogen is usually determined by inert gas melting, which accurately determines the content of non-metallic impurities by heating the sample and analyzing the released gas.

The analysis process needs to be carried out in a clean environment to avoid external contamination. Sample preparation involves acid dissolution or melting, ensuring that the molybdenum powder is completely broken down into a detectable solution. The test results should be compared with standards (e.g., GB/T 4325-2013 "Chemical Analysis Methods for Molybdenum and Molybdenum Alloys") to ensure that the purity requirements of molybdenum powder for spraying are met. Chemical composition analysis is not only used for raw material acceptance, but also for batch testing throughout the production process to ensure consistent quality.

8.1.2 Molybdenum powder particle size and morphology detection

The particle size and morphology of molybdenum powder affect its behavior in the process of pressing, sintering and drawing, which is an important control point for the production of molybdenum spray wire. The ideal molybdenum powder should have a uniform particle size distribution and regular particle morphology to ensure the density of the blank and the uniformity of the wire.

Particle size detection mainly uses a laser particle size analyzer to measure the size and distribution of particles through laser beam scattering. The device enables rapid analysis of the particle size range of molybdenum powders (typically 1-50 µm) to generate detailed particle size distribution curves. The test results must meet the standard (e.g., YS/T 358-2011 "Molybdenum Powder") to ensure that the particle size distribution is concentrated and there are no oversized or fine particles. Particles that are too large may cause sintering defects, while particles that are too fine may reduce flowability and affect pressing efficiency.

Topography detection uses scanning electron microscopy (SEM) to observe the particle morphology and surface characteristics of molybdenum powder. SEM provides high-resolution microscopic images that identify whether particles are spherical, agglomerate, or have surface defects. Spherical particles have good fluidity and bulk density, which is suitable for powder metallurgy process; Irregular particles may increase the difficulty of pressing and affect the quality of the blank. SEM detection is often combined with energy spectroscopy (EDS) to analyze the elemental distribution on the surface of particles and check for the presence of oxide or impurity contamination.

Particle size and morphology testing is carried out on a regular basis, covering the warehousing and pre-production inspection of each batch of molybdenum powder. The test data provides the basis for process optimization, such as adjusting grinding or reduction parameters to obtain the desired molybdenum powder properties.

8.1.3 Impurity content detection

The amount of impurities is a key indicator of the quality of molybdenum powder, and trace amounts of impurities can cause coating defects, such as porosity or cracks, during the spraying process. Impurity testing focuses not only on metallic elements (e.g., iron, nickel), but also on non-metallic elements (e.g., oxygen, nitrogen, carbon, sulfur) and other trace contaminants.

Oxygen content detection uses the inert gas melting method to accurately determine the oxygen content by infrared absorption or thermal conductivity to detect the released oxygen. Oxygen is the most common impurity in molybdenum powder, and too high oxygen content may cause molybdenum wire to oxidize at high temperatures, reducing coating performance. Nitrogen and carbon are detected similarly by burning a sample and analyzing the resulting gas, which is determined by gas chromatography or infrared spectroscopy. Sulfur levels are usually measured by chemical analysis or spectroscopy to ensure that they are below standard limits.

The detection of metal impurities relies primarily on ICP-OES or X-ray fluorescence analysis (XRF). XRF is a non-destructive detection method that analyzes the elemental composition by characteristic

TEL: 0086 592 512 9696

sales@chinatungsten.com

X-rays emitted by a sample, making it suitable for rapid screening of impurities such as iron, nickel, copper, etc. ICP-OES provides higher precision and is suitable for the precise analysis of trace impurities. The testing process requires the calibration of high-purity standards to ensure the accuracy of the results.

Impurity testing requires a rigorous sampling and analysis process, with each batch of molybdenum powder being sampled from multiple locations to ensure representativeness. Test results are compared to standards (e.g., ASTM B387-18 or GB/T 4325-2013), and non-conforming batches need to be repurified or discarded to ensure raw material quality.

8.2 Quality inspection of molybdenum wire

Molybdenum wire is the core material of the spraying process, and its dimensional accuracy, surface quality and mechanical properties directly affect the stability of the spraying process and the quality of the coating. The quality inspection of molybdenum wire needs to cover every link of production and delivery to ensure that the wire meets the standard requirements. This section will discuss dimensional accuracy and tolerance measurements, surface defect and roughness inspection, and mechanical property testing.

8.2.1 Dimensional accuracy and tolerance measurement

The dimensional accuracy of molybdenum wire is an important indicator of its quality, especially the uniformity and tolerance of the diameter, which directly affects the stability of the wire feeding system and the formation of molten droplets. The diameter of molybdenum wire for spraying is usually 1.0 mm to 3.0 mm, and the tolerance needs to be controlled within ±0.02 mm, in accordance with standards (such as GB/T 4181-2017 or ISO 14919).

Dimensional measurement mainly uses laser calipers and high-precision micrometers. The laser caliper measures the diameter of the molybdenum wire in real time through non-contact laser scanning, providing high-precision continuous data and is suitable for in-line inspection. The device is able to detect small fluctuations in diameter and identify defects that may occur during the drawing process. Micrometers are used for off-line inspections, where multiple cross-sections are manually measured to ensure uniform diameters. The measurement process needs to be carried out in a constant temperature environment to avoid errors caused by temperature changes.

The tolerance check needs to cover the entire roll of molybdenum wire, randomly select multiple sections for measurement, and record the maximum and minimum diameter values. The test results are compared with the standard to ensure that the wire meets the accuracy requirements of the spraying equipment. Molybdenum wire that is not in the right size can result in unstable wire feed or uneven coating thickness that requires rework or scrapping.

8.2.2 Surface defect and roughness detection

The surface quality of the molybdenum wire is critical to the spray effect, and any cracks, oxides, or lubricant residues can cause droplets to splash or coating defects. Surface defect and roughness detection is the focus of molybdenum wire quality control, ensuring that the wire has a smooth,

TEL: 0086 592 512 9696
sales@chinatungsten.com

flawless surface.

Surface defect inspection uses visual inspection and microscopic observation. Visual inspection is used to quickly screen for visible cracks, scratches, or oxide scale, and is usually performed under bright light. Microscopic observation provides higher resolution images and is capable of detecting surface defects such as string marks or microcracks in the micron range. Modern inspection equipment also integrates a digital imaging system that can automatically identify and record the location of defects, improving inspection efficiency.

Surface roughness is inspected using a profilometer or an atomic force microscope (AFM). The profilometer measures the surface profile with a contact probe and generates roughness parameters (e.g., Ra, Rz) to ensure that the surface roughness of the molybdenum wire complies with standards (e.g., ISO 4287). The AFM provides nanometer resolution for high-precision applications to inspect the microscopic texture of the filament surface. The roughness of molybdenum wire for spraying is usually required to be less than 0.2 μm Ra to reduce friction and spatter during the spraying process.

The surface inspection needs to cover a random sample of each batch of molybdenum wire, combined with an online monitoring system to check the quality of the drawing and polishing process in real time. Severely defective wires need to be re-cleaned or polished to ensure they meet the coating requirements.

8.2.3 Mechanical properties testing (tensile strength, hardness, etc.)

The mechanical properties of molybdenum wire, including tensile strength, ductility and hardness, are key to its stability during drawing and spraying. Mechanical property testing ensures that the wire can withstand the stresses of processing and wire feeding to meet the needs of the application.

Tensile strength and ductility are tested using universal tensile testing machines according to standards such as ASTM E8 or GB/T 14842-2007. During the test, the molybdenum wire sample is slowly stretched to record its maximum tensile force and elongation before breaking. The tensile strength reflects the load-bearing capacity of the wire, while the ductility reflects its plastic deformation capacity. Molybdenum wire for spraying usually requires moderate tensile strength to avoid breakage during wire feeding, and at the same time has a certain ductility to adapt to the drawing and annealing process.

Hardness testing is performed using a Vickers or Rockwell hardness tester to a standard such as ISO 6507 or ASTM E18. The Vickers hardness test uses a diamond indenter to apply a small load on the surface of the molybdenum wire, measure the indentation size, and calculate the hardness value. The Rockwell hardness test is applied to coarser wires, where the indentation depth is measured by means of a steel ball or diamond indenter. The hardness test can reflect the wear resistance and processability of the molybdenum wire, and the hardness of the molybdenum wire for spraying needs to be moderate to balance the strength and toughness.

The mechanical property test requires sampling each batch of molybdenum wire to ensure that the results meet the requirements of the standard. The test data provides the basis for process optimization, such as adjusting the annealing temperature or drawing rate, to obtain the ideal combination of properties.

8.3 Spray Coating Inspection

The quality of the spray coating is at the heart of the application of molybdenum spray wire, which directly affects the durability and performance of the part. Coating inspection evaluates thickness, adhesion, microstructure, and resistance to corrosion, temperature, and thermal shock to ensure that the coating meets the design requirements. These assays are explored in detail in this section.

8.3.1 Coating thickness and uniformity measurement

Coating thickness is a critical parameter that affects its protective performance, too thin can lead to insufficient protection, and too thick can increase stress or cost. The thickness of the coating prepared by molybdenum spray wire is typically 50-500 μm, and uniformity needs to be ensured to avoid local weakness.

Thickness measurement mainly uses ultrasonic thickness gauges and laser thickness gauges. Ultrasonic thickness gauges calculate the thickness of the coating by reflecting sound waves at the interface between the coating and the substrate, making it suitable for non-destructive testing. Laser thickness gauges measure the distance between the coating surface and the substrate by laser scanning, providing highly accurate thickness distribution data for parts with complex geometries. Off-line inspection can also be done using a metallurgical microscope to accurately measure the thickness of the coating by cutting the sample to observe the cross-section.

Uniformity evaluation involves measuring multiple areas of the coating surface, recording the maximum and minimum values of thickness, and calculating the deviation rate. The test results need to comply with the standard (e.g., GB/T 17733-2008 or ASTM C633), and coatings with uneven thickness need to be optimized for spray parameters, such as adjusting the spray distance or wire feed speed.

8.3.2 Coating Adhesion Test

Adhesion is a key indicator of the bonding strength of the coating to the substrate and determines the durability of the coating during operation. Coatings prepared by molybdenum spray wire need to have high adhesion to resist mechanical impact and thermal stress.

Adhesion testing is primarily done using a tensile test method with reference to a standard (e.g., ASTM C633). During the test, the coating sample is bonded between two fixtures, and a progressively increasing tension is applied by a stretching machine to record the maximum force when the coating peels off. Adhesion values are expressed in MPa, and spray molybdenum coatings typically require adhesion of 30-50 MPa, depending on the application.

Another method is the scratch test, in which an increasing load is applied to the surface of the coating by a diamond scribing needle to observe the critical point at which the coating peels. The scratch test is suitable for assessing the adhesion of a coating under local stress, and can be combined with acoustic emission detection to improve accuracy. Coatings with poor adhesion need to be checked for substrate pretreatment or spraying process, optimized blasting or parameter settings.

8.3.3 Coating microstructure and porosity analysis

The microstructure and porosity of the coating directly affect its mechanical properties and corrosion resistance. Spray molybdenum coatings need to have a dense microstructure and low porosity to ensure excellent protection.

Microstructural analysis uses scanning electron microscopy (SEM) and optical microscopy. SEM provides high-resolution cross-sectional images to visualize the grain size, interfacial bonding, and defect distribution of coatings. Optical microscopy is suitable for quickly analyzing a wide area of coating structure and identifying cracks or unmelted particles. During the inspection process, the sample is prepared by cutting, mounting and polishing to ensure that the cross-section is clear.

Porosity analysis is performed by image analysis or densitometry. Image analysis uses SEM or optical microscope images to calculate the proportion of porosity to the cross-sectional area of the coating, and the porosity of sprayed molybdenum coatings is typically less than 5%. The density measurement method uses the Archimedean principle to compare the actual density of the coating with the theoretical density, and indirectly calculates the porosity. Coatings with too high porosity require an optimized spraying process, such as increased spray velocity or HVOF technology.

8.3.4 Corrosion resistance and high temperature resistance test

The corrosion resistance and high temperature resistance of spray molybdenum coatings are key indicators in harsh environments, and are widely used in aerospace, chemical and energy fields. Corrosion and high temperature testing simulates real-world usage conditions to evaluate the long-term stability of the coating.

The corrosion resistance test adopts salt spray test and immersion test. The salt spray test (ASTM B117) places a coated sample in a salt spray chamber and is exposed to a high concentration of sodium chloride mist to observe the appearance time of corrosion spots. Immersion tests involve immersion of the sample in an acidic or alkaline solution (such as sulfuric acid or sodium hydroxide) and periodically checks the coating for loss of quality or surface changes. The chemical inertness of molybdenum coatings makes them excellent in a wide range of corrosive media, but special attention needs to be paid to the effect of porosity on corrosion.

The high temperature resistance test is carried out by high temperature oxidation test and thermal cycling test. The high-temperature oxidation test places the coating sample in a high-temperature furnace (e.g., 1000°C) and is exposed to air or oxygen to measure oxidative weight gain or coating loss. Thermal cycling tests simulate alternating hot and cold environments, and rapid heating and cooling are used to evaluate the thermal shock resistance of coatings. The test results need to be compared to a standard (e.g., ISO 20407) to ensure that the coating meets the application requirements.

CTIA GROUP LTD

Molybdenum Spray Wire Introduction

1. Overview of Molybdenum Spray Wire

Molybdenum spray wire is a high-purity molybdenum metal wire that is melted and deposited onto a substrate surface through thermal spray techniques such as flame spraying, plasma spraying, arc spraying, or HVOF (High Velocity Oxy-Fuel). The resulting coating offers excellent resistance to wear, corrosion, and high temperatures. Due to its high melting point and superior performance, molybdenum wire is widely used across various industrial sectors.

2. Characteristics of Molybdenum Spray Wire

High Melting Point: Approximately 2623° C, suitable for high-temperature environments.
Excellent Corrosion Resistance: Resists attack from acids, alkalis, and chemical media.
High Hardness & Wear Resistance: Tough coating that withstands mechanical wear.
Low Friction Coefficient: Reduces component wear and improves efficiency.
Chemical Stability: Maintains performance in harsh environments.
High Thermal Conductivity: Effectively dissipates heat and extends component lifespan.

3. Typical Uses of Molybdenum Spray Wire

Aerospace: Turbine blades, engine parts, thermal barrier coatings.
Automotive Industry: Wear-resistant coatings for piston rings, engine blocks, and brake discs.
Chemical & Energy Sectors: Corrosion-resistant pipelines, heat exchangers, wind power equipment.
Electronics & Semiconductors: Vacuum deposition heating wires, semiconductor leads.
Medical Field: Corrosion-resistant coatings for implants and surgical instruments.
Others: Marine anti-corrosion, wear-resistant construction machinery, high-temperature furnaces.

4. Basic Data of Molybdenum Spray Wire from CTIA GROUP LTD

Purity	≥99.95%
Density	10.2 g/cm³
Diameter Range	1.0-3.0 mm, customizable
Tensile Strength	Moderate to ensure stable wire feeding
Packaging	Customized Packaging

5. Procurement Information

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

8.3.5 Thermal shock performance test of coating

Thermal shock performance is an important indicator of sprayed molybdenum coatings in high-temperature cycling environments, especially in aero engines and gas turbines. Thermal shock testing evaluates a coating's resistance to cracking and spalling under rapid temperature changes.

Thermal shock testing is usually performed using the water quenching method or the hot air circulation method. In the water quenching method, a coating sample heated to a high temperature (e.g., 800°C) is quickly immersed in cold water and repeated several times to observe cracks or spalling. The hot air circulation method simulates a more realistic thermal cycling environment through the hot blast furnace and cooling system, and records the number of failure cycles of the coating. During the test, the formation of cracks can be monitored in combination with acoustic emission or infrared imaging to improve the detection accuracy.

Coatings with poor thermal shock properties require optimization of the microstructure, such as gradient coating or heat treatment to reduce thermal expansion mismatch. The test results provide the basis for coating design and process improvement, ensuring its reliability in extreme environments.

8.4 Testing technology and equipment

Advanced inspection technology and equipment are at the heart of molybdenum spray wire quality control, providing high precision, non-destructive and real-time analysis capabilities. This section will discuss commonly used inspection techniques and equipment, including X-ray fluorescence analysis (XRF), scanning electron microscopy (SEM) and energy dispersive dispersive analysis (EDS), hardness testers, ultrasonic testing and laser thickness gauges, and other advanced technologies.

8.4.1 X-ray fluorescence analysis (XRF)

X-ray fluorescence analysis (XRF) is a non-destructive testing technique used to rapidly analyze the chemical composition of molybdenum powders, molybdenum wires, and coatings. XRF equipment excites sample atoms by emitting X-rays, records the characteristic fluorescence they emit, and analyzes the type and content of elements.

The advantage of XRF is its speed and multi-element analysis capabilities, making it suitable for detecting impurities such as iron, nickel, and copper in molybdenum powders, as well as elemental distribution in coatings. Handheld XRF equipment facilitates on-site testing, while benchtop equipment offers greater accuracy for laboratory analysis. The test process requires calibration of standard samples to ensure the accuracy of the results. XRF is widely used in the production of molybdenum spray wire and meets the requirements of standards such as GB/T 15258-2009.

8.4.2 Scanning electron microscopy (SEM) and energy dispersive dispersive analysis (EDS)

Scanning electron microscopy (SEM) is the core equipment for microstructure analysis, scanning the surface of a sample with an electron beam to produce high-resolution images. SEM is widely used to inspect the topography of molybdenum powder, surface defects of molybdenum wire, and cross-sectional structure of coatings, and is able to identify characteristics such as grain size, porosity, and cracks.

Spectroscopy (EDS) is combined with SEM to analyze the distribution and content of elements by detecting the characteristic X-rays emitted by a sample. EDS is suitable for checking the distribution of impurities in molybdenum powder, oxides on the surface of molybdenum wire, or elemental diffusion at the coating interface. SEM/EDS testing is performed in a high vacuum environment, and the sample needs to be electrically conductive (e.g., carbon or gold plating) to avoid charging effects.

The high resolution and elemental analysis capabilities provided by SEM/EDS make it an indispensable tool for quality control of molybdenum spray wires, as required by standards such as ASTM E1508.

8.4.3 Hardness tester (Vickers, Rockwell)

Hardness testers are used to evaluate the mechanical properties of molybdenum wires and coatings, reflecting their wear resistance and strength. The Vickers hardness tester measures the indentation size by applying a small load through the diamond indenter and is suitable for inspecting fine molybdenum wires and thin coatings. The Rockwell hardness tester measures the indentation depth through a steel ball or diamond indenter and is suitable for coarser wires or thick coatings.

Hardness testing is carried out to a standard such as ISO 6507 or ASTM E18 to ensure the accuracy of load and indentation measurements. The test results provide the basis for process optimization, e.g. adjusting sintering or spraying parameters to achieve the desired hardness value. The hardness tester is easy to operate and is widely used in production sites and laboratories.

8.4.4 Ultrasonic testing and laser thickness gauges

Ultrasonic testing and laser thickness gauges are important tools for coating quality inspection, evaluating internal defects and surface thickness, respectively. Ultrasonic detectors detect porosity, cracks, or peeling through the reflection of sound waves at the interface between the coating and the substrate, making them suitable for non-destructive testing. The equipment needs to calibrate the standard samples to ensure the accuracy of the sound velocity and reflected signal.

Laser thickness gauges measure coating thickness through laser scanning, providing high-precision, non-contact inspection for parts with complex geometries. The machine is able to generate a thickness map, identify areas of unevenness, and optimize the coating process. The combination of ultrasonic testing and laser thickness gauges provides a comprehensive assessment of the quality of the coating in accordance with standards such as ASTM C633.

8.4.5 Other advanced detection technologies

In addition to the above-mentioned equipment, the detection of molybdenum spray wire also adopts a variety of advanced technologies to improve the detection accuracy and efficiency. For example:

TEL: 0086 592 512 9696

sales@chinatungsten.com

X-ray diffraction (XRD): It is used to analyze the crystal structure of molybdenum powder, molybdenum wire and coating, identify phase composition and stress state, and is suitable for studying the high-temperature performance of coatings.

Infrared thermography: It is used to monitor the temperature distribution during the spraying process in real time to prevent overheating of the substrate or uneven coating.

Acoustic Emission Detection: Evaluate the durability of a coating by monitoring its microcrack acoustic signal under thermal shock or mechanical stress.

Atomic Force Microscopy (AFM): Provides nanometer-scale surface topography and roughness analysis for high-precision inspection of molybdenum wires and coatings.

These technologies provide a variety of means for the quality control of molybdenum spray wire, combined with traditional methods, to meet the needs of different application scenarios.

8.5 Quality Management System

The quality management system is the core of the production of molybdenum spray wire, ensuring the reliability of the test results and the controllability of the production process. By establishing a standardized management process, enterprises can achieve continuous improvement of quality and customer satisfaction. This section will explore ISO 9001 quality certification, inspection reporting and traceability, and quality defect analysis and improvement.

8.5.1 ISO 9001 Quality Certification

ISO 9001 is an internationally accepted quality management system standard that provides a normative framework for the production of coated molybdenum wire. The standard requires enterprises to establish a comprehensive quality management process, covering raw material procurement, production process, testing and after-sales service. ISO 9001 emphasizes customer centricity and improving product quality and efficiency through continuous improvement.

In the production of coated molybdenum wire, ISO 9001 requires the development of detailed operating procedures (SOPs) that clarify the responsibilities and standards of each link. For example, the chemical composition of molybdenum powders is tested according to standardized sampling and analysis procedures, and the adhesion test of spray coatings needs to document all parameters and results. The standard also requires regular internal audits and management reviews to identify potential problems and develop improvements.

Companies that are ISO 9001 certified can increase their competitiveness in the market and meet the stringent requirements of industries such as aerospace and automotive. The certification process is carried out by a third-party organization to ensure the objectivity and compliance of management.

8.5.2 Test report and traceability

Test reports and traceability are important components of quality management to ensure that the quality of each batch of molybdenum spray wire and its coating is verifiable. The test report needs to record the test results of raw materials, molybdenum wires and coatings in detail, including chemical composition, size, performance and defect analysis. The report must comply with the format requirements of the standard (e.g., GB/T 15258-2009) and be signed and dated by the inspector.

Traceability requires the establishment of a complete production record, covering every step of the process, from the procurement of molybdenum powder to the finished coating product. Each batch of molybdenum wire and coating is assigned a unique identification number that records its raw material source, production parameters, test results and factory information. Modern businesses use electronic traceability systems to manage data through barcodes or QR codes, ensuring rapid retrieval and sharing of information.

Traceability not only helps with quality control, but also allows for quick identification of the cause of problems when they occur. For example, if the coating is peeling, the surface quality of the molybdenum wire or the coating parameters can be checked by a traceability system to develop targeted improvement measures.

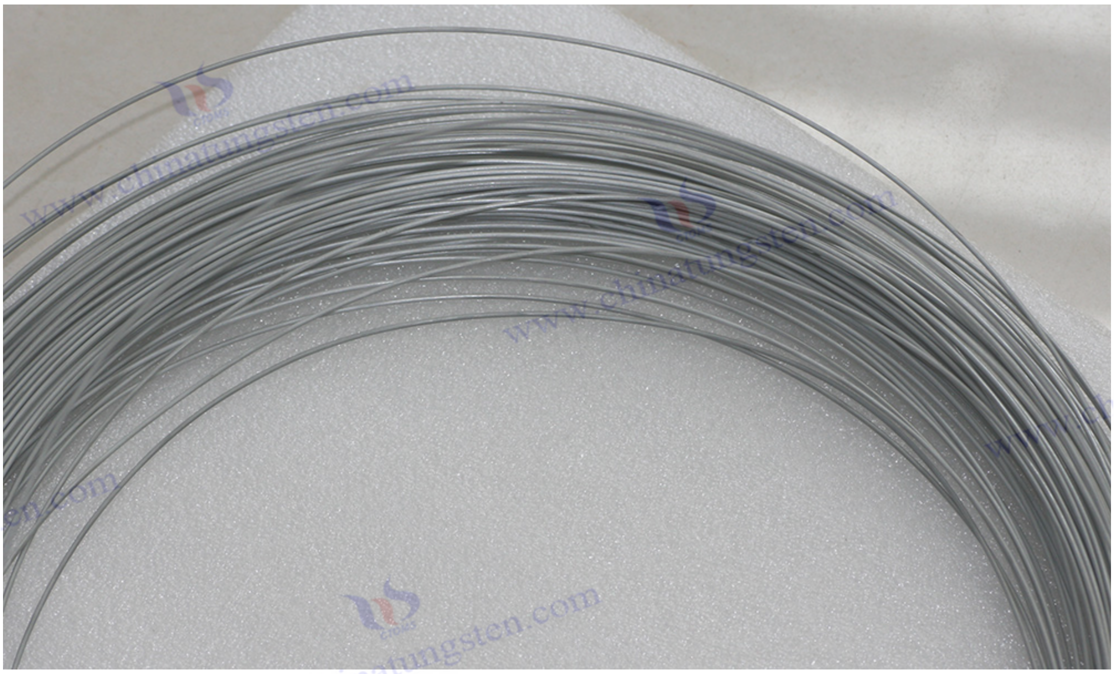
8.5.3 Quality defect analysis and improvement

Quality defect analysis is the key to continuous improvement, through the systematic analysis of defect causes, optimize the production process and inspection methods. Common defects include surface cracks in molybdenum wires, excessive coating porosity, and insufficient adhesion, requiring scientific analysis to identify the root cause.

Defect analysis typically uses a fishbone diagram, 5W1H (Why, Where, When, Who, What, How) and Failure Mode and Effects Analysis (FMEA). The fishbone diagram divides the causes of defects into five categories: man, machine, material, method, and environment, and systematically sorts out the possible influencing factors. 5W1H locates the scenarios and conditions under which defects occur through specific problems. FMEA assesses the potential risk of defects and develops preventive measures such as enhanced substrate pre-treatment or optimization of coating parameters.

Improvements need to be tested to ensure their effectiveness. For example, if the porosity of a coating is too high, try increasing the spray rate or using HVOF technology and verify the improvement through SEM analysis. Improvement outcomes need to be incorporated into SOPs and training plans to prevent recurrence of problems.

Quality defect analysis and improvement is a dynamic process of quality management, and through a data-driven approach, companies can continuously improve the performance and reliability of molybdenum spray wire to meet market demand.


CTIA GROUP LTD molybdenum spray wire

Chapter 9 Development Trend and Future Prospect of Molybdenum Spray Wire

As an important material of thermal spraying technology, molybdenum spray wire has played an irreplaceable role in aerospace, automotive industry, energy and chemical industry. With the transformation of the global industry to intelligent, green and high-end, the technology, market and application of molybdenum spray wire are ushering in new opportunities and challenges. This chapter will deeply discuss the technical development trend of molybdenum spray wire, market demand and application expansion, environmental protection and sustainable development, as well as the prospect of international technical exchanges and cooperation, and provide a systematic outlook for the future development of the industry.

9.1 Technical development trend of molybdenum spray wire

The technological development of molybdenum spray wire is moving towards higher performance, higher efficiency and more intelligence. The convergence of new materials, new processes and digital technologies has revolutionized spraying technology, enabling molybdenum wire and its coatings to meet the demands of increasingly complex and demanding applications. This section will focus on the development trends of new spraying materials and processes, intelligent and digital production, and composite coating technologies.

9.1.1 New spraying materials and processes

The development of new spraying materials and processes is the key direction to improve the performance of molybdenum spray wire. Conventional molybdenum wire is based on its high melting point, corrosion resistance, and excellent mechanical properties, but a single molybdenum coating may face limitations in some extreme environments, such as ultra-high temperatures or strong corrosion. The introduction of new materials and processes aims to overcome these

TEL: 0086 592 512 9696
sales@chinatungsten.com

limitations and expand the range of applications for molybdenum wire.

In terms of materials, molybdenum matrix composites and doped molybdenum wires have become research hotspots. Molybdenum matrix composites significantly improve the hardness, wear resistance and oxidation resistance of coatings by adding ceramic particles (e.g., zirconia, silicon carbide) or rare earth elements (e.g., lanthanum, cerium) to molybdenum. For example, molybdenum wire doped with lanthanum oxide can form a stable oxide protective layer in high-temperature spraying, extending the life of the coating. The development of nanoscale molybdenum powder has also brought a breakthrough in the spraying process, and the fine size and uniform distribution of nanoparticles make the coating denser and the porosity significantly reduced. The preparation of such nanoscale materials is often done using vapor deposition or mechanical alloying techniques to ensure high purity and consistency of the particles.

In terms of process, cold spray and laser-assisted spraying technologies are rapidly evolving. Cold spraying deposits molybdenum particles onto the surface of the substrate through supersonic gas streams, avoiding oxidation and thermal stress caused by high-temperature melting, and is particularly suitable for heat-sensitive substrates such as aluminum alloys or polymers. Laser-assisted spraying, combined with the high energy density of the laser, precisely controls the deposition path of the melt droplets and the microstructure of the coating, resulting in a more uniform coating and stronger adhesion. In addition, advances in supersonic flame spraying (HVOF) and suspended plasma spraying (SPS) technologies have also provided higher deposition efficiency and coating quality for molybdenum wire spraying. These processes achieve lower porosity and higher bond strength by optimizing gas flow, heat source power, and wire feed speed.

The combination of new materials and processes is also driving the development of functional coatings. For example, molybdenum-based self-lubricating coatings are doped with molybdenum disulfide or graphite, which significantly reduces the coefficient of friction and is suitable for high-precision sliding parts; Molybdenum-based thermal barrier coatings are applied to aero engine turbine blades by compounding with ceramic layers to extend their high-temperature service life. These technology trends show that spray-coated molybdenum wire is evolving from a single material to a multi-functional, customized direction, providing a more flexible solution for high-end applications.

9.1.2 Intelligent and digital production

Intelligent and digital production is a revolutionary trend in the molybdenum spray wire industry, and the integration of artificial intelligence, Internet of Things and big data analysis has significantly improved production efficiency, quality control and process optimization capabilities. Intelligent coating systems and digital production processes are reshaping the way molybdenum wire is manufactured and used.

The intelligent spraying system is based on industrial robots and sensors, which can monitor and adjust spraying parameters in real time. The robotic spraying system adapts to the substrate with complex geometries through visual recognition and path planning technology to ensure the uniformity of the coating. The sensor collects data such as temperature, pressure, and wire feeding speed in real time, and dynamically optimizes the process parameters through the feedback control system. For example, some advanced plasma spraying equipment is able to use machine learning algorithms to predict coating defects and automatically adjust spray distances or gas flow rates to reduce scrap rates.

Digital production enables device connectivity and data sharing through the Industrial Internet of Things (IIoT). Each piece of equipment in the production line (e.g. wire drawing machine, spraying gun, detector) is equipped with a data acquisition module that uploads process parameters and quality data to the cloud platform. Data analytics platforms, such as SCADA systems, enable real-time monitoring of production processes to identify potential problems and optimize processes. For example, analyzing the tension fluctuations during the drawing of molybdenum wire can make adjustments to lubricant formulations or die designs to improve wire quality. Digital production also supports remote maintenance, allowing technicians to access equipment status via the cloud to quickly diagnose faults and reduce downtime.

Artificial intelligence (AI) is playing an increasingly important role in process optimization. AI algorithms analyze historical production data to predict the best combination of process parameters and shorten trial cycles. For example, in HVOF spraying, the AI model can recommend the optimal fuel ratio and injection speed based on substrate type and application needs, significantly improving coating performance. In addition, AI supports quality prediction and reduces quality risks by analyzing inspection data, such as SEM images or adhesion test results, to identify non-conforming products in advance.

The trend of intelligent and digital production has not only improved production efficiency, but also promoted flexible manufacturing. Modern coating lines are able to quickly switch between different sizes of molybdenum wire and coating types to meet the needs of small batches and customized orders. This technological advancement enables the molybdenum spray wire industry to better adapt to market changes and provide high value-added products for high-end fields such as aerospace and automotive.

9.1.3 Composite Coating Technology

Composite coating technology significantly improves the overall performance of the coating by combining it with other materials, such as ceramics, metals or polymers. The development of composite coatings is an important direction of molybdenum spray wire technology, which can meet the application needs of multi-functional and extreme environments.

Gradient coating is a type of composite coating technology that reduces spalling caused by thermal stress by introducing a transition layer between the substrate and the molybdenum coating to smooth the difference in thermal expansion coefficient and hardness. For example, on aero-engine turbine blades, a nickel-based alloy binder layer is combined with a molybdenum coating and a zirconia thermal barrier coating to form a gradient structure, which significantly improves the thermal shock resistance of the coating. Gradient coatings are typically prepared using a multi-source spray system

TEL: 0086 592 512 9696
CTIAQCD -MA-E/P 2018- 2024V
sales@chinatungsten.com

that achieves a gradual change in composition and performance by precisely controlling the deposition rate of different materials.

Multi-layer coating is another important composite technology that optimizes the performance of coatings by alternating the deposition of different layers of material. For example, molybdenum coatings are deposited alternately with alumina coatings, which provide both wear and corrosion resistance, making them suitable for chemical reactor protection. The preparation of multi-layer coatings requires precise control of the thickness of each layer and the interfacial bonding, and modern plasma spraying equipment achieves efficient multi-material deposition through multi-gun design.

Functionalized composite coatings impart special properties to coatings by doping them with functional materials. For example, molybdenum coatings doped with carbon nanotubes have excellent conductivity and self-lubrication, which are suitable for high-speed sliding parts of electronic devices; The molybdenum coating doped with yttrium oxide improves the resistance to high-temperature oxidation and is suitable for gas turbine blades. The development of these functional coatings relies on advances in nanotechnology and surface modification technology to ensure that the doped material is evenly distributed and well bound to the molybdenum matrix.

The challenges of composite coating technology are process complexity and cost control. Future developments require intelligent equipment and process optimization to reduce production costs while improving the consistency and reliability of coatings. The wide application of these technologies will promote the market competitiveness of molybdenum spray wire in the high-end field.

9.2 Market demand and application expansion of molybdenum spray wire

The market demand for molybdenum spray wire is driven by global industrialization and the development of emerging technologies, and the application field is rapidly expanding from traditional industries to emerging industries. This section will analyze the application potential of emerging industries as well as global market trends to provide a market perspective for the future development of molybdenum spray wire.

9.2.1 Application potential in emerging industries

The rapid development of emerging industries such as renewable energy, electric vehicles, additive manufacturing, and biomedicine has opened up new application opportunities for molybdenum spray wire. These industries are demanding higher performance and versatility in high-performance coatings, driving innovation and market expansion of molybdenum wire technology.

In the field of renewable energy, spray-coated molybdenum wire is widely used as a protective coating for solar thermal and wind power generation equipment. Solar collector tubes need to operate at high temperatures for long periods of time, and molybdenum coatings improve heat transfer efficiency and durability through their high thermal conductivity and oxidation resistance. The blades and bearings of wind turbines are subjected to wind sand and moisture, and the wear and corrosion resistance of molybdenum coatings can significantly extend their service life. As the global demand for clean energy grows, the application potential of molybdenum wire in renewable energy equipment will continue to expand.

The rise of the electric vehicle (EV) industry has created a vast market for molybdenum spray wire. The battery management system and motor components of electric vehicles need to operate at high temperatures and high currents, and molybdenum coating can improve the conductivity and wear resistance of the electrodes, extending the life of the components. In addition, the braking system of electric vehicles uses regenerative braking, which requires higher wear resistance of brake discs, and molybdenum coating meets these needs through its low coefficient of friction and high hardness. The rapid growth of the electric vehicle market will drive the further popularity of molybdenum spray wire in the automotive industry.

Additive manufacturing (3D printing) is another emerging application area. Molybdenum coatings are used to protect the nozzles and molds of 3D printing equipment against wear and corrosion caused by high-temperature molten materials. Molybdenum wire can also be used as a raw material for 3D printing to prepare molybdenum-based parts with complex shapes by laser or plasma deposition for aerospace and medical applications. Additive manufacturing's high demands for material properties and process flexibility have fuelled technological innovation in molybdenum spray wire.

In the biomedical field, coatings prepared by molybdenum spray wire are applied to the surface protection of implants and surgical tools due to their biocompatibility and corrosion resistance. For example, molybdenum coatings on artificial joints can reduce fluid corrosion and increase the life of implants; The molybdenum coating of the scalpel improves the cutting accuracy through its high hardness and low friction. With the advancement of precision medicine and an aging society, molybdenum coatings have broad prospects for application in medical devices.

The application potential of these emerging industries shows that molybdenum spray wire is transforming from a traditional industry to a high-tech field. Enterprises need to increase R&D investment and develop customized products to meet emerging needs in order to seize market opportunities.

9.2.2 Global Market Trend Analysis

The global market for molybdenum spray wire is affected by the process of industrialization, regional economy and policy guidance, showing a diversified development trend. China, the European Union, North America, and Asia-Pacific are the major markets, with different market characteristics and demand drivers in each region.

China is the world's largest producer and consumer of molybdenum resources, and the molybdenum spray wire market benefits from the rapid development of domestic manufacturing and infrastructure construction. Aerospace, automotive and energy equipment are the core demand areas of the Chinese market, and national policies such as the "carbon neutrality" goal have promoted the development of the renewable energy and electric vehicle industries, further expanding the demand for molybdenum wire. Chinese companies have occupied an important position in the global market through technological upgrading and cost optimization.

The EU market is characterized by high-end applications and environmental requirements, with the aerospace and automotive industries being the main sources of demand. The European Union's green manufacturing regulations, such as REACH and RoHS, require companies to adopt low-polluting spray processes, driving the development of cold spray and green molybdenum coating technologies. European companies are leading the way in technological innovation and quality standards, focusing on technical cooperation with the international market.

The North American market is dominated by the aerospace and energy industries, and the demand for high-performance coatings in the U.S. continues to grow, especially in gas turbines and deep-sea oil and gas equipment. North American companies are leading the way in HVOF and plasma spray technology, emphasizing the development and application of intelligent equipment. The U.S. government's manufacturing reshoring policy has injected new vitality into the regional market.

Asia-Pacific, particularly India, Japan, and South Korea, is a fast-growing market, with expansion in automotive electronics, renewable energy, and shipbuilding industries driving demand for molybdenum wire. The low cost advantage of the Indian market has made it an emerging molybdenum wire processing center, while Japan and South Korea are focused on high-precision applications in the semiconductor and display industries. The advancement of regional economic integration, such as RCEP, has facilitated technology exchange and resource sharing in the Asia-Pacific market.

Global market trends indicate that the demand for molybdenum spray wire will continue to grow, especially in high-end and emerging segments. Enterprises need to pay attention to the differentiated needs of regional markets, and improve market coverage through localized production and global supply chain optimization. At the same time, the risk of international trade barriers and raw material price fluctuations needs to be addressed through diversified procurement and strategic cooperation.

9.3 Environmental protection and sustainable development of spraying

Environmental protection and sustainable development is an important development direction of the spraying molybdenum industry, and the concept of green technology and circular economy is profoundly affecting the production mode and process selection. Reducing environmental pollution, improving resource utilization, and promoting low-carbon production are common challenges faced by the industry. This section will discuss green spraying technologies and environmental management systems.

Green spraying technology

Green spraying technology aims to reduce pollutant emissions and energy consumption during the spraying process, and achieve environmental goals through process innovation and equipment upgrades. The development of green spraying technology provides a solution to the problems that traditional thermal spraying techniques, such as flame spraying, can produce exhaust gases, dust, and noise.

Cold spraying technology is a typical green technology, which avoids oxide emissions and heat energy waste caused by high temperature by jetting molybdenum particles at low temperature and high speed. Cold spray equipment uses an efficient gas circulation system that reduces the amount of helium or nitrogen used and lowers operating costs. The low heat input of cold spray makes it suitable for handling heat-sensitive substrates and reducing scrap generation, making it widely used in the automotive and electronics industries.

Low-emission spraying equipment is the focus of green development. Modern plasma spraying and HVOF systems are equipped with exhaust gas treatment units that remove harmful gases such as sulphur dioxide or nitrogen oxides through filtration and adsorption technology, ensuring compliance with emission standards (e.g. EU REACH). Efficient combustion systems reduce carbon emissions while improving energy efficiency by optimizing the ratio of fuel to oxygen. Some state-of-the-art spraying equipment also integrates heat recovery systems that use waste heat to preheat the substrate or for heating, reducing energy consumption.

The introduction of water-based cleaning technology has also promoted the development of green spraying. Conventional cleaning processes use organic solvents, which can produce volatile organic compound (VOC) contamination. Water-based cleaners are highly effective in removing oil and oxides from the surface of molybdenum wire through biodegradable formulations and ultrasonic cleaning technology, reducing environmental impact. The comprehensive application of these green technologies makes the production of molybdenum spray wire more environmentally friendly and meets the requirements of global sustainable development.

Scrap recovery and recycling

Waste recovery and recycling is an important part of the sustainable development of the molybdenum spray wire industry. As a rare metal, molybdenum has limited resources, and recycling can reduce production costs and reduce environmental burden. Splatter particles, waste filaments and old coatings from the spraying process are the main objects of recycling.

Splash particle recovery is achieved through a dedicated collection system. Modern spraying equipment is equipped with dust collectors and filters to capture and separate molybdenum particles escaping during the spraying process. These particles are screened and purified and can be reused for spraying or molybdenum powder production. The efficiency of the recycling system has a direct impact on resource utilization, and state-of-the-art equipment is capable of recovering up to 90% of splash particles.

The recycling of waste filaments and old coatings is handled by chemical or mechanical methods. The waste wire is purified by smelting or electrolysis and converted into high-purity molybdenum powder, which is re-entered into the production process. The recycling of old coatings usually uses sandblasting or chemical stripping techniques to separate the coating from the substrate, and the recovered molybdenum material is crushed and purified before being reused. The recycling process requires strict control of the introduction of impurities to ensure that the quality of the recycled material meets the standard (e.g. GB/T 3462-2017).

The establishment of a recycling system requires the cooperation of the upstream and downstream of the industrial chain. Molybdenum processors and spraying service providers need to establish a recycling network to collect and process waste in a unified manner. Leading companies, such as H.C. Starck, have developed closed-loop recycling systems that convert waste directly into raw materials, significantly reducing resource consumption. Policy support has also contributed to the development of a circular economy, such as China's Circular Economy Promotion Law, which encourages companies to adopt recycling technologies and reduce the waste of rare metals.

Waste recycling and recycling not only reduces production costs, but also enhances the company's social responsibility image. In the future, the industry needs to further improve recycling technologies and standards to promote the sustainable use of molybdenum resources.

9.4 International technical exchange and cooperation of molybdenum spray wire

International technical exchanges and cooperation are the key driving forces for the development of the molybdenum spray wire industry, which promotes technological innovation, standard unification and market globalization. Through cross-border R&D, industry collaboration, and international conferences, industries are able to share resources, solve common problems, and drive technological advancement. This section will explore the prospects for the harmonization of international technical standards and cross-border R&D and industrial collaboration.

9.4.1 Harmonization of international technical standards

The unification of international technical standards provides a basis for the global trade and technical exchange of molybdenum spray wire, and reduces the technical barriers caused by standard differences. At present, the standards for molybdenum spray wire are mainly dominated by ISO, ASTM and Chinese GB/T systems, but there are differences in chemical composition, test methods and application requirements between the standards, which affects the compatibility of multinational markets.

ISO standards, such as ISO 14919 and ISO 20407, are at the heart of the harmonization of international technical standards and cover the performance requirements of wire and coatings for spraying. These standards have been developed by experts from several countries and reflect the technical consensus of the global industry. For example, ISO 14919 specifies dimensional tolerances and surface quality for spray-coated molybdenum wire, which is widely recognized in the European Union, North America, and the Asia-Pacific region. In the future, ISO will need to further expand the coverage of standards to include specifications for emerging technologies (e.g., cold spraying, nanocoating) to adapt to industry developments.

TEL: 0086 592 512 9696
CTIAQCD -MA-E/P 2018- 2024V
sales@chinatungsten.com

CTIA GROUP LTD
Molybdenum Spray Wire Introduction

1. Overview of Molybdenum Spray Wire

Molybdenum spray wire is a high-purity molybdenum metal wire that is melted and deposited onto a substrate surface through thermal spray techniques such as flame spraying, plasma spraying, arc spraying, or HVOF (High Velocity Oxy-Fuel). The resulting coating offers excellent resistance to wear, corrosion, and high temperatures. Due to its high melting point and superior performance, molybdenum wire is widely used across various industrial sectors.

2. Characteristics of Molybdenum Spray Wire

High Melting Point: Approximately 2623° C, suitable for high-temperature environments.
Excellent Corrosion Resistance: Resists attack from acids, alkalis, and chemical media.
High Hardness & Wear Resistance: Tough coating that withstands mechanical wear.
Low Friction Coefficient: Reduces component wear and improves efficiency.
Chemical Stability: Maintains performance in harsh environments.
High Thermal Conductivity: Effectively dissipates heat and extends component lifespan.

3. Typical Uses of Molybdenum Spray Wire

Aerospace: Turbine blades, engine parts, thermal barrier coatings.
Automotive Industry: Wear-resistant coatings for piston rings, engine blocks, and brake discs.
Chemical & Energy Sectors: Corrosion-resistant pipelines, heat exchangers, wind power equipment.
Electronics & Semiconductors: Vacuum deposition heating wires, semiconductor leads.
Medical Field: Corrosion-resistant coatings for implants and surgical instruments.
Others: Marine anti-corrosion, wear-resistant construction machinery, high-temperature furnaces.

4. Basic Data of Molybdenum Spray Wire from CTIA GROUP LTD

Purity	≥99.95%
Density	10.2 g/cm³
Diameter Range	1.0-3.0 mm, customizable
Tensile Strength	Moderate to ensure stable wire feeding
Packaging	Customized Packaging

5. Procurement Information

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

ASTM standards, such as ASTM B387-18, have a significant impact in the North American market, and their high accuracy requirements are suitable for high-end applications such as aerospace. Compared to the Chinese GB/T standard, ASTM has stricter specifications for impurity content and detection methods. Efforts to harmonize standards require the harmonization of ISO and ASTM to develop more compatible specifications. For example, ASTM and GB/T can simplify the cross-border certification process by harmonizing the chemical composition and mechanical properties test methods of molybdenum wire through bilateral mutual recognition agreements.

China's role in international standard-setting is growing. Domestic enterprises (e.g., Chinatungsten High-tech) actively participate in ISO technical committees to promote the integration of GB/T standards (e.g., GB/T 4181-2017) with international standards. The unification of standards not only promotes technical exchanges, but also enhances the competitiveness of Chinese enterprises in the global market. In the future, the industry needs to strengthen multilateral cooperation, accelerate the revision and promotion of standards, and build a global unified technical framework for molybdenum spray wire.

9.4.2 Cross-border R&D and industrial collaboration

Transnational R&D and industrial cooperation is an important way to innovate molybdenum wire technology in spraying molybdenum, which accelerates the development of new materials and processes through sharing resources and expertise. Collaborations take the form of joint laboratories, technology licensing, industry alliances, and international conferences.

The joint laboratory is the core platform for cross-border R&D. For example, the Chinese Academy of Sciences has cooperated with the Fraunhofer Institute in Germany to establish a joint laboratory for thermal spraying technology, focusing on the research of molybdenum-based composite coatings and cold spray technology. By sharing equipment and data, these labs solve the technical challenges of high-temperature oxidation and thermal shock performance of molybdenum coatings. The joint laboratory has also cultivated international talents and provided technical reserves for the development of the industry.

Technology licensing is a common form of industry collaboration. European companies have promoted the technological upgrading of the regional market by licensing molybdenum wire production technology to Asian companies. Technology licensing is accompanied by strict quality control to ensure that the performance of the licensed products meets the standards. This collaborative model reduces the cost of technology diffusion while expanding the market reach of enterprises.

The industry alliance has promoted the large-scale application of molybdenum spray wire by integrating industrial chain resources. For example, the International Thermal Spray Conference jointly organized by the American Thermal Spray Society (ASM TSS) and the China National Thermal Spray Collaboration Group provides a platform for enterprises to exchange technology and connect with the market. The alliance also coordinates the collaboration of raw material suppliers, equipment manufacturers and coating service providers to optimize the global supply chain.

International conferences and exhibitions, such as the ITSC International Thermal Spray Conference, are important channels for technical exchange, bringing together experts and companies from around the globe to showcase the latest in molybdenum spray wire technology. The conference facilitated cross-border cooperation projects through technical presentations, seminars and exhibitions. For example, the 2024 ITSC conference focused on smart spraying and green technology, pointing out the direction for the future development of the molybdenum wire industry.

The challenge of cross-border R&D and industrial collaboration lies in intellectual property protection and cultural differences. In the future, the industry needs to establish a more transparent cooperation mechanism to balance the interests of all parties through patent sharing and joint filing. At the same time, strengthen talent training and cultural exchanges, improve collaboration efficiency, and promote the global development of molybdenum spray wire technology.

CTIA GROUP LTD molybdenum spray wire

Appendix

A. Glossary

Molybdenum Spray Wire: A material that uses high-purity molybdenum wire as raw material to form a functional coating on the surface of the substrate through thermal spraying technology.

Thermal Spraying: The process of melting or semi-melting a material by heat and spraying it onto the surface of a substrate to form a coating.

Plasma Spraying: A high-temperature spraying technology that uses plasma flame flow as a heat source.

Flame Spraying: A spraying method that uses a burning flame as a heat source.

Arc Spraying: A technique that melts metal wires by arcing and spraying them onto the surface of a substrate.

High-Velocity Oxy-Fuel Spraying (HVOF): A spraying technology that uses high-velocity combustion gas to inject molten materials.

Coating Adhesion: The strength of the bond between the coating and the substrate, typically assessed by tensile or shear testing.

Coating Porosity: The volume ratio of the pores in the coating, which affects the performance of the coating.

Corrosion Resistance: The ability of a material to resist chemical or galvanic corrosion.

Abrasion Resistance: The ability of a material's surface to resist mechanical wear.

Molybdenum Powder: high-purity molybdenum particles prepared by chemical reduction or physical methods.

Powder Metallurgy: The process of preparing materials by pressing and sintering metal powders.

Wire Drawing Process: The process of processing metal bars into filaments through drawing dies.

Surface Activation: A treatment that improves the surface activity of molybdenum wire by chemical or physical methods.

X-Ray Fluorescence Analysis (XRF): A spectroscopic analysis technique used to detect the elemental composition of materials.

Scanning Electron Microscopy (SEM): A microscopy technique used to observe the microscopic morphology and structure of materials.

Energy Spectroscopy (EDS): A technique used in combination with SEM to analyze the elemental distribution of materials.

Heat Treatment: The process of improving the properties of a material by controlling the heating and cooling process.

Green Manufacturing: A production method with the goal of energy saving, emission reduction and environmental protection.

B. References

[1] Chinatungsten Online. Tungsten molybdenum library.

[2] China Tungsten. Founded in 1986, bimonthly.

[3] Institute of Metal Research, Chinese Academy of Sciences. Research progress on molybdenum-based coatings.

[4] Praxair Surface Technologies. Thermal Spray Coating Brochure.

[5] GB/T 4181-2017 Molybdenum Wire. Standardization Administration of China.
[6] GB/T 3462-2017 "Molybdenum Bars and Molybdenum Blanks". Standardization Administration of China.
[7] ASTM B387-18《Standard Specification for Molybdenum and Molybdenum Alloy Bar, Rod, and Wire》. ASTM International.
[8] ISO 14919《Thermal spraying - Wires, rods and cords for flame and arc spraying》. International Organization for Standardization.
[9] ISO 20407《Fine ceramics - Test method for interfacial tensile and shear strength》. International Organization for Standardization.
[10] Journal of Materials Science. Trends in Thermal Spray Coatings.
[11] Surface and Coatings Technology. Advances in Cold Spray and Intelligent Spray Systems.
[12] International Thermal Spray Conference (ITSC). Proceedings 2024.
[13] ISO 9001:2015《Quality management systems - Requirements》. International Organization for Standardization.
[14] ISO 14001:2015《Environmental management systems - Requirements》. International Organization for Standardization.
[15] EU REACH Regulation. European Chemicals Agency.
[16] China Circular Economy Promotion Law. National Development and Reform Commission.
[17] Institute of Metal Research, Chinese Academy of Sciences. Research progress on molybdenum-based coatings.
[18] ASTM C633. Standard Test Method for Adhesion or Cohesion of Thermal Spray Coatings.
[19] ISO 4287. Geometric Product Specification (GPS) - Surface Texture.
[20] Journal of Thermal Spraying Technology. Molybdenum Coatings: Properties and Applications.