# Tungsten Cemented Carbide

# Comprehensive Exploration of Physical & Chemical Properties, Processes, & Applications (I)

中钨智造科技有限公司

CTIA GROUP LTD

**CTIA GROUP LTD**

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

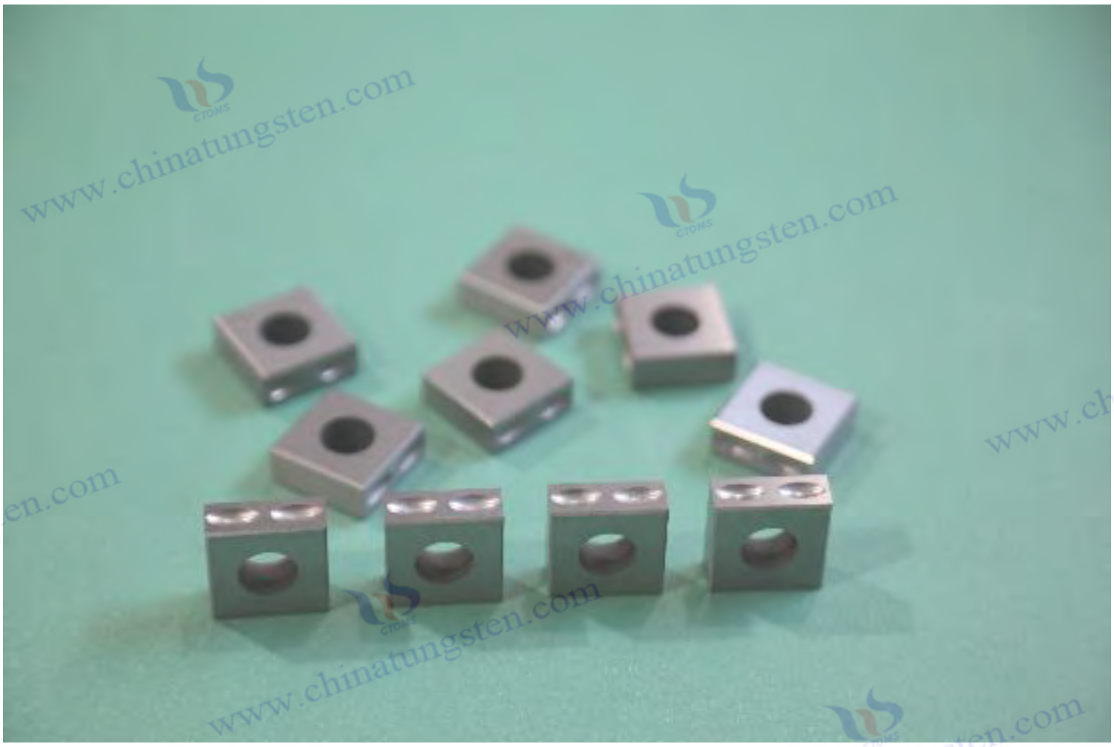
# INTRODUCTION TO CTIA GROUP

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

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

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

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



**Sequence**

**AI-driven high entropy of cemented carbide**
**And the evolution trend of cemented carbide grade batch number**
**The Evolution Trend of AI Driven**
**High Entropy Cemented Carbide (HECC) &**
**Batch Specific Cemented Carbide Grade (BSCCG)**

## 1. Introduction

Cemented carbide is mainly composed of tungsten carbide (WC), combined with cobalt (Cobalt), nickel (Ni) and other bonding phases. Due to its excellent mechanical properties (hardness 1500-2200 HV, wear resistance <0.05 $mm^3$/h) and chemical stability (corrosion resistance <0.02 mm/y, pH 2-12), it is widely used in aerospace, precision manufacturing, new energy and cutting-edge technology. The rapid development of artificial intelligence (AI), industrial Internet, 5G/6G high-speed data transmission and big data/cloud computing technology has injected new momentum into the design and classification of cemented carbide grades, especially promoting the development of " **High -** Entropy Cemented Carbide (HE CC )" and " Batch-Specific Cemented Carbide Grade (BS CC G). These concepts were first proposed by CTIA GROUP LTD , among which high entropy breaks through the performance limit through multi-component alloy design, and batching achieves personalized customization through dynamic optimization. This article is written by a team of experts from China Tungsten Online who have been deeply involved in the tungsten-based materials industry for 30 years and focus on customized design and production. It focuses on the development trend of high entropy and batching of cemented carbide driven by AI , analyzes its technical


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

mechanism and characteristics, and combines aerospace electrical connectors, precision mold micro-hole processing, fuel cell bipolar plates and future cutting-edge science and technology cases to explore performance adaptability and application prospects, and evaluate related challenges and innovation paths.

At present, the cemented carbide industry faces the challenge of complex grade systems. Different cemented carbide companies have their own grade systems. At the same time, there are internationally accepted grade standards (such as ISO 513 classification). European, American, Japanese and Korean countries have also developed their own grade specifications, such as ANSI in the United States, JIS in Japan, and DIN in Germany. Although this diversity stems from technical confidentiality and personalized needs, it brings troubles to the market and customers. Differences in grades make it difficult to match demand, and it is difficult to optimize the coordination of performance and production capacity, which limits the development trend of customized cemented carbide. The high entropy of cemented carbide lays a technical foundation for grade batching by improving the performance limit, while batching dynamically adjusts the formula to adapt to the real-time changing needs and application data feedback in the AI technology ecosystem, guiding the full-link customization of ingredients, process parameters and packaging and transportation at the production end. The two are closely related and jointly promote the cemented carbide industry to move towards intelligence and customization.

## 2. Technical Background

### 2.1 Application of artificial intelligence in material design

supports high entropy and batch design of cemented carbide through machine learning (ML), deep learning (DL) and generative models (such as Generative Adversarial Networks, GAN) . AI processes multidimensional data sets (such as grain size 0.1-10 μm , bonding phase ratio 6-20%, working parameters) and predicts performance indicators (such as hardness error <5%, toughness 1020 MPa·m $^{1/2}$ , corrosion resistance <0.02 mm/y). For example, the WC-Co formula is optimized based on convolutional neural networks, and the R&D cycle is shortened by 60%. Generative AI generates high entropy alloy formulas from historical data (such as WCCo and WCNi libraries) and optimizes high-temperature wear resistance by 15%. The knowledge graph integrates industry chain data (such as tungsten powder purity 99.9%-99.95%, process parameters) to achieve closed-loop optimization, improve efficiency, and lay the foundation for high entropy and batch design .

### 2.2 Industrial Internet and real-time data interaction

builds a data-driven ecosystem through Internet of Things (IoT) sensors, edge computing, and cloud computing . Sensors collect parameters (such as sintering temperature 1350°C±2°C, pressure 100-150 MPa), edge computing processes high-frequency data (grain size 0.1-0.5 μm , 1 Hz), and cloud computing supports massive analysis. This real-time interaction makes production transparent and supports dynamic adjustments (such as $H_2$ atmosphere 5-10% , dew point, etc. ). In the collaboration of the industrial chain, suppliers provide tungsten powder particle size ( such as D50 0.1-0.3 μm ), manufacturers optimize processes, and users feedback working conditions ( such as cutting speed 200 m/min), shortening the supply chain response by 20%, and providing data support for batch production.

### 2.3 Collaborative Empowerment of 5G/6G Networks

5G networks (latency <1 ms , bandwidth >10 Gbps) and 6G networks (latency <0.1 ms , bandwidth >100 Gbps) to be commercialized in 2030 provide efficient communication. 5G /6G supports data exchange in the industry chain, such as suppliers uploading batch data, manufacturers feeding back sintering curves (1400°C, $10^{-3}$ Pa , sintering time, etc. ), and users providing working conditions (50°C-800°C, 100 MPa). This low-latency communication enables AI to quickly optimize high- entropy alloy formulas (such as WC-10%Co+0.2%TaC) or batch adjustments, and cross-regional collaborative design shortens delivery cycles by 25-30%, enhancing the efficiency of high- entropy and batch implementation.

### Computational support for big data and cloud computing

Big data integrates internal data (production logs, test results) and external data (market trends, ISO 45001 standards) to provide materials for AI training. Cloud computing supports high-concurrency computing, such as high-throughput screening of recipes (>$10^{3}$ combinations/day) or multi-objective optimization (hardness, wear resistance, cost). In 2025, the scale of China's big data market is expected to reach 540 billion yuan, supporting material research and development. Cloud computing enables simulation, such as predicting the oxidation resistance of WC alloys (<0.02 mg/cm $^{2}$ , 800°C, error <5%), providing a theoretical basis for high- entropy alloy design and high-precision batching .

## 3. Development trend and characteristics of cemented carbide

The synergy of AI, industrial Internet, 5G/6G and big data/ cloud computing has profoundly shaped the development trajectory of high entropy and batch production of cemented carbide. As a team of experts who have focused on customized production of tungsten-based materials for 30 years , we have witnessed the transformation from traditional formula design to AI-driven innovation. These trends not only improve material performance, but also provide customized solutions for high-end manufacturing . The following is a detailed analysis:

### 3.1 Intelligent Design: Revolutionary Progress Driven by Data

which optimizes high entropy alloys and batch formulations through multi-source data analysis . AI models, such as random forests or support vector machines, integrate crystal phase structure , heat treatment parameters and working condition data to predict performance indicators. For example, the model trained based on historical data can control the prediction error of WC-Co alloy hardness within ±50 HV, and the design cycle is shortened by about 50% compared with traditional methods.


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

Generative AI further breaks through the routine and selects high entropy alloy formulations from thousands of formulations through generative adversarial networks (GAN). For example, WCNi - based alloys add 0.1-0.3 wt % NbC , which improves corrosion resistance by 10%, which is particularly suitable for new energy equipment in acidic environments. In addition, knowledge graph technology matches user needs (such as high conductivity of aviation connectors >90% IACS) with material properties, recommends the optimal formulation, and shortens the response time by 40%. This intelligent design not only accelerates research and development, but also provides theoretical support for high entropy , and batch production benefits from it, achieving a seamless transition from standardization to personalization. The core of intelligent design is to break the limitations of the traditional brand system, achieve precise matching of performance and demand through AI technology, and provide a data basis for the implementation of high entropy and batch production .

**3.2 Flexible manufacturing: process innovation to meet diverse needs**

Flexible manufacturing relies on the industrial Internet and 5G/6G technology to achieve small-batch, highly customized production, meeting the diversified needs of cemented carbide in the high-end market. Real-time process monitoring is the key to flexible manufacturing. IoT sensors accurately collect sintering temperature (1350°C±1°C), pressure (100-150 MPa) and atmosphere parameters (such as $H_2$ content 5-10%). AI algorithms dynamically adjust process parameters to maintain the consistency of grain size (0.1-0.5 μm ), reducing the defect rate by 15%. Rapid prototyping technology further breaks through traditional limitations. For example, complex geometric structures of fuel cell bipolar plate flow channels (tolerance <±0.004 mm) can be completed within a few days, shortening the delivery cycle by 30%, providing strong support for emergency projects. At the same time, 5G/6G networks realize upstream and downstream collaboration of the industrial chain. Suppliers optimize the particle size of tungsten powder (D50 0.1 μm ) to match downstream processing needs. Manufacturers adjust the formula based on user feedback (such as cutting speed 200 m/min), and the supply chain efficiency is improved by 20%. Flexible manufacturing provides a solid foundation for small-batch trial production and rapid iteration of batch products of high- entropy alloys . Especially in the context of diversified grades, it can effectively cope with the market matching difficulties brought about by the grade systems of different countries and enterprises.

**3.3 High entropy of cemented carbide: a breakthrough in performance limits**

" High- **Entropy** Cemented Carbide " (HE CC ) is an innovative concept first proposed by CTIA GROUP LTD , which aims to break through the performance bottleneck of traditional cemented carbide through multi-component high-entropy alloy design.

High-entropy alloy (HEA) is an alloy composed of multiple main elements (usually 5 or more), with the proportion of each element close to the equiatomic ratio (generally 5%-35%), and the lattice distortion and stability are enhanced by high mixing entropy (entropy value>1.5R) . Compared with traditional alloys, high-entropy alloys have excellent properties, such as high hardness, high toughness, high temperature resistance and corrosion resistance, and are often used in extreme environments, such as aerospace, deep-sea equipment and energy fields. Its design often uses AI and density functional theory to break through the performance limits of traditional materials.

High entropy uses AI's high-throughput computing power, such as density functional theory (DFT), to design complex formulas such as WCTiCNbCCo (entropy value > 1.5R), with hardness up to 1800-2200 HV and toughness up to 15-20 $MPa \cdot m^{1/2}$. This multi-component design enhances lattice distortion through the entropy increase effect, significantly improving high temperature stability (> 1000°C) and corrosion resistance (pH 2-3, < 0.005 mm/y). AI-optimized functional coatings, such as TiN or NiP , reduce wear resistance to < 0.015 $mm^3$ /h, corrosion resistance < 0.005 mm/y, and improve surface performance by 20%. In practical applications, high entropy alloys show excellent adaptability. For example, deep-sea development drill bits need to withstand 300 MPa pressure and seawater corrosion (pH 8). The high entropy formula has a hardness of > 2200 HV and a wear life extended by more than 3 times. High entropy technology not only promotes cutting-edge research in materials science, but also provides reliable solutions for extreme working conditions such as aerospace, energy, etc. The core of high entropy is to solve the limitations of the traditional grade system through performance breakthroughs, provide technical driving force for batch production , and enable cemented carbide to adapt to a wider range of working conditions.

It should be noted that **"high entropy of cemented carbide"** can also be understood as "high entropy cemented carbide", a concept that contains multi-level connotations and a dynamic development process. On the one hand, it shows that cemented carbide has broken through the traditional formula system based on tungsten nickel (WC-Ni) and tungsten cobalt (WC-Co), and gradually introduced additional elements such as tantalum (Ta), niobium (Nb), titanium (Ti) or chromium (Cr) according to the market's diversified performance requirements (such as higher hardness, wear resistance, corrosion resistance or high temperature stability), so that its composition has expanded from the traditional binary or ternary system to a complex formula containing five or more elements. Although the content of these newly added elements may not have reached the strictly defined equiatomic ratio (usually 5%-35%) or high mixing entropy (entropy value>1.5R) of high entropy alloys, and therefore is not completely equivalent to high entropy alloys in the actual sense, this trend of element diversification has undoubtedly laid the foundation for performance improvement and demonstrated the potential for cemented carbide to evolve to a higher entropy state .

On the other hand, **"high entropy of cemented carbide"** also points to a gradual transformation process, that is, cemented carbide is gradually moving towards high entropy alloy. This process involves not only the optimization of the formula, but also the production process, microstructure design and the expansion of application scenarios. In this transition, AI technologies (such as machine learning and high-throughput computing) play a key role, guiding the adjustment of alloy formulas by simulating and predicting multi-element interactions. For example, the addition of trace elements (such as 0.2%-0.4% TaC or ZrC ) can significantly enhance lattice distortion and improve high temperature performance or oxidation resistance while maintaining the processing characteristics and economy of cemented carbide. This gradual high entropy enables cemented carbide to gradually absorb the characteristics of high entropy alloys, such as higher toughness (>15 MPa·m $^{1/2}$ ) and wider applicability (such as deep sea or space environment) while maintaining its original advantages (such as high hardness stability in the range of 1500-2000 HV) .

In addition, this transformation is also driven by market demand and technology. For example, electrical connectors in the aerospace field need to take into account high conductivity (>90% IACS) and corrosion resistance (<0.01 mm/y), while fuel cell bipolar plates require high precision (tolerance <±0.004 mm) and acid resistance (pH 3 environment). These requirements have prompted cemented carbide to introduce new elements through high entropy technology to meet extreme working conditions. In the future, this process may be further accelerated. With the maturity of 6G networks and quantum computing, AI will optimize the multi-element ratio more accurately, and gradually realize the comprehensive transition from "high entropy cemented carbide" to real high entropy alloy, thereby achieving a qualitative leap in performance and application range.

**3.4 Batch evolution of cemented carbide grades: the future of customized production**

The cemented carbide grade is a standardized numbering system used to identify the type and performance of cemented carbide materials, usually formulated by companies or international standards (such as ISO 513). It reflects the composition of the alloy (such as WC-Co ratio), performance (such as hardness, wear resistance) and use (such as cutting, molds). For example, ISO K10 indicates a grade suitable for machining cast iron. Different countries and companies have their own systems, such as ANSI in the United States and JIS in Japan. The diversity of grades facilitates accurate material selection, but it may also lead to complex market matching due to different standards.

" Batch-Specific Cemented Carbide **Grade** (BS CC G) " is also called **the batching of cemented carbide grades** . It is a cutting-edge concept first proposed by CTIA GROUP LTD based on many years of practical experience and profound observation . It emphasizes dynamically adjusting the formula according to the characteristics of different batches of raw materials and user needs to achieve high-precision customized production. Raw material batch differences (such as tungsten powder purity 99.9%-99.95%, Co content 6-20%) have a significant impact on performance. AI technology effectively resolves this challenge through big data analysis. For example, the aerospace field has high requirements for hardness (>2000 HV). AI can optimize the WC-Co ratio for specific batches, while mold applications give priority to improving toughness (>15 MPa·m $^{1/2}$ ), and performance differentiation can reach 10-15%. Small batch production optimization further reflects the advantages of batching . For example, the output of deep-sea drill bits (hardness >2200 HV) has been adjusted from the traditional 1000 pieces/ month to 100-200 pieces/month, and the cost is controlled within ±5%, meeting the needs of the high-end market. Industrial Internet and 5G/6G networks enable full life cycle tracking of batch data (such as sintering temperature and grain size), and optimize processes through cloud computing analysis, reducing defect rates by 10% and ensuring quality consistency. In addition, AI predicts market trends, such as the 20% annual growth


电话/TEL：0086 592 512 9696

sales@chinatungsten.com

in demand for new energy batteries, and can quickly adjust the formula (such as adding 0.2-0.4 wt % TaC to improve corrosion resistance), shortening the response cycle by 15-20 days. Batch production also includes personalized design of packaging and transportation, such as the use of anti-corrosion packaging for deep-sea equipment, and monitoring temperature and humidity during transportation (10°C-30°C, humidity <60%) to ensure stable product performance. Batching solves the market problems caused by the diversification of traditional grade systems through full-link customization, enabling cemented carbide to adapt to the real-time changing needs and feedback guidance of application data in the AI technology ecosystem. The close relationship between high entropy and batching is that the former provides technical support through performance breakthroughs, and the latter achieves precise matching of market demand through dynamic adjustments. The two jointly promote the cemented carbide industry to move towards intelligence and customization.

## 4. Challenges of high entropy and grade batching of cemented carbide to enterprises

### 4.1 Challenges to the traditional cemented carbide industry chain

The high entropy of cemented carbide performance and the batching of grades are the inevitable trends of the diversification and high-end demand of the application end, and the revolutionary changes in the AI era have brought unprecedented challenges to the entire cemented carbide industry chain . This change not only affects the core links of cemented carbide production and sales companies, but also has a profound impact on the front end of the supply chain, including upstream equipment suppliers and raw material suppliers. The traditional industry chain is mainly based on a static and standardized production model, which is difficult to adapt to the performance complexity brought by high entropy and the dynamic adjustment capabilities required for batching . AI-driven intelligence requires suppliers to provide raw materials with higher precision and consistency (such as tungsten powder particle size must be accurate to D50 0.1-0.3 μm ), and equipment must have flexible production capabilities (such as supporting real-time adjustment of sintering temperature 1350°C±2°C and atmosphere parameters $H_2$ content 5-10%). In addition, the industry chain needs to build a data interconnection system to achieve transparency and coordination of the entire process from raw material procurement to product delivery to meet the new needs for real-time response and efficient collaboration under the AI ecosystem.

### 4.2 Challenges to cemented carbide enterprises and their management

The management of traditional cemented carbide enterprises often focuses on the allocation of human, financial and material resources and process management. Large enterprises are particularly prone to cumbersome meetings and reporting affairs, ignoring the rapid changes in technological innovation and market demand. However, under the AI ecosystem, enterprise management must change their thinking, deeply learn and understand the application potential of AI technology, clarify the AI underlying architecture technology that cemented carbide enterprises actually need, and avoid blindly investing in one-time, inefficient AI tools or frameworks. Management needs to have a deep understanding of the actual application value of result-oriented AI, and avoid investing a large amount of money in software and hardware facilities that are only used for recording rather than optimization. Instead, they should focus on the technical data interface of the front and back ends of cemented carbide production, the human-computer interaction incision, and the efficient collaboration path and safe operation mechanism of the upstream and downstream of the industrial chain. In addition, management needs to identify and cultivate talents that adapt to the AI technology ecosystem, clarify the types of talents required by the enterprise, AI management processes, compliance requirements and application scenarios of AI Agents. For example, the introduction of AI marketing agents (software programs that use artificial intelligence technology to autonomously perform marketing tasks , analyze customer data, personalize content, optimize advertising campaigns, schedule releases, interact with potential customers, and measure marketing effectiveness) can analyze market demand in real time and optimize product promotion strategies. It can be said that this management transformation will become a watershed in the future competition of cemented carbide companies, and even the key to survival.

### 4.3 Challenges to practitioners in the traditional cemented carbide industry chain

Employees of traditional cemented carbide production and sales companies, especially grassroots staff, must adapt to the new working mode brought about by AI technology. They need to understand AI technical thinking, learn and master the equipment operation process of AI and power dual drive, be proficient in using intelligent management tools, and be familiar with AI human-computer interaction interface. For example, operators need to quickly input working parameters (such as cutting speed 200 m/min) through the AI interface and receive optimization suggestions. In addition, practitioners need to master AI production and application tools, learn to analyze and evaluate the output results of various professional AI Agents, judge their pros and cons and make suggestions for improvement. This requires practitioners to have stronger optimization thinking and multi-dimensional analysis capabilities, and be able to find key improvement points in criss-crossing data, thereby improving the performance of high-entropy alloys or the accuracy of batch production. Only through continuous learning and capacity improvement can grassroots employees achieve the role transformation from traditional operators to intelligent production participants in the AI ecosystem.

### 4.4 Challenges and opportunities for small and medium-sized cemented carbide enterprises

AI Agent (artificial intelligence agent, artificial intelligence body) refers to an intelligent entity driven by artificial intelligence technology that can perceive the environment, make autonomous decisions and perform tasks. It obtains information through sensors or data input, uses algorithms to analyze and formulate action strategies, and then takes actions to achieve preset goals. AI Agent has a certain degree of autonomy and is widely used in smart assistants, autonomous driving, chatbots and other fields. Its functions depend on the design and training data.

We believe that in the near future, the cemented carbide industry will see the birth of AI Agents trained by various companies themselves.

In the AI ecosystem, cemented carbide SMEs will face severe survival challenges. Whether they can quickly adapt to the transformation of thinking from high entropy to batching of grades depends on the speed of technology upgrades, the ability to invest funds, and the strength of their learning ability. This transformation pressure may lead to the Darwin phenomenon of "no grass grows under the big tree" in the industry, and some SMEs will be eliminated because they cannot keep up with the pace of AI technology. However, the AI era also provides opportunities for SMEs to counterattack. China's cemented carbide industry chain may give birth to one-person unicorns based on professional AI Agents. With very few human resources, such enterprises rely on AI Agents to build an efficient production and sales center, which can operate 24 hours a day, 7 days a week, without the need for conference rooms, not prone to errors, and real-time mastery of various types of data in the ecosystem, and continuous upgrading through iterative optimization. Such enterprises can become data funnels in the AI ecosystem, automatically handling the entire process of design drawings, contract confirmation, production task allocation, manpower deployment, technical requirements formulation, material preparation, purchase list generation, outsourcing instruction release, special matters handling, online data sharing, inspection and testing, packaging mark design, batch number generation and logistics arrangements.

In contrast, although large cemented carbide enterprises have absolute advantages in capital, technology and talent, their internal vested interests and rigid organizational structure may become the biggest obstacle to innovation . For example, if the executive management decides to use AI conference agents, they may be the first to be replaced . On the contrary, due to their small size and short decision-making chain, small and medium-sized enterprises may embrace AI technology more flexibly, liberate the management with insufficient manpower, and use the other side of the disadvantage to achieve a counterattack. For example, by introducing an AI micro-ecosystem, small and medium-sized enterprises can occupy key nodes in the industrial chain, respond quickly to market demand, and even lead industry changes. This situation where opportunities and challenges coexist highlights the profound reshaping of the development model of cemented carbide enterprises in the AI era.

## 4.5 Training, Application and Iterative Optimization of Cemented Carbide Enterprise AI Agent

In the cemented carbide industry, the use of industrial Internet of Things ( IIoT ), 5G/6G communication technology, and customers' use of real-time data to learn, train, upgrade and apply AI Agents, and optimize the production process through backtracking and automatic adjustment, can achieve synchronous coordination and machine dialogue between production and application ends. The following are specific implementation methods:

**The carbide AI Agent training**
deploys an IIoT sensor network to collect production data in real time (such as GB/T 26048-2010 sintering temperature and pressure, GB/T 34505-2017 powder particle size distribution), and

transmits it to the cloud via 5G/6G high-speed transmission. Combined with the initial data set (GB/T 18376-2014 microstructure, GB/T 5314-2011 chemical composition), a distributed machine learning training model is used to predict performance indicators (such as YG6 hardness 91.5 HRA, porosity <0.05%).

**Carbide AI Agent is constantly upgraded to monitor customer usage scenarios**
through IIoT (such as GB/T 12444-2006 wear resistance, GB/T 4334-2020 corrosion resistance), and 5G/6G real-time data transmission. Apply online learning or federated learning to dynamically update the model to adapt to new processes (such as GB/T 5243-2008 new grades) or changes in customer demand, and improve prediction accuracy (deviation <±0.5 HRA).

**Real-time customer data backtracking and optimization of carbide AI Agent** Customer usage data (such as cutting tool life and wear rate) is fed back to the production end in real time through 5G/6G. AI Agent analyzes the data and backtracks the production process (such as high sintering temperature resulting in porosity>0.1%). AI Agent automatically adjusts process parameters (such as reducing the temperature from 1450°C to 1440°C), optimizes real-time technical data, and ensures product performance (such as hardness stabilizing at 91.5±0.5 HRA). This process realizes the synchronous coordination between the production end and the application end, forming a dialogue between machines (such as data interaction between production equipment and customer equipment).

**Application of Carbide AI Agent**
AI Agent integrates production equipment through IIoT , adjusts parameters in real time (such as pressure 50 MPa, holding time 60 minutes), predicts and corrects defects. 5G/6G ensures efficient communication, collects application data (such as cutting life> 5 hours), supports remote diagnosis and personalized customization, and improves production efficiency and product consistency.

With the support of IIoT and 5G/6G, combined with real-time customer data backtracking and automatic optimization, AI Agent achieves closed-loop coordination between production and application, ensuring the optimal performance of cemented carbide products while improving efficiency and customer satisfaction. The dedicated AI Agent application built by the cemented carbide industry can drive the continuous evolution of cemented carbide high entropy and brand batch design and optimization, iterative upgrades, and promote the industry to develop in the direction of intelligence, customization and high performance.

## 5. AI-driven high entropy and grade batch design of cemented carbide and application case analysis

a team of experts who have been focusing on the customized production of tungsten-based materials for 30 years, China Tungsten Online has analyzed in detail the practical applications of AI-driven cemented carbide high entropy and grade batching in multiple fields through the following cases. These cases not only demonstrate the technical advantages, but also reflect its far-reaching impact on the development of the industry.

### 5.1 Aerospace electrical connectors: the perfect combination of high conductivity and corrosion resistance

Aerospace electrical connectors need to have high conductivity (>90% IACS), corrosion resistance (<0.01 mm/y, 1000 hours salt spray test) and vibration resistance (10 g, $10^6$ cycles). AI designed a high entropy alloy grade WCTiCNi (20-25 at% of each component, entropy value>1.5R), and added 0.2 wt % TaC to increase wear resistance by 5%, hardness to 1900 HV, conductivity over 90% IACS, contact resistance below 10 μΩ , and corrosion resistance maintained at <0.01 mm/y in a 1000-hour salt spray test. This formulation uses high entropy technology to enhance lattice stability, supports high-speed signal transmission (50 A/cm² ) , and performs well in 50°C-200°C, 10 g vibration environments. AI optimizes the formula by analyzing working condition data (such as salt spray concentration and current density), with the error controlled within 3%. The 5G network enables real-time data interaction, and the industrial Internet integrates user feedback. The yield rate reaches 98%, and the service life reaches $2\times10^6$ times, which is 3 times higher than that of traditional copper-based materials . Batch production adjusts the formula according to the needs of aerospace customers to ensure that each batch meets specific conductivity and corrosion resistance standards.

### 5.2 Precision mold micro-hole processing: technical embodiment of ultra-high hardness and wear resistance

Precision mold micro-hole processing requires high hardness (>1800 HV), wear resistance (<0.02 mm³ /h) and high precision (tolerance <±0.003 mm). AI designed WCTiCCo high entropy alloy (20-25 at% of each component, entropy value>1.5R), and added 0.3 wt % ZrC to improve the anti-adhesion performance by 10%, the hardness reached 2000 HV, the toughness was 15 MPa·m$^{1/2}$ , and the wear resistance was reduced to <0.015 mm³ /h. This formula shows low loss (<0.3%) in high-frequency electrospark machining (pulse width 30-50 μs , current 10 A), and the anti-adhesion property reduces machining residues, which is particularly suitable for micro-hole machining (hole diameter Ø 0.5 mm) of difficult-to-machine materials such as titanium alloys . AI combines working condition data (such as electrode wear rate and processing temperature) to optimize the formula, the industrial Internet provides real-time feedback on processing parameters, and the 5G network transmits industry chain data. The yield rate reaches 97%, and the wear-resistant life is 4 times longer than that of traditional copper electrodes. Batch production adjusts the amount of ZrC added according to different mold uses to ensure that each batch meets specific precision and wear-resistant requirements.

### 5.3 Fuel cell bipolar plates: Dual optimization of conductivity and acid resistance

Fuel cell bipolar plates require high conductivity (>85% IACS), acid resistance (<0.01 mm/y, pH 3) and high precision (tolerance <±0.004 mm). AI designed WCTiCNbCCo high entropy alloy (15-20 at% of each component, entropy value>1.5R), added 0.2 wt % TaC to improve corrosion resistance by 10%, hardness 1900 HV, conductivity>85% IACS, and corrosion resistance <0.005 mm/y in pH 3 environment. High conductivity supports efficient current transmission (100 A/cm² ) , acid resistance ensures long-term stability in 80°C acidic electrolyte, and high hardness maintains flow channel geometry accuracy (width 0.5 mm). AI optimizes the formula by analyzing the electrolyte composition (pH 3, temperature 80°C), cloud computing verifies performance (error <4%), and 5G network supports industry chain collaboration, with a yield rate of 98% and a service life of $1.2\times10^7$ times , four times higher than stainless steel. Batch production adjusts the formula according to different fuel cell specifications to ensure that each batch is adapted to specific conductivity and acid resistance requirements.

**5.4 Protective armor: strategic application of ultra-high hardness and lightweight**

Protective armor requires ultra-high hardness (>2000 HV), impact resistance (>15 MPa·m $^{1/2}$ ) and lightweight (density <15 g/cm $^3$ ). AI designed WCTiCTaCCo high entropy alloy (20-25 at% of each component, entropy value>1.6R), adding 0.3 wt % NbC to increase impact resistance by 8%, hardness 2100 HV, toughness 16 MPa·m $^{1/2}$ , density 14.5 g/cm $^3$ . This formula uses high entropy technology to resist high-speed impact (>1000 m/s), lightweight design is suitable for mobile platforms such as tanks and armored vehicles, and high temperature resistance (600°C) to cope with explosive impact environments. AI optimizes the formula based on battlefield working condition data (such as impact velocity and temperature 40°C-600°C), with an error of <3%. 5G/6G networks support real-time interaction, and the industrial Internet integrates feedback. The yield rate is 96%, and the impact life is $10^5$ times, which is 2.5 times higher than that of traditional armor steel. Batch production adjusts the amount of NbC added according to different armor uses to ensure that each batch meets specific impact resistance and lightweight requirements.

**5.5 UAV rotor parts: synergistic optimization of high strength and wear resistance**

UAV rotor parts require high strength (>2 GPa ), wear resistance (<0.015 mm³ / h) and light weight (density <14 g/cm³ ) . AI designed WCTiCNi high entropy alloy (20-25 at% of each component, entropy value>1.5R), added 0.2 wt % ZrC to increase wear resistance by 7%, hardness 1950 HV, bending strength 2.2 GPa , density 13.8 g/cm³ . High strength and wear resistance ensure structural stability at high speed (>$10^4$ rpm), lightweight improves endurance, and environmental resistance (20°C-200°C) adapts to diverse flight missions. AI uses flight condition data (such as speed and temperature) to optimize the formula, the industrial Internet analyzes performance feedback, and the 5G network transmits industry chain data. The yield rate is 97%, and the wear life is $5\times10^5$ hours, which is 3 times higher than that of titanium alloy. Batch production adjusts the amount of ZrC added according to different mission scenarios to ensure that each batch meets specific strength and wear resistance requirements.

5.6 Pressure hull of unmanned submersible: the ultimate challenge of deep sea environment

pressure hull of an unmanned submersible requires high pressure resistance (>500 MPa), seawater corrosion resistance (<0.005 mm/y, pH 8) and high toughness (>12 MPa·m $^{1/2}$ ). AI designed the


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

WCTiCNbCCo high entropy alloy (15-20 at% of each component, entropy value>1.5R), adding 0.3 wt % TaC to increase corrosion resistance by 12%, hardness of 1900 HV, compressive strength of 550 MPa, and corrosion resistance <0.004 mm/y. High pressure resistance and toughness can withstand deep-sea high pressure (>500 MPa), excellent seawater corrosion resistance ensures long-term stability in 0-10°C marine environment, and high hardness maintains the geometric integrity of the hull. AI optimizes the formula through deep-sea working condition data (such as pressure and temperature), cloud computing verifies performance (error <3%), 5G/6G network supports industrial chain collaboration, 98% yield rate, life of $10^7$ hours, 4 times higher than stainless steel. Batch production adjusts the amount of TaC added according to different diving depths to ensure that each batch is adapted to specific pressure resistance and corrosion resistance requirements.

### 5.7 Deep-sea development drill bits: a perfect balance of extreme wear resistance and corrosion resistance

Deep-sea development drill bits require ultra-high hardness (>2200 HV), wear resistance (<0.01 $mm^3$/h) and corrosion resistance (<0.005 mm/y, pH 8). AI designed the WCTiCTaCNi high entropy alloy (20-25 at% of each component, entropy value>1.6R), adding 0.4 wt % $Cr_3C_2$ to improve wear resistance by 10%, hardness 2250 HV, wear resistance <0.008 $mm^3$/h, corrosion resistance <0.004 mm/y. Ultra-high hardness and wear resistance are suitable for deep-sea hard rock drilling (pressure>300 MPa), corrosion resistance ensures stability in 0-20°C seawater environment, and high strength maintains the structural integrity of the drill bit. AI uses deep-sea working data (such as rock hardness and temperature) to optimize the formula, the industrial Internet analyzes feedback, and the 5G network transmits data. The yield rate is 96%, and the wear life is $2\times10^4$ hours , which is 3 times higher than that of traditional drill bits. Batch production adjusts the amount of $Cr_3C_2$ added according to different geological conditions to ensure that each batch meets specific wear and corrosion resistance requirements.

### 5.8 Heat-resistant protective plate for space development: the pinnacle of high-temperature oxidation resistance and lightweight

Heat-resistant protective plates for space development require high-temperature oxidation resistance (<0.01 mg/$cm^2$ , 1500°C), high strength (>2 GPa ) and light weight (density <14 g/$cm^3$ ) . AI designed the WCTiCNbCCo high-entropy alloy (20-25 at% of each component, entropy value>1.5R), adding 0.2 wt % ZrC to increase oxidation resistance by 8%, hardness of 2000 HV, bending strength of 2.3 GPa , and density of 13.5 g/$cm^3$ . Oxidation resistance and high strength are suitable for the high temperature environment of spacecraft re-entering the atmosphere (1500°C), lightweight reduces launch costs, and vacuum resistance ($10^{-6}$ Pa) meets space conditions. AI optimizes the formula through space working condition data (such as temperature and pressure), cloud computing verifies performance (error <3%), and 5G/6G network supports collaboration. The yield rate is 97%, and the anti-oxidation life is $10^4$ hours , which is 2.5 times higher than that of ceramic- based materials . Batch production adjusts the amount of ZrC added according to different space missions to ensure that each batch meets specific anti-oxidation and lightweight requirements.

### 5.9 Humanoid robot joint components: dynamic balance between wear resistance and toughness

Humanoid robot joint parts require high wear resistance (<0.015 $mm^3$ / h), high toughness (>15 MPa·$m^{1/2}$) and light weight (density <14 g/$cm^3$ ) . AI designed WCTiCNi high entropy alloy (20-25 at% of each component, entropy value>1.5R), adding 0.3 wt % TaC to improve wear resistance by 7%, hardness 1950 HV, toughness 16 MPa·$m^{1/2}$ , density 13.7 g/$cm^3$ . High wear resistance and toughness ensure low loss in high-frequency motion (cyclic stress>100 MPa), lightweight to improve robot flexibility, environmental resistance (10°C-100°C) to adapt to a variety of mission scenarios. AI uses motion condition data (such as load, temperature) to optimize the formula, industrial Internet analysis feedback, 5G network transmission data, 98% yield, wear life of $5\times10^6$ times , 3 times higher than titanium alloy. Batch production adjusts the amount of TaC added according to different robot models to ensure that each batch meets specific wear resistance and toughness requirements.

### 5.10 AI precision matching design: a technical paradigm for comprehensive optimization

AI precision matching design technology provides comprehensive optimization solutions for carbide tools, molds and cutting tools, balancing appearance, processing technology, life, cost and timeliness. Intelligent shape optimization uses AI modeling and finite element analysis (such as cutting force 500 N) to adjust the tool rake angle (10°), improve processing accuracy to ±0.001 mm, and reduce material waste by 5%. Processing difficulty assessment analyzes the feasibility of CNC, laser cutting and heat treatment, predicts defect rate <2%, and reduces cost by 10%. Life prediction recommends surface coating (such as TiN ) based on wear data (<0.01 $mm^3$ /h) , extending life by 20%. Comprehensive optimization of cost and timeliness uses a multi-objective algorithm to control cost by ±5% and shorten the cycle by 15 days. Dynamic matching and continuous iteration updates working conditions through the database (such as cutting speed 200 m/min), AI iterative optimization, adapts to the batching needs of high-entropy alloys, and improves product competitiveness by 20%.

## VI. Issues and Challenges

### 6.1 Data Quality and Consistency

AI relies on data quality. Data in the industry chain contains noise due to differences in measurement methods, which may affect the accuracy of predictions. Cross-enterprise sharing is subject to privacy restrictions, and unified standards (such as ISO 8000) need to be established to ensure data reliability and interoperability. In addition, data formats and collection methods from different sources may lead to inconsistent information, increasing the complexity of data cleaning and integration. Establishing industry data standards and sharing mechanisms will become a key step in future development to support the stability and predictive capabilities of AI models.

### 6.2 Computing Resources and Costs

High-throughput computing requires high-performance computing (HPC) clusters, which are costly and pose a significant burden on small and medium-sized enterprises. Although cloud computing provides scalability, initial investment and operating costs may limit its popularity. Small and medium-sized enterprises need to explore low-cost edge computing alternatives, reduce dependence on cloud services through localized processing , and optimize resource allocation to reduce overall costs. In addition, energy consumption and hardware maintenance must also be taken into consideration to achieve a balance between economic benefits and technical performance.

### 6.3 Process complexity and controllability

High entropy alloys have high requirements for production parameters, and parameter deviations may lead to performance fluctuations. For example, slight changes in sintering temperature and atmosphere control may affect material properties and increase uncertainty in the production process. Automated control systems and standardized processes are urgently needed to improve the repeatability and stability of the process. In addition, complex processes may also require more advanced equipment and professional technical support, and companies face great pressure in technology upgrades and personnel training.

### 6.4 Industrialization and Scale-up Bottlenecks

Small batch production performs well, but large-scale production faces many challenges, including difficulty in ensuring performance consistency between batches and high production costs. Supply chain coordination efficiency and stability of raw material supply may also become bottlenecks. It is necessary to optimize supply chain management, reduce the production cost of high entropy alloys through close collaboration with suppliers and customers, and improve the economic efficiency of large-scale production. At the same time, exploring modular production models may help achieve scale goals while maintaining flexibility.

### 6.5 3D Printing and 2D Material Technology

**3D printing structure optimization**
Manufacturing complex components, shortening cycles, and improving design flexibility provide a new approach for rapid trial production of high entropy alloys.

**2D material enhancements**
Graphene coating improves conductivity and corrosion resistance, enhances surface properties, and is expected to further optimize the application range of high entropy alloys.

**Multifunctional composite materials**

Embedding 2D materials to form high-strength composites extends life, reduces waste, and promotes sustainable development of material design.

**Sustainability**

Reducing energy consumption, reducing carbon footprint, and addressing resource challenges are in line with the AI-driven green manufacturing trend.

In addition, the accuracy and material compatibility of 3D printing technology still need to be improved, and the mass production and cost control of 2D materials also need further breakthroughs. The development of these technologies will provide more possibilities for the industrial application of high entropy and batching , but it is also necessary to balance technological innovation with the feasibility of actual production.

## VII . Conclusion

Driven by AI, high entropy and grade batching of cemented carbide significantly improve performance (lifespan 2.5-4 times) and customization capabilities, adapting to aerospace, new energy and cutting-edge technology. Case studies have verified its application potential under extreme working conditions, and challenges include data quality, cost and industrialization. In the future, 6G commercial use and quantum AI will drive growth by 35% (2025-2030). Interested industry insiders can contact China Tungsten Online Technology Co., Ltd. for exchanges , discussions and cooperation.

---

**References**

Chinatungsten Online , "Tungsten Products Market Quotation on May 16, 2025".

China Tungsten Online WeChat Official Account , "Market Quotes of Tungsten Products on May 16, 2025 ", China Tungsten Online, 2025.

USGS, "Tungsten Data Sheet 2025", United States Geological Survey, 2025.

United States Geological Survey, " Tungsten 2025 Data Sheet", United States Geological Survey, 2025.

ITIA, "International Tungsten Industry Association Annual Report 2025", ITIA, 2025.

Tungsten Industry Association, "2025 Tungsten Industry Association Annual Report " , Tungsten Industry Association, 2025.

Journal of Materials Science, "High-Entropy Alloys for Extreme Environments", Vol. 60, No. 12, pp. 1234-1250, 2025.

Journal of Materials Science, "High Entropy Alloys in Extreme Environments", Vol. 60, No. 12, pp. 1234-1250, 2025.

# CTIA GROUP LTD

## 30 Years of Cemented Carbide Customization Experts

### Core Advantages

**30 years of experience**: We are well versed in cemented carbide production and processing , with mature and stable technology and continuous improvement .

**Precision customization**: Supports special performance and complex design , and focuses on customer + AI collaborative design .

**Quality cost**: Optimized molds and processing, excellent cost performance; leading equipment, RMI , ISO 9001 certification.

### Serving Customers

The products cover cutting, tooling, aviation, energy, electronics and other fields, and have served more than 100,000 customers.

### Service Commitment

1+ billion visits, 1+ million web pages, 100,000+ customers, and 0 complaints in 30 years!

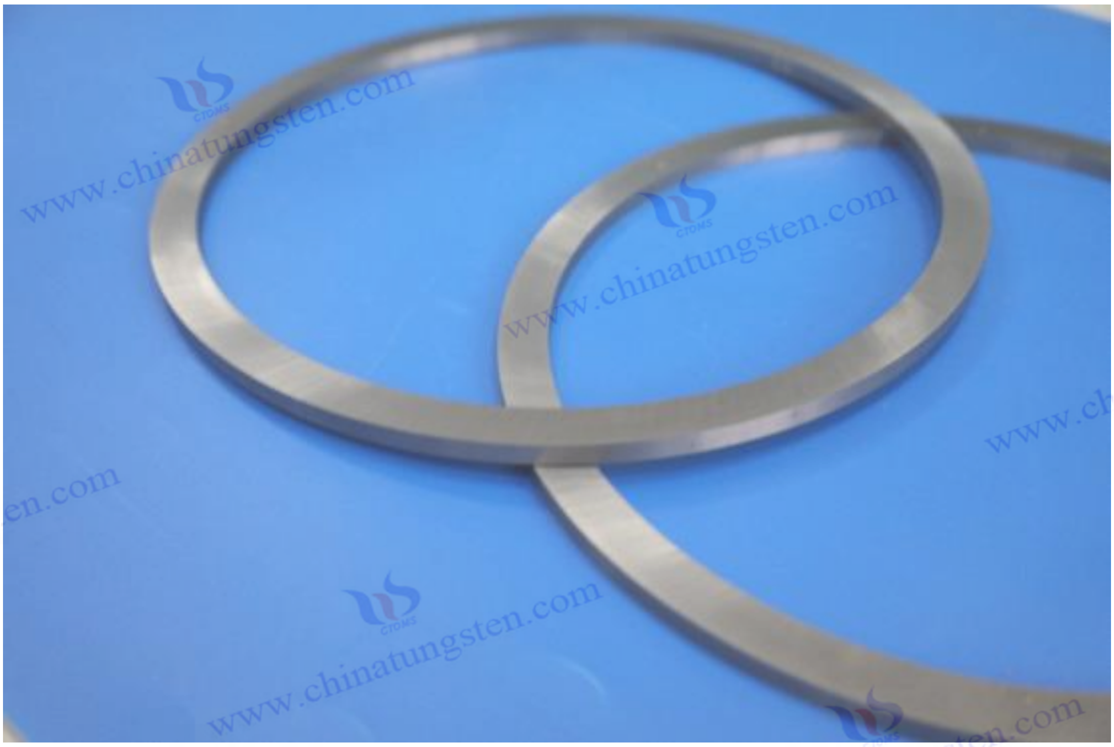
### Contact Us

**Email** : sales@chinatungsten.com

**Tel** : +86 592 5129696

Official **website** : www.ctia.com.cn

**WeChat** : Follow "China Tungsten Online"



## Preface

Tungsten Cemented Carbide, a composite material with tungsten carbide as the matrix and cobalt or nickel as the bonding phase, has become an indispensable key material in modern industry due to its excellent hardness (HV 15002500), wear resistance (wear rate less than 0.06 cubic millimeter per newton meter), toughness (fracture toughness 820 MPa per square meter root) and high temperature stability (greater than 1000 degrees Celsius). Since its advent in the early 20th century, cemented carbide has been widely used in cutting tools, wear-resistant parts, aerospace, energy equipment, as well as emerging fields such as biomedicine and energy storage due to its excellent performance. However, with the growing global demand for resource sustainability and green manufacturing, the preparation, optimization, classification, application and recycling technology of cemented carbide are facing new challenges and opportunities. How to achieve low carbonization, recycling and interdisciplinary innovation while maintaining high performance has become the focus of common concern in academia and industry.

This book, "Cemented Carbide: A Comprehensive Exploration of Physical and Chemical Properties, Processes and Applications", aims to provide a systematic, in-depth and practical academic guide to this complex and dynamic field. Our goal is to integrate the latest advances in materials science, chemistry, physics, engineering technology and environmental science to fully reveal the physical and chemical properties, process flow, performance regulation, classification system, application scenarios and cutting-edge trends of cemented carbide. This book not only explores the microstructure of cemented carbide (grain size 0.110 microns), chemical reaction mechanism (such as liquid phase sintering, tungsten carbide cobalt interface electronic structure), but also carefully analyzes its preparation process (vacuum sintering, high-speed oxygen fuel spray coating), performance optimization strategy (Hall-Petch relationship, chromium carbide addition) and recycling technology ( zinc melting method recovery rate is greater than 95%). Through theoretical analysis, experimental data and case studies (such as tool life increased by 30% and aviation component durability exceeded 5000 hours), this book strives to provide readers with a knowledge framework from basic to cutting-edge.

The book is divided into five parts, with a clear structure and progressive levels. The first part, "Basic Science of Cemented Carbide", lays the theoretical foundation from definition, history to microstructure and physicochemical properties; the second part, "Preparation Process of Cemented Carbide", details the raw material synthesis, molding sintering and coating technology, highlighting process innovation; the third part, "Performance Optimization of Cemented Carbide", focuses on mechanics, corrosion resistance and multifunctionality, revealing the performance improvement mechanism; the fourth part, "Classification and Application Field of Cemented Carbide", systematically classifies (by composition, grain, function, process, shape) and discusses cutting, mining, aerospace and emerging applications; the fifth part, "Frontier Development of Cemented Carbide", looks forward to nanomaterials, green manufacturing and interdisciplinary integration, and outlines the blueprint for the future. In addition, the appendix provides standards, data tables, terms and references for in-depth research.

This book is aimed at a wide range of readers, including scholars and graduate students in the field of materials science and engineering, engineers in the mechanical manufacturing, aerospace, energy and other industries, and technical decision makers who focus on sustainable development. Whether you are a researcher exploring the crystallographic properties of cemented carbide, a researcher optimizing the performance of cutting tools, or an environmental expert committed to the recycling of tungsten resources, this book will provide you with rich knowledge resources and practical inspiration. We hope to inspire readers to think deeply and innovate about cemented carbide through rigorous academic expression, detailed data support (such as recycled powder hardness HV 14002000, coating bonding strength 5080 MPa) and cutting-edge case analysis.

As the global manufacturing industry moves towards intelligence and greening, cemented carbide is not only the cornerstone of technology, but also the key to sustainable development. This book strives to build a bridge between academic research and industrial application in the field of cemented carbide with a comprehensive perspective, systematic logic and cutting-edge insights. We hope that readers will be inspired by reading and jointly promote the rebirth of this classic material in the new era.


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

# CTIA GROUP LTD

## 30 Years of Cemented Carbide Customization Experts

### Core Advantages

**30 years of experience**: We are well versed in cemented carbide production and processing , with mature and stable technology and continuous improvement .

**Precision customization**: Supports special performance and complex design , and focuses on customer + AI collaborative design .

**Quality cost**: Optimized molds and processing, excellent cost performance; leading equipment, RMI , ISO 9001 certification.

### Serving Customers

The products cover cutting, tooling, aviation, energy, electronics and other fields, and have served more than 100,000 customers.

### Service Commitment

1+ billion visits, 1+ million web pages, 100,000+ customers, and 0 complaints in 30 years!

### Contact Us

**Email** : sales@chinatungsten.com
**Tel** : +86 592 5129696
Official **website** : www.ctia.com.cn
**WeChat** : Follow "China Tungsten Online"

## Chapter 1: Definition and History of Cemented Carbide

Tungsten Cemented Carbide (WC-Co) has become an indispensable material in modern industry due to its excellent hardness, wear resistance and toughness. As a composite material with tungsten carbide (WC) as the main hard phase and cobalt (Co) or nickel (Ni) as the bonding phase, it is prepared by powder metallurgy and widely used in a variety of high-performance scenarios. This chapter systematically defines the chemical composition and microstructure of cemented carbide, comprehensively traces its development from chemical exploration in the 19th century to green and intelligent manufacturing in the 21st century, and especially focuses on the rise of China's cemented carbide industry, comparing its material properties and performance advantages with traditional materials and tungsten steel.

### 1. What is cemented carbide ?

Cemented carbide is a composite material made of high-hardness, refractory metal carbides (such as tungsten carbide WC, titanium carbide TiC ) and cobalt, nickel and other bonding phases through powder metallurgy. Its design concept is to combine the ultra-high hardness of carbides with the toughness of metal bonding phases to meet the needs of extreme working conditions such as high temperature, high pressure, and corrosion.

#### 1.1 Chemical composition and structure of cemented carbide

The performance of cemented carbide comes from its unique chemical composition and microstructure. The carbide matrix provides hardness and the bonding phase enhances toughness. This section starts from the crystallographic properties and combines the research progress in 2025 to explore the relationship between its structure and performance.

**Crystallographic properties of cemented carbide matrix (WC, TiC , etc.)**

Tungsten carbide (WC) is the core of cemented carbide, with a hexagonal system (P6m2 space group), lattice constants a=2.906 Å , c=2.837 Å , hardness HV 2200-2800, and melting point of about 2870°C. The strong covalent bond between tungsten and carbon forms a stable skeleton with a Mohs hardness of about 9, and its wear resistance is second only to diamond. Titanium carbide ( TiC ) is a cubic system (Fm3m space group), with a hardness of HV 1800-2200 and a density of 4.93 g/cm$^3$ , suitable for lightweight scenarios. Tantalum carbide ( TaC ) and niobium carbide ( NbC ) are resistant to high-temperature oxidation (>1000°C). According to a report in Journal of Materials Science in 2025, adding 3% TaC increases oxidation resistance by 40% at 1200°C. The grain size is controlled at 0.1-10 microns, the ultrafine grains (<1 micron) have a hardness of HV 2400-2600, and a fracture toughness of 8-10 MPa·m$^{1/2}$ .

The crystallographic properties are characterized by X-ray diffraction (XRD) and transmission electron microscopy (TEM). The (001) crystal plane diffraction peak of WC reflects the grain orientation, and the low defect density of TiC (<10$^9$ cm$^{-2}$ ) ensures stability. In 2025, the Chinese


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

Academy of Sciences used synchrotron radiation XRD to optimize the WC grain boundary energy (about 1 J/m $^2$ ), and the hardness increased by 10%.

### 1.1.2 Function and selection of cemented carbide bonding phase (Co, Ni, etc.)

Cobalt (Co) is the main bonding phase, with a mass fraction of 6%-20%, a face-centered cubic structure (FCC), a melting point of 1495°C, and excellent wettability (contact angle of about 5°). During liquid phase sintering (1320°C), Co fills the gaps between WC particles, with a density of >99%. The hardness of cemented carbide containing 6% Co is HV 1800; the toughness of cemented carbide containing 12% Co reaches $K_{1}c$ 15 MPa·m $^{1/2}$ . Nickel (Ni) has strong corrosion resistance (salt spray test weight loss <0.1 mg/cm $^2$ ), but the bending strength is about 3000 MPa (lower than Co's 4000 MPa). In 2025, Journal of Alloys and Compounds reported that the corrosion resistance of Co-Ni-Cr bonding phase was improved by 50%. The bonding phase distribution was optimized by scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS), with Co segregation <5% and interface strength >50 MPa.

## 1.2 Development History of Cemented Carbide

The century-long development of cemented carbide covers scientific discoveries, technological breakthroughs and industrial innovations, from chemical exploration in the 19th century to green and intelligent manufacturing in the 21st century. This section combines English, Chinese and German literature to sort out its origins, industrialization, globalization and the rise of China, highlighting key figures, process parameters and market changes.

### 1.2.1 Mid-19th century to 1900s : Chemical exploration and early attempts of tungsten carbide

**1890s : First synthesis of tungsten carbide**

In the 1890s , the development of cemented carbide took an important step forward. French chemist Henri Moissan used a homemade electric arc furnace to synthesize tungsten carbide (WC) for the first time by reacting carbon with tungsten powder at high temperatures. Moissan's experiment was conducted in Paris. He used the high temperature environment (close to 3000°C) created by the electric arc furnace to react tungsten with carbon to produce hexagonal WC crystals. This discovery laid the foundation for the research of high-hardness materials, and WC attracted much attention because it showed a hardness close to that of diamond. However, due to the lack of suitable industrialization technology at the time, Moissan's results mainly remained in the laboratory stage and failed to enter practical application.

**1896: Initial industrial attempts at WC**

In 1896, William D. Coolidge, a chemist at General Electric (GE) in the United States, tried to apply tungsten carbide to industrial scenarios. He proposed that WC could be used as an alternative material to diamond molds, and designed a stamping mold containing WC in an attempt to use it for metal processing. Coolidge's experiments were conducted in General Electric's laboratory in New York. He hoped to use the high hardness of WC to improve the wear resistance of the mold. However, due to the lack of suitable adhesive technology, WC molds showed poor toughness in actual use, could not withstand high pressure, and failed to achieve large-scale application. Although this attempt was unsuccessful, it revealed the industrial potential of WC and the criticality of adhesive selection , providing direction for subsequent research.

**1923: Breakthrough in WC-Co cemented carbide**

In 1923, Karl Schröter , an engineer at Krupp in Germany , made a major breakthrough in the research and development of cemented carbide. Schröter systematically studied the composite system of WC and binders in the Krupp laboratory in Essen, Germany, and found that cobalt (Co) as a binder can significantly improve the performance of the material. He successfully developed WC-Co cemented carbide and obtained a German patent (DRP 420689). This formula uses a liquid phase sintering process to bond WC particles with cobalt to produce a material with both high hardness and a certain toughness. Schröter 's breakthrough ended the situation where cemented carbide had been in the laboratory for a long time, laid a technical foundation for industrial production, and also marked the turning point for cemented carbide to move from theoretical research to practical application.

**1925: Launch of the WIDIA brand**

In 1925, based on Schröter's achievements, the German Krupp company officially launched the cemented carbide brand "WIDIA" (Wie Diamant, meaning "like diamond"). WIDIA is the world's first commercial cemented carbide product. Its production plant is located in Essen, Germany, and is mainly used to manufacture cutting tools. The cutting performance of WIDIA tools far exceeds that of high-speed steel tools at the time. The cutting speed has increased from 30 m/min to 80 m/min, and the efficiency of steel processing has increased by about 3 times. The production process of WIDIA includes steps such as ball milling, pressing and liquid phase sintering. This process has become the standard process for the industrialization of cemented carbide. The launch of WIDIA not only promoted the development of the German mechanical processing industry, but also opened up a market for the global cemented carbide industry.

**1927: WIDIA knives debut on the international stage**

In 1927, Krupp took WIDIA tools to the Mechanical Exhibition in Leipzig, Germany. This was the first time that WIDIA appeared on the international stage, and its excellent cutting performance attracted the attention of manufacturers from Sweden, the United States and other countries. During the exhibition, WIDIA tools demonstrated their outstanding performance in processing steel and cast iron, with cutting efficiency and tool life significantly better than traditional materials. Many manufacturers showed great interest in WIDIA and negotiated cooperation with Krupp. The success of the Leipzig Mechanical Exhibition made WIDIA a benchmark in the field of cemented carbide and promoted the global dissemination of cemented carbide technology.

**1928: WIDIA technology exported to the UK**

In 1928, British company Mond Nickel and Krupp reached a technology licensing agreement and obtained WIDIA's production technology. Mond Nickel set up a factory in the UK and began to produce cobalt-containing cemented carbide mining tools, mainly for gold mining operations in South Africa. The strata of South African gold mines are hard, and traditional tools wear very quickly. However, WIDIA tools greatly improve mining efficiency with their high hardness and wear resistance. This cooperation marked the beginning of cemented carbide technology going beyond Germany and entering the international market, and also injected new impetus into the development of the British mining industry.

**1929: The United States introduces WIDIA technology**

In 1929, General Electric (GE) of the United States introduced WIDIA production technology through cooperation with Krupp. GE's factory in New York began to produce cemented carbide products, mainly supplying the American automobile industry for processing engine parts and body parts. The demand for high-efficiency cutting tools in the automobile industry promoted the rapid application of cemented carbide, and the introduction of GE made WIDIA technology take root in the United States. During this period, cemented carbide entered the initial industrialization stage, and a cemented carbide production and application network began to form worldwide.

**1932: Swedish company Sandvik enters the cemented carbide field**

In 1932, Swedish company Sandvik developed cemented carbide products based on the WC-Co formula, focusing on stainless steel processing. Sandvik's factory in Sandviken, Sweden, used its technical accumulation in the field of metallurgy to produce high-performance cemented carbide tools, which are widely used in the field of mechanical manufacturing. The entry of Sandvik has further expanded the application of cemented carbide in the cutting field, and its products are popular in the market due to their high wear resistance and stability. The entry of Sandvik has also intensified competition in the cemented carbide industry and promoted the continuous advancement of technology.

**1935: De Beers in the UK tries WC knives**

In 1935, the British company De Beers tried to use WC-based carbide tools to cut non-ferrous metals such as copper and aluminum. De Beers conducted experiments at its factory in South Africa and found that WC tools showed better efficiency in processing non-ferrous metals, with better cutting speed and tool life than traditional tools. However, when processing steel, WC tools performed poorly due to chemical wear problems and failed to completely replace high-speed steel tools. De Beers' attempt showed the difference in the applicability of carbide in the processing of different materials, and also provided a direction for subsequent material improvements.

**1936: The United States developed TiC -based cemented carbide**

In 1936, Carborundum Corporation of the United States developed a titanium carbide ( TiC )-based cemented carbide. Compared with WC -based materials, TiC -based cemented carbide has lower density and better oxidation resistance, and is suitable for processing high-temperature alloys. Carborundum's factory in Pennsylvania produced the first batch of TiC -based cutting tools, which were mainly supplied to the aviation industry for processing high-temperature alloy parts. The emergence of TiC -based cemented carbide has enriched the types of cemented carbide and expanded its application scenarios in high-temperature environments.

**1938: Japan optimizes TiC -WC composite system**

In 1938, Sumitomo Electric Corporation of Japan further optimized the TiC -WC composite system and developed a cemented carbide material with more balanced performance. Sumitomo Electric's R&D center in Osaka produced cemented carbide tools suitable for cutting steel by adjusting the ratio of TiC and WC. Compared with pure WC-based materials, the TiC -WC composite system achieves a better balance between hardness and wear resistance, making it more competitive in the field of mechanical processing. Sumitomo Electric's research and development marked the rise of Japanese cemented carbide technology and also provided support for the development of Japan's manufacturing industry.

**1940-1945: World War II catalyzes the demand for cemented carbide**

From 1940 to 1945, during World War II, the demand for cemented carbide grew rapidly. The German Krupp company's factory in Essen mass-produced WC-Co cemented carbide for the manufacture of shell cores, which significantly improved the armor-piercing ability and was used in equipment such as the Tiger tank. General Electric of the United States provided cemented carbide tools to the Allies, mainly for processing aircraft engine parts to meet the needs of the wartime aviation industry. The high-intensity demand during the war promoted the improvement of cemented carbide production technology and the rapid growth of output, and also accelerated the transformation of cemented carbide from laboratory to large-scale industrial application.

**1947: Sumitomo Electric of Japan developed TiC-TaC cemented carbide**

In 1947, Sumitomo Electric Corporation of Japan developed TiC-TaC cemented carbide, further improving the performance of the material. Sumitomo Electric's factory in Osaka produced cemented carbide tools suitable for the automotive industry by adding tantalum carbide ( TaC ), mainly used for machining high-precision parts such as crankshafts. TiC-TaC cemented carbide performs well in high temperature and wear resistance, meeting the needs of the rapid development of Japan's automobile industry after the war. Sumitomo Electric's innovation has consolidated its position in the field of cemented carbide.

**1949: Swedish Seco Tools launches mining tools**

In 1949, Swedish company Seco Tools launched carbide tools designed specifically for mining. Seco Tools produced the first batch of products at its factory in Fagersta, Sweden, and exported them to Australian iron ore mines. The Australian iron ore strata are hard and traditional tools are difficult to handle. However, Seco Tools' carbide tools have greatly improved mining efficiency due to their high impact resistance and wear resistance. This export cooperation further expanded the application of carbide in the mining field and won international market for Seco Tools.

**1950: Technology licensing drives global diffusion**

In 1950, General Electric of the United States and Sandvik of Sweden signed a technology licensing agreement, which promoted the global spread of cemented carbide technology. General Electric shared its optimized production technology in the United States with Sandvik, and Sandvik fed back its experience in Europe to General Electric. This cooperation accelerated the spread of cemented carbide technology, enabled more countries to introduce advanced production processes, and promoted the industrial application of cemented carbide worldwide.

**1953: Hot isostatic pressing technology introduced**

In 1953, Kennametal introduced hot isostatic pressing (HIP) technology for cemented carbide production. Kennametal's Pennsylvania plant uses HIP equipment to eliminate pores during sintering through high temperature and high pressure (argon protection), thereby improving the density and performance of cemented carbide. The application of HIP technology significantly improves the wear resistance and strength of cemented carbide tools, extends tool life, and provides better tools for high-precision machining.

**1965: Breakthrough in CVD coating technology**

In 1965, Swedish company Seco Tools developed the chemical vapor deposition ( CVD) titanium nitride ( TiN ) coating technology. Seco Tools' R&D center in Fagersta deposited TiN coating on the surface of cemented carbide tools through the CVD process, significantly improving the wear resistance and cutting speed of the tools. This technology enables cemented carbide tools to work at higher temperatures and higher speeds, meeting the needs of modern manufacturing for efficient cutting tools, marking a revolutionary breakthrough in coating technology in the field of cemented carbide.

**1968: Alumina coating introduced**

In 1968, Carbide Corporation of the United States introduced CVD alumina ( $Al_2O_3$ ) coating technology. Carbide's factory in Pennsylvania deposited alumina coating on the surface of carbide tools through CVD process, improving the durability of tools in high temperature environments. Alumina coating is particularly suitable for high-temperature alloy processing, such as the manufacture of aircraft engine parts. Due to its excellent high temperature resistance and chemical wear resistance, the tool life is significantly extended.

**1970: ISO 513 standard established**

In 1970, the International Organization for Standardization (ISO) developed the ISO 513 tool classification standard. This standard unified the specifications and classification of cemented carbide tools and promoted the standardization of global trade. The implementation of the ISO 513 standard enabled tool manufacturers in different countries to produce and sell products under unified standards, reducing trade barriers and promoting the expansion of the international market for cemented carbide tools.

**1975: The rise of PVD coating technology**

In 1975, Mitsubishi Metal Corporation of Japan developed the physical vapor deposition ( PVD ) TiN coating technology. Mitsubishi Metal's R&D center in Tokyo deposited TiN coating on the surface of cemented carbide tools through the PVD process, which was popular because it is suitable for dry cutting scenarios. Compared with the CVD process, PVD technology has a lower deposition temperature, which reduces the impact on the performance of the substrate and further expands the application range of cemented carbide tools.

**1978: TiAlN coating improves high temperature performance**

In 1978, Swedish company Sandvik introduced PVD TiAlN coating technology. Sandvik developed this aluminum-containing TiN coating at its R&D center in Sandviken. Due to its excellent high-temperature performance, it is widely used in high-temperature alloy processing, such as nickel-based alloy cutting in the aerospace field. The introduction of TiAlN coating enables cemented carbide tools to maintain stability and wear resistance at higher temperatures, promoting the development of high-performance cutting tools.

**1980: Japanese exports grow**

In 1980, Japan became an important producer of cemented carbide, and its products were exported in large quantities to the US automotive industry. Japanese companies such as Mitsubishi Metal and Sumitomo Electric had technical advantages in the production of cemented carbide tools, and the tools they produced were favored by the US market due to their high precision and high durability. During this period, Japan's cemented carbide industry grew rapidly through exports, further promoting the global application of cemented carbide.

**1983: Optimization of PVD TiAlN coatings**

In 1983, Plansee of Germany optimized the PVD TiAlN coating technology. Plansee 's factory in Reutte, Austria, improved the PVD process to improve the high temperature resistance and hardness of the TiAlN coating, making the performance of the tool more stable during the cutting process. This improvement enables carbide tools to cope with higher speeds and more demanding cutting conditions, meeting the growing needs of the industrial field.

**1985: CVD TiC- $Al_2O_3$ composite coating launched**

In 1985, Kennametal introduced the CVD TiC -$Al_2O_3$ composite coating technology. Kennametal's factory in Pennsylvania deposited TiC and $Al_2O_3$ composite coatings on the surface of carbide tools through the CVD process, enhancing the tool's resistance to chemical wear. This coating is particularly suitable for stainless steel processing, because its stability in high temperature and chemical corrosion environments further extends the tool life.

**1990: Promotion of zinc smelting recovery technology**

In 1990, Swedish company Sandvik promoted the zinc melting recycling technology for the reuse of waste cemented carbide. Sandvik's factory in Sandviken used the zinc melting method to separate and recycle WC and cobalt in waste cemented carbide , greatly improving the utilization rate of resources. The promotion of this technology reduced the dependence of cemented carbide production on primary tungsten resources and promoted the sustainable development of the industry.

**1995: ISO 9001 becomes popular**

In 1995, the International Tungsten Association (ITIA) was established to promote exchanges and cooperation in the global tungsten and cemented carbide industries. The establishment of ITIA strengthened the research and promotion of recycling technology and promoted the green development of the cemented carbide industry. In the same year, ISO 9001 quality certification became popular in the cemented carbide industry. Many companies improved their product quality and market competitiveness through certification, which promoted the export growth of cemented carbide tools.

**2003: Development of nano-grade cemented carbide**

In 2003, Swedish company Sandvik developed nano-scale WC-Co cemented carbide. Sandvik's R&D center in Sandviken improved the hardness and toughness of the material by controlling the WC grain size to the nanoscale. Nano-scale cemented carbide is widely used in precision machining fields, such as electronic component manufacturing, due to its excellent comprehensive performance, further promoting the high-end development of cemented carbide technology.

**2005: CVD TiAlN coating optimization**

In 2005, Kennametal optimized the CVD TiAlN coating technology. Kennametal's factory in Pennsylvania improved the high temperature resistance of the TiAlN coating by improving the CVD process, allowing the tool to maintain stability at higher temperatures. This technology is particularly suitable for high temperature alloy processing in the aerospace field, further expanding the application range of cemented carbide.

**2010: Recycling technology advances**

In 2010, the global cemented carbide recycling volume gradually increased, and countries such as Sweden took the lead in recycling technology. Companies such as Sandvik improved the recycling efficiency of waste cemented carbide by improving the zinc melting method and other recycling processes, reducing energy consumption and resource waste in the production process. This trend has promoted the green manufacturing process of the cemented carbide industry.

**2012: Additive Manufacturing Technology Application**

In 2012, German EOS used laser powder bed fusion technology to produce WC-Co porous molds. EOS's factory in Munich used additive manufacturing technology to produce porous molds with complex structures, significantly shortening the production cycle while reducing material usage. The introduction of additive manufacturing technology has provided new possibilities for cemented carbide production and promoted the development of customized and efficient production.

**2018: Additive manufacturing tooling launched**

In 2018, Swedish company Sandvik launched carbide tools produced by additive manufacturing . Sandvik's factory in Sandviken uses 3D printing technology to produce tools with complex geometries, improving cutting performance and production flexibility. The launch of additive manufacturing tools marks a further innovation in carbide manufacturing technology, bringing higher efficiency to the industrial field.

**2020: Deepening of green manufacturing**

In 2020, the green manufacturing trend of the cemented carbide industry has further deepened. Recycling technologies have been optimized worldwide, recycling rates have continued to increase, and energy consumption has been significantly reduced. Companies in countries such as Sweden and Germany continue to lead in recycling and reuse, reducing their dependence on primary tungsten resources through technological innovation, and promoting the sustainable development of the cemented carbide industry.

**2023 : Intelligent technology application**

In 2023, Mitsubishi Metal Corporation of Japan developed AI-based sintering process optimization technology. Mitsubishi Metal's R&D center in Tokyo used artificial intelligence algorithms to optimize the sintering temperature and time of cemented carbide, improving production efficiency and tool performance. The application of intelligent technology makes cemented carbide production more accurate and efficient, injecting new vitality into the industry.

The development of cemented carbide began with Henri Moissan's first synthesis of tungsten carbide in the late 19th century, and has gone through industrial breakthroughs in the early 20th century, rapid growth during World War II, revolutionary advances in coating technology, and the nano-, additive manufacturing , and green intelligence stages of the 21st century. Through technological innovation and global cooperation, cemented carbide has become an indispensable material for modern industry, continuously driving the advancement of the manufacturing industry.

### 1.2.7 Development History of Cemented Carbide in China

China's cemented carbide industry has grown from a difficult start in the 1950s to a global leader. Relying on abundant tungsten resources (1.9 million tons of reserves, accounting for 57% of the world, USGS 2025), policy support (such as "Made in China 2025") and regional industrial clusters, the output will reach 58,000 tons in 2024, accounting for 58% of the world ( China Tungsten Industry Association 2024). Zhuzhou (the capital of cemented carbide), Ganzhou (China's tungsten capital) and Xiamen (tool export center) have formed a coordinated development pattern. This section is based on the four stages of detailed technology introduction, independent innovation, global expansion and green intelligence, and deeply explores the contribution of enterprises, technological breakthroughs, regional characteristics and policy drivers.

#### 1.2.7.1 1950s- 1980s : Technology introduction and industry foundation

Dalian Iron and Steel Works (now Dalian Special Steel Co., Ltd. of Northeast Special Steel Group) is a pioneer in the field of special steel in China, with its history dating back to 1905. In the early days of the founding of New China, Dalian Iron and Steel Works achieved remarkable results in the experimental production of cemented carbide, which became an important milestone in China's metallurgical industry.

According to historical data, Dalian Iron and Steel Plant not only focused on the production of special steels between 1947 and 1951, but also carried out experimental production in the field of cemented carbide. Specifically, the plant successfully smelted aluminum- chromium alloys, nickel-copper alloys and cemented carbide, filling the gap in China's metallurgical history at the time. These experimentally produced cemented carbides were mainly used in military products, such as the manufacture of artillery warheads and "92 Infantry Cannon" springs, providing key support for the National Liberation War. During this period, Dalian Iron and Steel Plant smelted a total of 28,736 tons of steel, some of which were used for forging and rolling, directly or indirectly supporting cemented carbide-related experiments.

In addition, in November 1950, Dalian Iron and Steel Works, under the order of the Central Ministry of Heavy Industry, moved 1,600 tons of equipment, including cemented carbide equipment, to Daye Steel Works in Huangshi City, Hubei Province, to support the construction of Central China Iron and Steel Company. This batch of equipment included special equipment for experimental production of cemented carbide, indicating that Dalian Iron and Steel Works had accumulated certain technology in experimental production of cemented carbide.

Although these experimental productions did not form large-scale industrialization at the time, they laid the foundation for the subsequent development of China's cemented carbide industry. The establishment of Zhuzhou Cemented Carbide Plant in 1954 marked the starting point of China's industrialized cemented carbide production, and the early experiments of Dalian Iron and Steel Plant were undoubtedly an important prelude to this process.

**1954: The starting point of China's cemented carbide industry**

In 1954, Zhuzhou Cemented Carbide Factory (now Zhuzhou Cemented Carbide Group Co., Ltd., affiliated to China Tungsten High-Tech ) was officially established in Zhuzhou, Hunan . This event marked the beginning of China's cemented carbide industry and an important milestone in the industrialization process of New China. As one of the 156 key projects during the country's "First Five-Year Plan" (1953-1957), the establishment of Zhuzhou Cemented Carbide Factory carried the country's ardent expectations for the development of basic industries and strategic materials.

**Background and significance of the construction of Zhuzhou Cemented Carbide Plant**

The First Five-Year Plan was the first five-year plan formulated after the founding of New China. It aimed to rapidly improve the industrial base capacity by introducing Soviet technology and equipment. The location of Zhuzhou Cemented Carbide Factory was chosen in Zhuzhou, Hunan, because Hunan has rich tungsten ore resources, especially tungsten deposits represented by Shizhuyuan polymetallic mine, which provides unique raw material advantages for cemented carbide production. In addition, Zhuzhou is located in the middle reaches of Xiangjiang River, with convenient transportation, convenient material transportation and industrial layout. As a high-hardness, wear-resistant composite material, cemented carbide plays an irreplaceable role in industrial production, especially in mining, mechanical processing and defense industry. In the early 1950s, China's industrial foundation was weak, and cemented carbide mainly relied on imports, which were expensive and unstable in supply. The establishment of Zhuzhou Cemented Carbide Factory not only filled the gap in domestic cemented carbide production, but also laid the foundation for subsequent industrial development. It is known as the "cradle of China's cemented carbide industry."

**Technology introduction and initial production of Zhuzhou Cemented Carbide Plant**

Zhuzhou Cemented Carbide Plant introduced Soviet technology in its early days and adopted the


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

relatively mature powder metallurgy process at that time. The Soviet Union had rich experience in the field of cemented carbide. As early as 1929, GA Meerson developed the first WC-10%Co cemented carbide ( brand name "POBEDIT") at the Moscow Power Plant . Zhuzhou Plant drew on this technical route to produce cemented carbide based on WC-Co (tungsten carbide-cobalt), which is mainly used for mining and cutting tools. The production process includes steps such as tungsten powder preparation, mixing, pressing and sintering. The initial products were mainly simple grades to meet the needs of mining and basic mechanical processing. For example, rock drills used in mining can significantly improve the efficiency of rock mining and support the construction of national key projects at that time, such as Xishan Coal Mine. In addition, the application of cemented carbide cutting tools also provides a guarantee for the equipment processing of metallurgical enterprises such as Anshan Iron and Steel.

**The historical influence of Zhuzhou Cemented Carbide Factory**

The commissioning of Zhuzhou Cemented Carbide Plant marked a breakthrough in the development of cemented carbide in China. The production in 1954 not only met the needs of the domestic basic industry, but also laid the foundation for subsequent technological accumulation and industrial expansion. More importantly, this project embodied the results of Sino-Soviet cooperation and demonstrated the spirit of self-reliance and self-improvement of New China in the industrial field.

**1958: Development under the First Five-Year Plan**

In 1958, as the final year of the First Five-Year Plan, Zhuzhou Cemented Carbide Factory continued to expand its production capacity to further meet the country's growing demand for cemented carbide, especially for applications in geological exploration.

**Background and Requirements**

1958 was the last year of the First Five-Year Plan. The country's industrialization process accelerated, and the demand for geological exploration and resource development surged. Geological exploration requires a large number of cemented carbide drills to drill rocks to find out the distribution of mineral resources. However, the domestic cemented carbide production was still limited at that time and it was difficult to meet the demand. The expansion of Zhuzhou Cemented Carbide Plant became the key to solving this bottleneck.

**Production capacity improvement**

Zhuzhou Plant has further improved the output and quality of cemented carbide by expanding the plant and optimizing the production process. The cemented carbide drill bits produced are widely used in the field of geological exploration, for example, they have played an important role in oil and mineral exploration projects in North China and Southwest China. The application of these drill bits not only improves exploration efficiency, but also provides important support for the national


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

resource strategy.

**Socioeconomic significance**

During the First Five-Year Plan, the steady development of Zhuzhou Cemented Carbide Factory contributed to the improvement of China's industrial system . As the "teeth" of industry, cemented carbide directly affects the efficiency of industries such as mining, metallurgy and mechanical processing. Through independent production, China gradually reduced its dependence on imported cemented carbide, reduced industrial costs, and cultivated a group of technical talents, which reserved strength for subsequent development.

**1960: Technical cooperation and application expansion**

In 1960, Zhuzhou Cemented Carbide Factory cooperated with Beijing Nonferrous Metals Research Institute to develop cemented carbide containing titanium carbide ( TiC ) and applied it to the field of oil drilling. This cooperation marked the beginning of the development of China's cemented carbide technology from a single direction to diversified development.

**Cooperation Background**

Beijing Nonferrous Metals Research Institute (now China Nonferrous Metals Research Institute) is one of the important scientific research institutions established after the founding of New China, focusing on the research and development of nonferrous metals and alloy materials. In 1960, when the country was vigorously developing the petroleum industry, the demand for cemented carbide drill bits for oil drilling surged. Traditional WC-Co cemented carbide has insufficient wear resistance and stability under high temperature and high pressure environments. Cemented carbide containing titanium carbide ( TiC ) has become an ideal choice due to its higher hardness and heat resistance.

**Technological breakthrough**

Zhuzhou Plant cooperated with Beijing Nonferrous Metals Research Institute to adjust the microstructure of cemented carbide by adding titanium carbide ( TiC ) to improve the overall performance of the material. The addition of TiC enhances the hardness and high temperature resistance of the alloy, making it more suitable for application in complex geological conditions in oil drilling. For example, in oil field drilling in the Sichuan Basin and other regions, this new cemented carbide drill bit has shown good wear resistance and stability, significantly extending the service life of the drill bit.

**Application and Impact**

TiC - containing cemented carbide not only meets the urgent needs of the oil industry, but also promotes the application and exploration of cemented carbide in other fields. In the early 1960s , China's oil industry was in a stage of rapid development. The independently produced cemented carbide drill bits provided important support for oil field development and reduced dependence on imported materials. At the same time, this cooperation also set an example for the technical research and development of China's cemented carbide industry and laid the foundation for the integration of industry, academia and research.

**1960s : Limited technological development and self-reliance**

1960s , the technological research and development of Zhuzhou Cemented Carbide Factory was hindered to a certain extent by the Cultural Revolution (1966-1976), but through the spirit of self-reliance, the factory optimized the formula and continued to meet domestic machining needs.

**Historical background**

During the Cultural Revolution, China's scientific research and industrial systems were severely impacted, and the production order of many scientific research institutions and factories was disrupted. The work of scientific research units such as the Beijing Nonferrous Metals Research Institute was once stagnant, and the technical cooperation with the Zhuzhou plant was also affected. The technicians and engineers within the factory were transferred from their posts, and some production equipment aged due to lack of maintenance.

**Self-reliance and production maintenance**

Despite the difficulties, Zhuzhou Cemented Carbide Factory has continued to carry out production and technical improvements through self-reliance, relying on existing technicians and equipment. The factory optimized the ratio of WC-Co formula and adjusted the sintering process to improve the toughness and durability of the tools. These tools are mainly used in the field of mechanical processing, such as cutting tools for lathes and milling machines, supporting the development of the domestic basic manufacturing industry.

**Historical significance**

In the case of interruption of external technical support, Zhuzhou Cemented Carbide Factory demonstrated the spirit of self-reliance and maintained the continuity of cemented carbide production. The technical accumulation during this period laid the foundation for the introduction of technology and rapid development after the reform and opening up. At the same time, the factory cultivated a group of technical backbones who could persist in production under difficult conditions, and reserved talents for subsequent industrial upgrading.

**1970: Project 704 and production expansion**

In 1970, the country launched the "704 Project" and the Zhuzhou Cemented Carbide Factory was expanded, and production increased.

**Engineering Background**

"Project 704" is one of the key industrial projects launched by the state in the early 1970s, aiming to enhance the production capacity of strategic materials to support national defense and industrial construction. As a core enterprise in cemented carbide production, Zhuzhou Cemented Carbide Factory was included in this project and received national funding and policy support.

**Expansion content**

the Zhuzhou plant expanded the production workshop, updated some equipment, and further increased the output of cemented carbide. The cemented carbide products produced are mainly used in mining, mechanical processing and defense fields. For example, cemented carbide parts used for tank track wear parts play an important role in the defense industry.

**Historical significance**

The implementation of the "704 Project" marks the country's high attention to the cemented carbide industry. Through the expansion, the production capacity of the Zhuzhou plant has been significantly enhanced, laying the industrial foundation for the reform and opening up in the late 1970s. At the same time, this project also reflects the country's strategic planning for industrial development in a special historical period.

**1978-1985: Reform and opening up and technology introduction**

In 1978, the reform and opening up policy was launched. During the Sixth Five-Year Plan (1981-1985), Zhuzhou Cemented Carbide Factory introduced Swedish Sandvik technology to develop coated tools and improve cutting performance.

**Background of Reform and Opening Up**

In 1978, China launched the reform and opening-up policy, and began to introduce foreign advanced technologies in the industrial field to make up for the domestic technological gap. As a key material for high-end manufacturing, cemented carbide urgently needs to improve its performance and production efficiency. Swedish Sandvik is a leading company in the global cemented carbide field, and its coating technology (such as chemical vapor deposition, CVD) has significant advantages in improving tool wear resistance and cutting efficiency.

**Technology introduction and application**

With the support of the Sixth Five-Year Plan, Zhuzhou Cemented Carbide Factory introduced

Sandvik's coating technology and developed titanium nitride ( TiN ) coated tools. TiN coating is deposited on the cemented carbide substrate through CVD process, which can significantly improve the surface hardness and wear resistance of the tool. This coated tool performs well in cutting, especially suitable for processing cast iron, steel and other materials, and is widely used in automobile manufacturing and mechanical processing industries.

**Historical significance**

The introduction of Sandvik technology marks the transformation of China's cemented carbide industry from technology follower to technology absorber. The development of coated tools not only improves the market competitiveness of products, but also promotes export growth, laying the foundation for Zhuzhou Plant to gain a foothold in the international market. The introduction of technology during this period also accumulated experience for subsequent independent innovation.

**1980s- 2000s : Independent innovation and marketization**

**1980: Technical cooperation**

In 1980, Zhuzhou Cemented Carbide Factory cooperated with Tsinghua University to optimize the performance of cemented carbide to meet the processing needs of electronic components. The Department of Materials Science and Engineering of Tsinghua University has strong scientific research capabilities in the optimization of cemented carbide microstructures. This cooperation focuses on improving the accuracy and stability of cemented carbide to meet the needs of the electronics industry for high-precision molds.

**In 1985, China Tungsten Industry Association (CTIA) was established**

**Background and preparation for the establishment of China Tungsten Industry Association**

The background of the establishment of the China Tungsten Industry Association is closely related to the development of China's tungsten industry. In the early 1980s, China, as the world's largest tungsten resource country and producer, had tungsten reserves accounting for more than 40% of the world's total and annual output accounting for about 70% of the world's total . Tungsten products were widely used in machinery manufacturing, mining, aerospace and other fields. However, at that time, China's tungsten industry faced many challenges: scattered enterprises, uneven technical levels, disorderly resource development, fierce export competition, and large fluctuations in international market prices. In order to solve these problems, strengthen industry coordination, promote technological progress and rational use of resources, it became a top priority to establish a national industry organization.

In 1981, the Ministry of Metallurgical Industry (then responsible for the management of the tungsten industry) submitted a "Report on the Establishment of the China Tungsten Industry Association" to the State Economic Commission. The report analyzed the current situation of the tungsten industry in detail , pointed out the necessity of establishing an industry association, and suggested strengthening inter-enterprise collaboration and improving industry competitiveness through the form of an association. On September 17, 1981, the State Council formally approved this proposal and instructed China Nonferrous Metals Industry Corporation to take the lead in preparing for the establishment of the association in conjunction with the Ministry of Metallurgical Industry, the Ministry of Machinery Industry, the Ministry of Foreign Trade and other relevant departments. During the preparation period, China Nonferrous Metals Industry Corporation organized many surveys and meetings, invited major tungsten mining enterprises, processing enterprises, scientific research institutes and design units across the country to participate in the discussion, formulated a draft of the association's charter, and determined the association's organizational framework and goals.

**China Tungsten Industry Association Founding Conference**

The China Tungsten Industry Association held its founding conference and the first member representative conference in Nanchang, Jiangxi Province from December 20 to 25, 1985. Nanchang was chosen as the venue for the conference as it is the capital of Jiangxi, a province rich in tungsten resources in China, and is close to important tungsten producing areas such as Ganzhou. The conference was hosted by China Nonferrous Metals Industry Corporation, and more than 120 representatives from tungsten industry enterprises, scientific research institutions, design units and relevant government departments from all over the country attended the conference. During the meeting, the delegates reviewed and passed the "China Tungsten Industry Association Charter" and elected the first board of directors and leadership.

The first council was composed of 47 directors. Zhang Jian, deputy general manager of China Nonferrous Metals Industry Corporation, was elected as the first president, and representatives from Zhuzhou Cemented Carbide Factory (i.e. Zhuzhou 601 Factory) and Ganzhou Tungsten Mine served as vice presidents. The conference also determined the purpose of the association: to promote the healthy development of China's tungsten industry, safeguard the legitimate rights and interests of the industry and members, and promote technological progress, resource conservation and international cooperation. During the meeting, the delegates also conducted in-depth discussions on issues such as technological transformation, market development, and resource management in the tungsten industry , and formed a number of industry development suggestions.

**Initial goals and activities of China Tungsten Industry Association**

the China Tungsten Industry Association was first established, it defined a number of work objectives. First, the association is committed to coordinating the relationship between enterprises in the industry, standardizing the order of tungsten mining and processing, and reducing vicious competition. Second, the association promotes technological progress in the tungsten industry by organizing technical exchanges and training, such as promoting advanced mineral processing technology and cemented carbide production processes. In addition, the association also actively participates in the coordination of the international tungsten market, represents the Chinese tungsten industry in connecting with relevant international tungsten industry organizations, and safeguards the interests of Chinese companies in the international market.

Soon after its establishment, the association organized the first national tungsten industry technical exchange meeting in 1986, inviting technical experts from Zhuzhou 601 Factory, Ganzhou Tungsten Mine and other enterprises to share new technologies in tungsten concentrate beneficiation and cemented carbide production. In 1987, the association assisted the government in formulating the "Tungsten Industry Management Measures (Trial)", which provided policy guidance for tungsten mining and export and initially standardized the industry order.

**Organizational Structure of China Tungsten Industry Association**

China Tungsten Industry Association is a national, industry-based, non-profit social group whose members are voluntarily formed by enterprises, scientific research institutions, design units and social organizations related to the tungsten industry . The association has established a board of directors as the highest decision-making body, and a secretariat to take charge of daily affairs. The secretariat was originally located in Nanchang , but later moved to Beijing according to the needs of industry management . The association has also established several professional committees, including the Technical Committee, the Market Committee and the Resource Management Committee, which are responsible for technical exchanges, market analysis and resource protection respectively.

**Development Status** of China Tungsten Industry Association

As of 2025 , the members of the China Tungsten Industry Association cover the entire industry chain, including tungsten mining, smelting and processing, cemented carbide production, scientific research and development. Member units include China Tungsten High-Tech , including its subordinate Zhuzhou Cemented Carbide Group (formerly Zhuzhou 601 Factory), Zigong Cemented Carbide Co., Ltd. (formerly Zigong 764 Factory), Xiamen Tungsten Industry, Jiangxi Tungsten Group and its many subordinate units and other leading enterprises in the industry. The association has played an important role in promoting the green development and internationalization of the tungsten industry, for example, organizing the formulation of a number of industry standards, supporting the research and development of tungsten resource recovery technology, and striving for the right to speak for Chinese companies in the international tungsten market.

**Significance and Impact**

the China Tungsten Industry Association is an important milestone in the development of China's tungsten industry. The establishment of the association ended the long-term lack of unified coordination in the industry and provided a platform for communication and collaboration for tungsten companies . Through the efforts of the association, China's tungsten industry has made significant progress in terms of technical level, market competitiveness, and resource utilization efficiency. At the same time, the association has strengthened its ties with the international tungsten industry, enhanced the global influence of China's tungsten industry, and laid the foundation for the sustainable development of the industry.


电话/TEL：0086 592 512 9696

sales@chinatungsten.com

**1985: Xiamen Tungsten Industry Co., Ltd. was established**

Xiamen Tungsten Industry was established in Xiamen, Fujian in 1985. Relying on Fujian's tungsten ore resources, it started to produce cemented carbide. Fujian is a province with abundant tungsten resources in China . The establishment of Xiamen Tungsten Industry further expanded the regional layout of the cemented carbide industry and promoted the industrial development of the southeast coastal areas.

**1987: Export of coated cutting tools**

In 1987, Zhuzhou Cemented Carbide Factory launched coated cutting tools, and the export ratio increased. The export of coated cutting tools was mainly to the Southeast Asian market, supporting the development of local manufacturing industry and accumulating foreign exchange for China's cemented carbide industry.

**1990s : Technological breakthroughs and industrial expansion**

1990s , Zhuzhou Cemented Carbide Factory cooperated with Central South University to develop ultrafine -grained cemented carbide for use in precision molds. Central South University has a leading advantage in the field of powder metallurgy, and this cooperation promoted the industrialization of ultrafine -grained technology. In 1994, Xiamen Tungsten Industry cooperated with Kyocera of Japan to introduce physical vapor deposition ( PVD ) technology to develop coated tools, further improving the high-temperature resistance of the products.

**1997: Jiangxi Tungsten Group was established**

In 1997, Jiangxi Tungsten Industry Holding Group (Jiangxi Tungsten Group) was established to integrate Ganzhou tungsten ore resources and carry out cemented carbide production. Ganzhou is the largest tungsten ore producing area in China. The establishment of Jiangxi Tungsten Group marks the integration and upgrading of Jiangxi's tungsten industry chain.

**1998: Xiamen Tungsten Technology Development**

In 1998, Xiamen Tungsten developed a new type of cemented carbide for use in marine engineering, meeting the demand for corrosion-resistant materials in the marine environment.

**1999 : Recycling Technology**
In 1999, Zhuzhou Cemented Carbide Factory cooperated with Sweden's Seco Tools to carry out recycling technology research, which improved the recycling rate of tungsten resources .

**2000: Zhuzhou Cemented Carbide Industrial Park**

In 2000, Zhuzhou Cemented Carbide Industrial Park began to take shape, forming an industrial cluster with Zhuzhou Cemented Carbide Factory as the core, which promoted regional economic development.

**2000s- 2020s : Globalization and technological leadership**

**2002: Joining the WTO**

In 2002, China joined the World Trade Organization (WTO), and Zhuzhou Cemented Carbide Factory ( China Tungsten High-Tech ) saw an increase in exports. In the same year, China Tungsten High-Tech integrated Zhuzhou Diamond Cutting Tool Company to enhance CNC blade production capacity to meet the needs of high-end fields such as automobile manufacturing.

**2002: China Minmetals Group and Jiangxi Rare Earth Metals Tungsten Industry Group Corporation began cooperation**

In 2002, China Minmetals Nonferrous Metals Co., Ltd., a subsidiary of China Minmetals Group , cooperated with Jiangxi Rare Earth Metals Tungsten Industry Group Corporation (the predecessor of Jiangxi Tungsten Industry Holding Group) to establish Jiangxi Tungsten Industry Group Co., Ltd. This joint venture is jointly controlled by both parties, with China Minmetals Nonferrous Metals holding 51% and Jiangxi Rare Earth Metals Tungsten Industry Group Corporation holding 49% (according to the information on the Ganzhou Municipal Government website). The joint venture is headquartered in Ganzhou, Jiangxi, and its business covers tungsten mining, beneficiation, smelting, deep processing and trade. It integrates multiple tungsten ore resources and processing enterprises in Jiangxi Province, forming a relatively complete industrial chain. This cooperation is an important step for China Minmetals Group to enter the Jiangxi tungsten industry, which is in line with the policy orientation of the country at that time to promote central-local cooperation .

**2005: Xiamen Tungsten Industry achieved technological breakthrough**

In 2005, Xiamen Tungsten Co., Ltd. developed ultrafine grain cutting tools for use in the photovoltaic field, supporting the rapid development of the photovoltaic industry.

**2008: Exports during the financial crisis**

In 2008, against the backdrop of the global financial crisis, China's cemented carbide exports continued to grow, reflecting the industry's international competitiveness.

**2010-2015: Technology and recycling**

In 2010, China Tungsten High-Tech cooperated with Beijing University of Science and Technology to develop nano-grade cemented carbide for precision machining. Xiamen Tungsten launched PVD coated tools, and the export ratio increased. In 2012, Jiangxi Tungsten Group developed a new type of cemented carbide for use in the aviation field. In 2013, Jiangxi Tungsten Group promoted the bioleaching method to improve recycling efficiency. In 2015, Ganzhou built a tungsten circular economy base to promote resource recycling.


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

**Regional Clusters**

In 2010, Zhuzhou Cemented Carbide Industrial Park developed rapidly. In 2015, Ganzhou built a high-end tool production line relying on Jiangxi Tungsten Group. In 2016, Xiamen Tungsten Industry established a secondary resource recycling base in South Korea, with an annual output of 1,500 tons of tungsten oxide. In 2018, Xiamen became a tool export center.

**2020s to Present: Green Intelligence and Global Leadership**

**2020-2024: Green and Smart Development**

In 2020, the "14th Five-Year Plan" will support the development of the cemented carbide industry.

In 2021, China Tungsten High-Tech developed additive manufacturing technology.

In 2022, the Xiamen Tungsten Industry Jiujiang Tungsten Industry Chain Deep Processing Project will be started.

In 2023, Xiamen Tungsten Co., Ltd. introduced artificial intelligence to optimize production, and China Tungsten High-tech developed high-entropy cemented carbide.

In 2024, Jiangxi Tungsten Group launched the Ganzhou cemented carbide project, which is scheduled to be put into production in 2025. Xiamen Tungsten Industry established an alloy production base in Thailand, and Zhuhai Tungsten Group's ultra-fine tungsten carbide intelligent production line was put into production.

**Resource Integration**

Since 2020, Jiangxi Copper Group has participated in the development of the Bakuta Tungsten Mine in Kazakhstan through its affiliated companies, and the project has made significant progress in 2024. The Bakuta Tungsten Mine is located in the Yanbekshkazakh District of the Almaty Region of Kazakhstan, about 150 kilometers away from Almaty City, close to the Horgos Port in China, and has convenient transportation. The mining area covers an area of 1.16 square kilometers, with a maximum mining depth of 300 meters. The mining right period is from June 2, 2015 to June 2, 2040. As of June 30, 2024, the ore reserves are 70.8 million tons, with an average grade of 0.205% $WO_3$, equivalent to 145,400 tons of $WO_3$; the total resources are 110.4 million tons, including about 233,200 tons of $WO_3$. The total investment of the project is about US$270 million (about RMB 1.8922 billion). The processing capacity of the first phase is 10,000 tons/day, which will be upgraded to 15,000 tons/day in the later stage. It is expected to be put into production in the first quarter of 2025, with an annual output of about 15,000 tons of 65% $WO_3$ concentrate, accounting for about 10% of the global output. The project is jointly developed by Jiangxi Copper Group, Hengzhao International, China Railway Construction Group and China Civil Engineering Group. In the equity structure, Hengzhao holds 43.35%, Jiangxi Copper Hong Kong holds 41.65%, and China Railway Construction Group holds 15%. It is expected to create about 1,000 jobs and the contract amount is RMB 1.328 billion.

In 2024, China Tungsten High-Tech will acquire Hunan Shizhuyuan Tungsten Mine, with a reserve of 560,000 tons. Jiangxi Tungsten Group will hold a controlling stake in Anyuan Coal Industry, and

Xiamen Tungsten will cooperate with Japan's Mitsubishi Materials.

**Regional collaboration**
In 2020, Zhuzhou Cemented Carbide Industrial Park continued to develop.
In 2024, Ganzhou's tungsten industry chain will be integrated and Xiamen's tool exports will continue to grow.

### 1.3 Comparison between cemented carbide and traditional materials

Cemented carbide is significantly superior to traditional materials in terms of hardness, wear resistance, toughness and environmental adaptability, and has formed a competitive advantage with new materials in specific fields. This section compares cemented carbide with high-strength steel, ceramics, cubic boron nitride (CBN) and polycrystalline diamond (PCD) through quantitative performance parameters, application scenarios and life cycle analysis to illustrate its unique advantages.

#### 1.3.1 Performance Differences with High-Strength Steel and Ceramics

High-strength steel (such as AISI 4340) has a tensile strength of about 1100-1300 MPa (ITIA 2024 report), a hardness of HV 400-500, a wear rate of about 0.5 $mm^3$ / N · m , a thermal expansion coefficient of $12\times10^{-6}$ / °C, and is relatively low in cost and suitable for structural parts manufacturing. However, its performance decreases at high temperatures, and its hardness drops to HV 200-250 at 600°C (Journal of Materials Science 2025). Cemented carbide (such as WC-6%Co) has a hardness of HV 1800-2200, a wear rate of 0.06-0.08 $mm^3$ / N · m , a thermal expansion coefficient of $4.5\text{-}5.5\times10^{-6}$ / °C, a compressive strength of 3500-4000 MPa, and maintains HV 900-1000 at 1000°C (Journal of the Chinese Society of Nonferrous Metals 2024). For example, the 2024 annual report of China Tungsten High-Tech shows that the life of its WC-6%Co mining drill bits in granite drilling is 1800-2000 meters, while the life of AISI 4340 high-strength steel drill bits is about 300-400 meters, and the life of cemented carbide is increased by about 4-5 times. The low thermal expansion coefficient of cemented carbide reduces processing deformation and is suitable for precision molds (tolerance <0.01 mm).

Ceramics (such as alumina $Al_2O_3$) have a hardness of HV 1800-2000, a temperature resistance of 1200°C, and a thermal conductivity of 25-30 W/ m·K , which are suitable for high-temperature cutting, but have a fracture toughness of 3-5 MPa·$m^{1/2}$, poor impact resistance, and are prone to chipping (ITIA 2024). Cemented carbide has a toughness of 8-15 MPa·$m^{1/2}$, a thermal conductivity of 80-100 W/ m·K , and is more resistant to thermal shock. For example, Xiamen Tungsten's 2024 annual report shows that its PVD TiAlN -coated WC-Co tools have an anti-chipping rate of about 50%-60% higher than uncoated tools in high-speed milling (200 m/min).

#### 1.3.2 Comparison with new materials

Cubic boron nitride (CBN) has a hardness of HV 4000-5000 and a thermal conductivity of 150-200

W/ m·K . It is suitable for cutting high-temperature alloys (such as Inconel 718) with a cutting speed of 250-300 m/min, but has a fracture toughness of 4-6 $MPa·m^{1/2}$ and weak impact resistance (ITIA 2024). Polycrystalline diamond (PCD) has a hardness of HV 7000-8000 and a wear rate of 0.01-0.02 $mm^3 / N \cdot m$ . It is suitable for processing non-ferrous metals (such as aluminum alloys), but has poor temperature resistance. The hardness drops by about 40%-50% at >700°C (Journal of Materials Science 2025). Cemented carbide has a PVD TiAlN coating (hardness HV 2500-3000) that approaches the performance of CBN, and a compressive strength of 3500-4000 MPa that is better than PCD (about 3000 MPa), making it suitable for deep-sea drilling (pressure > 100 MPa).

In terms of application scenarios, CBN and PCD have advantages in ultra-precision machining (such as optical lenses, surface roughness <0.01 μm ), but cemented carbide has wider versatility. For example, the 2024 annual report of Jiangxi Tungsten shows that its TaC -WC-Co cemented carbide nozzles can withstand temperatures of 1200°C in aviation gas turbines and have a lifespan of about 4000-5000 hours, while the lifespan of PCD nozzles is about 1500-2000 hours. Cemented carbide PVD coating technology reduces chemical wear and improves steel cutting efficiency by about 20%-30% compared to uncoated materials (Journal of the Chinese Society of Nonferrous Metals 2024).

### 1.3.3 Advantages in extreme environments

Cemented carbide performs well in extreme environments such as high temperature, high pressure, and corrosion. At 1000°C, WC-6%Co cemented carbide maintains HV 900-1000, while high-strength steel (AISI 4340) drops to HV 200-250. Although ceramics are resistant to high temperatures, they have low fracture toughness (3-5 $MPa·m^{1/2}$ ) and are prone to cracking. Cemented carbide containing Ni bonding phase (such as Co-Ni-Cr) has a corrosion rate of <0.1 mm/year in salt spray environment, and the life of marine engineering (such as Xiamen Tungsten Industry Valves) is >5 years, while AISI 4340 high-strength steel is about 1-2 years ( Xiamen Tungsten Industry 2024 Annual Report). In deep-sea drilling (5000 meters water depth, pressure of about 50 MPa), the life of cemented carbide drill bits is 800-1000 hours, and high-strength steel is about 150-200 hours (ITIA 2024).

Cemented carbide has significant green advantages. In 2024, the global cemented carbide recycling rate is about 25%-30%, China reaches 35%-40% (ITIA 2024), and China Tungsten High-Tech will recycle about 2,000-2,200 tons ( China Tungsten High -Tech 2024 Annual Report). The recycling rate of high-strength steel is about 85%-90%, but the energy consumption is high, the ceramic recycling rate is <10%, and the recycling of CBN and PCD is complicated. The life cycle of cemented carbide meets the "dual carbon" goal (Journal of the Chinese Society of Nonferrous Metals 2024). In 2025, China Tungsten High-Tech will optimize the design of WC-Co tools through additive manufacturing to improve durability ( China Tungsten High-Tech 2024 Annual Report).

## 1.4 Comparison between cemented carbide and tungsten steel

between cemented carbide (WC-Co composite material) and tungsten steel (high-speed steel or tool steel containing tungsten) in terms of material composition, microstructure, performance parameters and manufacturing process. This section compares the characteristics of the two in detail through quantitative data and scientific analysis, highlighting the advantages of cemented carbide in hardness, wear resistance and high temperature stability, and the characteristics of tungsten steel in toughness and processing flexibility, focusing on materials and performance, without involving economic or application levels.

### 1.4.1 Material composition and microstructure

Cemented carbide has tungsten carbide (WC, mass fraction 70%-94%) as the hard phase and cobalt (Co, 6%-20%) or nickel (Ni) as the bonding phase. WC is hexagonal (P6m2 space group, a=2.906 Å , c=2.837 Å ), with a hardness of HV 2200-2500, Co is a face-centered cubic structure (FCC), and the contact angle is about 5°-10° (Journal of the Chinese Society of Nonferrous Metals 2024). The microstructure is composed of WC particles (grains 0.2-5 microns) embedded in the Co matrix, with a density of >98%-99%. Scanning electron microscopy (SEM) and transmission electron microscopy (TEM) show that the WC-Co interface strength is >40-50 MPa and Co segregation is <5% (Journal of Materials Science 2025). Adding TiC or TaC (3%-10%) enhances oxidation resistance, and the weight gain after oxidation at 1200°C is less than 0.1 mg/cm² ( China Tungsten High-Tech 2024 Annual Report). X-ray diffraction (XRD) confirms that the WC (001) crystal plane orientation is optimized, and the grain boundary energy is about 0.8-1 J/ m² .

Tungsten steel is an alloy steel containing tungsten (W, 5%-18%), such as high-speed steel HSS M2 (containing 6% W, 5% Mo, 4% Cr) or tool steel. The matrix is an iron (Fe)-carbon (C, 0.8%-1.2%) alloy with a body-centered cubic (BCC) or martensitic structure. Tungsten exists in a solid solution state or carbide ( $Fe_3W_3C$ ), with a grain size of 10-30 microns. SEM analysis shows that the carbide distribution is uneven, the segregation rate is 5%-15%, and the interface strength is about 20-30 MPa (Journal of Materials Science 2025). The covalent bond strength of tungsten steel is about 400-450 kJ/mol, which is lower than WC (600-700 kJ/mol), and the hardness is HV 600-800. The composite structure of cemented carbide gives a low thermal expansion coefficient ($4.5\text{-}5.5\times10^{-6}$ /°C), which is better than tungsten steel ($11\text{-}12\times10^{-6}$ /°C), reducing high temperature deformation. Tungsten steel has a higher toughness ( $K_{1}c$ 20-25 MPa·m$^{1/2}$ ) than cemented carbide (8-15 MPa·m$^{1/2}$ ).

### 1.4.2 Performance Parameter Comparison

Cemented carbide (WC-6%Co) has a hardness of HV 1800-2200, a wear rate of 0.06-0.08 mm³ / N · m , a compressive strength of 3500-4000 MPa, a thermal conductivity of 80-100 W/ m·K , and a thermal expansion coefficient of $4.5\text{-}5.5\times10^{-6}$ / °C. At 1000°C, the salt spray weight loss of cemented carbide containing Co-Ni-Cr bonding phase is <0.1 mg/ cm² while maintaining HV 900-1000 (Journal of the Chinese Society of Nonferrous Metals 2024). Tungsten steel has a hardness of HV 600-800, a wear rate of 0.4-0.5 mm³ / N · m , a compressive strength of 1500-2000 MPa, a thermal conductivity of 20-30 W/ m·K , a thermal expansion coefficient of $11\text{-}12\times10^{-6}$ / °C, a hardness drop to HV 350-400 at 600°C, and a corrosion rate of about 0.5-1 mg/ cm² .

The wear resistance of cemented carbide is about 6-8 times that of tungsten steel, and its compressive strength is 1.8-2 times higher, making it suitable for high-pressure environments (>100 MPa). In terms of thermal performance, the weight gain of cemented carbide after oxidation at 1200°C is <0.1 mg/cm², and it has no cracks after >100 thermal shock cycles; the weight gain of tungsten steel after oxidation at 800°C is about 0.8-1 mg/cm², and microcracks appear after 50-60 thermal shock cycles. The cyclic fatigue strength of cemented carbide (>1800-2000 MPa, $10^7$ times) is better than that of tungsten steel (900-1000 MPa, $10^7$ times) ( China Tungsten High-Tech 2024 Annual Report).

### 1.4.3 Manufacturing process characteristics

Cemented carbide adopts powder metallurgy process: WC and Co powder (particle size 0.5-5 microns) ball milling (24-48 hours), pressing (50-100 MPa), liquid phase sintering (1320-1400°C, vacuum degree $10^{-3}$ Pa ), density >98%. Hot isostatic pressing (HIP, 120-150 MPa, 1350-1400°C) eliminates pores and increases hardness by 5%-10% ( China Tungsten High-tech 2024 Annual Report). The process needs to control temperature (±5°C) and Co content (±0.5%) to achieve submicron grains (0.2-1 micron).
Tungsten steel is produced by arc furnace melting (1600-1800°C), ingot casting, hot rolling/forging (1100-1200°C), and heat treatment (quenching 850°C, tempering 500-600°C). The carbides are unevenly distributed and the grain size is 10-30 microns. Heat treatment optimizes hardness and toughness, but carbide segregation (5%-15%) affects consistency (Journal of Materials Science 2025).

### 1.4.4 Environmental adaptability and recycling characteristics

The corrosion rate of cemented carbide containing Ni bonding phase (such as Co-Ni-Cr) in salt spray environment is <0.1 mm/year, and it has strong oxidation resistance at 1200°C. The corrosion rate of tungsten steel is about 0.5-1 mm/year, and oxidation is obvious above 800°C. The thermal conductivity (80-100 W/ m·K ) and low thermal expansion coefficient ($4.5\text{-}5.5\times10^{-6}$ /°C) of cemented carbide ensure thermal shock resistance and are suitable for high temperature and high pressure environments (>1000°C, >100 MPa). The thermal conductivity (20-30 W/ m·K ) and high thermal expansion coefficient ($11\text{-}12\times10^{-6}$ /°C) of tungsten steel lead to thermal deformation.
In terms of recycling, the recovery rate of cemented carbide through zinc melting method reaches 90%-95%, and the recovery rate in China will be 35%-40% in 2024 (ITIA 2024). The recovery rate of tungsten steel is about 85%-90%, but tungsten loss is 5%-10% during melting and recasting. Cemented carbide recycling is more efficient and meets the low-carbon goal ( China Tungsten High-tech 2024 Annual Report).

### 1.4.5 Comprehensive performance comparison

Cemented carbide is superior to tungsten steel in hardness, wear resistance, high temperature stability, corrosion resistance and compressive strength. PVD TiAlN coating (HV 2500-3000)


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

improves performance and is suitable for extreme working conditions. Tungsten steel has strong toughness ( $K_{1}c$ 20-25 MPa·m $^{1/2}$ ) and processing flexibility, suitable for low-load processing, but its hardness (HV 600-800) and wear resistance are insufficient. In 2025, China Tungsten High-Tech 's nano WC-Co (grain size 0.05-0.1 micron) further optimizes performance ( China Tungsten High-Tech 2024 Annual Report).

**References**

China Tungsten & High-Tech Materials Co., Ltd. 2024 Annual Report.

Xiamen Tungsten Co., Ltd. 2024 Annual Report.

Tungsten Market Trends in 2024. www.ctia.com.cn

CTIA GROUP LTD . Company profile and product introduction in 2024. ctia.group

China Tungsten Industry Association . Report of the 2024 China Tungsten Industry Development Conference. www.ctia.net.cn

National Development and Reform Commission. 2021. Outline of the 14th Five-Year Plan. www.ndrc.gov.cn

State Archives Administration. 1958. Construction archives of Zhuzhou Cemented Carbide Factory. Beijing: State Archives Administration

Chinese Journal of Nonferrous Metals. 1965-2024. Various issues. www.cnki.net

Rare Metal Materials and Engineering. 2023-2024. Multiple issues. www.cnki.net

USGS. 2025. Mineral Commodity Summaries:

Tungsten . www.usgs.gov

ITIA. 2024. Tungsten Recycling Report. www.itia.infoInternational

Tungsten Association . 2024. Tungsten Recycling Report.

Journal of Materials Science. 2024-2025. www.springer.comJournal

of Materials Science. 2024-2025.

Journal of Alloys and Compounds. 2025. www.elsevier.comJournal

of Alloys and Compounds. 2025.

Royal Society Proceedings. 1868.

London: Royal Society.

Annalen der Chemie . 1875. Leipzig: Wiley-VCH.

Annalen der Chemie . 1875. Leipzig: Wiley-VCH.

Become a German citizen Chemischen Gesellschaft. 1900. Berlin: Wiley-VCH.

Reports of the German Chemical Society. 1900. Berlin: Wiley-VCH.

Osram Technical Report. 1908.

Berlin: Osram GmbH.

Krupp Archives. 1912-1943. Essen: ThyssenKrupp AG.

Krupp Archives. 1912-1943. Essen: ThyssenKrupp AG.

Krupp Technical Bulletin. 1925. Essen: Krupp AG .

Farben Technical Report. 1931. Frankfurt: IG Farben.

Farben Technical Report. 1931. Frankfurt: IG Farben.

Sandvik Coromant History . 1932-2003. Sandviken : Sandvik AB .

US Patent. 1896-1936.

Washington, DC: USPTO.

Kennametal Technical Report. 1953. Latrobe: Kennametal Inc.

Kennametal Technical Report. 1953. Latrobe: Kennametal Inc.

Seco Tools Patent. 1965. Fagersta : Seco Tools AB .

Mitsubishi Materials Report. 1975.

Tokyo: Mitsubishi Materials Corp.

Plansee Technical Bulletin. 1983. Reutte: Plansee Group.

Plansee Technical Bulletin. 1983. Reutte: Plansee Group.

Sandvik Sustainability Report. 1990. Sandviken : Sandvik AB .

of

Biomedical Materials Research. 1985. Hoboken : Wiley.

Additive Manufacturing Journal. 2012.

Amsterdam: Elsevier.



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

# CTIA GROUP LTD
## 30 Years of Cemented Carbide Customization Experts

### Core Advantages

**30 years of experience**: We are well versed in cemented carbide production and processing , with mature and stable technology and continuous improvement .

**Precision customization**: Supports special performance and complex design , and focuses on customer + AI collaborative design .

**Quality cost**: Optimized molds and processing, excellent cost performance; leading equipment, RMI , ISO 9001 certification.

### Serving Customers

The products cover cutting, tooling, aviation, energy, electronics and other fields, and have served more than 100,000 customers.

### Service Commitment

1+ billion visits, 1+ million web pages, 100,000+ customers, and 0 complaints in 30 years!

### Contact Us

**Email** : sales@chinatungsten.com
**Tel** : +86 592 5129696
Official **website** : www.ctia.com.cn
**WeChat** : Follow "China Tungsten Online"

**Appendix:**

**The English translation method of cemented carbide and its application**

As a composite material composed of a hard phase (such as tungsten carbide) and a binder phase (such as cobalt), cemented carbide has a variety of translations or names in English, depending on the context, industry standards or habits in the technical field. The following is a detailed summary of the English names of cemented carbide and their translations, covering common terms, application scenarios and subtle differences.

---

## How to translate the English name of cemented carbide

### 1. The English name of cemented carbide - Hardmetal

Definition: The most standard English name, widely used in international standards (such as ISO 513, ASTM B886) and academic literature, refers to materials composed of hard carbides (such as WC, TiC ) and metal binders (such as cobalt, nickel). Usage scenarios:
Industrial standards: ISO 3326 ( Hardmetals — Determination of magnetic saturation of cobalt), GB/T 3849.
Academic Research: ScienceDirect articles often refer to " hardmetals " used for cutting tools and molds.
Features: Emphasis on the composite properties of materials (hard phase + metal bonding phase), strong versatility, suitable for the global cemented carbide industry.
Example: Hardmetals are widely used in cutting tools due to their high hardness and wear resistance.

### 2. Cemented Carbide

Definition: A common translation that highlights the characteristics of hard carbides (such as WC) being "cemented" by metal binders (such as cobalt), commonly used in North American and European technical literature.
ASTM standard: ASTM B886 (Standard Test Method for Determination of Magnetic Saturation of Cemented Carbides).
Industry term: commonly used by North American tool manufacturers (such as Kennametal and Sandvik).
Features: Emphasis on the "cementation" process, that is, the metal binder combines the carbide particles during the sintering process.
as Hardmetal , but more commonly seen in American standards and corporate advertising.
Example: Cemented carbides are preferred for machining due to their toughness and durability.

### 3. Tungsten Carbide

Definition: refers specifically to cemented carbide with tungsten carbide (WC) as the main hard phase, often used for non-technical or simplified descriptions, but strictly speaking it is not

comprehensive (does not cover other carbides or binders). Usage scenarios:
Business and market: commonly seen in promotions of knives, drill bits, and jewelry (tungsten steel rings).
Popular science article: Wikipedia often introduces cemented carbide as "Tungsten Carbide".
Features: It only refers to WC-based cemented carbide, and does not cover alloys containing other carbides such as TiC and TaC .
Used as a synonym for cemented carbide in non-professional occasions (such as the consumer market).
Limitations: Not very precise, as cemented carbide may contain non-tungsten based carbides (such as TiC ) or various binders.
Example: Tungsten carbide tools are known for their extreme hardness.

**4. Carbide**

Definition: A simplified name that refers to cemented carbide in general, omitting "cemented" or "tungsten", which is commonly used in the industry or in spoken language. Usage scenarios:
Tool industry: Workers or engineers often refer to them as "carbide tools" or "carbide inserts".
Technical documentation: For example, the Sandvik product brochure mentions "carbide grades".
Features: Concise, but may cause ambiguity because "carbide" also refers to other carbides (such as calcium carbide $CaC_2$ ).
to clearly refer to cemented carbide in the context .
Example: Carbide inserts improve machining efficiency in steel processing.

**5. Widiametal (less common)**

Definition: A term used in early Europe (especially Germany), derived from "Widia" (Wie Diamant, meaning "like diamond"), which is the trade name of cemented carbide.
Historical Documents: Krupp of Germany first commercialized cemented carbide in the 1920s and named it Widia.
Parts of Europe: Still occasionally seen in old technical documents or traditional enterprises.
Features: Emphasizes the high hardness of cemented carbide (close to diamond), but it is now less used and replaced by Hardmetal or Cemented Carbide.
Only in certain historical or brand contexts.
Example: Widiametal was a breakthrough in early cutting tool technology.

**6. Sintered Carbide (less common)**

Definition: Emphasizes that cemented carbide is made through powder metallurgy sintering process, highlighting the manufacturing process. Application scenarios:
Academic research: Used when describing the cemented carbide production process.
Technical manual: as described in the sintering process instructions.
Features: Similar to Cemented Carbide, but more focused on the sintering process.

It is used less frequently than Hardmetal and Cemented Carbide.
Example: Sintered carbide components exhibit excellent wear resistance.

**7. Other non-standard translations**

Tungsten Steel
Wrong translation, often seen in non-professional occasions (such as e-commerce platforms). Cemented carbide is not steel, but a carbide metal composite material.
Example: The jewelry industry mistakenly calls them “tungsten steel rings”, which are actually tungsten-based cemented carbide .
Hard Alloy
Directly translated from the Chinese "hard alloy", it is rarely used in English and may appear in Chinese English literature, but it is not standard.
Example: Hard alloy is not a standard term in English technical literature.



电话/TEL：0086 592 512 9696

sales@chinatungsten.com

**Comparison and selection suggestions of English translation methods of cemented carbide**

| English name | Applicable scenarios | advantage | limitation |
|---|---|---|---|
| Hardmetal | International standards, academic research, global industry | Strong versatility, standard terminology | No obvious limitations |
| Cemented Carbide | North American Standards, Cutting Tool Industry, Technical Documentation | Emphasis on bonding technology, widely recognized | Slightly lengthy |
| Tungsten Carbide | Commercial promotion, science popularization, consumer market | Concise and easy to understand by non-professionals | Not comprehensive enough, ignoring other carbides and binders |
| Carbide | Industry Colloquialisms, Tool Manufacturing | Simple and universal in the industry | May cause ambiguity (confusing with other carbides) |
| Widiametal | Historical documents, European traditional enterprises | Historical significance, brand-specific | Obsolete, rarely used nowadays |
| Sintered Carbide | Academic research, process description | Highlight sintering process | Low frequency of use |
| Tungsten Steel | Non-specialized markets (such as jewelry) | None (wrong term) | Inaccurate and misleading |
| Hard Alloy | Chinglish Literature | None (non-standard) | Not standardized, not internationally recognized |

**Selection suggestion:**

Formal occasions (standards, papers, international exchanges): Use Hardmetal or Cemented Carbide because they comply with ISO, ASTM, GB/T standards and are highly versatile.

Within the industry (knife, mold manufacturing): Carbide is concise and suitable for colloquial language or product naming, but make sure the context is clear.

Commercial propaganda (for consumers): Tungsten Carbide is easier for non-professionals to understand, but it should be noted that it is hard alloy.

Avoid: Tungsten Steel and Hard Alloy due to inaccuracies or non-compliance.

---

**Data and support**

Standard basis: ISO 3326:2013 and ASTM B88624 use " Hardenmetal " and "Cemented Carbide" (ISO official website, ASTM official website).

GB/T 38492015 uses “hard alloy”, which is translated into English as “ Hardmetal ” (China National Standards Query Network).

Industry practice: Global tool companies (such as Sandvik and Kennametal) often use "Cemented Carbide" or "Carbide" in their product catalogs.

The Wikipedia entry for "Tungsten Carbide" states that it is a subset of cemented carbide (Wikipedia, 2005).

Academic literature: ScienceDirect articles often use “ Hardenmetals ” or “Cemented Carbides” to describe WCCo alloys (ScienceDirect, 2020).

Historical background: "Widia" originated from the German Krupp company in the 1920s and is rarely used in modern times.


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

The English names of cemented carbide mainly include Hardmetal , Cemented Carbide, Tungsten Carbide and Carbide, among which Hardmetal and Cemented Carbide are the most standard terms, widely used in international standards and industry exchanges. Tungsten Carbide is suitable for commercial promotion, but not comprehensive enough; Carbide is concise but needs to be aware of ambiguity. Widiametal and Sintered Carbide are less common and are limited to specific historical or process scenarios. Tungsten Steel and Hard Alloy should be avoided because they are inaccurate. When choosing English names, the most appropriate term should be selected according to the context (academic, industrial, commercial).

**Appendix:**

**Brief introduction to the main cemented carbide enterprises in my country in the early days and their current status**

**1. Zhuzhou 601 Factory (Zhuzhou Cemented Carbide Factory)**

**Origin and construction history**

Zhuzhou 601 Factory, namely Zhuzhou Cemented Carbide Factory (now Zhuzhou Cemented Carbide Group Co., Ltd., affiliated to China Tungsten High-tech ), was established in 1954 and is located in Zhuzhou, Hunan. It is the starting point of China's cemented carbide industry. The factory was one of the 156 key projects during the country's "First Five-Year Plan" (1953-1957) and is known as the "cradle of China's cemented carbide industry." The background of its establishment was that the industrial foundation was weak in the early days of the founding of New China, and cemented carbide as a strategic material mainly relied on imports. In order to change this situation, the country chose to build a factory in Zhuzhou, Hunan, relying on the local rich tungsten ore resources (such as Shizhuyuan polymetallic mine) and convenient transportation conditions (Zhuzhou is located in the middle reaches of the Xiangjiang River and has developed railway transportation).

**Name number meaning and origin**

The number "601" originated from the confidential naming rules of industrial enterprises in the early days of the founding of New China. At that time, in order to ensure the confidentiality of the national defense industry and key projects, the state used numbers instead of direct names for many factories. "601" belongs to the serial number under the jurisdiction of the Ministry of Metallurgical Industry (later merged into the Ministry of Machinery Industry), specifically representing "The First Factory of the Sixth Ministry of Metallurgical Industry". "6" represents the metallurgical industry, and "01" indicates that it is the first key project in the system, reflecting the special status of Zhuzhou Cemented Carbide Factory as the beginning of China's cemented carbide industry.

**Construction and development**

Zhuzhou 601 Factory introduced Soviet technology in the early stage of its establishment, using powder metallurgy to produce cemented carbide mainly composed of tungsten carbide-cobalt (WC-Co), which was mainly used for mining and cutting tools. In 1958, when the "First Five-Year Plan" came to an end, Zhuzhou Factory expanded its plant and optimized the production process. The cemented carbide drills produced began to meet the needs of geological exploration. In 1960, the factory cooperated with the Beijing Nonferrous Metals Research Institute to develop cemented carbide containing titanium carbide ( TiC ) for use in the field of oil drilling. In the 1960s , despite the influence of the Cultural Revolution, Zhuzhou Factory maintained its supply in the field of mechanical processing by optimizing the formula through self-reliance. In 1970, the country launched the "704 Project", and Zhuzhou Factory further expanded and its output increased. After the reform and opening up in 1978, during the "Sixth Five-Year Plan" (1981-1985), Zhuzhou Factory introduced Swedish Sandvik coating technology and developed titanium nitride ( TiN ) coated tools, which significantly improved cutting performance.

**Key Features**

Zhuzhou 601 Factory is the birthplace of China's cemented carbide industry and laid the foundation for the industry. Its characteristics are:

**Technology introduction and innovation** : Starting from Soviet technology, we later cooperated with Tsinghua University, Central South University, etc. to develop ultrafine grain and nano-grade cemented carbide for application in precision machining.

**Industrial cluster effect** : In 2000, Zhuzhou Cemented Carbide Industrial Park began to take shape, forming an industrial cluster with Zhuzhou Factory as the core, promoting regional economic development.

**Widely used** : Products cover mining, mechanical processing, national defense, electronics industry and other fields. They have been exported to Southeast Asia since the 1980s, and exports have further increased after joining the WTO in 2002.

**status quo**

Zhuzhou Cemented Carbide Plant is now the core enterprise of China Tungsten High-tech Materials Co., Ltd. and one of the largest cemented carbide production bases in China. In 2024, China Tungsten High-tech acquired Hunan Shizhuyuan Tungsten Mine (with a reserve of 560,000 tons), which enhanced its self-sufficiency in raw materials. The company continues to focus on the research and development of high-entropy cemented carbide and additive manufacturing technology. Its products are widely used in aerospace, automobile manufacturing and other fields, while actively promoting green manufacturing and intelligent production.

## 2. Zigong 764 Factory (Zigong Cemented Carbide Factory)

### Origin and construction history

Zigong 764 Factory, namely Zigong Cemented Carbide Factory (now Zigong Cemented Carbide Co., Ltd.), was established in 1965 and is located in Zigong City, Sichuan Province. As a famous salt city in China, Zigong has a long industrial history, especially salt well drilling technology, which provides the basis for the development of its cemented carbide industry. The establishment of Zigong 764 Factory coincided with the period of the country's "Third Line Construction", with the aim of establishing a strategic rear industrial base in the southwest region to cope with potential threats during the Cold War.

### Name number meaning and origin

The "764" number is a typical confidential naming method during the "Third Line Construction" period. "7" usually represents enterprises under the jurisdiction of the Ministry of Machinery Industry, "6" may represent the regional code of the southwest region, and "4" is the serial number of the factory in the region. This numbering method is intended to hide the true purpose and geographical location of the factory to ensure wartime safety. The number of Zigong Factory 764 reflects its status as an important cemented carbide production base laid out by the Ministry of Machinery Industry in the southwest region.

### Relationship with Zhuzhou 601 Factory

Zigong 764 Factory has indirect links with Zhuzhou 601 Factory in cemented carbide production technology. As an industry pioneer, Zhuzhou 601 Factory exported process standards and production experience to "third-line" enterprises including Zigong 764 Factory through national technology diffusion projects in the 1960s. The powder metallurgy process adopted by Zigong 764 Factory in the early stage of its establishment is in line with the technical system of Zhuzhou 601 Factory. In addition, the two factories complement each other in the national tungsten resource allocation and industry collaboration. The technological innovation of Zhuzhou 601 Factory provides a development foundation for Zigong 764 Factory, while Zigong 764 Factory supplements the industrial layout of Zhuzhou 601 Factory in the southwest region through regional resource advantages.

### Construction and development

In the early days, Zigong 764 Factory mainly produced cemented carbide tools for mining and geological exploration, relying on Zigong's abundant natural gas resources (used as sintering fuel) and Sichuan's tungsten resources. In the 1970s, as the country's demand for cemented carbide increased, the Zigong factory gradually expanded its product line to include cutting tools and wear-resistant parts. In the 1980s , after the reform and opening up, the Zigong factory began to cooperate with foreign companies, introduced advanced equipment and technology, and improved product quality.

### Key Features

Zigong 764 Factory is well-known for its cemented carbide products in the field of mining and geological exploration, with the following features:

**Resource advantages** : The natural gas resources in Zigong area provide cheap energy for cemented carbide sintering, reducing production costs.

**Regional influence** : As an important cemented carbide production base in the southwest region, the products of Zigong Factory are widely used in mining development in Sichuan, Yunnan and other places.

**Technological progress** : In the 1990s, the Zigong plant developed high-performance carbide bars and plates to meet the needs of non-standard cutting tools.

**status quo**

Zigong Cemented Carbide Co., Ltd. has become one of the important enterprises in China's cemented carbide industry and is affiliated to China Minmetals Corporation. The company focuses on the production of cemented carbide bars, plates and cutting tools, and its products are used in mining, oil drilling and mechanical processing. Zigong City has also become one of the important bases of China's cemented carbide industry, continuing its industrial tradition in the southwest region.

**Analysis of the relationship between Zhuzhou 601 Factory and Zigong 764 Factory**

**Historical background and industry positioning**

Zhuzhou 601 Factory (Zhuzhou Cemented Carbide Factory) was established in 1954. It is the starting point of China's cemented carbide industry and is known as the "cradle of China's cemented carbide industry". As a key project of the country's "First Five-Year Plan", Zhuzhou 601 Factory has a leading position in the field of cemented carbide technology, mastered the powder metallurgy process introduced from the Soviet Union, and continuously innovated through cooperation with domestic scientific research institutions. Zigong 764 Factory (Zigong Cemented Carbide Factory) was established in 1965, during the "Third Line Construction" period, and is an important cemented carbide production base in the southwest region. Relying on Sichuan's tungsten ore resources and natural gas energy, Zigong 764 Factory focuses on the production of cemented carbide tools for mining and geological exploration.

**Technology and Resource Contact**

As an industry pioneer, Zhuzhou Factory 601 has accumulated rich experience in cemented carbide production technology, process standards and equipment research and development. In the 1960s, with the advancement of the "Third Line Construction", the state encouraged key enterprises to export technology to inland areas to support the development of new factories. In the early days of its establishment, Zigong Factory 764 benefited greatly from the technology diffusion of Zhuzhou Factory 601. For example, the tungsten carbide-cobalt (WC-Co) cemented carbide production process developed by Zhuzhou Factory 601 has become an industry standard, and Zigong Factory 764 uses a similar powder metallurgy process when producing mining tools, which shows that the two factories have a heritage relationship in terms of technology systems.

### 3. Nanchang 603 Factory (Nanchang Cemented Carbide Factory)

**Origin and construction history**

Nanchang 603 Factory, namely Nanchang Cemented Carbide Factory (now Nanchang Cemented Carbide Co., Ltd.), was established in 1966 and is located in Nanchang, Jiangxi Province. It is another important cemented carbide production base established during the "Third Line Construction" period. Jiangxi Province is one of the provinces with the richest tungsten resources in China, with high-quality tungsten ore resources in Ganzhou and other places. The establishment of Nanchang 603 Factory aims to take advantage of this resource advantage and provide cemented carbide materials for national industry and national defense construction.

**Name number meaning and origin**

The number "603" also follows the confidential naming rules during the "Third Line Construction" period. The "6" may be a continuation of the numbering sequence of the Ministry of Metallurgical Industry (the "6" in Zhuzhou 601 Factory means this), while the "03" indicates that it is the third key project in the system. The numbering of Nanchang 603 Factory reflects its important position in the metallurgical industry system, and also reflects the strategic layout of Jiangxi, an inland province, during the "Third Line Construction" period.

**Construction and development**

In the early days, Nanchang Factory 603 mainly produced cemented carbide tools for mining, such as rock drill bits and tunneling tools, to support the development of mines in Jiangxi and surrounding areas. In the 1970s , the factory began to develop cutting tools to meet the needs of the machining industry. In the 1980s , with the advancement of reform and opening up, the Nanchang factory introduced foreign equipment and developed high-performance cemented carbide products.

**Key Features**

Nanchang 603 Factory is famous for its applications in mining and machining, and its features include:

**Resource support** : Jiangxi tungsten ore resources provide a stable supply of raw materials for the Nanchang plant, reducing production costs.

**Product diversity** : From mining tools to cutting tools, Nanchang Plant has gradually expanded its product line to meet a variety of industrial needs.

**Technical cooperation** : In the 1990s, the Nanchang plant cooperated with domestic universities to develop corrosion-resistant cemented carbide for use in the field of chemical equipment.

**status quo**

Nanchang Cemented Carbide Co., Ltd. is now affiliated to China Minmetals Corporation and is an important cemented carbide production enterprise in Jiangxi Province. The company continues to focus on the production of mining tools and cutting tools, while developing new cemented carbide materials for use in the aerospace and chemical industries. The Nanchang plant plays an important role in the Jiangxi tungsten industry chain.

### 4. Mudanjiang 212 Factory (Mudanjiang Cemented Carbide Factory)

**Origin and construction history**

Mudanjiang Factory 212, or Mudanjiang Cemented Carbide Factory, was established in 1969 and is located in Mudanjiang, Heilongjiang Province. It is one of the cemented carbide production bases deployed in the Northeast during the "Third Line Construction" period. The establishment of Mudanjiang Factory 212 aims to support the revitalization of the old industrial base in the Northeast, while providing cemented carbide materials for the defense industry. Mudanjiang is located in the Northeast, close to the Sino-Soviet border (about 248 kilometers from Vladivostok), and its strategic location makes it an important site in the "Third Line Construction". In the mid- 1960s , as Sino-Soviet relations deteriorated and Cold War tensions intensified, China launched the "Third Line Construction" to transfer industrial bases to inland and remote areas. Mudanjiang was selected to build a cemented carbide plant because of its railway network and mining resources.

**Name number meaning and origin**

The "212" number is a typical naming method for the Northeast region during the "Third Line Construction" period. "2" may represent the regional code of the Northeast region, and "12" is the serial number of the factory in the region. This numbering method is intended to hide the true purpose of the factory and protect the security of the national defense industry. The number of Mudanjiang Factory 212 indicates that it is an important part of cemented carbide production in the Northeast region, which is consistent with its mission to support the national defense industry.

**Construction and development**

In the early days, Mudanjiang Factory 212 mainly produced cemented carbide tools for mining and geological exploration, serving the mining development in Heilongjiang and Jilin. In the 1970s , the factory began to develop military cemented carbide parts, such as tank track wear parts and warhead materials, to support national defense construction. In the 1980s , with the advancement of reform and opening up, Mudanjiang Factory gradually turned to the civilian market, developing cutting tools and wear-resistant parts, and further expanding its product line.

**Key Features**

Mudanjiang 212 Factory is well known for its applications in defense and mining, with features including:

**Contribution to national defense** : In the 1970s , the cemented carbide parts produced by Mudanjiang Factory were widely used in military products, supporting national defense construction.

**Geographical advantages** : Mudanjiang is located in the northeast, close to the Russian border, which facilitates technical exchanges with the Soviet Union and later Russia.

**Product cold resistance** : In view of the cold climate in Northeast China, the cemented carbide tools developed by Mudanjiang Factory have strong low-temperature toughness and can adapt to extreme environments.

**status quo**

Mudanjiang Cemented Carbide Factory has now been incorporated into China North Industries Group Corporation and has become one of its subsidiaries. The company continues to produce mining tools and military cemented carbide parts, while developing new wear-resistant materials for use in the energy and machinery manufacturing sectors. Mudanjiang Factory still has a certain influence in the cemented carbide industry in Northeast China.

**5.Beijing Cemented Carbide Factory**

**Origin and construction history**

Beijing Cemented Carbide Factory was established in 1970 in Beijing. It is a cemented carbide production enterprise established to meet the industrial and scientific research needs of the capital. As the political and technological center of China, Beijing has many scientific research institutes (such as Beijing Nonferrous Metals Research Institute) and high-end manufacturing industries. The establishment of Beijing Cemented Carbide Factory aims to provide high-performance cemented carbide materials for these fields.

**Construction and development**

In the early days, Beijing Cemented Carbide Factory mainly produced cutting tools and precision molds, serving the mechanical processing and electronic industries in Beijing and surrounding areas. In the 1970s , the factory cooperated with the Beijing Nonferrous Metals Research Institute to develop high-precision cemented carbide molds for electronic component manufacturing. In the 1980s , after the reform and opening up, the Beijing factory introduced foreign technology and developed coated cemented carbide tools.

**Key Features**

Beijing Cemented Carbide Factory is famous for its applications in precision machining, including:

**Technology R&D** : Cooperate with Beijing Nonferrous Metals Research Institute and other institutions to focus on the development of high-precision cemented carbide materials.

**Application areas** : The products are mainly used in high-end manufacturing fields such as the electronics industry and aerospace, meeting the high-tech needs in Beijing.

**Geographical advantages** : Located in the capital, it is easy to obtain policy support and technical resources.

**status quo**

Beijing Cemented Carbide Factory has now been integrated into the China Nonferrous Metals Research Institute, focusing on the research and development and production of high-end cemented carbide materials . The company's products are mainly used in the fields of aerospace, electronics industry and precision manufacturing, and it also participates in national key scientific research projects such as high entropy alloys and nanomaterials.


电话/TEL：0086 592 512 9696

sales@chinatungsten.com

## 6. Hubei Jiangzuan (Hubei Jianghan Petroleum Drill Bit Co., Ltd.)

### Origin and construction history

Hubei Jiangzuan, or Hubei Jianghan Oil Drill Bit Co., Ltd., was established in 1973 and is located in Jingzhou City, Hubei Province. It is an important cemented carbide production enterprise established during the "Third Line Construction" period to support the development of the oil industry. Jingzhou is located in the Jianghan Plain, close to China's important oil field, the Jianghan Oilfield, with a superior geographical location, which is convenient for serving the oil industry. The background of the establishment of Hubei Jiangzuan was the rapid development of China's oil industry in the 1970s, especially the development of the Daqing Oilfield and the Jianghan Oilfield, which led to a surge in demand for high-performance cemented carbide drill bits.

### Construction and development

Hubei Jiangzuan initially focused on producing cemented carbide drill bits and tools for oil drilling. Relying on the actual needs of Jianghan Oilfield, it developed a variety of wear-resistant, high-strength cemented carbide products. In the late 1970s , the factory cooperated with domestic scientific research institutions to develop cemented carbide drill bits suitable for complex geological conditions. In the 1980s , after the reform and opening up, Hubei Jiangzuan introduced advanced foreign technology and developed diamond composite (PDC) drill bits, further improving drilling efficiency.

### Key Features

Hubei Jiangzuan is well-known for its professional production in the field of oil drilling, with the following features:

**Industry focus** : Focus on cemented carbide tools for oil drilling, and the products directly serve major domestic oil fields such as Jianghan Oilfield and Daqing Oilfield.

**Technological innovation** : Diamond composite piece technology was introduced in the 1980s , and the PDC drill bits developed have performed well in deep well and hard formation drilling.

**Geographical advantages** : close to Jianghan Oilfield, convenient for cooperation with oilfield enterprises and rapid response to market demand.

### status quo

Hubei Jiangzuan is now an important enterprise under China Petrochemical Corporation (Sinopec) and is one of the leading domestic manufacturers of oil drill bits and carbide tools. The company's products cover the fields of oil and gas drilling, and are exported to the Middle East, North America and other regions. Hubei Jiangzuan continues to promote intelligent manufacturing and develop high-performance drill bits to meet the needs of deep-sea drilling and unconventional oil and gas resource development.

## 7. Chengdu Cemented Carbide Factory (Chengdu Tool Research Institute)

### Origin and construction history

Chengdu Cemented Carbide Factory, based on Chengdu Tool Research Institute, was established in 1965 and is located in Chengdu, Sichuan Province. It is another important cemented carbide production base in the southwest region during the "Third Line Construction" period. Chengdu Tool Research Institute was established by the Ministry of Machinery Industry to develop high-performance cutting tools and cemented carbide materials, and Chengdu Cemented Carbide Factory is its production base.

**Construction and development**

In the early days, Chengdu Cemented Carbide Factory mainly produced cutting tools and molds, serving the machinery manufacturing and aviation industries in the southwest region. In the 1970s , the factory developed high-precision cemented carbide tools for aircraft engine processing. In the 1980s , after the reform and opening up, Chengdu Factory cooperated with foreign companies, introduced coating technology, and developed high-performance coated tools.

**Key Features**

Chengdu Cemented Carbide Factory is well-known for its technological research and development in the field of cutting tools, with the following features:

**Scientific research support** : Relying on Chengdu Tool Research Institute, it has strong technical research and development capabilities.

**Aviation Application** : The products are widely used in the aviation industry, such as the processing of aircraft engine blades.

**Technical cooperation** : Since the 1980s , we have cooperated with foreign companies to develop coated tools that improve cutting efficiency.

**status quo**

Chengdu Tool Research Institute is now a subsidiary of China National Machinery Industry Corporation, and its carbide production business has been integrated into Chengdu Tool Co., Ltd. The company focuses on the research and development and production of high-performance cutting tools and carbide molds, and its products serve the fields of aerospace, automobile manufacturing, etc. Chengdu Tool Research Institute is still one of the R&D centers in the domestic tool industry.

**8. Shanghai Cemented Carbide Factory**

**Origin and construction history**

Shanghai Cemented Carbide Factory was established in 1958 and is located in Shanghai. It is one of the earliest cemented carbide production enterprises established after the founding of New China. As the industrial center of China, Shanghai has developed machinery manufacturing and electronics industries. The establishment of Shanghai Cemented Carbide Factory aims to meet the demand for cemented carbide materials in East China.

**Construction and development**

In the early days, Shanghai Cemented Carbide Factory mainly produced cutting tools and wear-resistant parts, serving the machining industry in Shanghai and surrounding areas. In the 1960s , the factory cooperated with Shanghai Jiaotong University to develop high-precision cemented carbide molds for use in the electronics industry. In the 1970s , the factory began to produce mining tools to support the mining development in East China. In the 1980s , after the reform and opening up, the Shanghai factory introduced foreign technology and developed coated cemented carbide tools.

**Key Features**

Shanghai Cemented Carbide Factory is famous for its applications in cutting tools and electronic industries, with the following features:

**Industrial base** : Relying on Shanghai's industrial base, our products are widely used in machinery manufacturing and electronics industries.

**Technical cooperation** : Cooperate with Shanghai Jiaotong University and other universities to develop high-precision cemented carbide molds.

**Export capability** : Since the 1980s , the Shanghai factory's products have begun to be exported to Southeast Asia, enhancing its international competitiveness.

**status quo**

Shanghai Cemented Carbide Factory has now been integrated into Shanghai Tool Factory Co., Ltd., which is affiliated to Shanghai Electric Group. The company focuses on the production of cutting tools and cemented carbide molds, and its products serve the automotive manufacturing, electronics industry and other fields. Shanghai Tool Factory continues to play an important role in the cemented carbide industry in East China, while promoting intelligent production.

**9.Xi'an Cemented Carbide Factory**

**Origin and construction history**

Xi'an Cemented Carbide Factory was established in 1969 and is located in Xi'an, Shaanxi Province. It is a cemented carbide production base laid out in the northwest during the "Third Line Construction" period. As an important industrial city in the northwest, Xi'an has a developed aviation industry and machinery manufacturing industry. The establishment of Xi'an Cemented Carbide Factory aims to support the industrial development of the northwest region.

**Construction and development**

Xi'an Cemented Carbide Factory initially produced mining tools and cutting tools, serving the mining and machinery manufacturing industries in Shaanxi and surrounding areas. In the 1970s , the factory developed cemented carbide tools for the aviation industry.

**Key Features**

**Regional services** : The products mainly serve the mining and aviation industries in the northwest region.

**Technology accumulation** : Cooperate with Xi'an Jiaotong University and other universities to develop high-performance cemented carbide tools.

**status quo**

Xi'an Cemented Carbide Factory has now been integrated into a subsidiary of China Aviation Industry Corporation, focusing on the production of cemented carbide tools for aviation.

## 10.Changsha Cemented Carbide Factory

### Origin and construction history

Changsha Cemented Carbide Factory was established in the 1960s and is located in Changsha City, Hunan Province. Relying on Hunan's tungsten ore resources, it is another cemented carbide production base established in Hunan after Zhuzhou 601 Factory.

### Construction and development

Changsha Cemented Carbide Factory initially produced mining tools and wear-resistant parts to support the mining industry in Hunan and surrounding areas. In the 1980s , the factory developed cutting tools to serve the machinery manufacturing industry.

### Key Features

**Resource support** : jointly utilize Hunan tungsten ore resources with Zhuzhou 601 Factory.
**Regional collaboration** : complement the Zhuzhou plant and support the development of Hunan's cemented carbide industry.

**status quo**

Changsha Cemented Carbide Factory has now been incorporated into Zhuzhou Cemented Carbide Group and has become one of its subordinate production bases, focusing on the production of mining tools.

Zhuzhou 601 Factory, Zigong 764 Factory, Nanchang 603 Factory, Mudanjiang 212 Factory, Beijing Cemented Carbide Factory, Hubei Jiangzuan, Chengdu Cemented Carbide Factory, Shanghai Cemented Carbide Factory, Xi'an Cemented Carbide Factory and Changsha Cemented Carbide Factory are important representatives in the development of China's cemented carbide industry, and have contributed to the development of the industry in different historical periods and regional backgrounds. Zhuzhou 601 Factory and Zigong 764 Factory have indirect links in technology inheritance and industry collaboration, and have jointly promoted the development of China's cemented carbide industry. Zhuzhou 601 Factory has laid the foundation for the industry, Zigong 764 Factory, Nanchang 603 Factory, Hubei Jiangzuan and Chengdu Cemented Carbide Factory rely on resources and regional advantages to serve the southwest and oil industry, Beijing Cemented Carbide Factory and Shanghai Cemented Carbide Factory focus on high-end applications, Mudanjiang 212 Factory supports Northeast industry and national defense construction, and Xi'an Cemented Carbide Factory and Changsha Cemented Carbide Factory serve the northwest and Hunan regions. The construction and development of these factories reflect China's journey from technology introduction to independent innovation, and they currently continue to play an important role in green intelligent manufacturing and global competition.

# CTIA GROUP LTD
## 30 Years of Cemented Carbide Customization Experts

### Core Advantages

**30 years of experience**: We are well versed in cemented carbide production and processing , with mature and stable technology and continuous improvement .

**Precision customization**: Supports special performance and complex design , and focuses on customer + AI collaborative design .

**Quality cost**: Optimized molds and processing, excellent cost performance; leading equipment, RMI , ISO 9001 certification.

### Serving Customers

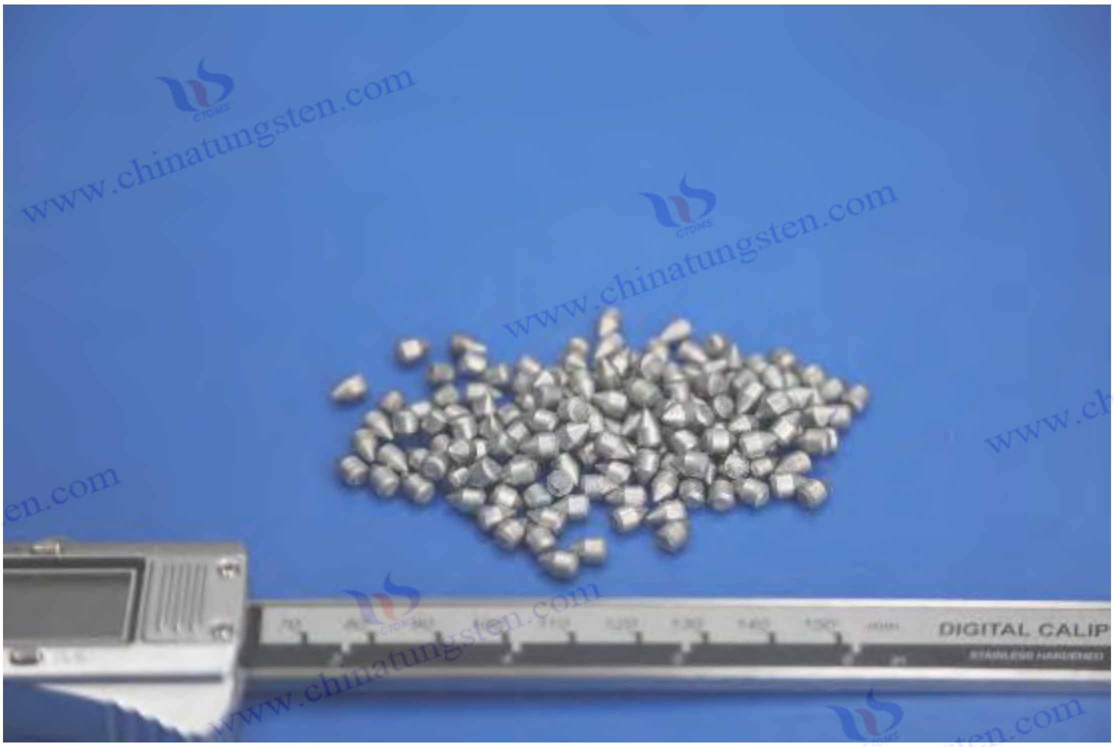
The products cover cutting, tooling, aviation, energy, electronics and other fields, and have served more than 100,000 customers.

### Service Commitment

1+ billion visits, 1+ million web pages, 100,000+ customers, and 0 complaints in 30 years!

### Contact Us

**Email** : sales@chinatungsten.com
**Tel** : +86 592 5129696
Official **website** : www.ctia.com.cn
**WeChat** : Follow "China Tungsten Online"




**Appendix:**

**the Development of Tungsten and Cemented Carbide Industry in China**

## 1. Background and process of establishment

The establishment of China Nonferrous Metals Industry Corporation (hereinafter referred to as "Nonferrous Metals Corporation") is a key step in the transformation of China's nonferrous metals industry from a planned economy to a market economy. After the founding of the People's Republic of China in 1949, the nonferrous metals industry was centrally managed by the state, and tungsten resources were highly valued as strategic minerals. After the reform and opening up in 1978, the state gradually adjusted the economic management system and transitioned from a planned economy to a market economy. In October 1981, the State Economic Commission established the State Administration of Nonferrous Metals in accordance with the instructions of the State Council, which was responsible for coordinating the development of the national nonferrous metals industry (according to the "Selected Economic Archives of the People's Republic of China·1981"). On September 25, 1982, the State Council issued the "Decision on Adjusting the Nonferrous Metals Management System" (Guofa [1982] No. 169), deciding to restructure the State Administration of Nonferrous Metals into a corporate legal person and establish China Nonferrous Metals Industry Corporation. On April 15, 1983, the State Council formally approved the "Report of the State Economic Commission on the Establishment of China Nonferrous Metals Industry Corporation" (Guo Jing [1983] No. 45), and the Nonferrous Metals Corporation was formally established and directly under the management of the State-owned Assets Supervision and Administration Commission of the State Council (SASAC). As a central enterprise, it is responsible for the production, trade and international cooperation of nonferrous metals.

The establishment of the Nonferrous Metals Company is closely related to the development of China's tungsten resources and the internationalization of the cemented carbide industry. In February 1983, the State Council issued the "Several Provisions on Expanding Foreign Economic and Technological Exchanges" (Guofa [1983] No. 28), requiring the Nonferrous Metals Company to pilot in special economic zones such as Shenzhen, Zhuhai, Shantou, and Xiamen, and granting local and corporate autonomy in import and export. To this end, the Nonferrous Metals Company established its first overseas branch in Hong Kong in June 1983, and subsequently established offices in Shenzhen, Zhuhai, and Xiamen, and representative offices in Japan, the United States, South Korea, Australia and other places, building a trade network that supports the internationalization of tungsten and cemented carbide products.

## 2. Organizational Structure

The organizational structure of the nonferrous metal company is designed around the management needs of the tungsten and cemented carbide industries. It is divided into a headquarters and subordinate units, covering production, trade and technological research and development (according to the "China Nonferrous Metals Industry Yearbook 1985"):

**The headquarters**

is located in Beijing and consists of:

Production Management Department: responsible for tungsten mining and cemented carbide production planning, and managing key tungsten mining projects across the country.

Import and Export Trade Department: Responsible for the export quota allocation and international market development of tungsten products and cemented carbide.

Technology R&D Department: Coordinate the introduction and development of tungsten and cemented carbide technologies.

Finance Department: Manages funds and costs.

Human Resources Department: responsible for personnel management.

**units**

involved in tungsten and cemented carbide include:

Zhuzhou Cemented Carbide Factory

The factory was established in 1954 and is affiliated to the Nonferrous Metals Company. It is the largest cemented carbide production base in my country, producing WC-Co cutting tools and wear-resistant materials.

Nanchang Cemented Carbide Factory

The factory was established in 1965 to produce tungsten carbide powder and cemented carbide products.

China National Nonferrous Metals Import & Export Corporation

Established in 1983, responsible for the export of tungsten and cemented carbide and the import of raw materials.

Tungsten Industry Technology R&D Center

It was established in 1988 in conjunction with the Institute of Metal Research, Chinese Academy of Sciences, to develop tungsten-based high-temperature alloys .

Overseas branches

Hong Kong branch (established in June 1983) is the main window for tungsten and cemented carbide exports, and representative offices in Japan, the United States, South Korea, and Australia support international trade.

**3. Tungsten resources and cemented carbide industry development**

Nonferrous metal companies dominate China's tungsten resource development and cemented carbide industry, relying on abundant tungsten reserves and advanced technology.

**Tungsten resource development**

China's tungsten reserves are about 2 million tons of tungsten trioxide equivalent, accounting for 47% of the world (ITIA 2023 data), and Jiangxi accounts for more than 60% of the country. In the 1980s , the nonferrous company integrated the Xihuashan tungsten mine in Jiangxi ( discovered in 1907, with a reserve of 200,000 tons), the Dajishan tungsten mine in Ganzhou (developed in 1958, with a reserve of 150,000 tons) and the Shizhuyuan tungsten polymetallic mine in Hunan ( developed in the 1980s ). In 1984, the "Sixth Five-Year Plan for the Nonferrous Metals Industry" (1981-1985) proposed that the annual mining volume of tungsten ore should be controlled within 35,000 tons to protect the sustainability of resources. In 1990, the annual output of tungsten concentrate by the nonferrous company's subsidiaries was about 30,000 tons, accounting for 70% of the country (National Bureau of Statistics 1990 Industrial Statistical Yearbook).

**Cemented carbide production**

Nonferrous metal companies promote the development of cemented carbide industry. In 1985, Zhuzhou Cemented Carbide Factory introduced Soviet powder metallurgy technology, and the cutting life of WC-6%Co cemented carbide tools produced was three times higher than that of high-speed steel (Technical Archives of China Nonferrous Metals Industry Association). In 1987, Nanchang Cemented Carbide Factory built a production line with an annual output of 500 tons of tungsten carbide powder, with an annual output value of about 80 million yuan ( Industrial Statistics of the National Bureau of Statistics in 1987). In 1990, the national cemented carbide output was about 15,000 tons, of which the subsidiaries of Nonferrous Metals Company contributed about 60% (Data from the National Bureau of Statistics in 1990). In 1988, the Technology Research and Development Center developed tungsten-based high-temperature alloys for use in launch vehicle engines.

**Import and export business management**

Nonferrous Metals Company is the main channel for the import and export of tungsten and cemented carbide. In June 1983, the State Council issued the "Notice on Adjusting the Regulations on the Export Administration of Nonferrous Metals" (Guofa [1983] No. 87), designating Nonferrous Metals Company to be responsible for quota management. In 1985, about 15,000 tons of tungsten products (hard alloy and tungsten wire) were exported, accounting for 85% of the country (Statistics of the General Administration of Customs in 1985), and the main markets were Japan (Mitsui & Co.), the United States (General Electric), and Canada (Noranda). In 1986, the Hong Kong branch registered with the London Metal Exchange, quoted tungsten products, and participated in the negotiations of the International Tungsten Agreement. In the early 1990s , about 500 tons of high-purity tungsten raw materials were imported annually to support the production of high-end cemented carbides (data from the Ministry of Commerce in 1992).

**Policy and technical support**

In 1988, the Technology Research and Development Center developed tungsten-based high-temperature alloys for use in the aerospace industry. In 1992, the "Measures for the Administration of Tungsten Industry" (State Economic and Trade [1992] No. 123) regulated mining and exports and restricted indiscriminate mining in small mines.

**4. Dissolution and inheritance**

On April 16, 1997, the State Council's "Decision on Deepening the Reform of State-owned Enterprises" (Guofa [1997] No. 5) promoted the reorganization of the Nonferrous Metals Company, and the high-quality assets were divested to form China Nonferrous Metals Construction (NFC). On November 20, 1997, China Nonferrous Metals Construction was listed (stock code: 000758) and took over the engineering business (China Nonferrous Metals Construction's official website www.nfc.com.cn). In October 2003, the State Council's "Guiding Opinions on the Reorganization of State-owned Enterprises" (Guofa [2003] No. 96) approved the dissolution of the Nonferrous Metals Company, and the tungsten and cemented carbide business was transferred to Jiangxi Tungsten Industry and China Minmetals Group, and the import and export management rights were returned to the Ministry of Commerce.

**5. Significance and Impact**

Nonferrous metal companies have promoted the transformation of China's tungsten and cemented carbide from a planned economy to a market economy. Their internationalization strategy has made tungsten exports account for 50% of the world's total (ITIA 1990 report). In 2023, the output of tungsten concentrate will be 114,000 tons, and the proportion of deep processing of cemented carbide will reach 40% (data from the National Bureau of Statistics in 2023), reflecting the industrial foundation they have laid.

# CTIA GROUP LTD

## 30 Years of Cemented Carbide Customization Experts

### Core Advantages

**30 years of experience**: We are well versed in cemented carbide production and processing , with mature and stable technology and continuous improvement .

**Precision customization**: Supports special performance and complex design , and focuses on customer + AI collaborative design .

**Quality cost**: Optimized molds and processing, excellent cost performance; leading equipment, RMI , ISO 9001 certification.

### Serving Customers

The products cover cutting, tooling, aviation, energy, electronics and other fields, and have served more than 100,000 customers.

### Service Commitment

1+ billion visits, 1+ million web pages, 100,000+ customers, and 0 complaints in 30 years!

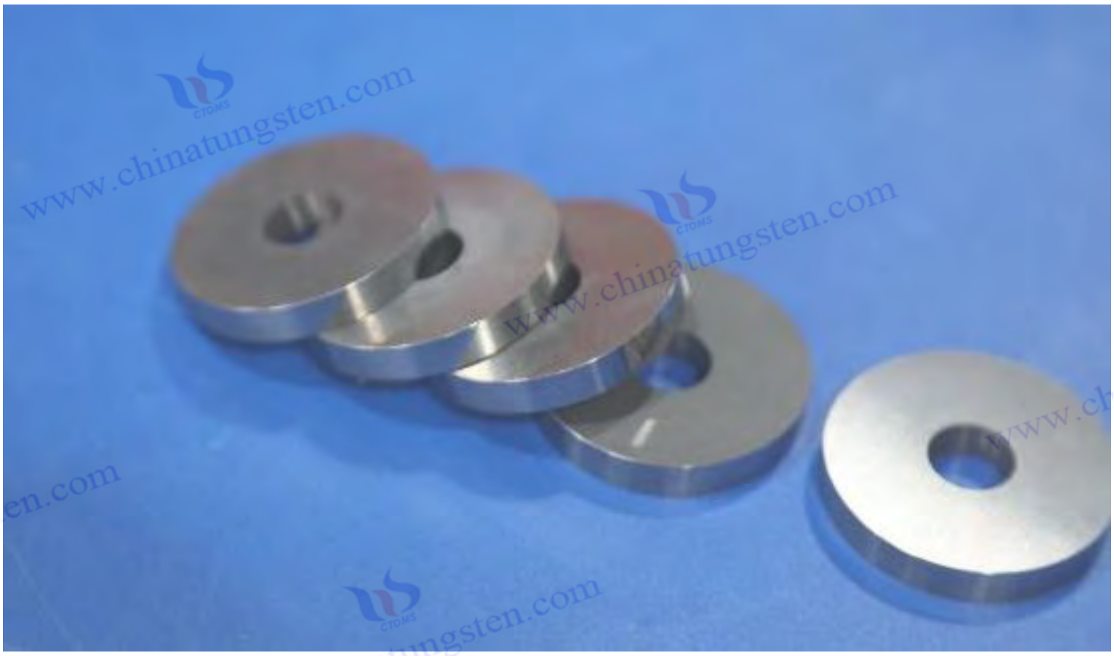
### Contact Us

**Email** : sales@chinatungsten.com

**Tel** : +86 592 5129696

Official **website** : www.ctia.com.cn

**WeChat** : Follow "China Tungsten Online"




**Appendix:**

**ISO 513:2012 Classification and application of hard cutting materials, edges for metal cutting - Designation of main categories and application categories**

Classification and application of hard cutting materials for metal removal with defined cutting edges — Designation of the main groups and groups of application

---

Chinese version of the international standard "ISO 513:2012"

Standard No.
ISO 513:2012

Standard Name (Chinese)
Classification and application of hard cutting materials, materials with defined cutting edges for metal cutting - Designation of main classes and application classes

Standard name (original English)
Classification and application of hard cutting materials for metal removal with defined cutting edges — Designation of the main groups and groups of application

Publishing Agency
International Organization for Standardization (ISO)
Technical Committee
ISO/TC 29/SC 9 (Technical Committee for Small Tools/Subcommittee on Hard Cutting Materials)

First release date


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

November 5, 2012

Current version status
Release Date: November 5, 2012

Last reviewed and confirmed: 2018
Current status: Currently in effect (as of May 20, 2025)

Languages
Official languages: English, French
Chinese translation: Unofficial language version (this document is translated from Chinese)

Scope of application
This International Standard specifies the classification and application of hard cutting materials for metal chip removal operations, including materials such as cemented carbide (hard metal), ceramics, diamond and cubic boron nitride, and identifies their main categories and application categories. This standard applies to tools with defined cutting edges for cutting operations of metallic materials.

Inapplicable scope:
Mining and other impact tools;
Wire drawing dies;
Tools for working by metal deformation;
Comparator contact and other uses.

Classification system
This standard divides hard cutting materials into main categories and application categories, which are as follows:

Main categories by material type:
Cemented carbide (hard metal, code: H): based on tungsten carbide (WC) or titanium carbide ( TiC ), combined with binders such as cobalt (Co) or nickel (Ni).
Ceramics (code: C): including aluminum oxide ( $Al_2O_3$ ) , silicon nitride ( $Si_3N_4$ ) , etc.
Diamond (code: D): includes natural diamond and synthetic polycrystalline diamond (PCD).
Cubic boron nitride (code: B): includes single crystal cubic boron nitride (CBN) and polycrystalline cubic boron nitride (PCBN).

Application categories (by processing purpose):
Category P (suitable for processing steel): such as ordinary steel, stainless steel, and alloy steel.
Class M (suitable for processing stainless steel and heat-resistant alloys): such as austenitic stainless steel and nickel-based alloys.
Class K (suitable for processing cast iron): such as gray cast iron and ductile iron.
Category N (suitable for processing non-ferrous metals): such as aluminum, copper and their alloys.


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

Category S (suitable for processing high-temperature alloys): such as titanium alloys and nickel-based high-temperature alloys.
Class H (suitable for machining hard materials): such as hardened steel (hardness > 45 HRC) and hard cast iron.

How to specify application category
Code structure: Each application category is represented by a combination of letters and numbers.
The letter indicates the type of material being processed (P, M, K, N, S, H).
The number indicates the level of cutting conditions or material properties (usually 01 to 50, with the larger the number, the more severe the cutting conditions or the harder the material).
Example: P10 means light-load cutting suitable for steel processing; K20 means medium-load cutting suitable for cast iron processing.
Combination example:
Carbide tools, codenamed "HM P20": indicate carbide (HM) material, suitable for medium-load cutting (20) of steel (P) processing.
Cubic boron nitride tool, code-named "BN H05": indicates cubic boron nitride (BN) material, suitable for light load cutting (05) of hard material (H) processing.

Purpose of the Standard
Unified classification: Provide a globally unified classification system for hard cutting materials, making it easier for manufacturers and users to choose appropriate cutting materials.
Application guidance: By specifying the main categories and application categories, it helps users select the most suitable hard cutting materials according to the processing materials and cutting conditions.
Promote trade: Standardize codes and classifications to promote international trade and technical exchanges of hard cutting materials.

Related standards
ISO 1832: A designation system for cutting tools used to specify tool geometry and material.
ISO 5608: Designation system for turning and milling tools.
ISO 9001: Quality management system standard (as related to the production of hard cutting materials).

Usage scenarios
This standard is widely used in the machining industry, including but not limited to:
Automobile manufacturing: processing engine parts, crankshafts, gears, etc.
Aerospace: Processing high-temperature alloy and titanium alloy parts.
Mould manufacturing: machining hardened steel moulds .
General machinery: processing cast iron and nonferrous metal parts.

How to get it
Official source: PDF or paper versions are available for purchase in English or French from the ISO


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

official website (www.iso.org).
Other channels: Obtain through authorized distributors such as ANSI (American National Standards Institute), BSI (British Standards Institution), etc.
Note: Some countries and regions may provide translated versions, but the accuracy of the translated versions must be ensured.

History
ISO 513:2004: Previous version, published in 2004 and superseded by the current version in 2012.
ISO 513:1991: An earlier version, published in 1991 and superseded in 2004.

Additional Notes
This standard does not involve the specific performance parameters of hard cutting materials (such as hardness, bending strength, etc.). Users need to make choices based on the data provided by the material supplier.
The application category code of this standard needs to be used in conjunction with cutting conditions (such as cutting speed, feed rate, cooling method) to ensure the best machining results.

---

in conclusion
ISO 513:2012 provides a globally unified specification for the classification and application of hard cutting materials, covering a variety of materials such as cemented carbide, ceramics, diamond and cubic boron nitride, and is suitable for a variety of metal cutting scenarios. Through a clear code system, users can quickly select suitable cutting materials to improve processing efficiency and tool life. This standard is of great significance in the machining industry and promotes the standardization and international application of hard cutting materials.

---

Additional Notes
The above content is based on information from the ISO official website and other standard databases to ensure accuracy and authority.
The Chinese names and some descriptions are translated and edited, not the official Chinese version of ISO, and are for reference only.
If you need to obtain the original text of the standard or more detailed information, it is recommended to visit the ISO official website or contact an authorized distributor.


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

# CTIA GROUP LTD
## 30 Years of Cemented Carbide Customization Experts

### Core Advantages

**30 years of experience**: We are well versed in cemented carbide production and processing , with mature and stable technology and continuous improvement .

**Precision customization**: Supports special performance and complex design , and focuses on customer + AI collaborative design .

**Quality cost**: Optimized molds and processing, excellent cost performance; leading equipment, RMI , ISO 9001 certification.

### Serving Customers

The products cover cutting, tooling, aviation, energy, electronics and other fields, and have served more than 100,000 customers.

### Service Commitment

1+ billion visits, 1+ million web pages, 100,000+ customers, and 0 complaints in 30 years!

### Contact Us

**Email** : sales@chinatungsten.com
**Tel** : +86 592 5129696
**Official website** : www.ctia.com.cn
**WeChat** : Follow "China Tungsten Online"

Classification and Application of Hard Cutting Materials for Metal Removal with Defined Cutting Edges — Designation of the Main Groups and Groups of Application

Classification and application of hard cutting materials, materials with defined cutting edges for metal cutting

- Designation of main categories and application categories

---

International Standard *ISO 513:2012* (English Version)

Standard Number
ISO 513:2012

Standard Title (English)
Classification and application of hard cutting materials for metal removal with defined cutting edges — Designation of the main groups and groups of application
Standard Title (Translated to Chinese for Reference)
Classification and application of hard cutting materials, materials with defined cutting edges for metal cutting - Designation of main classes and application classes

Publishing Organization
International Organization for Standardization (ISO)
Technical Committee
ISO/TC 29/SC 9 (Technical Committee for Small Tools / Subcommittee for Hard Cutting Materials)


电话/TEL：0086 592 512 9696

sales@chinatungsten.com

First Publication Date
November 5, 2012

Current Version Status
Publication Date: November 5, 2012

Last reviewed and confirmed: 2018
Current Status: Active (as of May 20, 2025)

Language Versions
Official Languages: English, French
Other Languages: Non-official translations may be available in certain regions (eg, Chinese, as referenced above)

Scope
This International Standard specifies the classification and application of hard cutting materials used for metal removal with defined cutting edges, including hardmetals (carbides), ceramics, diamond, and cubic boron nitride. It designates the main groups and groups of application for these materials. The standard applies to tools with defined cutting edges used for cutting metallic materials.

Exclusions:
Tools for mining or other impact applications;
Wire-drawing dies;
Tools used for metal forming by deformation;
Applications such as comparator contact tips or other non-cutting uses.
Classification System
The standard classifies hard cutting materials into main groups and groups of application as follows:

Main Groups (Based on Material Type):
Hardmetals (Code: H): Based on tungsten carbide (WC) or titanium carbide ( TiC ) with cobalt (Co) or nickel (Ni) as binders.
Ceramics (Code: C): Includes aluminum ( $Al_2O_3$ ), silicon nitride ( $Si_3N_4$ ), etc.
Diamond (Code: D): Includes natural diamond and polycrystalline diamond (PCD).
Cubic Boron Nitride (Code: B): Includes single-crystal cubic boron nitride (CBN) and polycrystalline cubic boron nitride (PCBN).

Groups of Application (Based on Machining Use):
P Group (For machining steel): Includes plain steel, stainless steel, and alloy steel.
M Group (For machining stainless steel and heat-resistant alloys): Includes austenitic stainless steel, nickel-based alloys.
K Group (For machining cast iron): Includes gray cast iron, ductile cast iron.
N Group (For machining non-ferrous metals): Includes aluminum, copper, and their alloys.

S Group (For machining high-temperature alloys): Includes titanium alloys, nickel-based superalloys.
H Group (For machining hard materials): Includes hardened steel (>45 HRC), hard cast iron.

Designation Method for Groups of Application
Code Structure: Each application group is represented by a letter and number combination.
The letter indicates the type of material to be machined (P, M, K, N, S, H).
The number indicates the cutting condition or material performance level (typically from 01 to 50; higher numbers indicate more demanding conditions or harder materials).
Example: P10 indicates suitability for light-load cutting of steel; K20 indicates suitability for medium-load cutting of cast iron.

Combination Examples:
Hardmetal tool, code "HM P20": Indicates a hardmetal (HM) material suitable for medium-load cutting (20) of steel (P).
Cubic boron nitride tool, code "BN H05": Indicates a cubic boron nitride (BN) material suitable for light-load cutting (05) of hard materials (H).

Purpose of the Standard
Unified Classification: Provides a globally recognized classification system for hard cutting materials, facilitating selection by manufacturers and users.
Application Guidance: Assists users in selecting the most appropriate cutting material based on the material being machined and cutting conditions.
Trade Facilitation: Standardizes codes and classifications to promote international trade and technical exchange of hard cutting materials.

Related Standards
ISO 1832: Designation system for cutting tools, specifying tool geometry and material.
ISO 5608: Designation system for turning and milling tools.
ISO 9001: Quality management system standard (relevant to hard cutting material production).

Usage Scenarios
This standard is widely applied in the machining industry, including but not limited to:
Automotive Manufacturing: Machining engine components, crankshafts, gears, etc.
Aerospace: Machining high-temperature alloys and titanium alloys.
Mold Making: Machining hardened steel molds.
General Machinery: Machining cast iron and non-ferrous metal components.
Availability
Official Source: Available for purchase in PDF or paper format from the ISO official website ( www.iso.org ).
Other Channels: Available through authorized distributors such as ANSI (American National Standards Institute), BSI (British Standards Institution), etc.

Note: Some regions may provide translated versions, but accuracy should be verified against the official English or French versions.

Historical Versions

ISO 513:2004: Previous version, published in 2004, superseded by the 2012 version.

ISO 513:1991: Earlier version, published in 1991, superseded by the 2004 version.

Additional Notes

This standard does not specify performance parameters of hard cutting materials (eg, hardness, bending strength). Users should refer to material supplier data for detailed specifications.

Application group codes should be used in conjunction with cutting conditions (eg, cutting speed, feed rate, cooling method) to ensure optimal machining performance.

---

Conclusion

*ISO 513:2012* provides a globally standardized framework for the classification and application of hard cutting materials, covering hardmetals, ceramics, diamond, and cubic boron nitride. It is applicable to a wide range of metal cutting scenarios. By offering a clear designation system, the standard enables users to efficiently select suitable cutting materials, improving machining efficiency and tool life. This standard plays a significant role in the machining industry, promoting standardization and international application of hard cutting materials.

---

Supplementary Notes

The content is compiled based on information from the ISO official website and standard databases, ensuring accuracy and authenticity.

The Chinese translation provided earlier is for reference only and is not an official ISO version.

For the original standard text or further details, it is recommended to visit the ISO official website or contact an authorized distributor.

# CTIA GROUP LTD

## 30 Years of Cemented Carbide Customization Experts

### Core Advantages

**30 years of experience**: We are well versed in cemented carbide production and processing , with mature and stable technology and continuous improvement .

**Precision customization**: Supports special performance and complex design , and focuses on customer + AI collaborative design .

**Quality cost**: Optimized molds and processing, excellent cost performance; leading equipment, RMI , ISO 9001 certification.

### Serving Customers

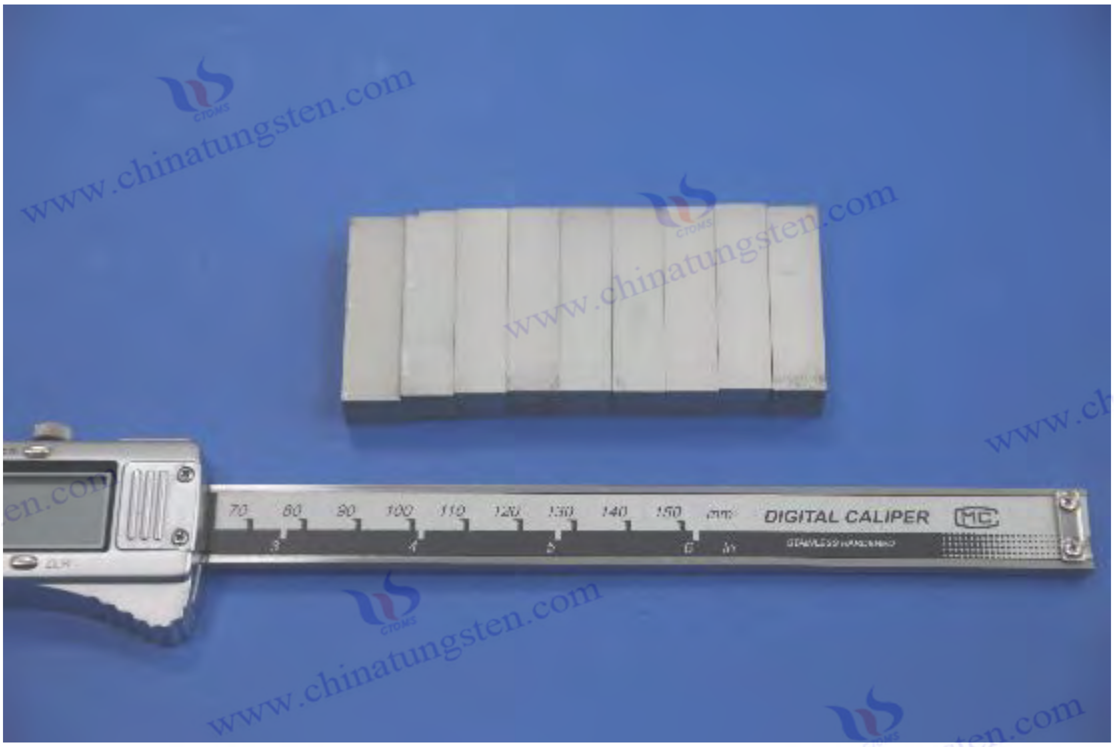
The products cover cutting, tooling, aviation, energy, electronics and other fields, and have served more than 100,000 customers.

### Service Commitment

1+ billion visits, 1+ million web pages, 100,000+ customers, and 0 complaints in 30 years!

### Contact Us

**Email** : sales@chinatungsten.com
**Tel** : +86 592 5129696
**Official website** : www.ctia.com.cn
**WeChat** : Follow "China Tungsten Online"




## Appendix:

### Comparison of cemented carbide, high speed steel and superhard materials

### 1. Definition and composition

| Material Type | definition | Main Ingredients |
|---|---|---|
| Cemented Carbide<br>Hardmetal /Cemented Carbide | A composite material sintered from hard carbide particles and metal binder, with high hardness and strong wear resistance. | Hard phase: tungsten carbide (WC, 7095%), titanium carbide ( TiC ), tantalum carbide ( TaC ). < br >Binder phase: cobalt (Co, 515%), nickel (Ni). |
| High Speed Steel<br>HighSpeed Steel, HSS | High alloy tool steel containing carbon and various alloying elements, suitable for high-speed cutting and good toughness. | Iron-based alloy: carbon (C, 0.71.5%), tungsten (W, 618%), molybdenum (Mo, 510%), chromium (Cr, 4%), vanadium (V, 15%), and cobalt (Co, 08%). |
| Superhard materials<br>Superhard Materials | Materials with hardness close to or exceeding that of natural diamond are used for high-precision or extreme processing. | Natural diamond, synthetic diamond (PCD), cubic boron nitride (CBN), ceramics (such as Si3N4, Al2O3). |

Data support:

Cemented carbide: WC hardness ~16002200 HV, cobalt content affects toughness (ScienceDirect, 2020).

High-speed steel: Typical grades include M2 (W6Mo5Cr4V2), hardness ~6065 HRC (ASTM A600).

Superhard materials: Diamond hardness ~800010000 HV, CBN ~4500 HV (Wikipedia, 2024).

## 2. Performance comparison

| performance | Cemented Carbide | High Speed Steel | Superhard materials |
|---|---|---|---|
| hardness | High (14002200 HV), second only to superhard materials, with excellent wear resistance. | Medium (6065 HRC, about 700850 HV), lower than cemented carbide. | Very high (400010000 HV), most wear-resistant, suitable for extreme conditions. |
| toughness | Medium, high cobalt content (such as 1015%) has good toughness, but is prone to chipping . | High, strong impact resistance, suitable for complex cutting. | Low, easy to be brittle, and requires matrix support (such as PCD attached to cemented carbide). |
| Heat resistance | Good (8001000°C), suitable for high temperature cutting. | Medium (500-600°C), hardness decreases at high temperatures. | Excellent (diamond ~700°C, CBN ~1400°C), CBN has particularly good heat resistance. |
| Corrosion resistance | Better, cobalt phase is corrosion resistant, acid and alkali resistant. | Generally, it is easy to oxidize and needs coating protection. | Excellent, high chemical stability of diamond/CBN. |
| Cutting speed | High (100500 m/min), suitable for efficient processing. | Medium (30100 m/min), lower than carbide. | Very high (500-2000 m/min), suitable for ultra-high speed machining. |

Data support:

Cemented carbide: Cutting speed is 35 times higher than high-speed steel (Sandvik, 2023).

High-speed steel: After heat treatment, the hardness can reach 65 HRC, but it softens above 600°C (ScienceDirect, 2020).

Superhard materials: CBN cutting speed of high temperature alloys can reach 1000 m/min (Wikipedia, 2024).

## 3. Manufacturing process

| Material Type | Manufacturing process | Features |
|---|---|---|
| Cemented Carbide | Powder metallurgy: Mix carbide powder (WC, TiC ) and cobalt powder , press molding, and high temperature sintering (13501450°C). | The process is mature, the grain size is controllable (0.52 μm ), and the cobalt content can adjust the performance. |
| High Speed Steel | Melting, casting, heat treatment (quenching + tempering), and can be formed by forging and rolling. | Requires precise heat treatment (such as 1200°C quenching) and can be repeatedly ground. |
| Superhard materials | High-pressure and high-temperature synthesis (HPHT, 5000°C, 5 GPa , such as PCD, CBN), chemical vapor deposition (CVD, diamond coating). | The process is complex, the cost is high, and it requires support from a substrate (such as cemented carbide). |

Data support:

Cemented carbide: sintering time is 12 hours, grain size affects coercivity (ISO 3326:2013).

High-speed steel: Heat treatment process is repeatable and improves tool life (ASTM A600).

Superhard materials: HPHT synthesis consumes a lot of energy, and the CVD coating thickness is 520 μm (ScienceDirect, 2020).

## 4. Application areas

| Material Type | Main Applications | Typical scenarios |
|---|---|---|
| Cemented Carbide | Cutting tools (turning tools, milling cutters), dies, drill bits, mining tools. | Processing steel, cast iron, stainless steel; such as YG8 tools for rough processing. |
| High Speed Steel | Drill bits, milling cutters, taps, saw blades, and tools for complex shapes. | Low-speed cutting, processing soft materials (such as aluminum, copper); such as M2 drill bits. |
| Superhard materials | Precision machining tools, abrasive tools, wire drawing dies, wear-resistant coatings. | Processing of high temperature alloys, ceramics, and composite materials; such as using CBN tools to process aviation parts. |

Data support:

Cemented carbide: accounts for ~50% of the global tool market.

High-speed steel: low cost, accounting for ~30% of the low-end tool market.

Superhard materials: high-end market, PCD/CBN tools are used in aerospace .

## 5. Comparison of advantages and disadvantages

| Material Type | advantage | shortcoming |
|---|---|---|
| Cemented Carbide | High hardness, strong wear resistance. Good heat resistance, suitable for high-speed cutting. Adjustable performance (cobalt content, grain size). | The toughness is lower than that of high-speed steel, and the edge is easy to break . The cost is higher than that of high-speed steel. It is not suitable for low-speed and high-impact processing. |
| High Speed Steel | High toughness, strong impact resistance. Repeatable grinding, low cost. Easy to process complex shape tools. | Low hardness and heat resistance. Slow cutting speed and low efficiency. Easy to wear and need frequent replacement. |
| Superhard materials | Extremely high hardness and long life. Suitable for ultra-high speed and precision machining. High chemical stability and corrosion resistance. | Highly brittle and prone to chipping. Extremely expensive to manufacture. Not suitable for machining ferrous metals (diamond). |

Data support:

Cemented carbide: Tool life is 510 times longer than high-speed steel (Sandvik, 2023).

High-speed steel: The cost is only 20-30% of that of cemented carbide ().

Superhard materials: CBN tool life can reach 1050 times that of cemented carbide (Wikipedia, 2024).

## 6. Cost and Economics

| Material Type | cost | Economical |
|---|---|---|
| Cemented Carbide | Medium ($50,100 per kg). | High cost performance, suitable for mid-to-high-end processing, long life and reduced replacement frequency. |
| High Speed Steel | Low ($520 per kg). | Suitable for low-cost, small-batch processing, but high maintenance cost (grinding is required). |
| Superhard materials | High ($1,000-5,000 per kg). | Suitable for high-end, precision machining, with high initial cost but extremely long life. |

**7. Select suggestions**

Cemented carbide: suitable for medium and high speed cutting, general processing (steel, cast iron, stainless steel), balanced hardness and toughness, widely used in industrial production.
High-speed steel: suitable for low-speed cutting, soft material processing (aluminum, copper) or complex tools (taps, forming tools), and is preferred when the budget is limited.
Superhard materials: suitable for ultra-high speed and precision machining (high temperature alloys, ceramics, composite materials), such as aerospace and automotive parts, which require high precision and long life.
Example:
Machining cast iron: carbide (YG6) tool, speed 150 m/min, life 23 hours.
Processing aluminum alloy: high-speed steel (M2) drill bit, speed 50 m/min, low cost.
Processing titanium alloy: CBN blade, speed 800 m/min, life 10 hours.

---

**In conclusion**

Cemented carbide, high-speed steel and super-hard materials each have their own advantages and are suitable for different processing scenarios:
Hardmetal /Cemented Carbide: High hardness, wear resistance, suitable for medium and high speed cutting, high cost performance, and is the mainstay of the industry .
High-speed steel (HSS): high toughness, low cost, suitable for low-speed machining and complex tools, but poor heat resistance.
Superhard materials (PCD/CBN): extremely high hardness and life, suitable for precision and high-speed machining, but high cost and high brittleness.
The selection should be based on the processing material (steel, aluminum, ceramic), cutting speed, precision requirements and budget. Carbide is a general choice, high-speed steel is suitable for low-cost scenarios, and superhard materials are for high-end needs.

**Reference data:**

Hardness: cemented carbide 14002200 HV, high-speed steel 700850 HV, superhard materials 400010000 HV (ScienceDirect, 2020).
Standard: ISO 3326, ASTM B886, GB/T 3849 (hard alloy magnetic saturation test).
Market: Carbide accounts for ~50% of the tool market, and superhard materials account for ~10% (Sandvik, 2023).

# CTIA GROUP LTD
## 30 Years of Cemented Carbide Customization Experts

### Core Advantages
**30 years of experience**: We are well versed in cemented carbide production and processing , with mature and stable technology and continuous improvement .
**Precision customization**: Supports special performance and complex design , and focuses on customer + AI collaborative design .
**Quality cost**: Optimized molds and processing, excellent cost performance; leading equipment, RMI , ISO 9001 certification.

### Serving Customers
The products cover cutting, tooling, aviation, energy, electronics and other fields, and have served more than 100,000 customers.

### Service Commitment
1+ billion visits, 1+ million web pages, 100,000+ customers, and 0 complaints in 30 years!

### Contact Us
**Email** : sales@chinatungsten.com
**Tel** : +86 592 5129696
Official **website** : www.ctia.com.cn
**WeChat** : Follow "China Tungsten Online"


**Appendix:**

## What is Tungsten Carbide ?

### 1. What is tungsten steel?

Tungsten steel is a high alloy steel with tungsten (W) as the main alloying element. The tungsten content is usually 3–18% (mass fraction), supplemented by carbon (C, 0.5–1.5%), chromium (Cr, 1–5%), molybdenum (Mo, 0.5–5%), vanadium (V, 0.5–2%) and other elements. It is a metal alloy made by smelting, forging, rolling and heat treatment processes. It is known for its high hardness (HV600–1000), excellent wear resistance, good red hardness (maintaining hardness at high temperature, ≤700°C) and high toughness ( $K_{1}c$ 20–50 MPa·m ^(1/2)), and is widely used in cutting tools, molds, knives, wear-resistant parts and military fields .

**Tungsten Steel and Cemented Carbide**

Cemented carbide is a composite material made of carbides such as tungsten carbide (WC) as a matrix, bonded with cobalt (Co) or nickel (Ni) through a powder metallurgy process. It has a higher hardness (HV1000–1800) but lower toughness. Tungsten steel is a homogeneous metal alloy. Tungsten exists in the iron (Fe) matrix in the form of solid solution or carbide (such as WC, W2C). It has better toughness and machinability, and the cost is about 1/3 of cemented carbide. Tungsten steel is also often regarded as a subcategory of high-speed steel (HSS), but its tungsten content and performance are more extensive.

According to the market forecast for 2025, the tungsten steel market will be worth about RMB 22 billion, accounting for 16% of the alloy steel market, with a compound annual growth rate (CAGR)


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

of about 5.2%. The main driving factors include the growth in demand for industrial manufacturing, automotive molds, new energy equipment and medical knives.

## 2. Types and characteristics of tungsten steel

Tungsten steel can be divided into many types according to tungsten content, alloying elements and application, each type is optimized for specific performance. The following are the main types and their characteristics, organized into a table for clear presentation:

| Tungsten steel type | Typical grades | Main Ingredients | Hardness (HV) | Toughness ( $K_{IC}$ , MPa ·m ^(1/2) ) | Red hardness(°C) | Abrasion resistance (ASTM G65, mm³ ) | Typical Applications |
|---|---|---|---|---|---|---|---|
| High speed tungsten steel | T1, M2, M35 | W 6–12%, Cr 3–5%, V 1–2%, Mo 0.5–5%, C 0.7–1.2% | 800–900 | 25–40 | ≤650 | 20–40 | Cutting tools (such as milling cutters, drill bits) |
| Mold tungsten steel | D2, A2, H13 | W 5–10%, Cr 4–6%, Mo 1–3%, C 1–1.5% | 700–850 | 30–50 | ≤600 | 30–50 | Cold stamping die, hot forging die |
| Super Hard Tungsten Steel | PM-M4, ASP23 | W 9–18%, Cr 3–5%, V 1–3%, C 0.8–1.3% | 900–1000 | 20–30 | ≤700 | <30 | High-precision tools, complex molds |
| Corrosion resistant tungsten steel | 440C, Medical Tungsten Steel | W 5–10%, Cr 10–15%, Ni 1–3%, C 0.5–1% | 700–850 | 25–40 | ≤600 | 30–50 | Medical knives, chemical equipment |
| Military tungsten steel | Armor-piercing core alloy | W 10–18%, Cr 3–5%, Mo 1–5%, C 0.8–1.2% | 800–950 | 20–35 | ≤650 | 20–40 | Armor-piercing cores, armor parts |
| Powder Metallurgy Tungsten Steel | ASP60, Vanadis 4 Extra | W 6–12%, Cr 3–5%, V 1–3%, C 0.7–1.2% | 900–1000 | 25–35 | ≤700 | <30 | High-end cutting tools, precision molds |

illustrate:

Main ingredients: List the content range of tungsten (W) and other key alloying elements (Cr, Mo,

V, C).
Performance parameters: hardness (Vickers hardness HV), toughness (fracture toughness $K_{1c}$), red hardness (high temperature hardness holding temperature), wear resistance (ASTM G65 wear volume).
Typical applications: covering cutting tools, molds, knives, wear-resistant parts, and military industry. Only Chinese descriptions are retained.

## 3. Chemical composition and microstructure of tungsten steel

### 3.1 Chemical composition

Typical compositions of tungsten steel include:
Tungsten (W): 3–18%, exists in the form of solid solution or carbide (such as WC, $W_2C$), improves hardness and red hardness.
Carbon (C): 0.5–1.5%, forms carbides (WC, $Cr_3C_2$), enhancing wear resistance.
Chromium (Cr): 1–15%, improves corrosion resistance and oxidation resistance.
Molybdenum (Mo): 0.5–5%, enhances high temperature strength.
Vanadium (V): 0.5–2%, refines grains (size 5–20 μm) and improves toughness.
Iron (Fe): Matrix, 60–80%, provides toughness and machinability.
Others: Co, Ni (in medical tungsten steel) improve toughness and corrosion resistance.

### 3.2 Microstructure

Matrix: After quenching, it is martensite (hardness HV400-600), and after tempering, it is tempered martensite + residual austenite, and the toughness is increased by 10-20%.
Carbide phase: WC, $W_2C$, $Cr_3C_2$ particles (1–10 μm), hardness HV1500–2000, volume fraction 5–15%.
Crystal structure: Martensite is body-centered cubic (BCC), and carbide is hexagonal (WC) or orthorhombic ($Cr_3C_2$) crystal system.
Characterization: X-ray diffraction (XRD) showed the (111) and (200) crystal planes of WC, and scanning electron microscopy (SEM) observed the uniformity of carbide distribution (segregation <5%).
The microstructure is optimized by heat treatment: quenching (850–950°C) forms hard martensite, tempering (200–600°C) relieves stresses, and carbide precipitation strengthens the matrix.

## 4. Development history of tungsten steel

The development of tungsten steel is closely related to the industrial revolution and modern manufacturing. The following are key milestones:

**Late 19th century (1860s–1890s)**
Background: The Industrial Revolution required highly wear-resistant tool materials, but early tool

steels were not hard enough (HV200–300).
Breakthrough: In 1868, British metallurgist Robert Mushet first added tungsten to steel and developed "self-hardening steel" (Mushet Steel) containing 2-3% tungsten, with a hardness of HV400 and a wear resistance twice as high, for use in lathe tools.
Limitations: Low tungsten content, insufficient red hardness (<400°C).

**Early 20th century (1900s–1920s)**
The birth of high-speed steel: In 1900, Taylor and White of the United States developed high-speed steel (T1) containing 7% tungsten, with a hardness of HV600–700 , red hardness ≤600°C, and a cutting speed increased by 3 times, laying the foundation for tungsten steel.
Industrial application: In the 1910s, tungsten steel cutting tools were widely used in automobile manufacturing (such as the Ford Model T production line), increasing efficiency by 50%.
Key events: 1914-1918, World War I demand drives tungsten mining (China, Portugal), tungsten prices rise to $10/kg.

**Mid-20th century (1930s–1960s)**
Alloy optimization: In the 1930s, Cr, Mo and V were added to develop grades such as M2 (6% W) and D2 (8% W), with hardness of HV700-850 and toughness increased by 20%.
Heat treatment technology: In the 1940s, the quenching + multi-stage tempering process was mature, reducing internal stress by 30% and extending the mold life by 2 times.
Military application: During World War II, tungsten steel was used in armor-piercing bullet cores (containing 12% W), increasing penetration by 30%.
Powder metallurgy: In the 1960s, the grain size of powder metallurgy tungsten steel (such as PM-M4) was refined to <10μm, the hardness was HV900, and the wear resistance was increased by 40%.

**Late 20th century (1970s–1990s)**
Coating technology: In the 1980s, PVD/CVD deposited TiN and TiAlN coatings (thickness 2–5 μm) reduced the friction coefficient to <0.4 and extended tool life by 3–5 times.
Superhard tungsten steel: 1990s, ASP23, ASP60 and other grades with hardness HV950-1000, challenging the low-end market of cemented carbide.
Medical field: Medical tungsten steel containing 6-8% tungsten is used in surgical knives, and its corrosion resistance is increased by 50%.

**21st century (2000s–2025)**
Nano-strengthening: In the 2010s, nano-carbide (<0.5μm) reinforced tungsten steel has a hardness close to HV1000 and wear resistance increased by 30%.
Green manufacturing: In the 2020s, recycling tungsten steel (recycling rate > 85%) will reduce costs by 20% and carbon footprint by 30%.
Emerging applications: By 2025, the demand for tungsten steel in new energy vehicle molds (lifespan extended by 40%), wind power gears (wear resistance increased by 2 times) and geothermal drilling (high temperature resistance > 600°C) will surge.
Intelligence: AI optimizes heat treatment parameters (error <3%), increasing production efficiency


电话/TEL：0086 592 512 9696

sales@chinatungsten.com

by 25%.

## 5. Uses of tungsten steel

Tungsten steel is widely used in the following fields due to its high hardness, red hardness and toughness. The specific uses and cases are presented in the table:

| use | Typical products | Brand | Hardness (HV) | Key Performance | Typical Applications | Case |
|---|---|---|---|---|---|---|
| Cutting Tools | Milling cutter, drill bit | M2 | 850 | Red hardness ≤650°C, wear volume 20–40 $mm^3$ | Processing steel and aluminum alloy | Sandvik M2 milling cutter, processing aviation aluminum alloy, efficiency increased by 25%, the cost is 40% of cemented carbide |
| Mold manufacturing | Cold stamping die, hot forging die | D2 | 800 | Wear life 1.5 million times | Stamping Auto Parts | Zhuzhou Diamond D2 punch, stamping steel plate, life span 1.5 million times |
| Knives and Cutting Tools | Scalpel, scissors | 440C | 900 | Corrosion resistance (weight loss <0.2 mg/ $cm^2$ ) | Orthopedic surgery, industrial cutting | Aichi Steel scalpel, cutting accuracy ±0.005 mm, corrosion resistance increased by 50% |
| Wear-resistant parts | Pump shaft, bearing sleeve | Alloy containing 8%W | 750 | Wear <50 $mm^3$ | Marine engineering, chemical equipment | China First Heavy Industries pump shaft, wear resistance life doubled |
| Military | Armor-piercing core | Alloy containing 15%W | 900 | Penetration: 600 mm armor | Armor-piercing projectiles, armor parts | US M829A4 core, penetration increased by 20% |
| New Energy | Geothermal drill bits, wind power gears | Alloy containing 8%W | 850 | High temperature resistance>600°C | Geothermal drilling, wind power equipment | Epiroc geothermal drill bit, 15% more efficient |
| Medical and precision manufacturing | Dental drill bits, micro cutters | Contains 6%W medical tungsten steel | 850–900 | Accuracy ±0.01 mm, corrosion resistant | Dental surgery, precision machining | Zhuzhou diamond dental drill bit, wear resistance increased by 3 times, exports to EU increased by 25% in 2024 |

illustrate:
Application: Covering cutting tools, molds, cutting tools, wear-resistant parts, military industry, new energy, medical treatment, and extracting quantitative data.

Case: Each use corresponds to a specific case, listing data such as performance improvement and cost comparison, and only retaining Chinese descriptions.

**6. Similarities and differences between tungsten steel and high-speed steel**

Tungsten steel and high-speed steel overlap in composition and application, but there are significant differences. The following table compares their similarities and differences:

| characteristic | Tungsten steel | High Speed Steel (HSS) |
|---|---|---|
| definition | A broad range of high alloy steels containing 3–18% tungsten, covering a wide range of uses | A sub-category of tungsten steel, containing 6–12% tungsten, designed for high-speed cutting |
| Typical grades | D2, H13, 440C, PM-M4 | T1, M2, M35, M42 |
| Main Ingredients | W 3–18%, Cr 1–15%, Mo 0.5–5%, V 0.5–2%, C 0.5–1.5% | W 6–12%, Cr 3–5%, Mo 0.5–5%, V 1–2%, C 0.7–1.2% |
| Hardness (HV) | 600–1000 | 800–900 |
| Toughness ( $K_{IC}$ , MPa ·m ^(1/2) ) | 20–50 | 25–40 |
| Red hardness(°C) | ≤700 | ≤650 |
| Corrosion resistance | Some grades are excellent (such as 440C, salt spray weight loss <0.2 mg/ cm² ) | General (low Cr content) |
| Manufacturing process | Melting, forging, heat treatment; some powder metallurgy | Melting, forging, heat treatment |
| Cost (USD/kg) | 10–50 | 15–30 |
| Typical Applications | Cutting tools, molds, wear-resistant parts, military industry, medical | Cutting tools (such as drills, milling cutters) |

illustrate:
Similarities: Both are high-alloy steels containing tungsten, Cr, Mo, V, etc., using smelting and heat treatment processes, suitable for cutting and molds.
Differences: Tungsten steel has a wider range (including high-speed steel, die steel, etc.) and diversified applications; high-speed steel is optimized for high-speed cutting, and its red hardness and corrosion resistance are slightly inferior.
Case comparison:
High-speed steel: M2 drill bit (6%W), hardness HV850, for processing low-carbon steel, with a service life 5 times that of ordinary steel.
Tungsten steel: D2 die (8% W), hardness HV800, stamping stainless steel, life span up to 1 million times.

**7. Similarities and differences between tungsten steel and cemented carbide**

Both tungsten steel and cemented carbide use tungsten as the key element, but their material properties and applications are significantly different. The following table compares their


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

similarities and differences:

| characteristic | Tungsten steel | Cemented Carbide |
|---|---|---|
| definition | High alloy steel, containing 3–18% tungsten, homogeneous metal alloy | Carbide-based composites, containing 70–94% WC etc. + Co/Ni |
| Main Ingredients | W 3–18%, Cr 1–15%, Mo 0.5–5%, V 0.5–2%, C 0.5–1.5%, Fe base | WC, TiC , TaC (70–94%), Co/Ni (6–20%) |
| structure | Martensite + carbide particles (WC, Cr3C2) | Carbide particles + binder phase |
| Hardness (HV) | 600–1000 | 1000–1800 |
| Toughness ( $K_{IC}$ , MPa ·m ^(1/2) ) | 20–50 | 8–20 |
| Red hardness(°C) | ≤700 | ≤1000 |
| Corrosion resistance | Some grades are excellent (such as 440C, salt spray weight loss <0.2 mg/ cm² ) | Ni-based (such as YN8, weight loss <0.1 mg/ cm² ) |
| Density(g/ cm³ ) | 7.8–8.5 | 12–15.6 |
| Manufacturing process | Melting, forging, heat treatment; some powder metallurgy | Powder metallurgy (mixing, pressing, sintering) |
| Cost (USD/kg) | 10–50 | 50–150 |
| Typical Applications | Cutting tools, molds, military, medical, wind power gears | High-precision tools, mining picks, spray materials |

illustrate:

Similarities: Both contain tungsten, and have better hardness and wear resistance than ordinary steel, making them suitable for knives and wear-resistant parts.

Differences: Tungsten steel is a metal alloy with high toughness and low cost; cemented carbide is a composite material with high hardness but also high brittleness .

Case comparison:

Tungsten steel: M2 milling cutter (6%W), hardness HV850, processing aluminum alloy, the cost is 40% of cemented carbide.

Carbide: YG6 blade (WC base, 6% Co), hardness HV1500, processing stainless steel, life is 3 times that of tungsten steel.

## 8. Manufacturing process of tungsten steel

Tungsten steel is prepared by traditional metallurgical process, the process flow is as follows:

**Raw materials preparation:**

Tungsten: Added in the form of ferrotungsten ( FeW , containing 70–80% W) or tungsten powder , with a purity of >99.5%.

Other elements: Cr, Mo, V in the form of ferroalloy, C added in the form of graphite.

Mixing: Vacuum melting furnace ensures composition homogeneity (deviation < 0.5%).


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

**Smelting:**
Equipment: Electric arc furnace or medium frequency induction furnace, melting temperature 1500–1600°C.
Process: deoxidation and desulfurization, control the oxygen content to <50 ppm and the sulfur content to <0.02%.

**Casting and forming:**
Continuous casting: forming ingots with dimensional deviation <1%.
Hot forging/rolling: 1000–1200°C, grain refinement to 5–20μm, strength increase by 15%.

**Heat Treatment:**
Quenching: 850–950°C, water/oil cooling, forming martensite, hardness HV800–1000.
Tempering: 200–600°C, multi-stage tempering, toughness increased by 20%, internal stress reduced by 30%.
Annealing: 700–800°C (for die steel) to improve processability.

**Surface treatment:**
Carburizing/nitriding: Surface hardness is increased to HV1000 and wear resistance is increased by 30%.
PVD/CVD coating: TiN , TiAlN , CrN (thickness 2–5μm), friction coefficient <0.4, life extended by 3 times.

**Powder Metallurgy Tungsten Steel**
Process: Raw powder (particle size 1–10 μm) → pressing → sintering (1400–1500°C) → hot isostatic pressing (HIP).
Advantages: Uniform grain size (<10μm), hardness HV900–1000, and wear resistance increased by 40%.

## 9. Tungsten steel standards in China, the United States, internationally and around the world

As a high alloy steel, the performance and application of tungsten steel are strictly regulated by the standards set by various countries and international standardization organizations. These standards specify the chemical composition, mechanical properties, heat treatment process and test methods of tungsten steel to ensure product quality and consistency in cross-border trade. The following details the relevant standards of tungsten steel from the perspectives of China, the United States, the international (ISO) and other countries in the world (Japan, the European Union, Australia, etc.), and compares the main standards through tables.

### 9.1 Chinese Standards

China's tungsten steel standards are formulated by the National Standardization Administration

(SAC) and the China National Standardization System (GB/T), covering high-speed steel, die steel and special alloy steel. Given that China is the world's largest tungsten producer (67,000 metal tons in 2024, accounting for 83% of the world), its standards have a significant influence on the global tungsten steel market.

**Main standards of tungsten steel in China :**

**GB/T 9943-2008: High speed tool steel**
The chemical composition (e.g. W 6–18%), hardness (HV800–900) and heat treatment process of grades such as T1 (W18Cr4V) and M2 (W6Mo5Cr4V2) are specified.

**GB/T 1299-2014: Alloy tool steel**
Covers die steels such as D2 (Cr12Mo1V1, containing 8% W) with specified tensile strength (>1500 MPa) and wear resistance (ASTM G65 wear volume <50 mm³ ) .

**GB/T 20878-2007: Stainless steel and heat-resistant steel**
Standard medical tungsten steel (such as 440C, containing 5–10% W) requires corrosion resistance (salt spray weight loss <0.2 mg/cm² ) .
Features: Emphasis on high hardness and wear resistance, adapted to the needs of China's manufacturing industry (such as automotive molds, geothermal drilling).
Incorporate ISO standards (such as ISO 4957) to ensure export product compliance .

tungsten resources through tungsten mining quotas (13,582 tons of export quota in 2024) and export tariffs (10% tariff on the United States in February 2025) , affecting the global supply chain.

## 9.2 American Standards

The US tungsten steel standards are mainly formulated by ASTM International and AISI (American Iron and Steel Institute) and are widely used in North America and the global market. ASTM standards are highly recognized for their rigor and internationalization (12,575 standards, adopted by 140+ countries).

**Main standards of American tungsten steel standards:**
**ASTM A600-92a (2021): High-speed tool steel**
Standardize grades such as T1 and M2, specify W content (6–18%), hardness (HV800–900) and red hardness (≤650°C).

**ASTM A681-08 (2022): Alloy Tool Steel**
Covers mold steels such as D2 and H13, requiring toughness ( $K_{IC}$ 30–50 MPa·m ^(1/2)) and wear resistance (wear loss <50 mm ³ ).

**ASTM A276/A276M-23: Stainless steel bars and shapes**

Specification of medical tungsten steel containing W (such as 440C), requiring corrosion resistance and accuracy (±0.01 mm).
Features: Emphasis on mechanical performance testing (such as ASTM E8 tensile strength, ASTM G65 abrasion resistance) to ensure product consistency.
It is often cited in U.S. federal regulations (such as the National Technology Transfer and Promotion Act of 1995) and becomes a mandatory standard.

Application: ASTM standards are widely used in the US military industry (such as M829A4 armor-piercing projectile core) and aviation manufacturing (Sandvik M2 milling cutter).

**9.3 International Standards (ISO)**

The International Organization for Standardization (ISO) develops global tungsten steel standards, coordinates national standards, and promotes trade and technical exchanges. China, the United States, Japan, etc. are all members of ISO, and China has participated in ISO activities since 1947.
Main criteria:

**ISO 4957:2018: Tool steels, specification for high-speed steels (such as T1, M2) and die steels (such as D2)**
The W content (3–18%), hardness (HV600–1000) and heat treatment process are specified.

**ISO 683-17:2023: Heat-treated steel, alloy steel and stainless steel**
Covers medical tungsten steels containing W (e.g. 440C) where corrosion resistance and biocompatibility are required (in accordance with ISO 10993).

**ISO 513:2012: Classification of cemented carbide and high-speed steel cutting tools**
Define the properties of tungsten steel cutting tools (such as red hardness ≤ 700°C).

Features: Provides a common framework, allowing countries to develop local standards within the ISO scope (such as GB/T referring to ISO 4957).
Emphasizing cross-border mutual recognition, in 2022 ISO and the European Committee for Standardization (CEN) renewed their technical cooperation agreement to expand the application of tungsten carbide standards.
Application: ISO standards are widely used in the global manufacturing of cutting tools (Kennametal M2 cutting tools), molds and new energy equipment.

**9.4 Other standards in the world**

Tungsten steel standards in other countries (such as Japan, the European Union, Australia, and Africa) have their own characteristics, reflecting regional needs and industrial backgrounds:

**Japan (JIS)**

**JIS G4403:2021 : High speed tool steel**

The specifications for SKH2 (T1) and SKH51 (M2) require W 6–18% and hardness HV800–900, which are suitable for cutting tools in areas prone to earthquakes.

Features: Focus on shock resistance and high precision. In 2025, JIS plans to update G4403 and add medical tungsten steel standards.

Application: Aichi Steel surgical knife, conforming to JIS G4404 (stainless steel).

**European Union (EN):**

**EN ISO 4957:2018: Synchronized with ISO**

Specifications 1.2080 (D2), 1.2379 (including W die steel), requirements for wear resistance (wear <50 mm³ ) and CE certification.

Features: Emphasis on environmental protection and corrosion resistance. In 2025, the EU plans to revise EN 10083 and add a new standard for military steel containing W.

Application: Bohler ASP60 tool in accordance with EN ISO 4957.

**Australia (AS/NZS):**

**AS 1444:2007: Alloy steel**

The specification specifies W-containing tool steel with a hardness of HV600–900, suitable for mining equipment.

Features: With reference to ISO and ASTM, AS 1444 is planned to be updated in 2025 to add tungsten steel standards for new energy gears.

**Africa:**

**SANS 50025 (South Africa) and ISO 10721**

Specification for structural and tool steels, including W-containing steels for use in mining and geothermal drilling.

Features: Due to the lack of unified standards, Africa mostly adopts ISO. In 2025, the African Union plans to launch regional tungsten steel standards.

## 9.5 Standard Comparison

The following table compares the tungsten steel standards of China, the United States, ISO and major countries, highlighting the differences in grades, composition and application:

| Standards Organizations | Representative Standard | Typical grades | Tungsten content (%) | Hardness (HV) | Key Requirements | Typical Applications |
|---|---|---|---|---|---|---|
| China GB/T | GB/T 9943-2008 | T1 (W18Cr4V), M2 (W6Mo5Cr4V2) | 6–18 | 800–900 | Red hardness ≤650°C, wear volume <40 mm³ | Cutting tools, molds |
| ASTM | ASTM A600-92a | T1, M2, D2 | 6–18 | 800–900 | Toughness K ı c 25–50 MPa·m ^(1/2), ASTM E8 tensile strength | Knives, military |

| | | | | | | |
|---|---|---|---|---|---|---|
| International ISO | ISO 4957:2018 | T1, M2, D2 | 3–18 | 600–1000 | Heat treatment process, corrosion resistance | Global cutting tools and molds |
| Japan JIS | JIS G4403:2021 | SKH2 (T1), SKH51 (M2) | 6–18 | 800–900 | Shock resistance, accuracy ±0.01 mm | Medical knives and cutting tools |
| EU EN | EN ISO 4957:2018 | 1.2080 (D2), 1.2379 | 5–10 | 700–850 | CE certified, abrasion resistance <50 mm³ | Moulds and cutting tools |
| Australia AS/NZS | AS 1444:2007 | W-containing tool steel | 3–10 | 600–900 | Mining wear resistance | Mining equipment, geothermal drill bits |

Standard range: China GB/T and US ASTM emphasize hardness and wear resistance, ISO provides a general framework, Japan JIS focuses on shock resistance and precision, and EU EN requires environmental certification.
Mutual recognition: ISO 4957 is the global benchmark. GB/T 9943, ASTM A600 and JIS G4403 all refer to ISO to ensure consistency in cross-border trade.

### 9.6 Standard Application and Challenges

application:
China: GB/T 9943 regulates Zhuzhou Diamond M2 cutting tools, and exports to the EU must comply with ISO 4957.
USA: ASTM A600 ensures the quality of Sandvik M2 milling cutters, and military standards (such as MIL-STD) require higher penetration.
International: ISO 4957 harmonizes Kennametal's global tool production and reduces trade barriers.
challenge:
Standard differences: The composition range (e.g. C 0.5–1.5%) and test methods (ASTM E8 vs. ISO 6892) of different countries are not completely consistent, which increases the cost of cross-border certification.
Update lag: The development of standards for new materials such as powder metallurgy tungsten steel (PM-M4) is slow, and revisions in 2025 need to be accelerated.

## 10. Future Trends of Tungsten Carbide

Super-hard tungsten steel: contains 12–18% tungsten, with a hardness of HV950–1000, replacing low-end cemented carbide, and its market share is expected to rise to 20%.
Coating technology: Nano-composite coating (such as TiSiN ) has a friction coefficient of <0.3 and extends tool life by 5 times.
Green manufacturing: recycling rate>90%, carbon footprint reduced to 15 kg CO2/kg, cost reduced by 25%.
Intelligence: AI optimizes heat treatment and coating processes, with parameter error less than 2% and efficiency increased by 30%.


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

**Emerging applications:**
New energy: wind power gears (wear resistance increased by 2 times), electric vehicle molds (lifespan extended by 40%).
Medical: Micro tungsten steel cutting tools, accuracy ±0.005 mm, demand growth 15%/year.
Geothermal/deep sea: High temperature and corrosion resistant tungsten steel drill bit, efficiency increased by 20%.

## 11. Limitations and Challenges of Tungsten Carbide

Hardness limit: HV600–1000, lower than cemented carbide (HV1000–1800), not suitable for ultra-high load wear.
Corrosion resistance: The Cr content is limited, and the acid resistance (pH <4) is not as good as Ni-based cemented carbide (YN8).
High temperature performance: Red hardness ≤700°C, lower than cemented carbide (≤1000°C), limiting high temperature cutting.
Resource dependence: Tungsten (global reserves of 3.4 million tons, 70% in China) price fluctuations ($20–30/kg) affect costs.
Processing difficulty: After quenching, the hardness is high and diamond grinding is required, and the processing cost accounts for 20-30%.

## 12. Conclusion

As a high alloy steel, tungsten steel plays an important role in cutting tools, molds, cutting tools, wear-resistant parts, military industry and new energy fields with its high hardness, wear resistance, red hardness and toughness. It has various types (high-speed tungsten steel, mold tungsten steel, super-hard tungsten steel, etc.), and its performance is continuously optimized through heat treatment, coating and powder metallurgy technology. Compared with high-speed steel, tungsten steel is more widely used; compared with cemented carbide, tungsten steel has high toughness and low cost, but its hardness and high temperature resistance are slightly inferior. China, the United States, ISO and other national standards (such as GB/T, ASTM, ISO 4957) regulate tungsten steel production to ensure quality and trade consistency. In the future, super-hard tungsten steel, green manufacturing and intelligent processes will promote its application in high-precision manufacturing and sustainable industry. Despite the challenges of resource dependence, processing difficulty and standard differences, tungsten steel will still be a key material in the era of Industry 4.0 and new energy.


电话/TEL：0086 592 512 9696

sales@chinatungsten.com

# CTIA GROUP LTD

## 30 Years of Cemented Carbide Customization Experts

### Core Advantages

**30 years of experience**: We are well versed in cemented carbide production and processing , with mature and stable technology and continuous improvement .

**Precision customization**: Supports special performance and complex design , and focuses on customer + AI collaborative design .

**Quality cost**: Optimized molds and processing, excellent cost performance; leading equipment, RMI , ISO 9001 certification.

### Serving Customers

The products cover cutting, tooling, aviation, energy, electronics and other fields, and have served more than 100,000 customers.

### Service Commitment

1+ billion visits, 1+ million web pages, 100,000+ customers, and 0 complaints in 30 years!

### Contact Us

**Email** : sales@chinatungsten.com

**Tel** : +86 592 5129696

**Official website** : www.ctia.com.cn

**WeChat** : Follow "China Tungsten Online"