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REPORT ON THE DEVELOPMENT OF CHINA'S TUNGSTEN INDUSTRY 2021

CTIA 2022

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厦门中钨在线科技有限公司，简称“中钨在线”，是中国第一家钨、钼、稀土行业的电子商务公司，1997 年 9 月以我国第一家顶级钨制品网站 www.chinatungsten.com 为基础在厦门设立。中钨在线以其在钨钼制品领域几十年积累的信息数据和专业经验为基础的设计、制造，卓越的商业信誉和优质服务闻名全球业界，使其成为钨钼稀土，特别是钨化学品、金属钨、硬质合金、高比重合金、钼及钼合金领域的最佳综合应用解决方案提供商。

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中钨在线的专业研究文章和报告由韩斯疆博士、专业分析师郑华小姐及其团队撰写。韩斯疆博士是中钨在线主要的市场和技术研究专家，郑华小姐是中钨在线的社交媒体主管。韩博士自 1990 年代初期开始从事钨钼制品的电子商务和国际贸易、硬质合金和高比重钨合金的生产制造，是有着 30 年多年经验，业内知名钨钼制品的电子商务、钨制品设计、加工和市场研究专家。郑小姐数年来一直来致力于钨制品市场的研究和社交媒体建设与推广，对钨制品市场与价格有极强的专业细腻和敏感性。

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BRIEF INTRODUCTION TO THE AUTHOR

As the 1st E-commerce company of Tungsten (W), Molybdenum (Mo), Rare Earth (RE) in China, China Tungsten Online Manu. & Sales (CTOMS) was founded in 1997 based on China's the 1st and top tungsten website www.chinatungsten.com. As its specialized design, professional manufacturing, excellent service and powerful information database, CTOMS is not only the most authoritative information source of Chinese and English information of W Mo and RE products globally, but also the best comprehensive application solution provider of W, Mo and RE, both chemical materials and machined products, such as tungsten oxide, metal, cemented carbide and heavy alloys.

CTOMS has been created more than 1 million web pages and WeChat information message of W, Mo and RE news, price and market research, analysis. The web www.ctia.com.cn and news.chinatungsten.com are the world's top index websites of tungsten which have received 1 billion visits from 1997.

The major business of CTOMS is to complete product design, R & D with customers and provide customers with processing and integration services. In the past 2 decades, it has provided more than 100,000 different types of W, Mo & RE products to more than 10,000 customers all over the world. Years experience and technology accumulation have laid a foundation for promoting the flexible and intelligent manufacturing of customized products.

The professional research articles and reports of CTOMS are written by Dr. Hanns, Miss Sunny Zheng, professional analyst and its marketing team. Dr. Hanns is an expert of the main market and technical research of CTOMS has been engaged in e-commerce and international trade of tungsten and molybdenum products, production and manufacturing of cemented carbide and high specific gravity tungsten alloy since the early 1990s. He is a well-known expert in e-commerce, tungsten product design, processing and Market Research of tungsten and molybdenum products in the industry with more than 30 years of experience. Miss Sunny has been committed to the research of tungsten market, creating and promoting CTOMS social media form many years. She has strong professional delicacy and sensitivity to tungsten products market and price.

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CONTENT

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Ding Xuequan, President of China Tungsten Industry Association (CTIA), delivered a welcome speech at the "**2021 China (Shanghai) Tungsten Raw Material Industry Development High-end Forum**" on October 18, 2021. The forum is sponsored by CTIA, specially invited and co-organized by China Tungsten High Tech Materials Co., Ltd., Jiangxi Tungsten Industry Holding Group Co., Ltd. and Xiamen tungsten Industry Co., Ltd., and jointly organized by Smelting Branch, Tungsten Cemented Carbide Branch and economic and Trade Research Branch of CTIA. The forum with the theme of "**Strengthening Foundation, Building Dreams, Cooperation and Win-Win**" was held in Shanghai. The purpose of this forum is to build a communication platform for the tungsten industry, promote upstream and downstream cooperation in the tungsten industry supply chain, help improve the ecology of the tungsten industry chain and lay a solid foundation for the development of the tungsten industry, help the high-quality development of the tungsten industry, and promote the tungsten industry from a large tungsten product to a powerful tungsten production.

2021 is a year of great significance in China's developing history and the beginning of China's 14th Five-year Plan. In the face of the complex environment of century changes and century epidemic, China's cadres and workers in the tungsten industry stick to their original intention, forge ahead, continue to consolidate the stable and good development trend, firmly continue the good trend of steady growth, firmly grasp the established direction of high-quality development, and restore the growth of product output, profits and taxes, Operating income reached a record high, key projects were promoted in an orderly manner, the industrial structure was continuously optimized, new achievements were made in scientific and technological innovation, brand building was fruitful, and new progress was made in greening and intellectualization.

PART I

OVERVIEW OF TUNGSTEN INDUSTRY DEVELOPMENTS GLOBALLY

1.1 Global Tungsten Resource Reserves & Production Increased Slightly

According to the data of the U.S. Geological Survey (USGS), the world's tungsten reserves in 2021 were 3.7 million tons (all ton here is metric ton, e.g., MT, tungsten metal, the same below), with a year-on-year increase of 8.28%. Global tungsten resources are mainly distributed in China, Russia, Vietnam and other countries. Among them, China's tungsten reserves are 1.9 million tons, accounting for 51.35%, Russia's tungsten reserves are 400,000 tons, accounting for 10.81%, and Vietnam's tungsten reserves are 95,000 tons, accounting for 2.70%. China has obvious advantages in tungsten resources and reserves (see Table 1).

Table 1 Distribution of Global Tungsten Resources & Reserves

国家	2020 年			2021 年		
	储量（吨，金属量）	同比，%	占比，%	储量（吨，金属量）	同比，%	占比，%
中国	1900000	0.00%	55.88	1900000	0.00%	51.35
俄罗斯	400000	66.67%	11.76	400000	0.00%	10.81
越南	95000	0.00%	2.79	100000	5.26%	2.70
西班牙	54000	0.00%	1.59	52000	-3.70%	1.41
朝鲜	29000		0.85	29000	0.00%	0.78
奥地利	10000	0.00%	0.29	10000	0.00%	0.27
葡萄牙	3100	0.00%	0.09	5100	64.52%	0.14
蒙古	4300		0.13		-100.00%	0.00
其他国家	880000	7.32%	25.88	1200000	36.36%	32.43
世界合计	3400000	6.25%	100.00	3700000	8.82%	100.00

USGS (Canada, Kazakhstan and the US also have a large amount of tungsten resources)

According to the data of the USGS, the global output of tungsten concentrate in 2021 was 79,000 tons, with a year-on-year increase of 0.77%, and the overall growth remained stable.

The output of tungsten concentrate is mainly distributed in China, Vietnam, Russia and other countries. Among them, the output of tungsten concentrate in China is 66,000 tons (there is a certain difference with the verified data of China, see below), accounting for 83.54%, and the output of tungsten concentrate in Vietnam is 4,500 tons, accounting for 5.70%. China's tungsten concentrates production accounts for a prominent proportion in the world, and the consumption of tungsten resources is too fast, which does not match the proportion of reserves. The output of each country is shown in Table 2.

US SALIENT TUNGSTEN STATISTICS

(Metric Tons, Tungsten Content)

	Concentrate				Intermediate products		
			Stocks, end of period			Stocks, end of period	
Period	Reported consumption	Imports for consumption	Industry[2]	U.S. Government[3]	Net production[4]	Producer[5]	U.S. Government[3]
2020:							
December	W	140	W	7,600	W	W	93
January–December	W	2,020	W	7,600	W	W	93
2021:							
January	W	136	W	7,600	W	W	93
February	W	122	W	7,360	W	W	92
March	W	75	W	7,220	W	W	93
April	W	130	W	7,020	W	W	93
May	W	73	W	7,020	W	W	93
June	W	100	W	6,900	W	W	--
July	W	108	W	6,900	W	W	--
August	W	180	W	6,850	W	W	--
September	W	135	W	6,850	W	W	--
October	W	107	W	6,850	W	W	--
November	W	176	W	6,660	W	W	--
December	W	252	W	6,570	W	W	--
January–December	W	1,590	W	6,570	W	W	--

W Withheld to avoid disclosing company proprietary data. --Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Reported by consumers; includes estimates.
[3]Data from the Defense Logistics Agency Strategic Materials.
[4]Net production of tungsten metal powder and tungsten carbide powder; includes estimates.
[5]Data for tungsten metal powder and tungsten carbide powder reported by producers; includes estimates.

Nuiphao Tungsten Mine is located in Nguyen Viet Nam Province in northern Vietnam. The mine has an estimated ore reserve of 66 million tons and an ore grade of 0.21%. As the flagship asset of Mashan Group, the deposit is also associated with fluorite,

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bismuth and copper. In addition, the deposit has a wide range of open-pit mines with low stripping rate, and the estimated mining life is 20 years. The mine has an annual output of 6000 tons of tungsten concentrate and an annual increase of 10%. Compared with China, Vietnam has labor costs and many posts development advantages. Therefore, the mine is a strong competitor of China's enterprises in terms of product competitiveness and future strategy.

Table 2 Global Tungsten Concentrate Output

	2017 年	2018 年	2019 年	2020 年	2021 年 E	2021 年 同比，%	2021 年 中国占比，%
中国	67000	65000	69000	66000	66000	0.00	83.54
越南	6600	4800	4500	4500	4500	0.00	5.70
俄罗斯	2090	1500	2200	2400	2400	0.00	3.04
玻利维亚	994	1370	1060	1350	1400	3.70	1.77
卢旺达	720	920	900	860	950	10.47	1.20
奥地利	975	936	892	890	900	1.12	1.14
西班牙	564	750	603	500	900	80.00	1.14
葡萄牙	724	715	518	550	620	12.73	0.78
朝鲜		1410	1130	410	400	-2.44	0.51
英国	1090	900					0.00
蒙古	753	1940	1900	1900			0.00
其他国家	1300	900	1070	960	1200	25.00	1.52
世界合计	82100	81100	85000	78400	79000	0.77	100.00

CTIA

Dolphin Tungsten Mine is one of the top ten tungsten mine projects outside China. The latest data released in September 2019 showed that the total mineral resources of Dolphin Tungsten project were increased by 18% to 11.36 million tons, the average grade of tungsten trioxide was 0.9%, and the resource of tungsten trioxide was 102400 tons. Among them, the resources of bold head mining area in the north of Dolphin Tungsten are 1.76 million tons, and the average grade of tungsten trioxide is 0.91%. (news.chinatungsten.com)

Tungsten mining out of China and beneficiation projects are gradually promoted, and the international tungsten output is expected to increase in the future. Tungsten West Ltd continues to promote the transformation of Hermerdon Tungsten Mine in the UK, and the resumption of production is expected to be postponed to 2023; The Bakuta tungsten mine project in Kazakhstan continues to be promoted. It is planned to be completed and put into operation in 2023, with an annual output of about 15000 tons of tungsten concentrate; According to the prospectus of Almonty Industries Inc in Canada, the affiliated Sangdong Tungsten Molybdenum project in South Korea is planned to be put into operation within the year. The tungsten reserves of the mine are equivalent to about 51000 tons of W03, and the grade of W03 is 0.41%; King Island Sheelite of Australia raised funds to restart Dolphin Tungsten mine project. The project was operated from 1917 to 1990 and was closed due to low market prices. After that, it was restarted many times without success.

On November 11, 2020, Kazakhstan Jietesu Tungsten Industry Co., Ltd., invested by Jiangxi copper and started the Bakuta extra-large open-pit tungsten mine project, which has world-class tungsten resources. it will become one of the single tungsten mines with the largest production capacity in the world, and the annual output of tungsten concentrate is expected to exceed 10% of the world's annual output of tungsten concentrate.

1.2 Good Benefits of Top Advanced Enterprises

In the application field of high-end cemented carbide, the revenue and profit of top well-known tungsten cemented carbide enterprises in Euro and US increased well. Sandvik's, a Swedish enterprises, the tops tungsten carbide powder manufacturer worldwide, operating revenue in 2021 was SEK 99.105 billion (equivalent to RMB 73.516 billion), a year-on-year increase of 14.70%, its operating profit was SEK 18.654 billion (equivalent to RMB 13.838 billion), a year-on-year increase of 66.32%, and its profit margin was 18.8%, an increase of 5.8 percentage points over the previous year; The operating revenue of its processing solutions business segment was SEK 3.681 billion (equivalent to RMB 27.210 billion, with a year-on-year increase of 12.94%, and the operating profit was SEK

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8.058 billion (equivalent to RMB 5.97 billion).

Sandvik 800i series high-performance interconnected cone crushers. The largest tungsten enterprise in the world is Sandvik of Sweden. Its main tungsten products are tungsten cemented carbide products, but its main income has indeed been all kinds of complete sets of equipment, software and services with cemented carbide as cutting tools. This is also the great advantage of the company in the global tungsten products market

The year-on-year growth was 74.95%, and the profit margin was 22.0%, an increase of 7.8 percentage points over the previous year. In fiscal year 2021, Kennametal, another top tungsten carbide powder manufacturer of American achieved an operating revenue of US $1.841 billion (equivalent to RMB 11.831 billion), a year-on-year decrease of 2.33%, a net profit of US $544 million (equivalent to RMB 3.497 billion), turning losses into profits, and a profit margin of 5.5%, an increase of 4.3 percentage points over the previous year.

Kennametal MEGA 45 ° heavy end socket milling cutter can improve the metal removal rate (MRR) up to 30%; Tungsten Cemented carbide tool pads provide protection for the tool body.

PART II

DEVELOPMENT STATUS OF CHINA TUNGSTEN INDUSTRY IN 2021

Horizontal multi tube reduction furnace for tungsten powder production

2.1 Overview of Economic of China

2.1.1 Tungsten Production Capacity Increased Steadily

The production capacity of main tungsten products increased steadily. According to the statistics of CTIA, the production capacity of China of tungsten concentrate, ammonium paratungstate (hereinafter referred to as APT), ferrotungsten, tungsten carbide powder and tungsten cemented carbide is 177,000 tons, 196,000 tons, 30,000 tons, 90,000 tons and 70,000 tons respectively.

Due to the implementation of resource replacement projects and technical transformation and capacity expansion in some mines, the production capacity of tungsten concentrate increased slightly; Part of apt capacity gradually withdrew, while some capacity was added by technological transformation and capacity expansion, which decreased slightly overall; The technological transformation and capacity expansion of some powder and alloy enterprises have led to an increase in the production capacity of tungsten carbide powder, a strong demand for tungsten cemented carbide and a rapid growth in production capacity; Tungsten iron production capacity was flat. The production capacity of major tungsten products in China in recent five years is shown in Figure 1.

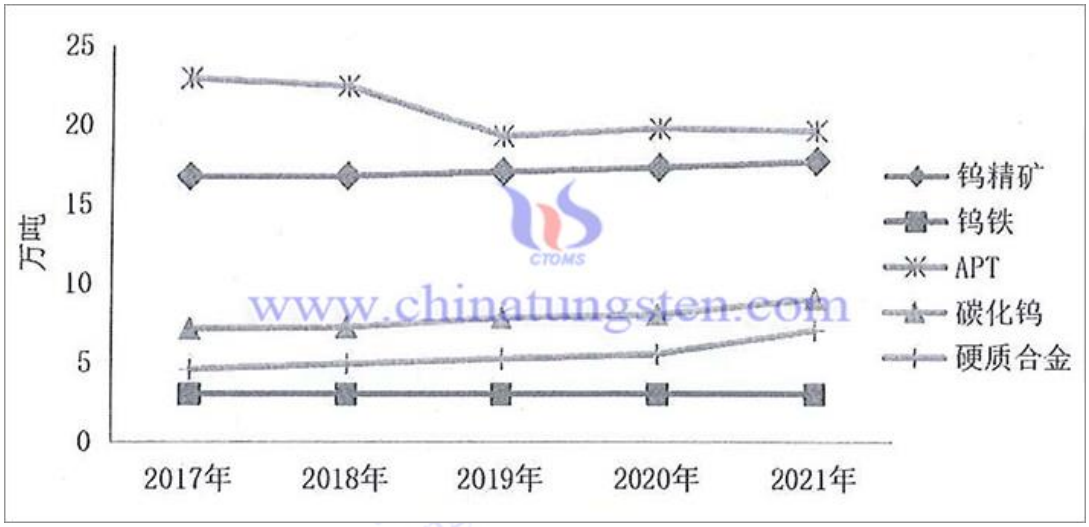

Figure 1 Production capacity of major tungsten products in China from 2017 to 2021 (CTIA)

2.1.2 The Output of Main Tungsten Products Increased Significantly

According to the statistical analysis of CTIA, in 2021, the output of tungsten concentrate of China was 135,500 tons (converted into WO3, 65% tons, hereinafter referred to as standard tons), a year-on-year decrease of 2.25%. The national output of APT, tungsten carbide powder, tungsten cemented carbide and ferrotungsten increased by 9.52%, 29.04%, 24.39% and 20.00% respectively year-on-year: the economic situation at home and abroad improved and the recovery of demand driven the restorative growth of production and operation of tungsten industry. The output of tungsten products in recent 5 years is shown in Figure 2.

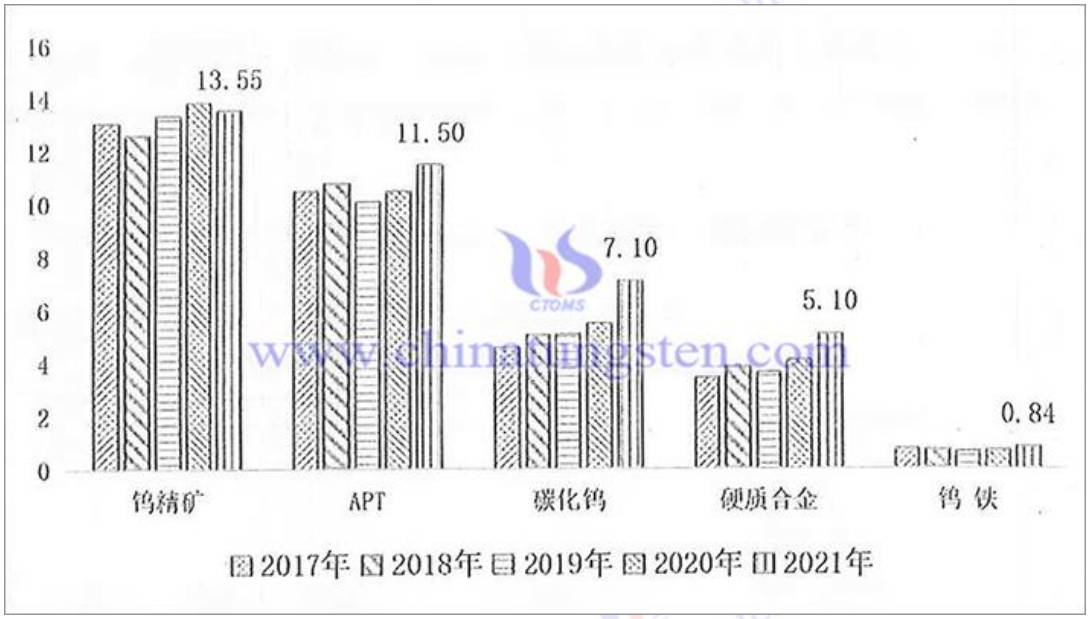

Figure 2 Output of main tungsten products in China from 2017 to 2021 (CTIA)

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The Sandgong Tungsten, also known as the Almonty Korea Tungsten is a historical mining site in South Korea that is currently being developed by Canada-based Almonty Industries through its wholly-owned subsidiary, Woulfe Mining Corp. NS ENERGY

2.1.3 Tungsten Industry has Improved Better as Income has Reached a Record High

In 2021, the epidemic prevention and control achieved phased results, the global economy recovered well, the production of all walks of life resumed, driven the restorative growth of the tungsten industry, and the operating efficiency improved significantly. According to the statistical analysis of CTIA, the main business of the national tungsten industry received 106 billion RMB Yuan/ton, a year-on-year increase of 42.28%; The total profits and taxes reached 9.5 billion RMB Yuan/ton, a year-on-year increase of 29.25%; The profit was 5.9 billion RMB Yuan/ton, a year-on-year increase of 68.57%. The main business income and profit of tungsten industry in recent 5 years are shown in Figure 3.

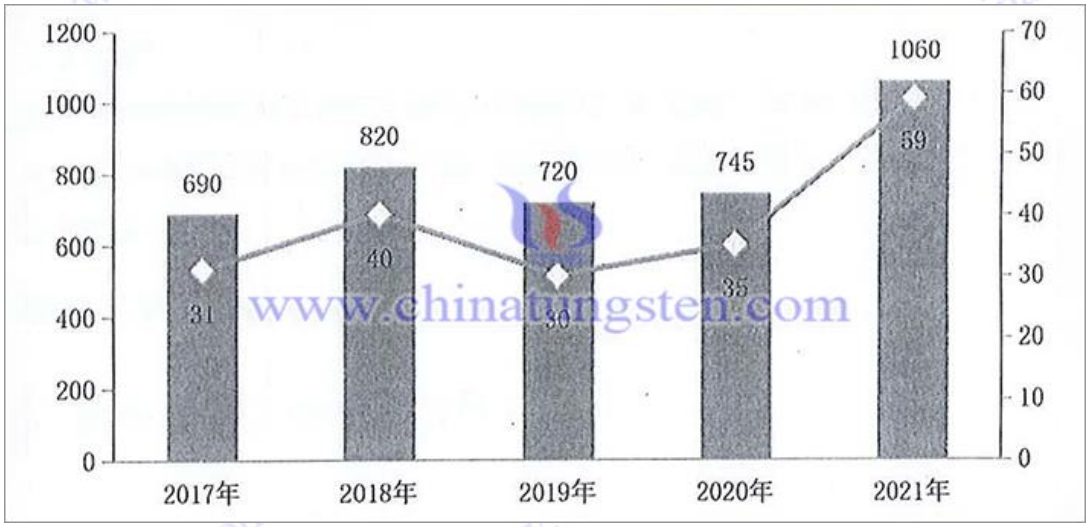

Figure 3 Ain business income and profit of tungsten industry from 2017 to 2021 (unit: 100 million RMB RMB Yuan/ton, CTIA)

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2.2 Tungsten Products Structure

2.2.1 The Tungsten Product Structure Extends to Deep-processing

The adjustment of Tungsten product structure and industrial transformation and upgrading continued, and the output of high-end products increased. The production capacity of tungsten cemented carbidekeeps growing, especially the investment in bars and high-end tungsten cemented carbideNC blades continues to grow. In 2021, the conversion rate of APT to tungsten cemented carbidewas 53%, an increase of 6 % over the previous year, breaking the 50% mark for the first time, and showing an upward trend year by year.

2.2.2 The Overall Industrial Pattern Remained Stable

China's tungsten concentrate is mainly produced in Jiangxi, Hunan and Henan provinces, accounting for 85.47% of the total output, an increase of 0.53 % year-on-year. Apt producing areas are mainly distributed in Jiangxi, Hunan and Fujian. In 2021, the output of the three provinces totaled 89,200 tons, accounting for 77.64% of the country, an increase of 1.24 % over the previous, of which the output of Jiangxi accounted for 48.40% of the country, an increase of 5.06 % over the previous year.

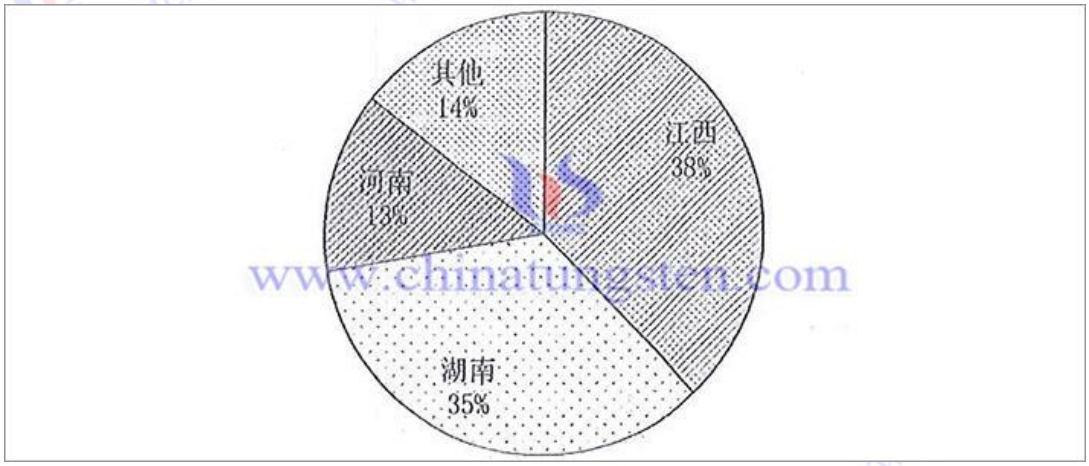

Figure 3 Proportion of tungsten concentrate output in Jiangxi, Hunan and Henan provinces in 2021 (CTIA)

Tungsten Cemented carbide NC cutting tips

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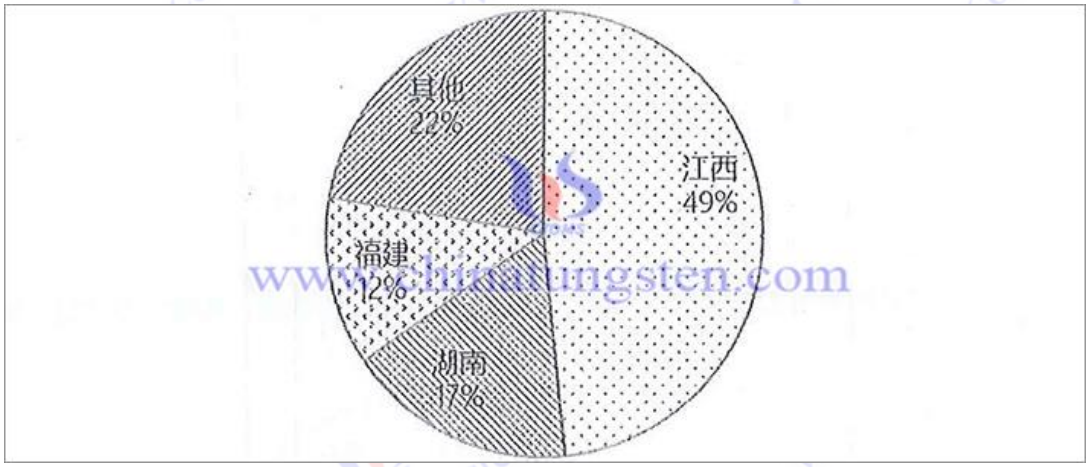


Figure 4 Proportion of APT output in Jiangxi, Hunan and Fujian in 2021 (CTIA)

The producing areas of tungsten cemented carbide are mainly distributed in Hunan, Fujian, Jiangxi and Sichuan. In 2021, the total output of the four provinces was 35,600 tons, accounting for 70% of the national output, which was basically the same as that of the previous year. Among them, the output of Hunan accounted for 34% of the national output, ranking first. Among the four provinces, the output of Fujian increased by 33.50% year-on-year, with the fastest growth. See Fig. 3, 4 and 5 for the output proportion of main production areas of tungsten concentrate, apt and tungsten cemented carbidein 2021.

Ammonium paratungstate(APT) is one of the tungstate salts. Its appearance is white powder crystal, and its molecular formula is (NH4) 10w12h2042 • 4H2O. It is slightly soluble in water and stable in air at room temperature. It begins to decompose into WO3 at 25 ℃. It is an intermediate product of tungsten industry and the main raw material for the production of tungsten oxide. Tungsten oxide is obtained by calcining at 700-800 ℃. APT can be purified by evaporation crystallization. The pH value largely determines and affects the physical and chemical properties of APT.

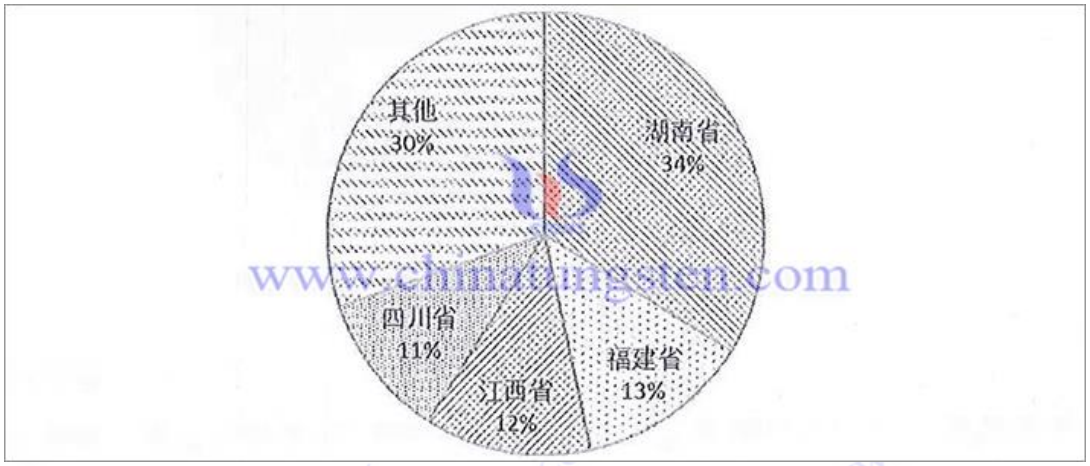
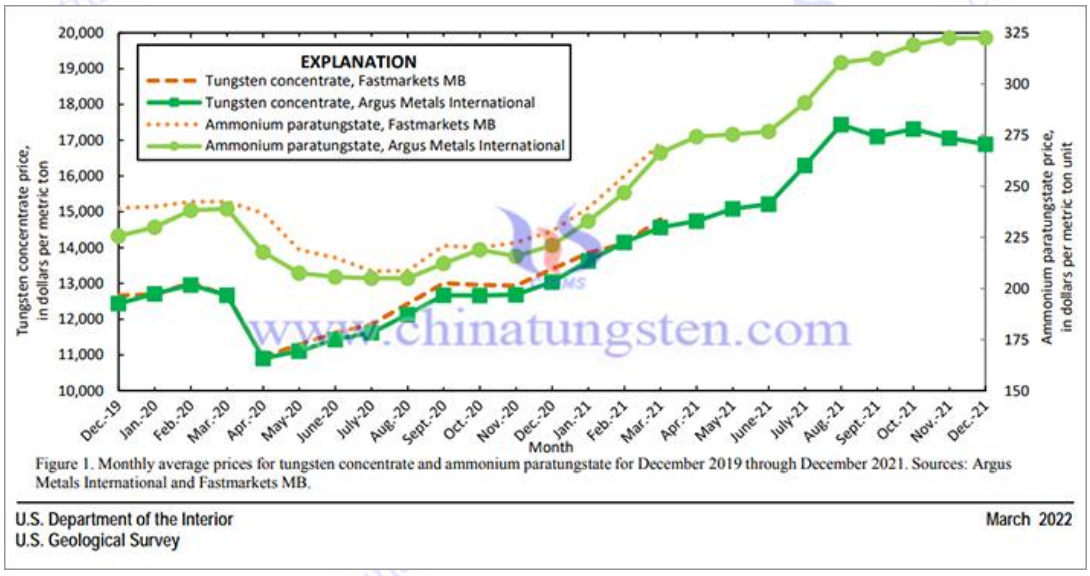


Figure 5 Proportion of tungsten cemented carbideoutput in Hunan, Fujian, Jiangxi and Sichuan in 2021 (CTIA)

2.3 Tungsten's Market Price

Tungstens' market prices rose moderately and returned reasonably. In 2021, major economies implemented loose monetary and fiscal policies and actively responded to the impact of the epidemic. The recovery momentum was obvious, which led to the recovery and stable operation of the tungsten market. Compared with other metals, the market price of tungsten has increased moderately and gradually upward, which is generally in the market equilibrium range in recent years.



Monthly average price curve of tungsten concentrate & ammonium paratungstate (APT) from Dec. 2019 to Dec. 2021

The price of tungsten concentrate in Chian was in the range of 86,000 ~ 112,000 RMB RMB Yuan/ton. The price of tungsten concentrate was below 100,000 RMB Yuan/ton by the end of May, and rised rapidly in July, it fluctuated around 110,000 RMB Yuan/ton in the second half of the year. In 2021, the average annual price of tungsten concentrate was 100,500 RMB Yuan/ton, a year-on-year increase of 21.21%, the average annual price of apt was 153,800 RMB Yuan/ton, a year-on-year increase of 20.31%, the average annual price of APT in

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Europe was 289.30 USD/ton, a year-on-year increase of 35.86%, and the average annual price of ferrotungsten in Rotterdam was 28.39 USD / kg of tungsten, a year-on-year increase of 23.79%. See Figure 6, 7, 8, 9 and table 3

Figure 6 Variation curve of daily average price of tungsten concentrate in Chinese market from 2020 to 2021（CTIA）

Tungsten mines in open pit mining, Jiangxi, China

The content of tungsten in the earth's crust is only 0.007%, of which more than 50% is in China. China's tungsten reserves are mainly distributed in Hunan, Guangdong, Jiangxi, Fujian, Henan and other provinces; Jiangxi is the most concentrated in the south, Daji mountain, Xihuashan, Kuimeishan and Pangushan are all world-famous tungsten mines located in Jiangxi. After tungsten ore is mined from tungsten mine, tungsten concentrate is produced through technological processes such as crushing, ball milling, gravity separation (mainly shaking table and jigging), flotation, electric separation and magnetic separation. The content of tungsten trioxide, the main component, can reach more than 65%. Tungsten concentrate is raw material for the production of tungsten compounds such as ferrotungsten, sodium tungstate, ammonium paratungstate (APT) and ammonium

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metatungstate (AMT) and then processing tungsten trioxide (YTO), blue tungsten oxide (BTO), violet tungsten oxide (VTO, Purple Tungsten), cesium tungsten, nano tungsten oxide, tungsten powder, tungsten carbide, cemented carbide, tungsten steel and tungsten bar. All news and prices of China Tungsten products, please visit news.chinatungsten.com.

Figure 7 Variation curve of average monthly price of tungsten concentrate in Chinese market from January 2019 to December 2021 （CTIA）

In December 2007, Wolf Minerals, a special metals exploration and development company, acquired Hemerdon Tungsten Mine and renamed it Drakelands Tungsten Mine (DTM). In May 2011, wolf minerals completed the feasibility study of the DTM project and officially put into operation in 2015. However, the mine has never achieved its mining or financial objectives. In October 2018, Wolf Minerals was overwhelmed and went bankrupt after losing £ 100 million. The DTM was announced to be closed again. In November 2019, Tungsten West acquired the DTM with £ 2.8 million in cash. At present, feasibility study and further financing plan are under way to restore the production activities of the mine in 2021. The restart cost is expected to be £ 30-40 million. Tungsten West hopes to fill the gap in the tungsten concentrate market outside China through the DTM.

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Figure 8 Annual average price change curve of tungsten concentrate in China market from 2011 to 2021 (CTIA)

Figure 9 European APT price of Metal Guide from January 2019 to December 2020 (CTIA)

Table 3 Annual Average Price of Tungsten Products Worldwide

	中国钨精矿（万元/吨）	中国 APT（万元/吨）	欧洲 APT（美元/吨度）	鹿特丹钨铁（美元/千克钨）
12 月	10.68	16.62	322.50	37.63
同比%	26.44	29.31	41.76	14.43
环比%	-0.15	-0.74	0.00	0.32
4 季度均价	10.79	16.82	321.50	37.63
同比%	29.80	32.26	43.98	27.57
环比%	-0.36	2.99	5.11	-4.51
1～12 月	10.05	15.38	289.30	35.86
同比%	21.21	20.31	28.39	23.79

(CTIA)

According to customs statistics, in 2021, the average price of China's exported tungsten products was US $39,607.91/ton of tungsten metal, with a year-on-year increase of 16.21%. The export prices of apt, tungsten trioxide, tungsten powder and tungsten carbide powder increased by 23.65%, 24.57%, 16.44% and 18.79% respectively.

Application of ammonium paratungstate(APT): as an important intermediate in tungsten metallurgical industry, apt can not only be used to produce tungsten oxide(trioxide, WO3), ammonium metatungstate(AMT), metal tungsten powder, tungsten bar, tungsten wire and cemented carbide, but also be used as a colorant in ceramic industry, a catalyst in petrochemical industry and a water absorbing gel in chemical industry.

2.4 Import and Export of Tungsten

2.4.1 Import and Export Recovered Growth

In 2021, China exported 32,962.24 tons of tungsten products (metal volume, the same below), a year-on-year increase of 45.62%. After two years of continuous decline, it showed a restorative growth, and the export volume returned to the average level of nearly five years, which was still lower than the historical high of 15.85% in 2018. In 2021, the export volume of tungsten products was US $1,547 million, with a year-on-year increase of 59.35%. After two years of continuous decline, it turned to positive growth. The export of raw material grade tungsten products was 21,634.71 tons, with a year-on-year increase of 60.22%, turning from decline to positive growth; The export of tungsten cemented carbide is about 8,300 tons (converted into metal), with a year-on-year increase of 22.06%. The competitiveness of China's tungsten cemented carbide products in the international market is gradually improved. See Table 4 for the export of tungsten products in recent 5 years.

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Table 4 Export of Tungsten Products from 2017 to 2021

(tons of tungsten, US $100 million)

	2017 年	2018 年	2019 年	2020 年	2021 年
出口总量	35401.07	39171.77	30360.77	22636.17	32962.24
其中：原料级钨品	26452.19	28492.70	19966.39	13502.91	21634.71
钨材	1204.49	852.08	588.22	678.23	940.56
钨丝	345.30	290.85	287.08	282.35	320.53
硬质合金	6416.76	7853.00	7600.00	6800.00	8300.00
出口额	12.99	19.02	13.51	9.71	15.47

(CTIA)

The formula of violet tungsten (VTO) is WO2 72 (or W18O49). Compared with nano blue tungsten, nano violet tungsten is more suitable for the preparation of nano tungsten powder and nano tungsten carbide powder. High purity nano violet tungsten is not only a very important n-type semiconductor material, but also a very excellent photothermal conversion material. It has a strong absorption of electromagnetic waves, especially short wavelength ultraviolet and near-infrared. More details about VTO, please visit the web of CTIA.

In 2021, the import of tungsten products was 5,986 tons (converted into metal volume, the same below), with a year-on-year increase of 13.07%, with positive growth for two consecutive years, slightly higher than the average level in recent five years. Tungsten concentrate and tungsten cemented carbideare the main imported products. In 2021, 2,656 tons of tungsten concentrate were imported, with a year-on-year increase of 62.60%, accounting for 44.37% of the total import, an increase of 13.52 percentage points over the previous year; 1400 tons of tungsten cemented carbidewere imported, down 6.67% from the previous year. See Figure 10.

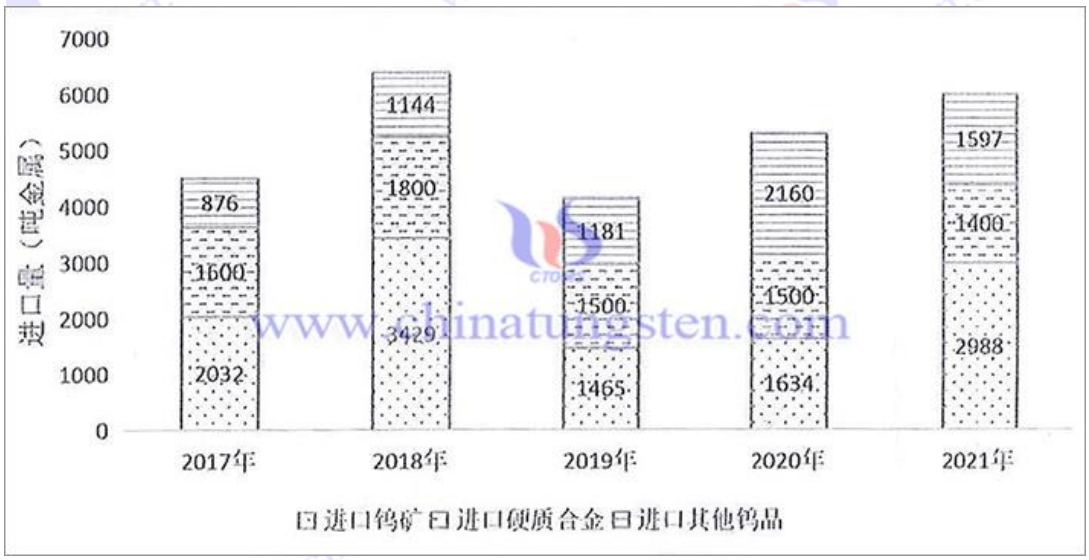

Figure 10 Tungsten import volume from 2017 to 2021 (China Customs)

In 2021, China's net export of tungsten products was 27000 tons, with a year-on-year increase of 55.55%; the net export volume was 768 million US dollars, with a year-on-year increase of 225.45%; In 2021, the total export volume of tungsten products was 5.5 times of the total import volume, while the total export volume was only 2.0 times of the total import volume, mainly due to the high price of imported high-end cemented carbide cutting tools.

2.4.2 The Four Major Export Destinations Increased Significantly Except the US

Japan, South Korea, Europe and the United States are the four major destinations for China's Tungsten exports. In 2021, tungsten products exported to Japan, South Korea, Europe and the United States were 6408.55 tons, 5856.12 tons, 7356.43 tons and 1940.9 tons respectively. Japan, South Korea and Europe increased by 73.19%, 62.11% and 75.64% respectively year-on-year, and the United States decreased by 17.58%. The tungsten products exported to the above four countries and regions accounted for 87.43% of the total tungsten products exported, a decrease of 0.07 percentage points over the previous year. Among them, the tungsten products exported to Japan, South Korea, Europe and the United States accounted for 25.99%, 23.75%, 29.83% and 7.87% of the total tungsten products exported respectively. Compared with the same period, the proportion of Japan, South Korea and Europe increased by 2.62%, 0.93 and 3.38 percentage points respectively, as shown in Figure 11 and 12.

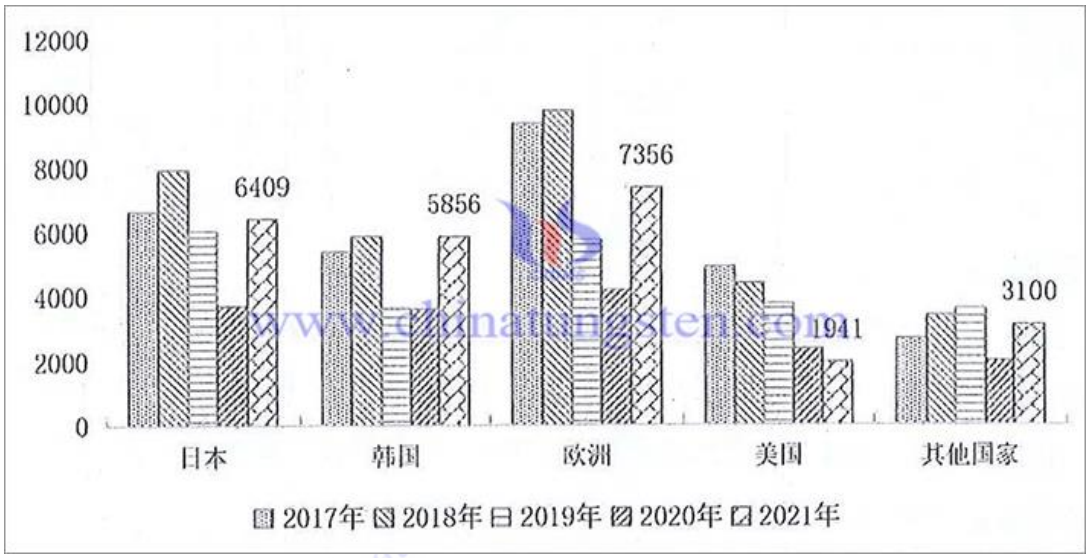

Figure 11 Change trend of export volume of tungsten export destinations from 2017 to 2021 (China Customs)

Ammonium metatungstate (AMT) ((NH4) 6h2w12040 • xH2O) is a water-soluble compound of tungsten, which is white crystalline powder or yellowish, harmless and weakly acidic. It can be used to produce raw materials for catalysts, capacitors, nuclear shielding, flame retardants and corrosion inhibitors. It is also an excellent raw material for preparing ultra-fine tungsten powder, high specific gravity alloy tungsten powder, phosphotungstic acid, arsenic tungstic acid and silicon tungstic acid; AMT can be used in catalytic chemical industry, medical industry, semiconductor and other scientific and chemical disciplines. (www.chinatungsten.com)

2.5 Investment, Financing & Promotion of New Tungsten Projects

In 2021, the tungsten producers of China carefully planned a number of key projects around industrial transformation and upgrading, process and technology innovation, product optimization and quality improvement, which promoted the green and intelligent development of the industry and provided strong support for the high-quality development of the industry. The technological transformation of tungsten carbide powder intelligent production line of Zhuzhou Cemented Carbide Group, a branch of China Tungsten High Tech

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Co., Ltd, the CNC blade production line of Zigong Cemented Carbide, another branch of China Tungsten High Tech, the underground 5g network construction for mining of tungsten ore in Shizhuyuan Nonferrous Metals Co., Ltd. have been completed. Meanwhile, Ganzhou Industrial Park project with a total investment of 10.2 billion RMB Yuan by Jiangxi Tungsten Holding Group has been started, and the phase I construction of an annual output of 10,000 tons of tungsten powder and 8000 tons of tungsten carbide powder line, tungsten powder and tungsten cemented carbide mining production line of Xiamen Jinlu Haicang Tungsten Cemented Carbide Industrial Park (phase II) with a total investment of 2 billion yuan by Xiamen Tungsten are also have been started, and the annual output of construction has been increased 12000 tons of tungsten powder, 11,200 tons of mixture tungsten carbide powder (tungsten ready to press powder), 2000 tons of tungsten carbide mining tips production line and supporting facilities; With a total investment of 560 million RMB Yuan, the main infrastructure of the industrialization project of Lugu Base of Boyun Dongfang with an annual output of 2000 tons of high-efficiency and precision cemented carbide tools and high-strength and toughness extra coarse-grained tungsten cemented carbide tunneling tools has been completed.

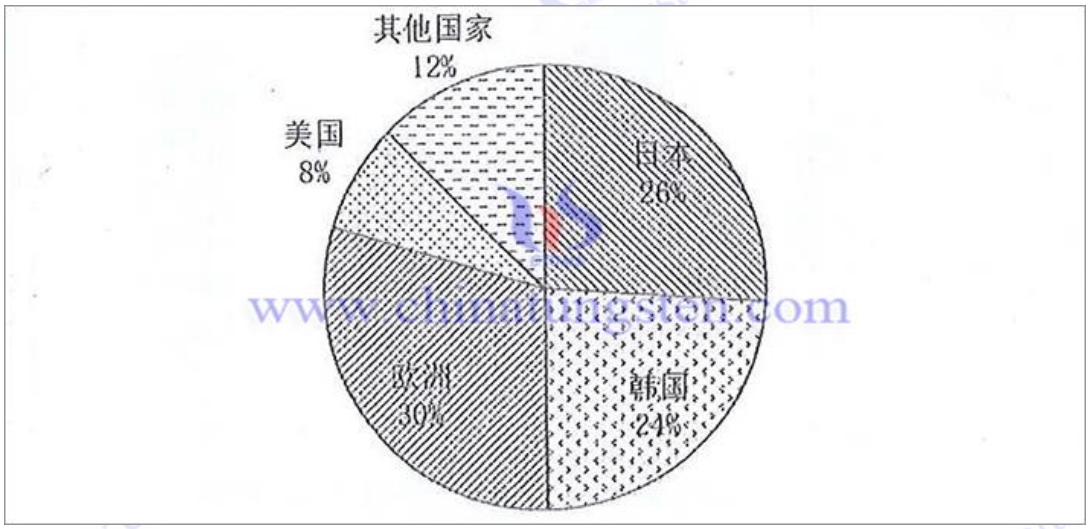

Figure 12 Proportion of tungsten export destinations in 2021 (China Customs)

Tungsten Cemented Carbide Buttons & Tips of China Tungsten Online

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PART III

ANALYSIS ON THE SITUATION OF CHINA TUGNSTEN INDUSTRY 2021

At the opening ceremony of 2021 China (Shanghai) Tungsten Raw Material Industry Development High-end Forum, Chang Guowu, deputy director of the Raw Material Industry Department of the MIIT, pointed out that China has the world's largest tungsten resource reserves and is also the world's largest tungsten producer, consumer and trading country. The tungsten industry shows a good trend of vigorous development, a number of deep-processing products have made breakthroughs, and several cemented carbide industry clusters are beginning to take shape. In accordance with the spirit of the outline of the national "14th five year plan", we should firmly grasp the positioning of tungsten as China's advantageous strategic resources, give full play to the advantages of reserves and industrial scale, supplement the shortcomings restricting the high-quality development of China's tungsten industry, promote the high-end, intelligent and green tungsten industry, and improve the basic industrial capacity and the modernization level of industrial chain. He stressed that China's tungsten industry should optimize the industrial structure, improve industrial concentration, strengthen resource control, strengthen the supervision of resource development order, severely crack down on all kinds of illegal mining, and strictly implement the total tungsten mining plan; We should improve the green and intelligent level, promote the construction of smart mines and smart factories in the tungsten industry, support the promotion of new efficient and green smelting processes, develop renewable tungsten resource recovery system, and realize the efficient and green development of the tungsten industry chain; We should make up for the shortcomings in the development of high-end materials, accelerate the promotion and application of tungsten materials and cemented carbide, focus on the needs of the development of aerospace, national defense and military industry, integrated circuits and other fields, accelerate the breakthrough of core technologies such as special powder preparation and tool coating, improve the consistency and stability of product quality, and promote China's tungsten industry to move towards the middle and high end of the global value chain.

3.1 Industrial Policies Ensure the Stable Running of the Industry

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The Chinese government continues to implement the management principle of total amount control of tungsten mining yearly. In 2021, the total amount control index of tungsten concentrate mining was 108,000 tons, an increase of 2.86% over the previous year.

China will continue to implement "the Guiding Catalogue for industrial restructuring (2019) (NDRC No. 29)", "the Negative List of Market Access (2019) (FGJT (2018) No. 1892)", and the state-owned trade management policies for tungsten exports, the Ministry of Commerce issued "the Special Management Measures for Foreign Investment Access (Negative List) (2021) and the Special Management Measures for Foreign Investment Access in the Pilot Free Trade Zone (Negative List) (2021)". The negative list of foreign investment access in 2021 puts forward that investment in tungsten exploration, mining and beneficiation is prohibited. The Ministry of Industry and Information Technology, the Ministry of Science and Tchnology and the Ministry of Natural Resources jointly issued the " '14th Five-year Plan' for the Development of Raw Material Industry (MIIT Lian GUI (2021) No. 212)", and the NDRC issued "the Notice on the "14th Five-year Plan" for the Development of Circular Economy (FGHZ (2021) No. 969).

The above industrial policies and plans have important guiding significance for the tungsten industry and effectively ensure the smooth operation of the tungsten industry.

On June 30, 2021, the commissioning ceremony of Konfoong Materials International Co., Ltd ("KFMI") super large specification hot isostatic pressing equipment was held in Ningbo KFMI Hot Isostatic Pressing Technology Co., Ltd. The super large-scale hot isostatic pressing equipment put into operation this time is jointly and independently developed by KFMI and Western Sichuan Machinery, which has realized full localization, and the relevant technical parameters have reached the international advanced level. The working height of the effective hot zone of the equipment is 4.5m, the diameter is 1.25m, the maximum heating temperature can reach 1500 ℃, and the maximum pressure can reach 2000 atmospheres, which is equivalent to the pressure of 20000 meters deep seabed. It is an important national instrument for preparing large-size Tungsten and Molybdenum Alloy

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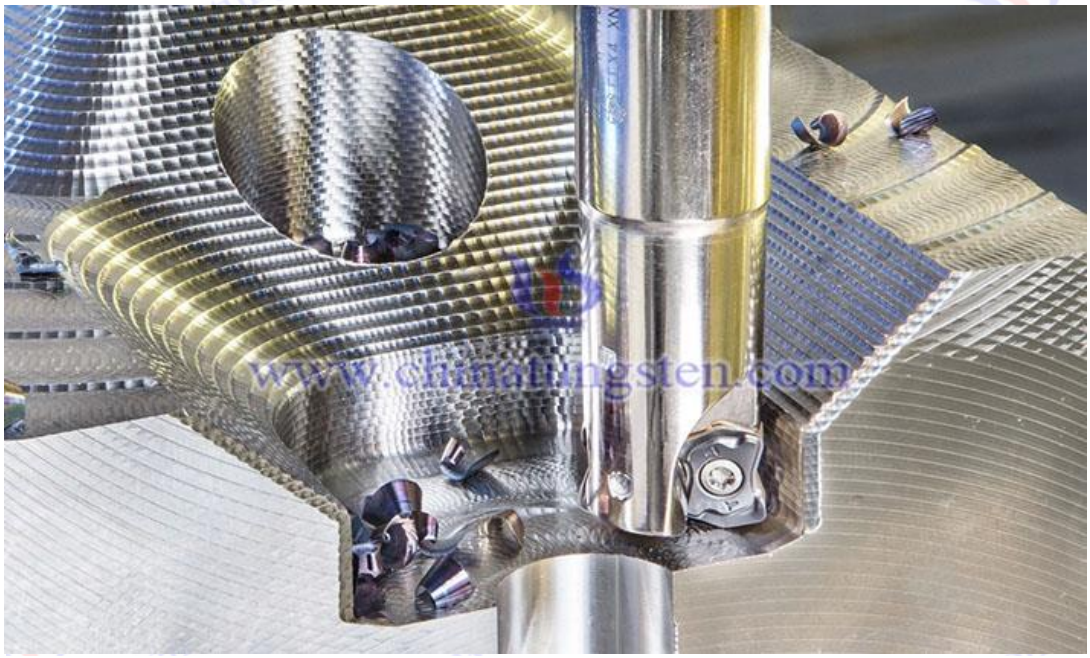
Targets for high-end liquid crystal panels, powder metallurgy materials, aerospace and other key materials. After the equipment is put into operation, it will promote the application of hot isostatic pressing technology in the preparation of ultra-high purity targets. China's electronic material industry is expected to rank among the leading level of international equipment, supplement China's equipment shortcomings in this field, and provide new equipment support capacity for China's electronic material field.

3.2 Tungsten Industrial Structure Optimization Continuously

The level of technological equipment of tungsten industrial of China has been gradually raised to the international level. The automation and intelligent construction of tungsten mines have been gradually started, and the smelting process have made a breakthrough in green environmental protection and energy saving. The advanced equipment such as Automatic 15-Tube Tungsten Reduction Furnace, molybdenum wire carbonization furnace, fully automatic hydraulic press and multi atmosphere tungsten cemented carbide pressure sintering furnace have been basically popularized, and the manufacturing equipment and coating equipment of hard alloy cutting tools have reached the international advanced level. The market share of high-end products has gradually increased. High light tungsten cemented carbide such as nano，ultra-fine cemented carbide, fine grain size , medium grain, coarse grain and ultra coarse grain tungsten cemented carbide, coating cemented carbide, net micro structure tungsten cemented carbide and gradient structure tungsten cemented carbide have been industrialized, and CNC blades have achieved leapfrog development. In 2021, the output of CNC blades exceeded 450 million pieces, and significant progress has been made in category and quality, basically meeting the needs of the national economy, defense and military industries for CNC blades, especially, the annual output of Zhuzhou Cemented Carbide set a record and took the lead in breaking through 100 million pieces. The tungsten products' structure of China has been continuously improved, the proportion of tungsten cemented carbide and other deep-processing products has increased, and the export volume proportion of high-tech products has gradually increased.



Iscar launched LOGIQ-4-feed milling cutter with small diameter and large feed, which holds narrow milling insert with 4 cutting edges. The new milling cutter FFX4 - 04 provides economical solutions for most applications, and provides milling cutters with the following structures: FFX4 ED – end milling cutter, with milling cutter diameters of 12,16,20,25 and 32 mm, and the handle type is cylindrical handle and flat handle; FFX4 ed-mm - multi-master module threaded end milling cutter head with a diameter of 16 mm; FFX4 ed-m – FlEXFIT module threaded end milling cutter head with milling cutter diameters of 20, 25, 32 and 35 mm; FFXFD - face milling cutter with diameters of 32 and 40 mm.

3.3 The Macroeconomic & Microeconomic Factors are More Complex

The global epidemic continues, the momentum of world economic recovery is insufficient, commodity prices fluctuate at a high level, and the external environment is becoming more complex, severe and uncertain. China's economic development faces the triple pressure of shrinking demand, supply shock and weakening expectation. Local outbreaks occur from time to time. The recovery of consumption and investment is slowing, it is more difficult to stabilize exports, the supply of energy and raw materials is still tight, the production and operation of small, medium-sized and micro enterprises and individual industrial and commercial households are difficult, and the task of stabilizing employment is even more arduous. The ability to support innovation in key areas is not strong. In some places, the contradiction between fiscal revenue and expenditure has increased, and there are many hidden risks in the economic and financial field. Then, tungsten industry faces more severe challenges.

Energy policies and environmental protection regulations such as oil and electricity, carbon emission standards and the concept of carbon neutralization have brought great challenges and driving forces for change to the tungsten products industry with high energy consumption.

3.3.1 The Operation Cost of Tungsten Industry is Higher

In 2021, influenced by the global COVID-19, liquidity flooding, supply bottlenecks and other factors, bulk commodities price will remain at a high level. This has dragged down the recovery of the global economy, especially squeezing the profit margins of final tungsten

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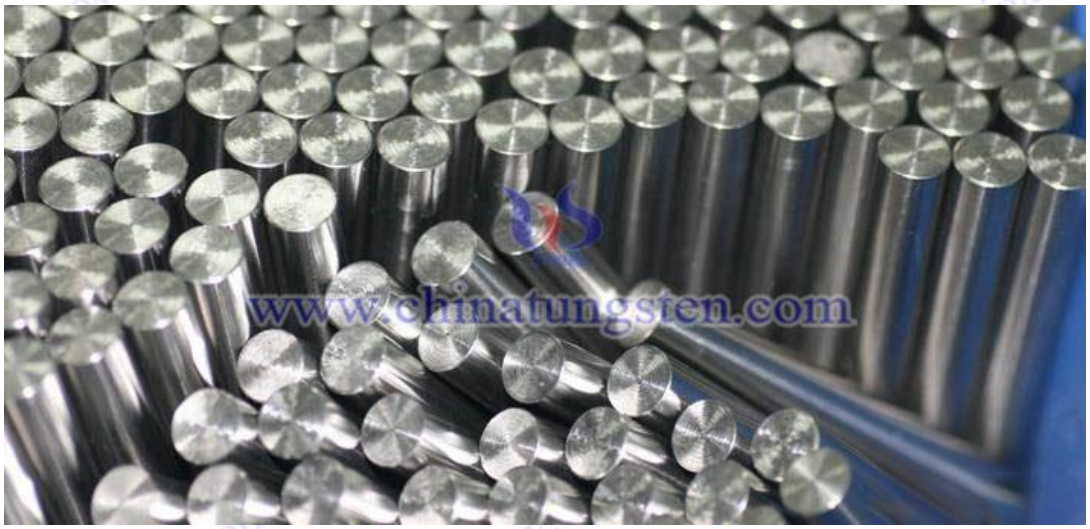
and its carbide, alloy manufacturing enterprises. Since 2022, affected by international risk events, the prices of crude oil and natural gas have continued to rise, posing a challenge to the domestic work of ensuring supply and stabilizing prices, and the tungsten industry is facing the pressure of high operating costs.

3.3.2 The Supply & Demand of Tungsten has Turned into a Weak Balance

In 2021, China's epidemic prevention and control was effective, making the economy take the lead in global recovery, with GDP growth of 8.1%, higher than in recent years, and domestic tungsten consumption and export achieved related reasonable growth. Combined with the domestic and international economic environment, the expected GDP target in 2022 is about 5.5%, and the growth of China's tungsten consumption and export is expected to slow down. The trend of China's tungsten consumption in recent five years is shown in Figure 13.

Figure 13 China's tungsten consumption from 2017 to 2021 (CTIA)



The customized tungsten rods of China Tungsten Online include forged and rolled tungsten rods, straightened tungsten rods,

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polished tungsten rods, ultra-fine tungsten needles, etc. tungsten rods and needles have the characteristics of high melting point, good thermal conductivity, high resistance, high elastic modulus and low coefficient of thermal expansion. They are used in electrodes, filaments, wires, printer needles, sputtering targets, chip testing, high-speed tools, weapons, etc.

In terms of supply, the global supply of tungsten concentrate is expected to increase gradually. Some foreign tungsten mines have been shut down due to the market downturn in the past period of time. At present, the progress of tungsten mine projects under construction or reconstruction is slow, and some projects with new production capacity originally planned to be put into operation in 2021 have not been put into operation as scheduled.

The tungsten project continues to be promoted, and it is expected that new tungsten production capacity will be put into operation in the next two years. The technological transformation and capacity expansion of some domestic tungsten mines will gradually and steadily release the new production capacity; The production of some mines is reduced due to the decline of grade, and some mines are shut down for a long time due to ecological red line, resource depletion, low efficiency and other factors.

Russia is the second largest tungsten resource country in the world, and also a country that developed and processed tungsten products earlier. China's earliest tungsten products finishing came from the technical assistance of the former Soviet Union. Now, the turbulence of resource remediation and the instability of the world economy caused by the conflict between Russia and Ukraine have brought great uncertainties to the tungsten products industry. For the significant impact of the conflict between Russia and Ukraine on the price and market of China's tungsten products, you can visit China Tungsten online website to read detailed analysis and reports.

In terms of demand, internationally, regional conflicts have led to abnormal increases in the prices of energy, food and some metals, sanctions have led to supply chain interruption, market chaos or short-term price fluctuations of tungsten products, and demand

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uncertainty has increased. China still maintains its position as a global manufacturing power, continues to promote industrial transformation and upgrading, has a good momentum of new energy and new infrastructure, and the demand for tungsten is growing continuously. The layout of China's tungsten industry has been gradually optimized, the coordinated development of tungsten industry chain and regions has been gradually promoted, the new advantages of international competition have been continuously improved, and the ability to provide industrial supporting services has been gradually strengthened.

PART IV

OUTSTANDING PROBLEMS & SOLUTIONS OF CHINA TUNGSTEN

4.1 Outstanding Problems Faced

4.1.1 Consumption Rate of Tungsten in China is Higher than the Global Average

China's tungsten resources account for less than 60% of the global reserves, but the exploitation volume has reached more than 80% of the world. The resource consumption rate of China is higher than the global average, and the resource advantage is gradually weakening. Although the identified tungsten resource reserves have increased, the updated basic reserves have decreased significantly, and the newly discovered large-scale mineral resource endowment is relatively poor. Under the current technical conditions, the economic benefits of development and utilization are expected to be poor.

The good comprehensive performance of tungsten cemented carbide tools makes them widely used in the processing of steel, stainless steel, cast iron, non-ferrous metals, heat-resistant steel and hardened steel materials, accounting for about 63% in the global tool market and 53% in the China. Cutting accounts for about 90% of the whole machining workload, efficient and advanced cutting tools can significantly improve the machining efficiency and reduce the production cost by 10% ~ 15%. Cutting tool materials should have the characteristics of hardness and wear resistance, strength and toughness and heat resistance.

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Cutting tools mainly include cemented carbide, high-speed steel, ceramics and super hard materials; Among them, cemented carbide has higher hardness, wear resistance and red hardness compared with high-speed steel, and cemented carbide has higher toughness compared with ceramics and super hard materials.

4.1.2 The Production Capacity of High-end Tungsten Products Needs to be Improved.

In recent years, China has developed rapidly in tungsten deep processing, and has made great achievements in Numerical Control (NC) blade, PCB micro drill and high-performance tungsten materials. However, at present, more than 10 billion RMB Yuan of high-end tungsten products are still imported from abroad every year; The price of imported tools is much higher than the export price. The average import price of coated blades is about 3.81 times that of export, 6.41 times that of uncoated blades, 2.71 times that of milling cutters and 17.06 times that of measuring tools. Domestic product upgrading has a long march to go, and localization still has great potential. 60% of the exported tungsten products are raw material grade tungsten products. In terms of industrial structure, the proportion of deep processing is relatively small, and its global advantages are still concentrated in the upper reaches of the industrial chain; The market share of high-end tungsten products is still relatively low, and the overall solution service system is in its infancy

Tungsten cemented carbide numerical control (NC) blade

4.1.3 China's Capacity of High-end Equipment for Tungsten is not Enough

The machining accuracy of China's cutting tool products is close to the international advanced level, and the matching of key equipment is one of the important links. There is still a certain gap between China's key equipment and the international leading level, and some high-end equipment for tungsten manufacturing depends on imports.

4.1.4 The Market Mechanism is Single and Lack of Innovation and Vitality

The concentration of China's tungsten industry is relatively low, and the upstream and downstream of the industrial chain are in a full competition pattern. Under the single spot market mechanism, the market competition consumes technological progress and resource advantage dividends. The overall benefit level of the industry is relatively low, which restricts the R & D investment and industrial upgrading process, and the value of strategic metals has not been fully reflected.

Powder metallurgy pressure sintering furnace, Made in China. In order to promote the implementation of "China's tungsten industry development plan (2021-2025)", understand the gap between the current situation of tungsten industry equipment and foreign advanced equipment and the development ideas of key equipment in the future, build an exchange platform for equipment manufacturing, technology and application, and promote coordinated development, CTIA plans to hold the "**China Tungsten Industry Equipment Industry Forum**" (hereinafter referred to as the **CTEIF**) in September in Xiamen, China every two years. CTEIF will be Supported by Xiamen Tungsten Industry Co., Ltd. and China Tungsten High Tech Materials Co., Ltd., CTEIF will be hosted by geological and Mining Branch, Smelting Branch Tungsten C Cemented Carbide Branch, Tungsten Raw Material Branch, Tungsten Ferro Alloy Branch of CTIA and China Tungsten Online. CTEIF plans to hold 12 thematic reports on advanced equipment and technology in tungsten industry, and the conference will collect and publish the list of tungsten industry equipment, tools, analysis and testing instruments. In particular, the meeting welcomes the active participation of all international manufacturing and processing equipment, inspection and testing manufacturers, intelligent manufacturing software and hardware manufacturers and service providers for tungsten, molybdenum and rare earth mining, smelting and production. For details, please contact Miss Zheng, Secretary of the Permanent Management Office of the CTIAIF zhenghua@ctia.com.cn , or please visit CTIA's web, also, please follow us at about CTEIF here below.

4.2 Suggestions for China's Tungsten Industry

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4.2.1 Slow Down the Consumption of Tungsten Resources

Great attention should be paid to slowing down the rate of resource consumption, maintaining the sustainable and healthy development of the industry and improving the ability of strategic resource support. Reducing the rate of resource consumption to the global average and matching the resource reserves is a phased goal. The specific measures are as follows: first, continue to implement and optimize the management policy of total tungsten mining index control, and orderly develop and utilize tungsten resources on the premise of fully ensuring the development of national economy; Second, accelerate the pace of "going global", coordinate the international and domestic markets and resources, actively carry out international cooperation, and encourage backbone enterprises with strong international operation ability to explore and exploit overseas resources; The third is to increase the recycling of waste tungsten and moderately liberalize the import of qualified renewable raw materials of tungsten resources; the fourth is to strengthen the deep edge prospecting of mines in production and prolong the service life of mines.

4.2.2 Continue to Promote & Upgrading the High-quality Development of Tungsten Industry

The vitality and hope of China's tungsten industry not only come from our rich tungsten resources, but also from the long-term unremitting technical research and improvement of production capacity with China's tungsten products enterprises.

Introduce special incentive policies to encourage the tungsten industry to take scientific and technological innovation as the driving force, improve industrial profitability, improve industrial structure, enhance international competitiveness and promote the high-quality development of the tungsten industry. (1) Improve the innovation system of tungsten industry, focus on intensive processing technology, aim at the scientific and technological

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frontier of the development of tungsten industry, strengthen basic research and lead major breakthroughs in original achievements; (2) Expand the application of tungsten terminals, focus on the research and development of tungsten precision and deep-processing products, strengthen the research on common technologies, and expand the application of tungsten in various fields of the national economy; (3) Promote the intelligent manufacturing of high-end cemented carbide and support the technological progress of key equipment; (4) Governments at all levels should increase their support, support enterprises' scientific and technological investment, talent introduction and training, and reward original core technological achievements; (5) Promote the supply side reform of the tungsten industry, improve the industry access system, study and formulate supporting regulatory measures, stop low-level repeated construction, promote energy conservation and emission reduction, prevent pollution, and eliminate production lines with backward technology and unqualified safety and environmental protection.

4.2.3 Improve the Management Policy of Tungsten Industry.

From the perspective of strategic resources, re-examine the management policy of tungsten industry, and build and improve the strategic resource management policy system. Improve the development and management mechanism of tungsten resources, regulate the "main gate" of tungsten resource allocation, and promote the protection and rational development and utilization of tungsten resources; Implement the dynamic strategic reserve mechanism to maintain the healthy operation of the industry and ensure the autonomy and controllability of key industrial chains; Optimize and implement policies related to renewable resources and raise renewable utilization to the height of industrial strategy.

序号	产品编码	产品名称	调整后退税率(%)
1112	82081011	经镀或涂层的硬质合金制的金工机械用刀及刀片	16
1113	82081019	其他硬质合金制的金工机械用刀及刀片	16
1114	82081090	其他金工机械用刀及刀片	13
1115	82082000	木工机械用刀及刀片	13
1116	82083000	厨房或食品加工机器用刀及刀片	13
1117	82089000	其他机器或机械器具用刀及刀片	13
1118	82090010	未装配的工具用金属陶瓷板	16
1119	82090021	未装配的工具用金属陶瓷条、杆	16
1120	82090029	其他未装配的工具用金属陶瓷条、杆	16
1121	82090030	未装配的工具用金属陶瓷刀头	16
1122	82090090	未装配的工具用金属陶瓷板、条、杆、刀头的类似品	16

Since November 1, 2018, China has increased the export tax rebate rate of some tungsten cemented carbide blades and other cutting, drilling and other tools to 16%. For products not involved in the table, if the original export tax rebate rate is 15%, the export tax rebate rate will be increased to 16%; If the original export tax rebate rate is 9%, the export tax rebate rate will be increased to 10%; If the original export tax rebate rate is 5%, the export tax rebate rate will be increased to 6%. This policy is a favorable policy for the development of China's cemented carbide industry, especially high-end CNC cutting tools.

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4.2.4 Improve the Market Mechanism and Enrich the Market Regulation Tools.

Research on listed tungsten futures, enrich the market mechanism, provide hedging tools for the industry, enable the financial attribute of tungsten strategic resources, help the scientific and technological innovation of the industry, and promote the sustained, healthy and high-quality development of the industry

Any more about China Tungsten, and any news about tungsten worldwide, please visit CTIA, Any questions, comments and suggestions, please contact: zhenghua@CTIA.com.cn.

Tungsten Cemented Carbide Coated Cutting tools, NC blades will be the technical direction that China Tungsten Industry, especially tungsten cemented carbide enterprises will strive to improve for a long time in the future.

Physical vapor deposition (PVD) is a method of producing hard coatings on metal substrates. It generates locally ionized metal vapor, reacts with specific gases, and forms thin films with specified components on the substrate. The most common methods are sputtering and cathodic arc. In sputtering, steam is generated by bombarding metal targets with energetic gas ions. The cathode arc method uses repeated vacuum arc discharge to impact metal targets and evaporate materials. All PVD processes are carried out under high vacuum. PVD process is used for the coating of a large number of tools and components. The coating is composed of nitrides, carbides and carbon nitrides and alloys of Ti, Cr and Zr, such as alcr, alti and TiSi. Applications include cutting and forming tools, mechanical components, medical devices and products that benefit from the hard and decorative characteristics of coatings. Typical process temperatures for PVD coatings are between 250 and 450 ° C. In some cases, PVD coatings can be deposited at temperatures below 70 ° C or up to 600 ° C, depending on the substrate in the application and the expected performance. The coating can be deposited in single, multiple and graded layers. The latest generation of thin films are multilayer coatings with nanostructure and superlattice changes, which provide enhanced properties. The coating structure can be adjusted according to hardness, adhesion and friction to produce the desired performance. The final choice of coating depends on the requirements of application. The coating thickness ranges from 2 to 5 microns, but can also be as thin as hundreds of nanometers or as thick as 15 microns or more. Base materials include steel, non-ferrous metals, tungsten carbide and pre–Electroplated Plastics. The suitability of PVD coating substrate is only limited by its stability in terms of deposition temperature and conductivity.

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