

## Powder Metallurgy in China

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### Abstract

*China's PM has made great progress both in the research and development of new materials and large scale production, and has played a more and more important role in the world powder metallurgy industry. In this paper, the status quo of advanced PM materials, and traditional PM industries in China, will be discussed.*

**Keywords:** Powder metallurgy industry, Research and development, China

### 1. Introduction

The modern Powder Metallurgy industry in China started in the 1950's. After nearly half a century's development, China has now become one of the leading countries in the world in many aspects of powder metallurgy industry, including the application of new PM materials and techniques. The manufacture of powder metallurgy products has achieved a remarkable progress, the output of cemented carbide and Nd-Fe-B alloy in China for the year 2005 account for 40% and 70% of the total output of the world, respectively. The main PM industries will be briefly described.

### 2. Iron & Copper Based P/M Industries

In 1952, the Cu-based oil-impregnated bearings fabricated by Shanghai Factory of Textile Machine marked the beginning of Copper based P/M industry in China. The foundation of Beijing Tianqiao PM Factory in 1961 and the production of reduced iron powder in Shanghai PM Factory indicated that the Chinese P/M industry had stepped into a new developing period. Since the late of 1980s, high precision presses and advanced sintering furnaces have been imported, which greatly improved the precision and the shape complexity of P/M parts.

Since 2001, the output of Fe powders has been kept increasing by 20% each year. The proportion of atomized Fe powder has reached 20% of the total Fe powder production in China. Now, Shandong Laiwu Iron & Steel Group can produce 40,000 t atomized Fe powder annually.

The output of copper powder has been more than 8400 ton/year(t/y) since 2002. The surface modification technique of the water atomized copper powder has been used.

The output of ferrous-based P/M parts in China has increased quickly since the 1990s, especially between 2001

and 2004, when the annual growth rate of the P/M part is over 25%. This was attributed to the rapid development of automotive industry in China. Up to now, about 4 kg P/M parts are used in a Chinese car. For the coming 5 years, if the P/M parts used in each car increase by 2kg, based upon the estimation of 6 million cars made in China each year (China produced 5.7 million cars in 2005), the output of P/M will reach 100,000 tons. For the output of copper based parts in recent years, the oil-impregnated bearings account for 50%. In the recent years, copper based P/M parts increase rapidly. The output was 38000 t in 2001, and then reached to 65000 t in 2004. Since 1995, Wuhan Iron & Steel Company, Beijing University of Science and Technology, Central South University and South China University have carried out a series of investigations in the warm compaction, an 0.95kg magnetic part with density of 7.41 g/cm<sup>3</sup>, and higher compressibility powders for warm compaction were successfully fabricated. For Fe-1.5Ni-0.5Mo-1Cu-0.5C (wt.%) powder mixtures, the green density can reach 7.46 g/cm<sup>3</sup> under a compacting pressure of 637MPa. High load helical gear used in engines and valve canals were manufactured by the addition of hard carbides to the ferrous-based powders. In 1998, Yangzhou Porite Company imported the warm compaction processing. It now produces 700 t/a warm compaction parts, 70% the total output in China.

### 3. Cemented Carbide Industry

In 1948, the first 30 kg batch of WC-Co cemented carbides was produced by Dahua Electrometallurgy Plant. In 1958, China's largest cemented carbides manufacturer --- Zhuzhou Cemented Carbide Works (the present Zhuzhou Cemented Carbide Group Corp. Ltd.) with a designed capacity of 500 t/a was put into production. In 1965, the second cemented carbide manufacturer --- Zigong Cemented Carbide Works (the present Zigong Cemented Carbide Co.,

Ltd.) with a designed capacity of 400 t/a was put into production.

Now, there are around 200 cemented carbides enterprises in China, with a total production capacity of more than 20,000 t/a. Enterprises with tungsten resources, such as Chongyi Zhangyuan Tungsten Co., Ltd., grow fast in recent years. Some of these enterprises have modulated their product structure from tungsten concentrate oriented products to powders and cemented carbides, so as to bring their resources advantage into full play. In 2005, around 63% of the tungsten concentrate was used in cemented carbides industry. According to the statistics from China's 48 cemented carbide enterprises which are the main cemented carbide producer, China's cemented carbide production output created a record high of 15,000 t in 2004, accounting for nearly 40% of the global output. The two largest China's cemented carbide enterprises, Zhuzhou Cemented Carbide Group Corp. Ltd and Zigong Cemented Carbide Co., Ltd, accounted for about 50% of the total output in 2004.

China's cemented carbide products cover almost all the varieties, from metal cutting inserts, mining tips, wire-drawing dies to various wear parts and down-stream finished products. Nevertheless, some high-precision ground and coated cutting inserts and their toolholders, ultra-fine cemented carbide rod as well as special and large products still rely on the import.

#### 4. Refractory Metals Industry

China's tungsten industry began in the 1950's. Chinese tungsten-filament industry is the second industry of tungsten product following cemented carbide. According to the statistics, in 2005, around 12% of tungsten concentrate was used in the production of tungsten products, including tungsten heavy alloys, tungsten-copper alloy, tungsten-filament, tungsten stick, tungsten material and tungsten sheet, et al. The output of tungsten-filament is over 25% in all tungsten products. In recent years the capacity of tungsten electrode increases quickly in China. In 2003, the capacity of the 16 corporations for tungsten electrode achieved 962 t, with an output of 660 t. However, in 2005, the output of tungsten electrode was almost doubled, which is about 1000 t. The annual output of tungsten sheet is 60~100 t, over 80% of which is pure tungsten.

China's heavy alloy industry began with W-Ni-Cu in the 1960s. In the 1980s the output of tungsten heavy alloys was 300 t, but now is 2,500 t.

The production of molybdenum in China has the history of about 60 years. In the periods of 1981 to 2000, the output of the fine molybdenum wire increased from 150 million meters to 2.1 billion meters, and the output of the stick and the thick wire increased from 40 t to 400 t. TZM and TZC alloys have been used widely. Recently HTM alloy was prepared through Liquid-Solid adulteration. The re-crystallization temperature of HTM is increased to 1,800 °C, and the alloy still has high strength and good plastic after

re-crystallization.

In Ta powder industry, Ta powder with a capacitance of over 100,000  $\mu\text{F}\cdot\text{V/g}$  was developed. Moreover, Nb powder with a high capacitance of 100,000  $\mu\text{F}\cdot\text{V/g} \sim 120,000 \mu\text{F}\cdot\text{V/g}$  was recently produced.

#### 5. Magnets Industry

Currently there are four main types of magnetic commodities in China: the AlNiCo permanent magnets which was developed in the late 1930's; the ferrimagnets, developed in the early 1950's; the SmCo permanent magnets, developed in the late 1960's; and the third generation of Rare Earth permanent magnets NdFeB, which was developed in the early 1980's.

There has been rapidly development during recent 10 years in the magnets industry in China. By 2004, China's sintered ferrimagnets had reached a production of 350,000 t, which was 10 times of the output of 35,000 t in 1990, and the binding ferrimagnets 50,000 t. The sintered NdFeB permanent magnets has a production of 27,510 t, the binding NdFeB permanent magnets 1,350 t; and the casting magnets 3,500 t. Up to now, there are several enterprises with a production ability of 1000 t/a of sintered NdFeB and 300 t binding NdFeB respectively.

The production of China's NdFeB increases very rapidly. The output was 6,500 t in 2001, increased to 8,800 t in 2002 by 35%, doubled in 2003, and kept on increasing by 50% in 2004. The average yearly increasing rate was 61.8% from 2001 to 2004. The main magnet producers in China are Beijing Zhongke Sanhuan Hi-Tech Co. Ltd., which has products for computer hardpan driver's Voice Coil Motor (VCM), automotive accessories and nuclear magnetic resonance imagining instruments (NMR); Beijing General Research Institute of Mining & Metallurgy, which has successfully developed a new rotary stove furnace dealing with iron scales with a capacity of 8,000 t/a; Advanced Technology & Materials Co., Ltd. (AT&M), which produces over 1,500 t/a sintered magnets; and DMEGC Magnetics Co., Ltd., the biggest producer of permanent ferrimagnets and the soft ferrimagnets in China, with a capacity of 100,000 t/a permanent magnets.

#### 6. Friction materials industry

Sintered friction materials have been made in China since 1950. Now, China's production ability is approximately 8.5 million parts a year. These parts are applied in many fields, such as airplane, ship, engineering machinery, agricultural machinery, cars, heavy vehicle, etc. In terms of materials, it can be divided into iron based, copper based and other metal matrixes. Now, iron and copper based friction materials accounts for more than 90% of the total. It basically can satisfy our country demands of friction materials supply and

application in ultimately primary mainframe and import-machine.

The output of Cu-based materials was stable growing, and reached 2013t in 2004, which accounted 92.5% of the total output of friction material parts.

The brake materials for civil airplane have been developing well. The iron based brake materials for Boeing airplane can satisfy internal requirements of spare parts, and the average service life is 1400-1500 times of flying-off/lading, the most reached 1800 times; The brake materials for Tu154 have been exported to Russia, and Ukraine, and others by batch.

## 7. Research and education

The rapid progress of powder metallurgy technology and industry in China is benefited by the incessant educating of professionals and the emphasis on the research and development of new techniques and new materials.

There are several universities in China, which have a long history of educating powder metallurgy professionals and specialists. They are Central South University, University of Science and Technology Beijing, South China University of Technology, Hefei University of Technology, Harbin Institute of Technology, Beijing University of Technology and Northeastern University. In 2005, there were about 800 undergraduates, 250 M.D. students and 200 doctor Ph.D. students majoring in powder metallurgy in China. It is estimated that about 8,000 high-ranked powder metallurgy professionals (Professor and Associated Professor levels) working in China.

Chinese government has paid much attention to the research of new PM technology and materials. Research divisions or laboratories specialized in Powder metallurgy have been established in many large institutes, such as Beijing Research Institute for Nonferrous Metals, Beijing Research Institute for Iron and Steel, Guangzhou Research Institute for Nonferrous Metals, Northwestern Research Institute for Non-ferrous Metals, Beijing Research Institute for Aerial Materials, Institute of Metal Research Chinese Academy of Sciences, and Kunming Research Institute for Precious Metals. In addition, some specialized powder metallurgy institutes have been established, such as Beijing Powder Metallurgy Research Institute and Hangzhou Powder Metallurgy Research Institute. Besides professionals' cultivation, much research work has also been focused on this field by many universities and colleges, such as Powder Metallurgy Research Institute, National Engineering Research Center of Powder Metallurgy (NERC-PM), State Key Laboratory for Powder Metallurgy (SKL-PM), Analysis and Measurement Center for Powder Metallurgy have been established in Central South University. University of Science and Technology Beijing has also set up a research institute for powder metallurgy. Additionally, many enterprises have also set up relevant PM R & D centers, such as Zhuzhou

Cemented Carbide Group Corp. Ltd and Zigong Cemented Carbide Co., Ltd.

## 8. Conclusions

Powder metallurgy industry in China has achieved tremendous development in production, research and education, but there is still a certain distance between China and other developed countries. As the acceleration of Chinese industrialization and rapid development of the equipment manufacturing, especially the development of automobile industry and the information industry, the future five to ten years will be the period for high speed development of powder metallurgy industry in China.

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