

# The 40 Years of Baoji Titanium

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The paper briefly introduces the history and the future prospect of Baoji Ti. The largest scientific research and production base of rare metal material and product is mainly on titanium-BAOTi Group Co. Ltd., after 40 years constructing and developing, its capacity of titanium mill products has reached 5,000t/a, and it has got certifications of ISO 9002 and several aerospace companies abroad. It can be estimated that, BAOTi Group's capacity will reach 10,000t/a after 5 year's developing, and process, technique and quality of its product will achieve the international advanced levels.

**Keywords:** Baoji Ti, BAOTi Group Co. Ltd., History, Prospect

BAOTi Group Co. Ltd. (The following simply called BAOTi Group), with Titanium and Titanium alloy leading products, specialized base for the production and research of rare metals. The Group was built as a national important enterprise, coded "902". Formerly, it was called Baoji Nonferrous Metals Works, and reformed to BAOTi Group Co. Ltd. in 2005.

The Group has 9 stock-holding corporations including Baoji Titanium Industry Co. Ltd., Nanjing Baose Titanium Industry company and West-north Zirconium Pipe Company etc., 5 subsidiary corporations and 7 direct managing sections after 40 years developing. It has a test center for large materials with top testing equipment in the world. Products are widely used in aircraft, aeronautics, chemical industry, petroleum, chemistry, electricity, metallurgy, medicine and ocean engineering, geothermal engineering, cryogenics industry, sports and tourism etc. and is exported far to more than 10 countries and regions including America, Japan, Germany, France, England, Norway, Sweden, Singapore, Italy, India, Taiwan and Hong Kong etc.

The Group has passed foreign company quality system, process technology, and several products accreditation such as ISO 9002 Quality System Accreditation, French Astronautics Company, American Boeing Company and British Rolls-Royce etc. It is judged as "High-Tech. Enterprise" by China National Science and Technology Ministry and The Chinese Academy of Science in 1999. The Group joined Japanese Titanium Association in 2003 and International Titanium Association (ITA) in 2005.

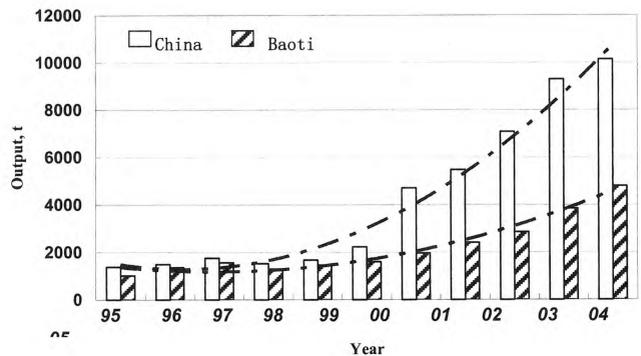
## 1. The Developing of BAOTi Group is the Witness for the Development of China Titanium

The production of titanium mill products was 500t before 1983 and over 1,000t after 1985 in China. The production reached 1,400t in 1992, among it, BAOTi Group accounted for about 90% (see Table 1). The developing velocity of other titanium processing enterprises is far along with the rapidly developing of China titanium industry after 40 years developing. (See Figure 1), BAOTi Group has been the Chairman Unit of China Titanium Association since 2006 as the leader of China titanium processing industry. So the development state for BAOTi

Group is reflection for the development of China titanium industry<sup>1-6</sup>).

**Table 1.** The statistics of products produced by BAOTi (t)

Period	Total	Average	The share in China,%
1970	1.4	1.4	1.7
1971-1975	507	101	35.0
1976-1980	1170	134	57.0
1981-1985	2069	412	71.0
1986-1990	4397	879	77.0
1991-1995	5352	1070	89.0



**Figure 1.** The production of China and BAOTi Group Titanium mill product during 1995-2005

## 2. BAOTi Group is the Major Maker for the National Standards of Titanium Products in China

As the largest specialized base for the production and research of titanium products, BAOTi Group is the major maker for the national standards of titanium products and plays an important role for the steady developing of titanium processing industry and connects with international standards. The Group has compiled and taken part in the following national standards and industry standards:

- 1) 43 National Standards

- 2) 20 National-military Standards
- 3) 9 Nonferrous Industry Standards

### **3. BAOTi Group is the Leader of China Titanium Processing Technology**

There are titanium, nickel, refractory metals, zirconium and hafnium products, precision casting, clad material, equipment design and manufacturing, etc., 10 large production systems in BAOTi Group. There are 4,322 sets equipment and test instruments. The Group has imported a lot of equipment from developed countries including America, Germany and Japan, etc., for which make up 70 percent of the total value of the equipment. The melting capacity will reach 20,000t/a by the end of 2012 and the capacity of titanium mill products now is 10,000t/a.

As base for the production and research of rare metals with titanium leading products, BAOTi Group fully use the new technology and new achievements and improve the technology all the time. The Group has constructed an advanced titanium scrap processing production line in 1970s. Its capacity is up to 1,000t/a. The production cost is low and the Group gets a good economic results. The automatic mixer and distributor systems were imported from Germany at the beginning of 1990s and 6t vacuum consumable arc furnace was developed by itself. The melting production line was constructed and had the top level in China and advanced level in the world. The Group brought 3150t free forging hydraulic press, imported SXP-13 precision forging press, 3000mm CNC ring rolling mill and related auxiliary equipment and primary constructed high quality titanium alloy forging production line. 3300mm wide-heavy plate rolling mill production line was imported from Germany. The mill makes perfect for the plate production line. The Group has invested 300 million RMB for the production line above and now it has invested 500 million RMB to construct new titanium alloy production line since mid 1990s to improve the quality of the nonferrous metal products, expand the capacity and form the nonferrous metals development and research system and production platform with titanium leading product. The mainly constructing as following;

#### **1) The Constructing of Master Alloy Production Line**

The Group has been paid attention to develop and produce master alloy all the time. The Group has developed many master alloys itself for a special purpose to produce Ti-55, Ti-60, BT16, TA15, Ti-1023, Ti-15-3 and BT25. These master alloys play an important role to stabilize and improve the quality of titanium alloy ingots.

#### **2) The Constructing of High Quality Titanium Ingots Production Line**

The Group has constructed the production line for high quality titanium ingots, invested 200 million RMB to import international advanced equipment such as 10t vacuum consumable arc furnace and 2,400KW electric beam clad hearth furnace etc., consisting of international advanced melting production line.

#### **3) The Constructing of 2500 Fast Forging Production Line**

The Group has imported a lot of advanced equipment such as 2500 fast forging press, nature gas furnace, skinning machine for bars and nondestructive inspection in order to improve the uniform of structure and properties of the titanium forgings as well as the lead time. At the same time, it has constructed key equipment such as electric heating furnace, flattening machine etc., consisting of the fully titanium alloy forging production line with the primary production equipment.

#### **4) Construction of the High Performance, High Precision Ti Alloy Sheets Production Line**

Process technology such like sandwich rolling, vacuum creep straightening, surface treatment were developed after 10 years research work with 50 million RMB investment. Vacuum creep straightening furnace was also developed, and abrasive grinding machine for sheets was imported. The key technical problems for the high performance, high precision Ti alloy sheets production were solved.

#### **5) Establishment of the Rare Material Test Center**

In 2002, BAOTi invested 30 million RMB. Many new advanced equipments were imported, such like material tensile tester, fatigue tester, ZISS metallographic microscope, scanning electron microscope, energy spectrometer, ICP-AES, LECO O/N analyzer, LECO hydrogen, and other relevant test, heat treatment and sample processing equipments. The complete rare metal material test center was established.

#### **6) Process Technology Development for Ti Products and Equipment Manufacturing**

To promote the application of Ti products, BAOTi devoted much attention to the Ti downstream processing technology and products development, and formed Ti equipment manufacturing capability. These products include: expanded sheets, baskets cathode rolls, anode plates, plate and tubular heat exchangers, standard products and handicrafts. Special process has been formed for Ti alloy, Ni, clad plate welding. With gr. 1, gr. 2 and gr. 3 pressure vessel production licenses, and ASME specification production license, BAOTi Group Ltd. can produce all kinds of titanium pressure vessels and equipments, which are widely used in chemical industry, light industry, metallurgy, medicine and food industry.

#### **4. BAOTi Group is the Pioneer of Chinese Ti and Alloy New Material, New Products Research and Extending**

For new material, new products research and development, BAOTi Group cooperates closely with scientific research institutes, material application units and colleges, develops new material and new products by taking the priority of the Group.

## 4.1 New Material Research

### 4.1.1 High Temperature Ti Alloy

During the Eighth, Ninth “Five Year Plan”, BAOTi Group undertook many projects for high temperature Ti alloy industrial experiments, including: Ti-60, Ti-55, Ti-6242s, BT20, Ti-811, Ti-17, etc., completed some experiments like melting process, components uniformity, free forging, precision forging, bars, sheets and plates rolling and heat treatment, developed bars, sheets and plates, cakes, rings of these alloys whose performance index can meet the standard of similar products in foreign countries. From the success of these Ti alloys research, serialized products of high temperature Ti alloys at 300~600°C formed in China (Table 2).

### 4.1.2 High Strength and Structure Ti Alloy

After years of research and development, BAOTi Group has developed many high strength and structure Ti alloy products. During the research and application for Ti-1023, the suitable raw material, master alloy, feeding method and rational melting process were selected under industrial conditions, so the alloy contents can meet the relevant technical requirements.

During the research and application for high strength cold forming alloy Ti-15-3, good formality, high strength efficient sheets and plates, coils, bars, wires and tubes were

developed. Tests showed, all the performances can meet the relevant technical conditions.

Currently, BAOTi Group is developing different strength grade Ti alloys, low, middle, high series are formed (see Table 3), which can meet the requirements for all sectors of aviation and national economy.

### 4.2 Bioengineering and Corrosion Resistant Ti Alloy

In order to meet the requirements of medical and corrosion resistant usage, BAOTi Group is developing series designations of medical and resistant Ti alloys, such like: Ti-5Al-2.5Fe, Ti-6Al-7Nb, Ti-15Mo-3Zr, Ti-3Al-1Zr-1Mo-1Ni, Ti-3Al-2Zr-2Mo, Ti-3Al-8V-6Cr-4Zr-4Mo, Ti-0.5Ni-0.05Ru, Ti-0.3Co-0.05Pa, Ti-0.1Ru, Ti-3Al-2.5V-0.1Ru, Ti-6Al-4V-0.1Ru, Ti-6Al-4V-0.5Ni-0.05Pa, Ti-1~5Ta, Ti-2Al-2.5Zr<sup>1,2)</sup>.

### 4.3 Ti Alloy for Special Purpose

In order to meet the demand of special Ti alloys for different users, BAOTi Group is studying some Ti alloys for special purpose, such like: shape memory alloy : Ti-Ni-Fe, Ti-Ni-N ; high elastic modulus alloy : Ti-Al-Zr-V-Mo-Si; low cost alloy: Ti-Al-Mo-V-Fe; wear resisting alloy: Ti-Al-V-Cr-C, etc.

**Table 2 .** The main properties of high temperature titanium alloys (≥)

Designation	The maximum temperature of useage, °C	RT tensile				High temperature tensile				Durability		
		$\sigma_b$ MPa	$\sigma_{0.2}$ MPa	$\delta_5$ %	$\Psi$ %	°C	$\sigma_b$ MPa	$\delta_5$ %	$\Psi$ %	°C	$\sigma_b$ MPa	$\tau$ h.
TC4	300	900	830	10	25	400	615	12	40	400	570	100
BT20	350	930	-	7-10	-	350	685	-	-	350	665	50
						500	570	-	-	500	470	50
TA7	350	785	680	10	25	350	490	-	-	350	440	100
Ti-17	370 or 400	1120	1030	7	15	370	907	12	30	370	685	100
Ti-811	400	895	825	10	20	425	620	10	25	-	-	-
TC6	400 or 450	980	840	10	25	400	735	-	-	400	665	100
TC11	500 or 530	1030	900	10	30	500	685	-	-	500	595	100
Ti-6242s	520	895	825	10	25	480	620	10	25	525	480	35
Ti-55	550	980	900	10	25	550	610	12	30	550	430	100
Ti-60	600	1100	1030	11	18	600	700	14	27	600	350	100

**Table 3.** The main properties of titanium alloys of high strength and structure (≥)

Alloy	Description	State	RT mechanical properties			
			$\sigma_b$ MPa	$\sigma_{0.2}$ MPa	$\delta_5$ %	$\Psi$ %
Ti-15Mo-3Al-2.7Nb	Sh/Plt	ST	795	760	8-15	-
	Bar	STA	1250	1105	6-8	10-15
Ti-5Al-5Mo-5V-1Cr-1Fe	Bar	M	1080-1280	-	9-10	25-29
		STA	1280	-	6-7	14-16
Ti-10V-2Fe-3Al	Bar	STA	1105	1035	6-8	10-15
Ti-6Al-2Sn-4Zr-6Mo	Bar	STA	1172	1103	8	15
Ti-15V-3Cr-3Sn-3Al	Sh/Plt	ST	705-945	690-870	12	-
		STA	1080	1010	6	-
Ti-2.8Al-5Mo-4.5V	Bar	M	815-930	-	14	60
		STA	1030-1180	-	10	30
Ti-6.5Al-2Zr-1Mo-1V	Bar	M	930-1130	-	8-12	-
Ti-6Al-4V (TC4)	Bar	STA	895	825	10	25
Ti-4Al-2V	Bar	M	560-800	520	15	30
Ti-3Al-2.5V	Bar	M	620	515	15	30
Ti-2Al-1.5Mn (TC1)	Bar	M	585	460	15	30

## 5. Outlook

After 40 years of construction and development, BAOTi Group has become the largest comprehensive rare metal research and production base, whose main product is titanium, and some other metals such like tungsten, molybdenum, tantalum, niobium, zirconium, hafnium, nickel and their alloys. The capacity of mill products will be 15,000~20,000 tons in 2010. At that time, the Group will meet the growing demand for the development of national economy and have the competitive power in the world market. BAOTi will have a brilliant future.

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