BERYLLIUM

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Beryllium is very light and strong, has a high melting point of 1,280°C, is resistant to acids and has a high thermal conductivity. These characteristics make beryllium very useful in a number of applications, either as a metal, as part of an alloy or as an oxide. High processing costs mean that beryllium is expensive so it tends to be used where there are no practical alternatives or where performance is critical.

The vast majority of world beryllium ore production, over 95% in 1999, is carried out in the US with most of the remaining material mined in Brazil and Madagascar. Brazilian beryl production declined rapidly after 1992, when Brush Wellman of the US, the main consumer, ceased to purchase material following reduced demand caused by the ending of the Cold War. In 1999, Brazilian beryl production was estimated as rising to 263 t, based on the reported production of beryllium concentrate. However, there are no Brazilian companies known to process beryl into concentrates and all domestic beryl production is sold domestically. Beryllium ores are also produced in small quantities on a regular basis in Portugal and Zambia.

During the 1990s, other significant producers of beryllium ores were located in Russia, China and Kazakhstan. During the 1990s, beryl was also mined in Argentina, Namibia and Zimbabwe but output appears to have ceased. Production of beryl is also reported to take place in Bolivia, but no data are available.

Production by Main Companies

Brush Wellman of the US is the only fully integrated beryllium company in the world. In 2000, the company probably accounted for over 95% of all the beryllium ore mined in the world. Brush Wellman mines bertrandite ore from the Spur Mountain area of Utah for use as feedstock in beryllium hydroxide concentrate production at its Delta plant in Utah. The concentrate is then used as

World production of beryllium ores by country, 1991 to 1999 (t)

	1991	1992	1993	1994	1995	1996	1997	1998	1999
Argentina[e]	34	34	34	-	-	-	-	-	-
Brazil	[e]850	[e]850	225	150	141	153	168	115	263
China[e]	500	500	500	500	500	500	500	500	500
Kazakhstan[e]	-	100	100	-	-	-	-	-	-
Madagascar[e]	3	3	3	3	32	11	28	30	30
Namibia	6	10	15	-	-	-	-	-	-
Portugal[e]	4	4	4	5	5	5	5	5	4
Russia[e]	-	1,100	70	70	70	70	70	-	-
US	4,340	4,830	4,940	4,330	5,040	5,260	5,770	6,080	5,070
FSU[e]	1,300	-	-	-	-	-	-	-	-
Zambia[e]	1	1	1	1	2	4	4	4	4
Zimbabwe[e]	29	23	-	-	-	-	-	-	-
World total	***7,067***	***7,455***	***5,892***	***5,059***	***5,790***	***6,003***	***6,545***	***6,734***	***5,871***

[e] -estimated

feedstock in metal, alloys and ceramic grade powder at Elmore in Ohio and strip and wire products at Reading in Pennsylvania. In 1999, the hot and cold rolling technology in use at Elmore was upgraded leading to a trebling in beryllium-copper strip production capacity. Ceramic powder from Elmore is also supplied to plants in Tucson in Arizona and Newburyport in Massachusetts. In May 2000, Brush Wellman became a wholly-owned subsidiary of a holding company, Brush Engineered Materials.

Other important US beryllium product companies are NGK Metals and Starmet which use raw materials supplied by Brush Wellman. NGK Metals Corp. is the largest producer of beryllium-copper alloy castings, strip, rod bar and plate products in the world from its plants in France, Germany, Japan and the US. In 1998, NGK Metals invested a reported US$12 million in its Sweetwater plant in the US, mainly on the installation of the first beryllium-copper alloy continuous caster in the world. The company also invested US$30 million in its Japanese plant at Nagoya in the late 1990s. Starmet, formerly known as Nuclear Metals Inc., jointly developed beryllium-aluminium alloys with Lockheed. The company has since developed a family of beryllium-aluminium alloys under the trade name Beralcast®.

The Ulba Metallurgical Plant (UMP) in Kazakhstan was the largest beryllium product manufacturer in the former USSR mainly using beryllium concentrate from mines in Russia. UMP ceased importing beryllium concentrate from Russia in the mid-1990s, partly as it had accumulated considerable stocks of material. This eventually caused the ending of Russian beryllium concentrate production during 1997, as producers no longer had a market for their concentrates. Production of beryllium concentrate in Kazakhstan reportedly ceased in 1993. UMP is currently 90%-owned by Kazatom Prom, a state-owned company. In 2001, Kazatom Prom is expected to exchange a 34% share in UMP for an equivalent share in some subsidiaries of TVEL, the state- owned Russian nuclear fuel company. TVEL also owns Zabalisky GOK, the most recent Russian producer of beryllium concentrate.

Beryllium product output by UMP rose in the late 1990s as capital was obtained from overseas. According to the National Statistic Agency of Kazakhstan, UMP produced 371 t of beryllium and beryllium articles in 2000, an increase of 150 t over output in 1999 and 1998. In the first quarter of 2000, UMP commissioned a new plant for the production of alloying compositions using carbo-thermal and chemical-metallurgical processes. The new plant produces unwrought beryllium metal from a semi-product. In the period June to July 2000, UMP commissioned hydrometallurgical production equipment and started production of refined beryllium metal.

At the end of 1999, Kazatom Prom and Brush Wellman signed long-term contracts. Brush Wellman is funding the first two years of beryllium production by UMP and investing in modern equipment at the plant. In return, Brush Wellman is exclusively supplied with beryllium products by UMP. One of the contracts agreed with UMP was for the supply of beryllium-copper 4% master alloy to Brush Wellman for use in the manufacture of high performance alloy products.

In China, three companies are known to produce beryllium in a variety of forms. These are the Ningxia Orient Tantalum Industry Co., Shuikoushan Mining Bureau and the Ningxia Non-ferrous Metals Smeltery. The combined capacity of these companies is estimated to be around 500 t/y gross weight of beryl or about 20 t/y of beryllium, mainly in the form of alloys.

Applications

In 1991, the value of Brush Wellman's beryllium business was mainly divided between electronic components (45%), defence and aerospace (29%) and electrical components (20%). By 1999, this pattern had substantially changed with electronic

components accounting for 56%, electrical components 17% and defence and aerospace falling to only 6%. The importance of the optical media market had grown substantially to account for 10% by value of Brush Wellman's beryllium business by 1999.

Alloys are the most common form of beryllium used, accounting for around 75% of US consumption. In the US, ceramics (15%) incorporating beryllium oxide, also known as beryllia, are the next most important form of beryllium followed by metal (10%).

Beryllium-copper is the most commonly used type of beryllium alloy. Beryllium-copper alloys can be divided into high strength, typically containing between 1.6% and 2% beryllium, and high conductivity, containing around 0.3% beryllium, types. High-strength alloys are typically used in telecommunications applications and high conductivity alloys in automotive markets. Beryllium copper is also used in drilling equipment, aircraft landing gear and other heavy industrial machinery where its properties outweigh its expense.

Beryllium-aluminium alloys are becoming increasingly important in terms of beryllium consumption as they can contain up to 65% beryllium compared with the 0.5% and 2% typically present in beryllium-copper. Applications for beryllium-aluminium alloys include aerospace, hard disc drives and brakes.

Beryllium oxide ceramics have excellent electrical insulation properties and a thermal conductivity close to that of pure aluminium and double that of copper. These characteristics, together with the high melting point of 2,570^{o}C and resistance to chemical attack, means that beryllium oxide ceramics have a wide variety of applications in the electronics sector. They are used in the manufacture of heat sinks in electronic and microelectronic applications where a high rate of thermal dissipation is required. The communication industry uses beryllium oxide ceramics in substrates, where performance and the need for high levels of reliability and heat dissipation outweigh the cost.

Beryllium metal is used in spacecraft, inertial guidance systems, high performance brakes and space optical systems because of its strength, low weight and stability over a wide range of temperatures. Beryllium metal is also used in research reactors as a reflector. Beryllium is also transparent to X-rays so is also used in applications where this is desirable.

Trade

US companies play a pivotal role in world trade in beryllium; either exporting beryllium products or importing raw or scrap materials for processing. The US Government imposes import tariffs of 3.7% on beryllium oxide or hydroxide, 5.5% on wrought beryllium and 8.5% on beryllium waste and scrap on imports from countries with normal trade relations. All other forms of beryllium are allowed to be imported free of tariff.

The majority of reported world beryllium trade is in the form of waste, scrap, powder, wrought and unwrought material. The most commonly traded type of beryllium material is almost certainly beryllium-copper alloy but data for this commodity is not generally available, with the exception of some information for the US. The only known significant reported trade in beryllium oxide is between US and Chinese companies and consumers in Japan. Outside the US, Japanese companies are one of the main consumers of beryllium along with those in France, Germany and the UK.

Stocks

The US Government has long held quantities of beryllium in the National Defense Stockpile (NDS) in order to guarantee supplies to the defence industry in times of conflict. The NDS is a reserve of strategic and critical materials that are unavailable to the US to meet anticipated national security emergency requirement. In fiscal year 2000, significant

quantities of beryllium materials held in the NDS were sold. These included around 1,810 t of beryl ore containing about 73 t of beryllium, 2,404 t of beryllium-copper master alloy (BCMA) and 23 t of beryllium metal. For fiscal year 2001 NDS stocks of beryllium are 4,000 st of beryl ore, 40 st of beryllium metal and 2,200 st of beryllium-copper master alloy. The amount of beryllium held in the NDS declined sharply in the 1990s following the end of the Cold War. In 1980, the NDS held 16,330 st of beryl, 7,167 st of beryllium-copper master alloy and 363 st of beryllium metal.

Prices

Prices for beryllium products are inevitably determined by the Brush Wellman published producer price. Prices change very infrequently and are, at best, a very general indicator of price movements. The last reported increase in beryllium prices by Brush Wellman took place in July 2000. The price of all wrought and cast beryllium containing bulk products, except for Protherm® bar and plate, was raised by an average of 5%. Minimum order requirements for all products were also raised from US$100 to US$300 for the first item and US$100 for each additional item. The previous reported increase in beryllium prices by Brush Wellman took place in 1998 when they were raised by an average of 4%.

Market Trends

Following the end of the Cold War in 1992 with the break-up of the former USSR, world demand for beryllium declined as defence expenditure was reduced. Rising demand for electronic products, partially the result of growing internet capacity, revived demand for beryllium towards the end of the decade.

Demand for beryllium, especially in the form of alloys, is increasing but is unlikely to encourage the development of new sources of beryllium raw materials as current beryllium producers have access to sufficient resources.

The miniaturisation of electronic products requires the use of strong materials, such as beryllium-copper alloys, able to cope with higher operating temperatures. The electronic content of automobiles is steadily rising, leading to higher demand for beryllium-copper alloys. The use of beryllium-aluminium alloys in aerospace applications is growing, especially in defence projects, but from a low base. Demand for beryllium oxide ceramics for use as substrates is also increasing as ever more powerful computer chips generate larger amounts of heat that must be rapidly dissipated. Beryllium metal consumption is likely to remain static for the present.