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RHENIUM [ADVANCE RELEASE]

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Rhenium

By Michael J. Magyar

Domestic survey data and tables were prepared by Martha L. Jackson, statistical assistant, and the world production table was prepared by Linder Roberts, international data coordinator.

U.S. estimated rhenium production in 2007 was 7,100 kilograms (kg), a decrease of about 12%, while apparent consumption of rhenium increased by about 3% from that of 2006 to 48,100 kg (table 1). World production of rhenium in 2007 was estimated to be 51,100 kg, an 8% increase from that of 2006.

In the United States, rhenium is a byproduct of molybdenite concentrates that are recovered as a byproduct of porphyry copper-molybdenum ore mined in the Western States. Domestic mine production data for rhenium (table 1) were derived by the U.S. Geological Survey (USGS) from reported molybdenum production at the copper-molybdenum mines. Domestic demand for rhenium metal and other rhenium products was met principally by imports but also from domestic recovery from ores and from stocks.

Consumption

In the past decade, the two most important uses of rhenium have been in high-temperature superalloys and platinum-rhenium catalysts. Rhenium is used in single-crystal, high-temperature superalloy turbine blades for aircraft engines and other land-based turbine applications. Platinum-rhenium catalysts are used to produce high-octane, lead-free gasoline. Other applications of rhenium, primarily as tungsten-rhenium and molybdenum-rhenium alloys, are more diverse; these included electrical contact points, flashbulbs, heating elements, metallic coatings, temperature controls, thermocouples, vacuum tubes, and x-ray tubes and targets. Industry continued to research the potential for recycling the rhenium bearing alloy from turbine blades and the development of new alloys and catalysts.

Metallurgical uses, such as in nickel-based superalloys and powder metallurgy, were estimated to represent about 77% of rhenium consumption; rhenium improves the strength properties of nickel alloys at high temperatures (1,000° C). An additional 15% was used in the production of reforming catalysts for the petroleum industry (Roskill Information Services Ltd., 2007, p. 88). Other uses for rhenium alloys, which collectively represented only about 8% of total consumption, were in crucibles, electrical contacts, electromagnets, electron tubes and targets, heating elements, ionization gauges, mass spectrographs, metallic coatings, semiconductors, temperature controls, thermocouples, and vacuum tubes.

Rhenium was used in petroleum-reforming catalysts for the production of high-octane hydrocarbons, which are used in the formulation of lead-free gasoline. Bimetallic platinum-rhenium catalysts have replaced many of the monometallic catalysts. Rhenium catalysts tolerate greater amounts of carbon formation when making gasoline and make it possible to operate the production process at lower pressures and higher temperatures, which leads to improved yields (production per unit of catalyst used) and higher octane ratings. Platinum-rhenium catalysts also were used in the production of benzene, toluene, and xylenes, although this use was small compared with that used in gasoline production.

Exxon Mobil Corp. and Qatar Petroleum (QP) abandoned plans to build the world's largest gas-to-liquids (GTL) plant. Spiraling costs for the project and Qatar's shifting energy priorities were cited. The ExxonMobil GTL deal, first announced in 2004, would have produced 154,000 barrels per day of clean diesel and other products. ExxonMobil and QP developed a replacement agreement to develop Qatar's Barzan gas field, part of Qatar's massive North Field, to produce 1.5 billion cubic feet of natural gas for Qatar's domestic market. Other GTL proposals, including those by Chevron Corp., ConocoPhillips Co., Marathon Oil Corp., and Sasol Ltd., were already frozen by Qatar's moratorium on further development of the North Field (Armstrong, 2007).

Prices

Metal powder and ammonium perrhenate (APR) average annual prices were estimated to be about $8,410 per kg and $7,070 per kg of rhenium content, respectively. Powder prices were about $5,900 per kg in January, rose sharply to about $8,100 per kg in March, and rose steadily to about $9,700 per kg in December. APR began January at about $4,600 per kg, rose sharply to about $7,000 per kg by the end of March, and rose steadily to about $8,200 per kg in December.

Foreign Trade

Imports of metal increased about 39% (table 2) owing to increased production in Chile, Germany, and the Netherlands, and strong U.S. demand, while imports of APR decreased by about 38% (table 3), owing to reduced imports from Kazakhstan. Imports for consumption of rhenium metal are listed in tables 1 and 2, and those of APR are listed in tables 1 and 3.

World Review

World production of rhenium was estimated to have been about 51,100 kg in 2007 (table 4). This estimate was based on the quantity of rhenium recovered from concentrates that were processed to recover rhenium values. Rhenium was recovered as a byproduct from porphyry copper-molybdenum ores mined primarily in Canada, Chile, Mexico, Peru, and the United States, while sedimentary copper deposits were mined primarily in Armenia, Kazakhstan, Russia, and Uzbekistan. The major producers of rhenium metal and compounds were Chile, Germany, the Netherlands, the United Kingdom, and the United States.

World reserves of rhenium are contained primarily in molybdenite in porphyry copper deposits. U.S. reserves of rhenium are concentrated in Arizona, Montana, Nevada, New Mexico, and Utah. Chilean reserves are found primarily at four large porphyry copper mines and in lesser deposits in the northern one-half of the country. In Peru, reserves are concentrated primarily in the Toquepala open pit porphyry copper mine and in about 12 other deposits. Other world reserves are contained in several porphyry copper deposits and sedimentary copper deposits in Armenia, northwestern China, Iran, Kazakhstan, Russia, and Uzbekistan and in sedimentary copper-cobalt deposits in Congo (Kinshasa). The U.S. reserve base was estimated to be about 4,500 metric tons (t), and rest-of-the-world reserve base was estimated to be about 5,500 t.

Armenia.—Armenian Molybdenum Production LLC (AMP) increased ferromolybdenum (FeMo) production by 29% year-on-year to 1,392 t through the first half of 2007. AMP also started a new plant for processing rhenium-bearing residues that produced about 80 kg of APR in the first half of 2007 (Metal-Pages, Ltd., 2007a). Yerevan Pure Iron OJSC (Yerevan) increased its production of FeMo by about 19% year-on-year to 735 t through the first quarter of 2007 and also produced about 45 kg of APR, up from 8.5 kg in the same period of 2006 (Metal-Pages Ltd., 2007b).

Chile.—Xstrata Copper's North Chile Division began feasibility studies in 2007 to more than double molybdenum processing capacity at its Altonorte facility. If approved, construction was expected to begin in the second half of 2008, with production commencing in the second half of 2009. Approximately $40 million would be spent to refurbish a molybdenum roaster and to construct a molybdenum leaching plant. When completed, the two combined projects were expected to increase processing capacity at Altonorte to 28,000 metric tons per year (t/yr) of molybdenum concentrate from 12,000 t/yr. The leaching plant would allow the processing of different ore feeds, opening the possibility of rhenium recovery from Chilean copper-molybdenum ores. Rhenium-bearing waste water has been collected to study the possibility of producing rhenium at Altonorte (Metal-Pages Ltd., 2007i).

Poland.—KGHM Metale DSI (a subsidiary of KGHM Polska Miedź S.A.) changed its name to KGHM Ecoren S.A. and began production of rhenium in 2006. Production was estimated to have increased to 3,500 kilograms (kg/yr) of APR in 2007 from 1,500 kg/yr in 2006. KGHM has the advantage of being an integrated rhenium producer, owning the mine, smelter, and the new rhenium recovery plant. In 2008, KGHM expected to produce 4,500 kg/yr of APR (about 3,000 kg/yr of rhenium content) with an ultimate goal of 5,000 kg/yr of rhenium content including 1,000 kg/yr of rhenium as metal powder (Metal-Pages Ltd., 2007e). In December, Ecoren signed a 5-year supply agreement with Rolls-Royce to provide about one-half of Ecoren's annual rhenium production to the engine manufacturer (Metal-Pages Ltd., 2007f).

United Kingdom.—Precious metals refiner Johnson Matthey Plc. announced plans to expand operations into the rhenium market to meet demand from customers in the aerospace sector. Johnson Matthey already supplied platinum coating and ruthenium for the manufacture of turbine blades. It intended to secure long-term, offtake agreements with rhenium suppliers in China and Poland and refine the rhenium in the United Kingdom. Johnson Matthey was not interested in recycling rhenium from catalysts but saw potential for recovery of rhenium from grinding dust and recycling of turbine blades (Metal-Pages Ltd., 2007d).

Outlook

World demand for rhenium is likely to increase during the near term. In 2007, Airbus S.A.S. recorded more than 1,200 orders for aircraft, and Boeing Co. reported more than 1,400 orders (Metal-Pages Ltd., 2007h). The two manufacturers have engineered rhenium into the designs of their latest series of aircraft, the Airbus A380 and the Boeing 787 (Metal-Pages Ltd., 2008). Construction of the F22 and F35 in the United States and the European Typhoon will require increasing amounts of superalloys with 6% rhenium content (Metal-Pages Ltd., 2007g). Other military uses of rhenium include parts that control high-temperature exhaust gases from the jet engines of stealth aircraft. Rhenium allows heat to be radiated away from the aircraft quickly before infrared heat-seeking missiles can target the engine (Lifton, 2007).

In addition, the Chinese Government reportedly was considering imposing an export quota system on rhenium and establishing a strategic stockpile system for rare metals, including rhenium (Metal-Pages Ltd., 2007c). These changes will likely result in reduced Chinese imports of rhenium in the future, which could lead to tightened rhenium supplies and increased prices.

Perhaps the greatest potential for increased rhenium production lies in the molybdenum concentrates that are presently being roasted in facilities that are not equipped to recover the rhenium values. For instance, a significant portion of the molybdenum concentrate production of Codelco, the leading producer of molybdenum concentrates in Chile, is exported unroasted or roasted without rhenium recovery. In addition, Xstrata's Altonorte facility was not capturing rhenium from molybdenum concentrates processed through its roaster. Capturing lost rhenium could increase world rhenium production capacity by an estimated 15,000 kg/yr (Roskill Information Services Ltd., 2007).

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TABLE 1
SALIENT U.S. RHENIUM STATISTICS[1]

(Kilograms, gross weight)

	2003	2004	2005	2006	2007
Supply[2]	6,300 r	6,500 r	7,900 r	8,100	7,100
Apparent consumption[e, 3]	20,800 r	25,700 r	36,900 r	46,900 r	48,100
Imports:					
Metal	13,200	11,800	21,800	22,000	30,500
Ammonium perrhenate	1,990	10,600	10,300	24,300 r	15,100

[e]Estimated. [r]Revised.
[1]Data are rounded to no more than three significant digits.
[2]Rhenium contained in molybdenite concentrates, based on calculations by the U.S. Geological Survey.
[3]Calculated as production plus imports minus exports and industry stock changes.

TABLE 2
U.S. IMPORTS FOR CONSUMPTION OF RHENIUM METAL, BY COUNTRY[1]

	2006		2007	
Country	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
Belgium	--	--	10	$16
Chile	19,700	$21,600	22,700	35,400
China	28	94	822	1,010
Germany	1,100	2,950	2,650	4,110
Japan	200	927	--	--
Netherlands	130	281	3,480	6,070
United Kingdom	759	1,970	871	3,070
Total	22,000	27,800	30,500	49,600

-- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau, with adjustments by the U.S. Geological Survey.

TABLE 3

U.S. IMPORTS FOR CONSUMPTION OF AMMONIUM PERRHENATE, BY COUNTRY[1]

	2006		2007	
Country	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
Belgium	229 r	$186	--	--
Chile	364	336	2,340	$4,990
China	1,160 r	1,000	1,580	4,890
Estonia	--	--	32	92
Germany	1,610	1,990	1,160	3,270
Kazakhstan	18,000	14,600	9,930	27,900
Netherlands	682 r	556	--	--
Poland	1,260 r	981	--	--
Russia	--	--	46	129
United Kingdom	--	--	48	135
Uzbekistan	1,040 r	842	--	--
Total	24,300 r	20,500	15,100	41,400

rRevised. -- Zero.

1Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau, with adjustments by the U.S. Geological Survey.

TABLE 4

RHENIUM: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Kilograms)

Country	2003	2004	2005	2006	2007
Armenia	1,000	1,000	1,200	1,200	1,200
Canada	1,700	1,700	1,700	1,700	1,700
Chile[3]	19,300 r	20,500 r	22,900 r	19,800	22,900
Kazakhstan	2,600	5,000	8,000	8,000	7,700
Peru	5,000	5,000	5,000	5,000	5,000
Russia	1,400	1,400	1,400	1,400	1,500
United States, supply[4]	6,300 r, 5	6,500 r, 5	7,900 r, 5	8,100 5	7,100 5
Uzbekistan	NA	NA	NA	NA	NA
Other	1,000	1,000	1,000	2,000	4,000
Total	38,300 r	42,100 r	49,100 r	47,200	51,100

rRevised. NA Not available.

1World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

2Table includes data available through June 13, 2008.

3Data revised based on new information from Comisión Chilena del Cobre; also includes rhenium content from Mexico processed at Molymet in Chile.

4Calculated rhenium contained in molybdenite concentrates. Data rounded to two significant digits.

5Reported figure.