RHENIUM

By John W. Blossom

Rhenium's two most important uses in the past decade have been in platinum-rhenium catalysts used primarily in producing lead-free, high-octane gasoline and in high-temperature superalloys for jet engine components. Other uses of rhenium, primarily as tungsten-rhenium and molybdenum-rhenium alloys, though smaller in quantity, are more diverse. These include use in thermocouples, heating elements, temperature controls, flashbulbs, vacuum tubes, X-ray tubes and targets, metallic coatings, and electrical contact points. Research by industry continues in rhenium recovery from ore and concentrate and on development of new catalysts and alloys.

In 1995, domestic demand for rhenium metal and other rhenium products was met by domestic recovery, domestic stocks, and imports.

Domestic mine production data for rhenium are developed by the U.S.G.S. from reported molybdenum production at the eight operating porphyry copper-molybdenum-rhenium mines in the United States.

Rhenium is a byproduct of molybdenite recovered as a byproduct of porphyry copper ore from eight mines in the western United States. Consumption of rhenium increased about 26% in 1995. Imports for consumption increased 36% in 1995. The major uses for rhenium during the year were bimetallic platinum-rhenium catalysts and jet engine high-temperature components. The average price for metal power was $1,100 per kilogram and for ammonium perrhenate $700 per kilogram.

Consumption

The major uses of rhenium are in petroleum-reforming catalysts and in high-temperature superalloys used in jet engine components. Rhenium is used in petroleum-reforming catalysts for the production of high-octane hydrocarbons, which are used in the production of lead-free gasoline. Bimetallic platinum-rhenium catalysts have replaced many of the monometallic catalysts. Rhenium catalysts tolerate greater amounts of carbon formation and make it possible to operate at lower pressures and higher temperatures, which leads to improved yields and octane ratings.

Catalytic units employing platinum-rhenium catalysts are used in about 80% of total U.S. reforming capacity. Platinum-rhenium catalysts also are used in the production of benzene, toluene, and xylenes, although this use is small compared with that used in gasoline production.

A significant property of rhenium is its ability to alloy with molybdenum and tungsten. Molybdenum alloys containing approximately 50-weight-percent rhenium have greater ductility and can be fabricated by either warm or cold working. Unlike other molybdenum alloys, this alloy is ductile, even at temperatures down to 196° C, and can be welded. Also, alloys of tungsten with 24-weight-percent rhenium have improved ductility and lower ductile-to-brittle transition temperature than pure tungsten. Rhenium improves the strength properties at high temperatures (1,000° C) of nickel alloys. Some of the uses for these alloys are in thermocouples, temperature controls, heating elements, ionization gauges, mass spectrographs, electron tubes and targets, electrical contacts, metallic coatings, vacuum tubes, crucibles, electromagnets, and semiconductors. These various uses represented only 10% of total demand in 1995.

Foreign Trade

Imports for consumption of ammonium perrhenate came from Chile, Germany, Kazakstan, Russia, and the United Kingdom; whereas Austria, Chile, Germany, the Netherlands, and the United Kingdom supplied rhenium metal. World production of rhenium was estimated to be 40 metric tons; however, the quantity of rhenium actually recovered is much lower because not all concentrates are processed to recover the rhenium values. Rhenium was recovered from some byproduct molybdenite concentrates from porphyry copper deposits in Canada, Chile, China, Iran, Kazakstan, Peru, Russia, and the United States. Rhenium metal and compounds were recovered from molybdenum concentrates in Chile, France, Germany, Russia, Sweden, the United Kingdom, and the United States.

World Review

The definitions of reserves and reserve base are published in Appendix C of U.S. Geological Survey "Mineral Commodity Summaries, 1997." Rhenium reserves are contained primarily in molybdenite in porphyry copper deposits. U.S. reserves are concentrated in Arizona and Utah, but also are found in Montana, Nevada, and New Mexico. Canadian reserves are in British Columbia, primarily on Vancouver Island. 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 openpit porphyry copper mine and in about a dozen other deposits in the southern one-half of the country.

Reserves in the former Soviet Union are in several porphyry copper deposits and one sedimentary copper deposit mainly in the south-central part of the country between the Caspian Sea and northwestern China. Other world reserves are in Europe

and in sedimentary copper-cobalt deposits in Zaire.

Outlook

In the next 5 years, demand for rhenium metal will increase from the 1995 level. The demand will follow the demand for aircraft engines and for petroleum. For the long term (10 to 20 years), recycling of rhenium-bearing waste and scrap must be greatly improved. As identified, U.S. resources are estimated to be about 5,000 metric tons, and identified rest-of-world resources are on the order of 6,000 metric tons.

OTHER SOURCES OF INFORMATION

U.S. Geological Survey Publications

King, R.L., Shaine, D.R., and Mackevett, E.M., Jr., 1973, Rhenium in Brobst, D.A., and, W.P., United States Mineral Resources: U.S. Geological Survey Professional Paper 820, p. 557-559.

Rhenium. Ch in Mineral Commodity Summaries, annual.

Rhenium. Ch in Mineral Yearbook annual.

TABLE 1
SALIENT U.S. RHENIUM STATISTICS 1/

(Kilograms)

	1991	1992	1993	1994	1995
Mine production 2/	19,200	16,000	12,200	15,500	17,000
Consumption e/	8,870	6,800	6,900	12,900	16,200
Imports (metal)	10,800	6,390	2,700	5,870	9,550
Imports (ammonium perrhenate)	3,510	5,690	3,170	2,330	3,280

e/ Estimated.

1/ Data are rounded to three significant digits.

2/ Calculated rhenium contained in molybdenite concentrates.

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

	1994		1995	
Country	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
Austria	--	--	776	$627
Chile	4,090	$4,360	3,600	3,180
Germany	1,480	1,220	2,510	1,790
Japan	301	305	--	--
Netherlands	--	--	2,580	1,430
Switzerland	5	4	--	--
United Kingdom	1	2	88	29
Total	5,870	5,890	9,550	7,050

1/ Data are rounded to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 3
U.S. IMPORTS FOR CONSUMPTION OF AMMONIUM PERRHENATE, BY COUNTRY 1/

	1994		1995	
Country	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
Chile	717	$308	1,120	$558
Germany	458	185	773	340
Japan	1	1	--	--
Kyrgyzstan	--	--	89	27
Netherlands	993	463	--	--
Russia	--	--	744	184
Sweden	159	54	--	--
United Kingdom	--	--	551	121
Total	2,330	1,010	3,280	1,230

1/ Data are rounded to three significant digits; may not add to totals shown.

Source: Bureau of the Census.