RHENIUM

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In the last decade, the two most important uses of rhenium have been in platinum-rhenium catalysts and high-temperature superalloys. Platinum-rhenium catalysts are used to produce lead-free, high-octane gasoline. Superalloys are used for turbine engine components. Other applications of rhenium, primarily as tungsten-rhenium and molybdenum-rhenium alloys, are more diverse; these included thermocouples, heating elements, temperature controls, flashbulbs, vacuum tubes, X-ray tubes and targets, metallic coatings, and electrical contact points. Research by industry continued on the recovery of rhenium from ore and concentrate and the development of new catalysts and alloys.

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

Compared with that of 1998, 1999 rhenium consumption increased by about 14% and imports for consumption decreased by 33% (table 1). The average prices for metal powder and ammomium perrhenate were $1,000 and $700 per kilogram, respectively.

Consumption

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 in 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. In 1999, catalytic uses comprised about 20% of rhenium consumption reported in table 1. Platinum-rhenium catalysts also were used in the production of benzene, toluene, and xylenes, although this use was small compared with that of gasoline production.

A significant property of rhenium is its ability to alloy with molybdenum and tungsten. Molybdenum alloys containing about 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 at temperatures above 196° C and can be welded. Alloys of tungsten with 24-weight-percent rhenium have improved ductility and have lower ductile-to-brittle transition temperatures than pure tungsten. Rhenium improves the strength properties of nickel alloys at high temperatures (1,000° C). In 1999, metallurgical uses comprised about 75% of rhenium consumption. Other uses for these alloys, which collectively represented only 5% of total consumption, were in thermocouples, temperature controls, heating elements, ionization gauges, mass spectrographs, electron tubes and targets, electrical contacts, metallic coatings, vacuum tubes, crucibles, electromagnets, and semiconductors.

Foreign Trade

Imports for consumption of rhenium metal are listed in tables 1 and 2, and those of ammonium perrhenate are listed in tables 1 and 3. World production of rhenium in ore was estimated to be 50 metric tons; the quantity of rhenium actually recovered, however, was much lower because not all concentrates were processed to recover the rhenium values. Rhenium was recovered from some byproduct molybdenite concentrates from porphyry copper deposits in Canada, Chile, China, Iran, Kazakhstan, Peru, Russia, and the United States. Rhenium metal and compounds were recovered from molybdenum concentrates in Chile, France, Germany, Russia, the United Kingdom, and the United States.

World Review

World reserves of rhenium are contained primarily in molybdenite in porphyry copper deposits. U.S. reserves of rhenium are concentrated in Arizona, 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 in the rest of the country.

Other world reserves are in several porphyry copper deposits and sedimentary copper deposits in Armenia, northwestern China, Russia, and Uzbekistan and in sedimentary copper-cobalt deposits in the Congo (Kinshasa).

Outlook

In the next 5 years, demand for rhenium metal was expected to follow the demand for turbine engines and petroleum. For the long term (10 to 20 years), recycling of rhenium-bearing waste and scrap was expected to increase. Identified U.S. resources are estimated to be about 5,000 tons, and identified rest-of-world resources are estimated to be about 6,000 tons.

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Rhenium. Ch. in Minerals Commodity Summaries, annual.[1]
Rhenium. Ch. in Minerals Yearbook, annual.[1]

[1]Prior to January 1996, published by the U.S. Bureau of Mines.

Rhenium. Ch. in United States Mineral Resources, Professional Paper 820, 1973.

Other

Rhenium. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.

TABLE 1
SALIENT U.S. RHENIUM STATISTICS 1/

(Gross weight, kilograms)

	1995	1996	1997	1998	1999
Mine production 2/	17,000	14,000	15,400	14,000	12,000
Consumption e/	16,200	24,100	17,900	28,600	32,500
Imports (metal)	9,550	10,800	8,510	14,200	12,800
Imports (ammonium perrhenate)	3,280	10,000	6,560	11,000	2,750

e/ Estimated.
1/ Data are rounded to no more than three significant digits.
2/ Rhenium contained in molybdenite concentrates, based on USGS calculation.

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

	1998		1999	
Country	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
Chile	11,700	$12,100	10,100	$11,200
Estonia	--	--	31	15
Germany	579	450	1,650	1,990
Japan	69	33	--	--
Kazakhstan	35	13	--	--
Russia	1,250	693	785	516
Slovakia	198	104	--	--
Switzerland	301	226	--	--
United Kingdom	15	17	209	258
Total	14,200	13,600	12,800	14,000

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

Source: U.S. Census Bureau.

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

	1998		1999	
Country	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
Chile	2,080	$1,000	829	$689
China	--	--	270	71
Estonia	87	47	470	243
France	48	43	--	--
Germany	5,140	1,860	--	--
Kazakhstan	1,430	524	1,070	610
Russia	2,070	576	109	61
Uzbekistan	149	39	--	--
Total	11,000	4,090	2,750	1,670

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

Source: U.S. Census Bureau.