RHENIUM

By John W. Blossom

In the last decade, the two most important uses of rhenium 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 are more diverse. These include thermocouples, heating elements, temperature controls, flashbulbs, vacuum tubes, X-ray tubes and targets, metallic coatings, and electrical contact points. Research by industry continues 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 eight operating porphyry copper-molybdenum-rhenium mines in the Western States. Domestic mine production data for rhenium 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 by domestic recovery, domestic stocks, and imports, the principal source of supply.

Consumption of rhenium decreased by about 26%, and imports for consumption decreased by 28%. The major consumption was in bimetallic platinum-rhenium catalysts and high-temperature jet engine components. The average prices for metal powder and ammonium perrhenate were $900 and $300 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. Catalytic units with 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 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). Some of the uses for these alloys, which represented only 10% of total demand, 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.

Foreign Trade

Imports for consumption of ammonium perrhenate came from Chile, France, Germany, Ireland, Kazakstan, Switzerland, the United Kingdom, and Uzbekistan; those for rhenium metal came from Chile, Germany, Kazakstan, Russia, and the United Kingdom. World production of rhenium in ore was estimated to be 50 metric tons; the quantity of rhenium actually recovered is, however, 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, 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 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 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 one sedimentary copper deposit in Armenia, northwestern China, Russia, and Uzbekistan and in sedimentary copper-cobalt deposits in the Democratic Republic of the Congo (Kinshasa).

Current Research and Technology

The 1997 annual meeting of the International Symposium on Rhenium and Rhenium Alloys commemorated the 70th anniversary of the discovery of rhenium. This symposium produced 78 papers associated with rhenium (Bryskin, 1997). The material covered is extensive—rhenium history; extraction and recycling; chemical processing of compounds and catalysts; component design and fabrication of the metal and alloys; processing, structure, and properties of rhenium and its alloys;

"rhenium effect" and alloy development; and single crystal technology—rhenium and rhenium alloys. The proceedings of this symposium provides an extensive record of the research and development of rhenium and its alloys.

Outlook

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

Reference Cited

Bryskin, B.D., 1997, Rhenium and rhenium alloys: International Symposium on Rhenium and Rhenium Alloys, Orlando, FL, February 10-13, 1997, Proceedings, 826 p.

SOURCES OF INFORMATION

U.S. Geological Survey Publications

Rhenium. Ch. in Mineral Commodity Summaries, annual.[1]

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

Rhenium. Ch. in United States mineral resources, U.S. Geological Survey Professional Paper 820, 1973.

Other

Rhenium. Ch. in Mineral facts and problems, U.S. Bureau of Mines Bulletin 675, 1985.

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

TABLE 1
SALIENT U.S. RHENIUM STATISTICS 1/

(Kilograms)

	1993	1994	1995	1996	1997
Mine production 2/	12,200	15,500	17,000	14,000	15,400
Consumption e/	6,900	12,900	16,200	24,100	17,900
Imports (metal)	2,700	5,870	9,550	10,800	8,510
Imports (ammonium perrhenate)	3,170	2,330	3,280	10,000	6,560

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/

	1996		1997	
Country	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
Chile	8,500	$7,960	6,290	$5,910
Germany	1,730	1,380	2,160	1,700
Kazakstan	50	26	--	--
Russia	425	102	56	21
United Kingdom	100	39	--	--
Total	10,800	9,500	8,510	7,640

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/

	1996		1997	
Country	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
Chile	5,280	$2,100	13	$6
France	278	12	--	--
Germany	1,090	310	81	30
Ireland	--	--	700	235
Kazakstan	628	147	3,840	931
Russia	871	322	--	--
Switzerland	--	--	1,680	497
United Kingdom	1,500	441	247	58
Uzbekistan	350	105	--	--
Total	10,000	3,440	6,560	1,760

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

Source: Bureau of the Census.