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MOLYBDENUM

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GOVERNMENT OF INDIA
MINISTRY OF MINES
INDIAN BUREAU OF MINES

Indira Bhavan, Civil Lines,
NAGPUR – 440 001

PHONE/FAX NO. (0712) 2565471
PBX : (0712) 2562649, 2560544, 2560648
E-MAIL : cme@ibm.gov.in
Website: www.ibm.gov.in

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11 Molybdenum

Molybdenum (Mo) is a refractory metal used principally as an alloying agent in steel, cast iron & superalloys to enhance strength and resistivity to wear & corrosion. It does not occur in nature in free state. Usually, it is found in chemically combined form with other elements. Molybdenite (MoS_2) is the principal ore of molybdenum. About two-thirds of global molybdenum production is as by-product of copper mining and only about one-third is obtained from primary molybdenum mines. In India, by-product concentrates of molybdenum are produced intermittently from uranium ore of Jaduguda mine belonging to Uranium Corporation of India Ltd (UCIL) in Jharkhand. The internal demand for molybdenum and its products is met mostly through imports.

RESERVES/RESOURCES

India though is endowed with rich mineral wealth, there are several critical minerals that it lacks and one of them is molybdenum. In India, molybdenum is associated generally with copper, lead and zinc ores. Rakha copper deposit in Jharkhand contains 45 to 48 ppm molybdenum. Malanjkhand copper deposit in Madhya Pradesh contains 0.04% recoverable molybdenum. Dariba-Rajpura lead-zinc deposit in Rajasthan contains molybdenum besides bismuth, arsenic and cadmium. The multimetal deposit at Umpyrtha in Khasi and Jaintia Hills, Meghalaya, reportedly contains molybdenum in association with copper, lead and tungsten. Molybdenum deposit in Karadikuttam in Madurai district, Tamil Nadu, contains 0.02 to 0.14% recoverable molybdenum.

As per NMI database as on 1.4.2015, based on UNFC System, the resources of molybdenum ore in the country have been estimated at 19.37 million tonnes containing about 12,668 tonnes MoS_2. The above resources of ore are located in Tamil Nadu (10 million tonnes), Madhya Pradesh (8 million tonnes) and Karnataka (1.32 million tonnes) (Table-1).

EXPLORATION & DEVELOPMENT

The exploration and development details, if any, are covered in the Review on "Exploration & Development" under "General Reviews".

USES

Molybdenum is a versatile alloying agent for alloy steel, cast iron, nickel, cobalt and titanium alloys. For desired metallurgical properties, it is used in the form of molybdic oxide or ferro-molybdenum. It is used in different proportions for imparting desired properties, such as, increased strength, hardness and resistance to corrosion, temperature and chipping. It also finds application in permanent magnet alloys. As a refractory metal, it is used in many electrical and electronic components and as resistance element in electric furnaces and other equipment which are operated at extremely high temperatures. Its non-metallurgical uses are in lubricants, catalysts, pigments, as an additive in oil and greases, in aerosol sprays, in reducing surface friction and as an antiwear and antifriction agent in plastics. Molybdenum plays a vital role in the Energy Industry and it may become an increasingly essential factor in green technology.

SUBSTITUTES

There is hardly any substitution for molybdenum in its major application, viz, as an alloying element in steel and cast irons. Owing to the non-availability of molybdenum, there was an apparent need to develop new materials that could be a suitable subsititute vis-a-vis the alloying properties of the metal. Potential substitutes for molybdenum include chromium, vanadium, niobium (columbium) and boron in alloy steels; tungsten in tool steels; graphite, tungsten and tantalum for refractory materials in high temperature electric furnaces and chrome-orange, cadmium-red and organic-orange pigments for molybdenum orange.

Table – 1 : Reserves/Resources of Molybdenum as on 1.4.2015
(By Grades/States)

(In tonnes)

Grades/States	Reserves	Remaining Resources						Total Resources (A+B)
	Total (A)	Pre-feasibility STD221	Measured STD331	Indicated STD332	Inferred STD333	Reconnaissance STD334	Total (B)	
All India : Total								
Ore	**-**	**1500000**	**36000**	**569304**	**17098594**	**167800**	**19371698**	**19371698**
Contained MoS_2	**-**	**1050**	**83**	**287**	**11198.03**	**50.34**	**12668.37**	**12668.37**
By States								
Karnataka								
Ore	-	-	-	-	1320900	-	1320900	1320900
Contained MoS_2	-	-	-	-	1718.7	-	1718.7	1718.7
Madhya Pradesh								
Ore	-	-	-	-	8000000	-	8000000	8000000
Contained MoS_2	-	-	-	-	5020	-	5020	5020
Tamil Nadu								
Ore	-	1500000	36000	569304	7777694	167800	10050798	10050798
Contained MoS_2	-	1050	83	287	4459.33	50.34	5929.67	5929.67

Figures rounded off

INDUSTRY AND CONSUMPTION

Usually, molybdenum is used in the form of roasted concentrates, oxide or ferro-molybdenum in the Defence industries. The production of ferro-molybdenum decreased from 1,003 tonnes in 2018-19 to 527 tonnes in 2019-20 (Table-2).

Non-ferrous Technology Development Centreat the Defence Metallurgical Research Laboratory, Hyderabad, has a pilot plant for producing molybdenum powder. Institute of Minerals and Materials Technology (formerlyRRL), Bhubaneswar, has been undertaking basic research on recovery of molybdenum from spent catalysts.

Table – 2 : Production of Ferromolybdenum 2015-16 to 2019-20

(In tonnes)

Year	Production
2015-16	1459
2016-17	1603
2017-18	1205
2018-19	1003
2019-20 (P)	527

Source: *Monthly Statistics of Mineral Production, March, 2021, IBM*

Moly Metal LLP, a leading manufacturer of Molybdenum alloys ferromolybdenum (FeMo) and molybdenum disulphide (MoS_2), commenced production in 2007 at a new manufacturing plant in the U.T. of Daman. RUBAMIN, a Gujarat-based Company, reportedly has a capacity of 1,500 tonnes per annum sodium molybdate and 800 tonnes per annum ammonium molybdate both of which are derivates of molybdenum.

TRADE POLICY

As per Foreign Trade Policy, 2015-2020, imports and exports of molybdenum ores & concentrates under Exim Code 2613 and molybdenum & articles thereof under Exim Code 8102 are allowed free, except waste and scrap (under ITC-HS Code No. 8102 9700) which are restricted.

WORLD REVIEW

The world reserves of molybdenum are at 18 million tonnes, located mainly in China (46%), Peru & USA (15% each), Chile (8%) and Russia (6%) (Table-3).

Table – 3 : World Reserves of Molybdenum (By Principal Countries)

(In '000 tonnes of molybdenum content)

Country	Reserves
World: Total (rounded off)	**18000**
Argentina[(e)]	100
Armenia[(e)]	150
Canada	96
Chile[(e)]	1400
China[(e)]	8300
Iran[(e)]	43
Mexico	130
Mongolia	370
Peru[(e)]	2800
Russia[(e)]	1000
Turkey	800
USA	2700
Uzbekistan[(e)]	60

Source: *USGS, Mineral Commodity Summaries, 2021.*

The world mine production of molybdenum in terms of metal content decreased marginally by 5% to 2.75 lakh tonnes in 2019 from 2.89 lakh tonnes in 2018. China with 38% production was the main producer of molybdenum in the world followed by Chile (19%), USA (16%), Peru (11%) and Mexico (6%) in 2019 (Table-4).

Table-4: World Mine Production of Molybdenum (By Principal Countries)

(In tonnes of metal content)

Country	2017	2018	2019
World:Total (rounded off)	**290000**	**289000**	**275000**
China	117104	113308	104435
Chile	62454	60248	53541
USA	40700	41400	43500
Peru	28141	28034	30441
Mexico	13985	20265	16890
Iran[(a)]	7767	7662	7600[(e)]
Armenia	5886	5666	7304
Canada	4941	5036	3955
Mongolia	2639	2579	2492
Other countries	6646	5281	5029

Source*: BGS World Mineral Production, 2015-19,*
(a) years ended 20th March following that stated.

To give a generalised view of the development in various countries, the countrywise description sourced from available publication, i.e., Minerals Yearbook of USGS, 2018 is furnished below.

Canada

Teck Resources Ltd announced that its Highland Valley Mine in south-central British Columbia produced 3,900 tonnes of molybdenum in concentrate in 2018, about 7% decrease from the 4,200 tonnes produced in 2017. The Company attributed the decrease to lower ore grades.

At its Gibraltar Mine in south-central British Columbia, Taseko Mines Ltd produced 1,070 tonnes of molybdenum, about 11% decrease from the record 1,200 tonnes of molybdenum in concentrate produced in 2017.

Chile

Amerigo Resources Ltd (Canada) reported that it produced 860 tonnes of molybdenum in 2018, compared with 730 tonnes of molybdenum in 2017 at its Minera Valle Central processing facility in central Chile. Amerigo forecast production of 1,100 tonnes of molybdenum in 2019.

Antofagasta plc (United Kingdom) announced that 2018 by-product molybdenum production at its 60% owned Los Pelambres Mine was 13,300 tonnes a 27% increase compared with 10,500 tonnes produced in 2017. Antofagasta also announced that its new molybdenum plant at the 70% owned Centinela Mine produced 300 tonnes of molybdenum in concentrate in 2018. The Centinela molybdenum plant started production in the third quarter of 2018 and had a capacity to produce an average of 2,400 tonnes per year of molybdenum in concentrate. The Centinela Mine is 1.350 kilometers north of Santiago in the Antofagasta Region. The company expected Centinela of produce aprroximately 2,000 tonnes of molybdenum in concentrate 2019. **C**orporacion Nacional del Cobre de Chile (CODELCO), the state-controlled copper and molybdeenum producer, announced that it produced 24,000 tonnes of molybdenum in 2018 compared with 28,700 tonnes in 2017. The Sierra Gorda Mine produced 6,900 tonnes of molybdenum in concentrate in 2018, a decrease from 2017 molybdenum production. The company attributed the decrease to lower grade ore.

Mexico

Southern Copper Corp. (a subsidiary of Grupo Mexico S.A.B. de C.V.) reported that it produced 21,990 tonnes of molybdenum in concentrate in 2018, a 3% increase from 21,330 tonnes in 2017, owing mainly to higher production at the Buenavista Mine. The Buenavista Mine produced 8,400 tonnes of molybdenum in concentrate in 2018 as compared with 3,460 tonnes in 2017. Southern Copper reported that its La Caridad Mine, in northeastern Sonoro, produced 9,800 tonnes of molybdenum in concentrate in 2018, compared with 9,900 tonnes in 2017. The molybdenum recovery plant had a capacity to process 2,000 tonnes per day of copper-molybdenum concentrates.

Peru

Teck announced that it produced 4,600 tonnes of molybdenum in concentrate in 2018 at its Antamina copper-zinc mine in Peru, 17% more than that in 2017 Copper, molybdenum and zinc production at Antamina can vary significantly from year to year owing to the geology of the deposit and proportion of copper to copper-zinc ore processed.

The Cerro Verde Mine is an open pit copper and molybdenum mining complex with the production in 2018 was approximately 12,700 tonnes of molybdenum in concentrate as compared with 12,200 tonnes in 2017. Southern Copper produced 3,100 tonnes of molybdenum in concentrate at its Cuajone operation in 2018 as compared with 3,700 tonnes in 2017. Production at the Cuajone operation began in 2016.

China

China's molybdenum production took place predominantly in Hebei, Henan, and Shaanxi Provinces and the Nei Mongol Autonomous Region. China had a large number of small-scale mining operations that were susceptible to changes in prices and also were able to quickly increase or decrease production during price fluctuations. Environmental inspections at molyblenum mines and processing facilities continued in 2018 and disrupted production at a variety of molybdenum producers. Jiangxi Copper Co. Ltd, produced 7,500 tonnes of molybdenum concentrate in 2018, a 3% increase from 2017.

Jinduicheng Molybdenum Co.Ltd. announced that it was expected to produce 48,000 tonnes of 45% grade molybdenum concentrate in 2019 as compared with 47,500 tonnes in 2018. China announced that it was expected to impose a 5% tariff on imports of

both roasted and unroasted molybdenum concentrates, effective September 24,2018.

Armenia

The Zangezur Copper-Molybdenum Combine continued to produce molybdenum at its Kajaran Mine. According to Cronimet Mining AG, the Kajaran Mine is the leading copper and molybdenum mine in Armenia. Zangezur's company shareholders are Cronimet Mining (60%), Pure Iron Plant OJSC (15%), Armenian Molybdenum Production Ltd (12.5%), and Zangezur Mining Ltd (12.5%).

Table – 5 : Exports of Molybdenum Ores & Conc. (By Countries)

Country	2018-19 (R)		2019-20 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**6**	**81**	**3**	**3023**
UAE	-	-	3	3023
Malaysia	6	81	-	-

Figures rounded off.

Table – 6 : Exports of Molybdenum & Scrap (By Countries)

Country	2018-19 (R)		2019-20 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**517**	**281068**	**85**	**122337**
Austria	4	48600	3	40669
Netherlands	409	124962	60	14723
China	2	15037	1	12745
Germany	92	32905	11	11089
USA	1	10150	1	7657
Belgium	++	4853	1	7067
Poland	1	8658	1	4721
UK	++	703	2	3678
Bangladesh	1	2933	3	2840
Pakistan	1	8370	++	2450
Other countries	6	23897	3	14699

Figures rounded off.

FOREIGN TRADE

Exports

Exports of molybdenum ores & concentrates decreased sharply by 50% to 3 tonnes in 2019-20 from 6 tonnes in 2018-19. Exports were solely to UAE (100%). Exports of molybdenum and scrap also decreased sharply by 84% to 85 tonnes in 2019-20 from 517 tonnes in 2018-19. Exports were mainly to Netherlands (71%) and Germany (13%) (Tables-5 & 6).

Imports

Like exports, imports of molybdenum ores & concentrates decreased by 28% to 7,901 tonnes in 2019-20 from 11,028 tonnes in 2018-19. Imports were mainly from Chile (42%) , Thailand (29%), UAE (6%), Turkey (5%) and USA (4%). Imports of molybdenum and scrap also decreased by 13% to 430 tonnes in 2019-20 from 493 tonnes in the 2018-19. Imports were mainly from China (79%), Austria (11%) and USA (5%) (Tables-7 & 8).

Table – 7 : Imports of Molybdenum Ores and Conc. (By Countries)

Country	2018-19 (R)		2019-20 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**11028**	**13606784**	**7901**	**9809779**
Chile	4962	6089700	3329	3793869
Thailand	1933	3178550	2302	3230436
Turkey	201	345915	376	619472
UAE	270	384710	502	604464
Netherlands	1080	1051223	200	308666
USA	698	857459	288	279469
China	103	145231	215	235472
Switzerland	223	360397	137	227884
Korea, Rep. of	326	488426	188	153457
Malaysia	-	-	68	123630
Other countries	1232	705172	297	232961

Figures rounded off

Table –8 : Imports of Molybdenum & Scrap (By Countries)

Country	2018-19 (R)		2019-20 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**493**	**1698724**	**430**	**1545908**
China	285	887244	341	1021928
Austria	95	421319	48	293675
USA	27	130467	20	123114
Germany	4	27932	9	36913
Singapore	3	24083	3	23532
UK	5	15646	7	20740
Japan	++	7580	++	6495
France	++	9630	++	6335
Hong Kong	21	53070	1	5486
Canada	1	2065	++	2353
Other countries	52	119689	1	5337

Figures rounded off

FUTURE OUTLOOK

The principal uses for molybdenum are expected to continue to be as catalysts and in chemicals and as an additive in steel manufacturing, most importantly alloy and stainless steel. Molybdenum plays a vital role in the Energy Industry, and it may become an increasingly important factor in environmental protection technology, where it is used in high-strength steels for automobiles to reduce weight and improve fuel economy and safety. Molybdenum-based catalysts have a number of important applications in the Petroleum and Plastics industries. A major use is in the hydrodesulfurisation of petroleum, petrochemicals, and coal-derived liquids. Catalysts are estimated to account for more than 70% of chemical uses of molybdenum. Molybdenum not only allows for economical fuel refining, it also contributes to a safer environment through lower sulphur emissions. Analysts expect global demand for molybdenum-based catalysts to continue its increasing trend as there are no practical alternatives to molybdenum in many of the catalytic applications. The need for companies to reduce carbon dioxide emissions from coal-fired power stations will require plants to run at higher temperatures, resulting in greater demand for higher grade molybdenum-bearing steels. Increase in molybdenum use is expected to continue in stainless steels and full alloy steels mainly in the consumer product and transportation industries.

According to the International Molybdenum Association (2019), global molybdenum consumption in 2018 increased to 264,400 tonnes as compared to 253,100 tonnes in 2017. The consumption of molybdenum in structural and engineering steel is forecast to remain the leading end use for molybdenum products.