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TUNGSTEN

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GOVERNMENT OF INDIA
MINISTRY OF MINES
INDIAN BUREAU OF MINES

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18 Tungsten

Tungsten, in its raw form, is a hard steel-grey metal that is often brittle and hard to work. If made very pure, tungsten retains its hardness and become malleable enough. Tungsten objects are also commonly formed by sintering. Tungsten is found in the minerals wolframite (iron - manganese tungstate, $FeWO_4/MnWO_4$), scheelite (calcium tungstate, $CaWO_4$) ferberite and huebnerite.

Off all metals in pure form, tungsten is one of heaviest metals and has the highest melting point of any element except carbon (3422 ^{o}C, 6192 ^{o}F), lowest vapor pressure (at temperatures above 1650 ^{o}C, 3000 ^{o}F) very high thermal creep resistance and the highest tensile strength. It is extremely resistant to corrosion and can be attacked only slightly by most mineral acids. When exposed to air, a protective oxide is formed on the surface of the metal, but tungsten can be oxidised more fully at high temperature. When alloyed in small quantities with steel, tungsten greatly increases the hardness of steel.

A significant amount of tungsten is recovered through recycling of tungsten scrap products. Old scrap consists of tungsten bearing products such as cemented carbide parts include metal cutting tools & metal forming tools. As tungsten has extremely high melting point and is ductile (can be readily drawn into wires), it is widely used in filaments of light bulbs and vacuum tubes, and for heating elements in electrical furnaces.

RESERVES/RESOURCES

The total reserves/resources of tungsten ore in the country, as per NMI data, based on UNFC system, as on 1.04.2015 have been estimated at 87.39 million tonnes with WO_3 content of 1,42,094 tonnes. All these resources are placed under 'remaining resources' category.

Resources of tungsten bearing minerals are mainly distributed in Karnataka (42%), Rajasthan (27%), Andhra Pradesh (17%) and Maharashtra (9%). The remaining 5% resources are in Haryana, Tamil Nadu,Uttarakhand and West Bengal (Table- 1).

At Degana, Rajasthan, WO_3 value in vein deposits varies from 0.25 to 0.54% while in gravel deposit, it is on an average of 0.04%. In Sirohi deposit, Rajasthan,WO_3 content ranges from 0.02 to 2.2%. In West Bengal, Bankura deposit contains an average of 0.1% WO_3. In Kuhi-Khobana-Agargaon belt, GSI has identified seven mineralised zones in Sakoli basin in Bhandara and Nagpur districts, Maharashtra. The analysis showed 0.01 to 0.19% WO_3 in Kuhi block, 0.13 to 0.38% WO_3 in Khobana block and 0.48% WO_3 in Pardi-Dahegaon-Pipalgaon block. The deposit contains an average of 0.17% WO_3. Gold ore at Mysore mine of BGML in Karnataka has been reckoned as a potential source of scheelite. The tailing dumps at Kolar Gold Fields contain about 0.035 to 0.18% WO_3.

EXPLORATION & DEVELOPMENT

The Exploration and development details, if any, are given in the review on Exploration & Development in "General Reviews".

PRODUCTION & PRICES

There was no production of tungsten ore/concentrate during 2016-17. The past production of tungsten was reported from Degana, Rajasthan and Chendapathar, West Bengal. The domestic prices of tungsten ore and concentrate are furnished in the General Review on 'Prices'.

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

(In tonnes)

Grade/State	Reserve Total (A)	Remaining Resources							Total Resources (A+B)
		Feasibility STD211	Pre-feasibility STD222	Measured STD331	Indicated STD332	Inferred STD333	Reconnaissance STD334	Total (B)	
All India : Total									
Ore	-	**2230000**	**173063**	**19611152**	**23435954**	**25356049**	**16581246**	**87387464**	**87387464**
Contained WO_3	-	**3568**	**450**	**9914**	**20180.92**	**103415.15**	**4566.28**	**142094.35**	**142094.35**
By States									
Andhra Pradesh									
Ore	-	-	-	3640000	4700800	5952500	509000	14802300	14802300
Contained WO_3	-	-	-	5096	6574.64	8273.65	318.28	20262.57	20262.57
Haryana									
Ore	-	2230000	-	-	-	-	-	2230000	2230000
Contained WO_3	-	3568	-	-	-	-	-	3568	3568
Karnataka									
Ore	-	-	-	15361152	11805499	172921	9338246	36677818	36677818
Contained WO_3	-	-	-	2915	1775	142	1403	6235	6235
Maharashtra									
Ore	-	-	-	610000	5637250	1830000	-	8077250	8077250
Contained WO_3	-	-	-	1903	10304	3828	-	16035	16035
Rajasthan									
Ore	-	-	-	-	963666	17000628	5964000	23928294	23928294
Contained WO_3	-		-	-	1421.44	90171.5	2115	93707.94	93707.94
Tamil Nadu									
Ore	-	-	-	-	-	-	250000	250000	250000
Contained WO_3	-	-	-	-	-	-	50	50	50
Uttarakhand									
Ore	-	-	-	-	138000	-	520000	658000	658000
Contained WO_3	-	-	-	-	25	-	680	705	705
West Bengal									
Ore	-	-	173063	-	190739	400000	-	763802	763802
Contained WO_3	-	-	450	-	80.84	1000	-	1530.84	1530.84

MINING & PROCESSING

Deposits of wolframite that were established at Degana in Rajasthan and at Chendapathar in West Bengal are found associated with quartz veins, with width that varied from a few centimetres to three metres or sometimes even more. In Degana, it is also associated with gravel beds overlain by 2.5 m thick sand.

Gravel mining was carried out in the past in selected areas where wolframite was found to be concentrated. The overburden sand was at first loosened and loaded manually and transported by tractor unit to dump sites. The payable gravel was then worked.

In case of vein deposits, the orebody was cut with chisel and hammer at convenient places, to form undercuts. At Degana, tungsten orebody occurs as vein, stockwork and alluvial deposits.

Inclined veins were developed by putting adits in the stockwork.

Degana in Rajasthan and Chendapathar in West Bengal were the only mines of tungsten in India that produced meagre quantities of concentrate. These mines, owing to economic non-viability, had to be closed down. As per the press release by NMDC dated 24th October 2016, NMDC Ltd & Mishra Dhatu Nigam (MIDHANI) have signed a Memorandum of Understanding (MoU) to develop tungsten mines and processing technology for the metal.

USES

Tungsten is mainly used in the form of ferro-tungsten in making of special and alloy steels and military applications. Ferro-tungsten typically contains between 25% and 75% tungsten. The other principal use of tungsten is in the manufacture of tungsten carbide, one of the hardest synthetic materials used in various industries like construction , metalworking, mining and oil drilling. It is used widely in the manufacture of cutting tools & devices and in wear-resistant materials, particularly those that need to be operated at high temperatures. In making this, cobalt or nickel metal powder is used as a binder to hold together the tungsten carbide grain. Tungsten compounds are used in dyes and pigments; manufacture of paints & printing ink; and also in Ceramic Industry for producing yellow tint. Other alloys bearing tungsten have wide range of applications, i.e., ornaments, heat sinks, radiation shielding, weights & counter-weights,super alloys for turbine parts, tool steels wear-resistant alloy parts & coatings, etc. Tungsten alloys and tungsten composites are used as a substitute for lead in bullet and shot. Tungsten is used as filament in incandescent light bulbs and cathodes for electronic tubes, cell phones, television set, HID lamps and other electrical consumer products. The metal is used in superalloys with copper or silver and in Chemical Industry. Tungsten carbide is often used in armor-piercing ammunition.

SUBSTITUTES

Tungsten remains essentially unsubstitutable in its use for production of filaments, electrodes and contacts in lamp & lighting applications. However, an electrodeless, non-tungsten lamp is available as alternative for commercial and industrial uses. Titanium, tantalum and niobium carbides can be used in certain wear-resistant applications. Molybdenum tool steels and tungsten tool steels are interchangeable. In some cutting tool applications, bulk ceramic is an alternative. In some applications, substitution would most often result in increased cost or reduction in product performance.

TECHNICAL POSSIBILITIES

Further development of new metal shaping methods, i.e., laser is becoming a viable proposition. Development of new cutting tool materials coating on cemented carbide parts, that increase their useful life could reduce the usage of tungsten. Use of tungsten scrap could be increased. The recycling of tungsten bearing scrap and the recovery of tungsten from scrap materials are well established practices for a number of reasons. The value of tungsten and other metals present in the scrap, such as cobalt, columbium, copper, nickel, rhenium, silver, titanium, and

tantalum, provides economic reasons to recycle. Recycling of tungsten in high speed steel is high and a typical melt contains about 60-70 % scrap, including internally generated scrap. On the other hand, recycling in such applications as lamp filaments, welding electrodes and chemicals uses is done. Recycling is more environment friendly and usually more economic than waste disposal. Tungsten compounds could be used in light-sensitive applications. Scrap recycling is an important factor in the world's tungsten supply.

POLICY

As per the Foreign Trade Policy, 2015-20, the imports and exports of tungsten ores and concentrates (HS Code 26000000) allowed free.

CONSUMPTION

The entire domestic requirement of tungsten ore/ concentrates is met by imports. Sandvik Asia Pvt. Ltd, Pune, Maharashtra,Widia (India) Ltd, Bengaluru, Karnataka, Rapicut Carbides Ltd, Ankleshwar, Gujarat, Mishra Dhatu Nigam Ltd, Hyderabad, Andhra Pradesh and Sunflag Iron & Steel Co. Ltd, Bhandara, Maharashtra were the important consumers of ferro-tungsten for production of alloy steel. Mining Machinery Industry is the main consumer of the imported ore/ concentrates.

WORLD REVIEW

The world reserves of tungsten in terms of metal content are about 3.2 million tonnes, distributed broadly amongst China (56%), Russia (5%), Vietnam (3%), Mongolia and Spain (2% each) (Table-2).

Table - 2: World Reserves of Tungsten (By Principal Countries)

(In '000 tonnes of Tungsten content)

Country	Reserves
World Total (rounded)	**3200**
Austria	10
Bolivia	NA
China	1800
Mongolia	63
Portugal	3
Russia	160
Rwanda	NA
Spain	54
UK	43
Vietnam	95
USA	NA
Other countries	950

Source : Mineral Commodity Summaries, 2018

The world mine production of tungsten in terms of metal content in 2016 increased slightly to 88,700 tonnes from 88,200 tonnes in 2015. China was the leading producer (81%), followed by Vietnam (7%), Russia (3%) and Zimbabwe, Rwanda, Austria, UK & Bolivia (1% each) (Table-3).

Table – 3: World Mine Production of Tungsten (By Principal Countries)

(In tonnes of metal content)

Country	2014	2015	2016
World: Total (rounded)	**80900**	**88200**	**88700**
Austria	830	870	950
Bolivia	956	1116	848
Brazil[c]	510	500[e]	500
Myanmar[ed]	140	90	110
Burundi	115	78	131
Canada	2689	2114	-
China	65360	72163	72163
Congo,Democratic Republic	10	65	93
Korea, Dem. P. R. of [e]	70	70	50
Kyrgyzstan[e]	100	100	100
Peru	77	139	-
Portugal[a]	671	474	549
Russia	2659	2608	2600
Rwanda	1313	1081	1000
Spain	822	835	688
UK	-	195	923
Uzbekistan[e]	300	300	300
Vietnam	4134	5123	6357
Zimbabwe	-	200	1248
Other countries	171	91	134

Source: *World Mineral Production, 2012-2016.*

a :Wolframite & scheelite.

d : Including tungsten content of tin-wolframite concen trates.

c *: Mainly scheelite.*

FOREIGN TRADE

Ammonium paratungstate (APT) $(NH_4)_{10}(H_2W_{12}O_{42}).4H_2O$ is the main intermediate and also the main tungsten raw material traded in the market.

Exports

Exports of tungsten and alloys including scrap increased to 373 tonnes in 2016-17 from 314 tonnes in the previous year. Exports were mainly to Germany & USA (17% each), Sweden (8%), UK (7%), Thailand (6%), Austria (4%) and Japan (3%). In 2016-17, exports of tungsten ore & concentrates increased to 8 tonne as against only 1 tonne in the preceding year. Large part of exports were to Rwanda (87.5%) and rest to Nepal (12.5%) (Tables-4 & 5).

Imports

Imports of tungsten and alloys including scrap increased to 401 tonnes in 2016-17 from 385 tonnes in the previous year. Imports were mainly from China (54%), Austria (11%), Vietnam & Korea, Rep. of (10% each), Germany (7%) and Singapore (4%). Imports of tungsten ores and concentrate also drastically increased to 283 tonnes in 2016-17 from 78 tonnes in the prevoius year. Imports were mainly from Netherlands (60%) followed by Singapore (22%) (Tables-6 & 7).

Table-4: Exports of Tungsten and Alloys Incl. Scrap (By Countries)

Country	2015-16 (R)		2016-17 (P)	
	Qty (kg)	Value (`'000)	Qty (kg)	Value (`'000)
All Countries	**313688**	**1196647**	**372621**	**1198574**
Germany	78260	309856	64318	311211
USA	63552	162883	64234	144206
Poland	8124	127765	7922	129174
Italy	4963	71964	4409	79820
Japan	2428	69875	10474	75101
Sweden	32191	78134	30413	51756
France	3585	47158	3353	44001
UK	24069	40762	24980	43430
Thailand	6223	22464	23333	41125
Austria	25110	38930	15319	37017
Other countries	65183	226856	123866	241733

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**1**	**390**	**8**	**6064**
Rwanda	-	-	7	6014
Germany	-	-	1	50
Nepal	1	390	-	-

Table –6: Imports of Tungsten & Alloys Incl. Scrap (By Countries)

Country	2015-16 (R)		2016-17 (P)	
	Qty (kg)	Value (`'000)	Qty (kg)	Value (`'000)
All Countries	**384803**	**1591491**	**400849**	**1558902**
China	224700	790689	214893	677684
Austria	36925	266864	45614	330963
Korea, Rep. of	42368	156025	38531	153879
Germany	29340	171139	26152	140776
Vietnam	1525	3971	39600	79824
Singapore	14197	49891	14174	52271
USA	10797	47726	8043	44225
Japan	10073	35080	3238	20684
Italy	6644	23296	3732	15327
Switzerland	2183	12192	1591	12523
Other countries	6051	34618	5281	30746

Table 7: Imports of Tungsten Ores & Conc. (By Countries)

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**78**	**34080**	**283**	**29630**
Netherlands	-	-	171	13668
Australia	-	-	23	7435
Singapore	52	1566	63	5271
Germany	++	191	3	2769
Slovenia	-	-	23	487
Rwanda	15	13199	-	-
USA	2	10128	-	-
Uganda	9	8996	-	-

FUTURE OUTLOOK

World tungsten supply will continue to be dominated by China's production and exports. As per Global Tungsten Market Trends, statistics and forecast 2015-20, Europe is an important market for tungsten demand. The demand for tungsten for industrial applications is expected to witness strong growth,particularly in Asia Pacific and Latin America regions. In the next few years, tungsten concentrates production from outside China is expected to increase. Some of the increase is expected to come from improved production from existing mines and some is expected to come from the ramp up of production at recently started mines and tailings operations. The consumption of tungsten in cemented carbides, which is the leading end-use sector is expected to rise in the near future.

In India, the entire demand can only be met by imports and recycling, as there is no indigenous production of tungsten concentrates. High content of WO_3 in the tailing dumps of Kolar can be worked on priority basis to meet the demand.