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COBALT

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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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4 Cobalt

Cobalt is an important ferromagnetic strategic alloying metal having irreplaceable industrial applications. Cobalt is associated mostly with copper, nickel and arsenic ores.

RESOURCES

Occurrences of cobalt are reported from Singhbhum district, Jharkhand; Kendujhar and Jajpur districts, Odisha; Jhunjhunu district, Rajasthan; Tuensang district, Nagaland; and Jhabua and Hoshangabad districts, Madhya Pradesh. Cobalt associated with lateritic nickel deposit in Sukinda area, Odisha and copper slags are two possible secondary resources of cobalt along with sea-bed multimetal nodules.

As per UNFC system, resources of cobalt in terms of ore as on 1.4.2010 are estimated at 44.91 million tonnes of which about 69%, i.e. 30.91 million tonnes are estimated in Odisha. The remaining 31% resources are in Jharkhand (9 million tonnes) and Nagaland (5 million tonnes). Resources of cobalt as per UNFC system are furnished below in Table-1.

USES

Major use of cobalt is in metallurgical applications, in special alloy/super alloy industry, in magnets and cutting tools industries. Cobalt-based super alloys normally contain 45% or more cobalt, while nickel and iron-based super alloys contain 8 to 20% cobalt. Cobalt oxide is used in chemical applications such as catalyst, dyes and pigments, paint driers/adhesives and glass & ceramics. Cobalt catalyst, mostly cobalt acetate, is used in terephthalic acid (TPA) and di-methyl-terephthalate (DMT) manufacture.

Super alloys made of cobalt have improved strength and wear & corrosion-resistance characteristics at elevated temperatures. Another use of cobalt-based super alloys is in turbines for pipeline compressors and jet aircraft engines. Hard-facing or cutting tools with cobalt alloys provide greater resistance to wear, heat, impact and corrosion. Cobalt powder finds an important application as a binder in the production of cemented tungsten carbides for heavy-duty and high-speed cutting tools. It is also used on bonded tools for diamond industry. Cobalt is used to improve the coating adhesive property of enamel in steel appliances and in manufacturing steel-belted tyres. Cobalt-molybdenum-alumina compound is used as catalyst in hydrogenation and for petroleum desulphurisation. Elemental Cobalt-60 (radioactive isotope, a production of atomic pile) is used in industrial radiography and therapeutics. Cobalt can retain ferromagnetic property up to a temperature of 1,100°C, highest for any metal. It is used in manufacturing of Alnico magnets, magnetic recording media, soft magnetic material, alloys for spacecraft, etc. The use of cobalt-rare earth permanent magnet will continue where specific advantages of reliability and good performance are required. Other significant uses of cobalt are in battery electrodes, airbags in automobiles, etc.

Table – 1: Reserves/Resources of Cobalt Ore as on 1.4.2010
(By States)

(In million tonnes)

State	Reserves total (A)	Remaining resources					Total Resources (A+B)
		Measured STD331	Indicated STD332	Inferred STD333	Reconnaissance STD334	Total (B)	
All India	**–**	**30.63**	**2**	**0.28**	**12**	**44.91**	**44.91**
Jharkhand	–	–	2	–	7	9	9
Nagaland	–	–	–	–	5	5	5
Odisha	–	30.63	–	0.28	–	30.91	30.91

INDUSTRY & PRODUCTION

Presently, there is no production of cobalt in the country from indigenous ores. The refined production of cobalt was reported to be around 1,187 tonnes in 2010, 1300 tonnes in 2011 and 580 tonnes in 2012 from imported feed material. The remaining demand of cobalt is met through imports.

Refining capacity of cobalt in India is estimated at about 2,560 tonnes per year. Of these, Nicomet Industries Ltd and Rubamin Ltd were India's leading producers of cobalt cathodes and compounds. Installed capacity for cobalt metal and different cobalt salts at Nicomet is 1,000 tpy. Another cobalt refinery, Conic Metals Ltd, Mumbai which produced cobalt sulphate and carbonate reportedly remained closed since 2001.

The refiners source the heterogeneite-type cobalt ores from the Democratic Republic of Congo and other countries. The units manufacture high-purity cobalt metal and salts, viz, sulphate, acetate, oxide, chloride, carbonate and nitrate of cobalt. Cobalt metal powder is reportedly recovered from cemented carbide scrap by Sandvik Asia Ltd at its pilot plant in Pune, Maharashtra. In addition, spent cobalt catalysts from plants producing DMT, TPA and oxo alcohols are also understood to be reprocessed by several small cobalt chemical processors. However, information on reprocessing of cobalt from scrap is not available. It is expected that recycled cobalt would continue to be used for domestic supply.

SUBSTITUTES

Cobalt is used in specialised applications and is difficult to be substituted. Potential substitutes include barium or strontium ferrites, neodymium-iron-boron or nickel-iron alloys in magnets; nickel, cermets or ceramics in cutting and wear-resistant materials; nickel-based alloys or ceramics in jet engines; nickel in petroleum catalysts; rhodium in hydroformylation catalysts; and cerium, lead, manganese, iron, or vanadium in paints. Presently, about one-third of cobalt is replaced by cobalt-manganese-nickel in lithium-ion batteries.

TRADE POLICY

As per the Foreign Trade Policy 2009-2014, imports of cobalt ores & concentrates under heading No. 2605 and cobalt alloys and its products under heading No. 8105 are allowed freely, except cobalt waste & scrap (ITC-HS Code No. 8105 3000) which are restricted.

WORLD REVIEW

The world cobalt reserves are estimated at 7.2 million tonnes of metal content. Cobalt reserves are mainly in the Democratic Republic of Congo (DRC) which contributes 47% to the total reserves. Besides, major reserves are located in Australia, Cuba, Zambia, Canada, Russia and New Caledonia. Majority of these reserves are in nickel-bearing laterite deposits and rest in nickel-copper sulphide deposits hosted in mafic and ultramafic rocks in Australia, Canada and Russia and in sedimentary copper deposits of Congo (DRC) and Zambia. Several million tonnes of potential resources of cobalt are also contained in sea-bed manganese nodules. Exploitation of cobalt-bearing manganese nodules from the deeper parts of the sea may be witnessed in the present century. The world reserves of cobalt are given in Table-2.

Table – 2 : World Reserves of Cobalt (By Principal Countries)

(In '000 tonnes of metal content)

Country	Reserves
World: Total (Rounded)	**7203**
Australia	1000
Brazil	89
Canada	260
China	80
Congo, Dem. Rep. (Kinshasa)	3400
Cuba	500
Morocco	18
New Caledonia	200
Russia	250
USA	36
Zambia	270
Other countries	1100

Source: *Mineral Commodity Summaries, 2014.*

The world mine production of cobalt in terms of metal content decreased marginally to 128,000 tonnes in 2012 from 141,000 tonnes in the previous year. The Democratic Republic of Congo (DRC) was the principal producer contributing about 68%, followed by China (5%), Zambia and Australia (4% each), Brazil, Canada & Cuba (3% each), Phillipinese New Caledonia & Russia (2% each) and Morocco (1%) (Table-3).

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

(In tonnes of metal Content)

Country	2010	2011	2012
World: Total	**135000**	**141000**	**128000**
Australia	4838	4254	5413
Brazil	3139	3150	3650
Canada	4636	7071	3652
China	6382	6843	7000e
Congo, Dem. Rep.	97693	99475	86433
Cuba	3721	3850	3700e
Morocco	1582	1518	1314
New Caledonia	1735	2404	2631
Philippines	1500	1500	2269
Russia	2460	2337	2186
Zambia	5134	5956	5665
Other countries	2180	2642	4087

Source: *World Mineral Production, 2008-2012.*

Australia

The Yakubu Ni-Co refinery in Townsville, Queensland (2631 tonnes refined Co), BHP Billiton, W. Australia (500 tonnes Co sulphide), Glencore's Murrin Murrin Ni-Co-laterite mine, W. Australia (2091 tonnes Co metal), First Quantum Minerals Ltd (200 tonnes of Co), Panoramic Resources Ltd (453 tonnes of Co) and Xstrata Nickel Australasia (396 tonnes of Co) were the noteworthy producers in 2011. OJSC, MMC, Norilsk Nickel also started production from the Lake Johnston nickel sulphide mine and mill during the year 2011.

Belgium

Umicore's 2011 cobalt refinery production increased to 3187 tonnes due to greater availability of scrap resulting from higher prices and higher levels of downstream production. Umicore converted cobalt metal, residues and other cobalt-bearing materials into a wide range of cobalt speciality products, including metal powders, hydroxides, oxides, salts and compounds. Umicore built plants in S. Korea, Japan & in Hoboken, Belgium using recycling facility for spent rechargeable batteries and battery manufacturing scrap.

China

China's total production of refined cobalt made it the world's leading producer. Most of the production was from imported ores, concentrates and semi-refined materials sourced from Congo (Kinshasa).

Congo (Kinshasa)

Congo(Kinshasa) was the world's leading producer of mined cobalt. Some of Congo's (Kinshasa's) ores and concentrates were exported, some were processed to semi-refined materials such as cobalt carbonate, cobalt hydroxide or cobalt-bearing alloys and some were refined to cobalt metal.

Boss Mining had commissioned the new copper solvent extraction portion of its new cobalt solvent extraction - electrowinning (SX-EW) plant at Luita, but had suspended the cobalt extraction portion due to its economic non-viability. In 2011, Mutanda mined Copper-Cobalt oxide ore from open pits near Kolwezi and produced 7,900 tonnes of Cobalt in concentrate and hydroxide.

Finland

Talvivaara Mining Co. Plc continued to ramp up and optimise production from its polymetallic sulphide mine and bioheap-leaching operation in Sotkamo in central Finland. In 2011, Talvivaara sold nickel-cobalt sulphide containing approximately 400 tonnes of cobalt to Norilsk for processing at Harjavalta.

Japan

Sumitomo planned to increase Niihama's production capacity to accomodate the nickel-cobalt mixed sulphide feed that would be generated from its Taganito project in the Philippines. Sumitomo's production of electrolyte cobalt at its Niihama nickel refinery increased by 4% in 2011.

New Caledonia

Vale completed commissioning of its Vale New Caledonia project in the southern tip of New Caledonia's main island and produced 245 tonnes of cobalt. The project, which was originally called Goro comprised a nickel-cobalt-laterite mine, high pressure acid leaching processing plant and refinery. Vale expected to ramp up production to reach the nominal production capacity of 60,000 tonnes per year of nickel contained in nickel oxide and 4,600 tonnes per year of cobalt contained in cobalt carbonate.

South Africa

The Nkomati nickel sulphide mine produced 513 tonnes of cobalt in 2011 (667 tonnes in 2010). At full steady-state production forecast for 2014, the mine was expected to produce 1,000 tpy of cobalt in concentrates.

Some of South Africa's PGM operations produced cobalt sulphate at its base metal refinery. Rustenburg Base Metal Refinery, North West Province and Impala Platinum Ltd near Springs, Gauteng Province produced cobalt metal powder at its base-metal refinery. Two other platinum producers - Lonmin plc and Northam Platinum Ltd operated base-metal refineries and produced semi-refined nickel sulphate containing cobalt.

Zambia

Konkola Copper Mines Plc (KCM) mined copper ores from its Nchanga open pit and Konkola operations. China Non-ferrous Metal Mining Group Co Ltd (CNMC) mined and processed Cu-Co ore in the Zambian copper belt through 4 majority-owned subsidiaries namely NFCA, CLM, CCS and Sino-Metal leach Zambia Ltd.

Zimbabwe

Aquarius Platinum Ltd in the year 2011 produced 86 tonnes of cobalt from its Mimosa platinum mines. The concentrates were refined by Impala in South Africa.

FOREIGN TRADE

Exports

Exports of cobalt and alloys including waste and scrap sharply decreased to 67 tonnes in 2012-13 as against 298 tonnes in the previous year. Out of the total exports in 2012-13, exports of cobalt and alloys were 58 tonnes and those of cobalt waste & scrap were 9 tonnes. Exports were mainly to Netherlands (31%), France (21%) and USA (12%),Rep. of Korea & UAE (9% each) (Tables - 4 to 7).

Imports

Imports of cobalt ores and concentrates sharply decreased to 443 tonnes in 2012-13 from 1,196 tonnes in the previous year. Imports were mainly from Congo Rep.of (31%), Congo Democratic Rep.of (33%), Australia (17%) and Malayasia (7%). Imports of cobalt and alloys decreased to 672 tonnes in 2012-13 from 994 tonnes in the previous year. Imports in 2012-13 were mainly from Norway (26%), USA (15%), Belgium (11%), Canada (10%), China (8%) and Zambia (4%). However, imports of cobalt in the form of cobalt powder, other articles and unwrought cobalt also took place (Tables-8 to 12). Imports of cobalt powder at 174 tonnes, cobalt (other articles) at 223 tonnes and cobalt (unwrought) at 275 tonnes.

Table – 4 : Exports of Cobalt Ores & Conc. (By Countries)

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**51**	**3741**	-	-
China	51	3740	-	-
Netherlands	++	1	-	-
Other countries	-	-	-	-

Table – 5 : Exports of Cobalt & Alloys (Including Waste and Scrap) (By Countries)

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**298**	**424073**	**67**	**80649**
Netherlands	113	176828	21	31566
USA	115	142878	8	6070
Korea, Rep. of	32	58552	6	16719
UK	16	20453	4	4245
Germany	12	6277	3	1063
UAE	++	1	6	9992
Italy	1	3523	3	8055
Belgium	-	-	1	719
Sri Lanka	1	2630	++	944
France	-	-	14	556
Other countries	8	12931	1	720

Table – 6: Exports of Cobalt & Alloys (By Countries)

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**285**	**414093**	**58**	**73025**
Netherlands	113	176828	21	31566
Korea, Rep. of	32	58552	6	16719
UAE	++	1	6	9992
Italy	1	3523	3	8055
USA	114	141637	6	3753
Sri Lanka	1	2630	++	944
Belgium	-	-	1	779
France	-	-	14	556
Saudi Arabia	++	68	++	449
Bangladesh	-	-	1	57
Other countries	24	30854	++	215

Table – 7 : Exports of Cobalt Waste & Scrap (By Countries)

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**13**	**9979**	**9**	**7624**
UK	6	5772	4	4245
USA	1	1241	2	2317
Germany	6	2966	3	1062

Table – 8 : Imports of Cobalt Ores & Conc. (By Countries)

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**1196**	**1251501**	**443**	**548799**
Zaire Rep/Congo, Dem. Rep. of	168	227913	148	195871
Congo, Rep. of	417	357291	135	180435
Australia	++	8	76	80711
Unspecified	336	322723	31	41263
Malayasia	-	-	31	29572
Brazil	-	-	22	20947
Other countries	275	343566	-	-

Table – 9 : Imports of Cobalt & Alloys (By Countries)

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**994**	**1911680**	**672**	1409349
Norway	259	522990	175	315463
USA	115	256790	104	278962
Belgium	91	222073	76	176265
China	79	138175	54	112771
Canada	42	75787	64	100492
France	22	69589	28	87516
Zambia	79	132686	28	45910
Germany	7	23096	9	38432
Congo Rep of	21	36584	22	35249
Korea, Rep. of	43	62173	19	33260
Other countries	236	371737	93	185029

Table – 10 : Imports of Cobalt Powders (By Countries)

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**154**	**386247**	**174**	**421923**
Belgium	66	163087	51	123043
USA	31	80880	34	96163
China	23	55263	27	54890
Canada	4	6645	25	37793
France	8	21390	12	33470
Germany	1	3200	4	19253
UK	5	10031	6	17114
Finland	3	7885	6	14992
Japan	1	4792	2	6285
Equatorial Guinea	-	-	1	3698
Other countries	12	33074	6	15222

Table – 11 : Imports of Cobalt (Other Articles) (By Countries)

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**426**	**729503**	**223**	**503880**
USA	80	168538	65	171219
Belgium	24	54738	25	52558
China	49	66697	21	45837
France	12	41721	12	41462
Zambia	40	65439	23	38516
Canada	13	25819	20	34236
Germany	5	17955	5	18624
South Africa	10	17256	9	14747
Qatar	-	-	10	13618
UK	14	28763	7	13338
Other countries	179	242577	26	59725

Table – 12 : Imports of Cobalt (Unwrought) (By Countries)

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**414**	**795930**	**275**	**483546**
Norway	259	522990	175	315463
Morocco	-	-	21	32240
Congo Rep. of	11	19631	18	28480
Canada	25	43323	19	28463
Korea, Rep of	3	5206	13	19056
France	2	6478	4	12585
China	7	16215	6	12044
USA	4	7371	5	11579
Zambia	39	67246	5	7394
Myanmar	-	-	4	6492
Other countries	64	107470	5	9750

FUTURE OUTLOOK

India does not have any primary cobalt resources. Two possible secondary sources are nickel-bearing laterite deposits in Odisha and declining copper slag produced by HCL, which have been under R&D studies for commercial applications over the years. Recovery in small quantities of cobalt from wastes like cutting-tool scrap and beta-naphtha cake from the zinc industry was carried out in the late 1980s. In addition, conversion of spent catalysts from plants producing TPA, DMT and the oxo-alcohols were also carried out as a regular source of cobalt, though, these were mostly recycled. The cobalt refiners in India have catered to the market for chemical applications or where the cobalt metal or salt is dissolved and converted to cobalt oxide for cutting tools application.

Due to specialised nature of applications and difficulty in substitution, the future demand for cobalt is likely to follow an increasing trend. The bulk demand for cobalt in the world would be in cemented carbides used in cutting tools, catalysts in petrochemical industry, drying agent in paint industry and in super alloys used mainly in jet engine parts. The demand for cobalt is supposed to go up with use of super-alloys in civil aviation, catalysts for gas-to-liquid production of synthetic liquid fuels, rechargeable batteries for hybrid electric vehicles, cellular telephones, aerospace and energy generation industries which use cobalt-bearing super alloy gas turbine engine parts. During the last year, global demand for lithium-ion batteries has grown rapidly as a result of the increase in demand for mobile phones, portable PCs & electronic devices. In India, cobalt will find major applications in metallurgy due to greater demand in special alloys/super alloys and in cutting tools and as an alloy in permanent magnets. Cobalt powder demand will continue to grow for bonded tools in diamond industry.