

25 Cobalt

Cobalt is an important 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, Orissa; Jhunjhunu district, Rajasthan; Tuensang district, Nagaland; and Jhabua and Hoshangabad districts, Madhya Pradesh. Cobalt is associated with lateritic nickel deposit in Sukinda area, Orissa; and copper slags are two possible secondary resources of cobalt along with sea-bed multimetal nodules.

Total resources of cobalt in terms of ore as on 1.4.2005 are estimated at 44.91 million tonnes of which about 69%; i.e., 30.91 million tonnes are located in Orissa. The remaining 31% are available in Jharkhand (9 million tonnes) and Nagaland (5 million tonnes). Reserves/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 powder is used for bonded tools for diamond industry. Cobalt is also used in chemical applications such as catalyst, dyes and pigments, paint driers/ adhesives and glass & ceramics.

Cobalt catalysts, mostly cobalt acetate, is used in terephthalic acid (TPA) and di-methyl-terephthalate (DMT) manufacture.

Super alloys improve strength and wear & corrosion-resistance characteristics at elevated temperatures. Another use of cobalt-based super alloys is in turbines for pipeline compressors. Cobalt-based super alloys normally contain 45% or more cobalt while nickel and iron-based super alloys contain 8 to 20% cobalt. 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. In chemical application, cobalt oxide is an important additive in paint, glass and ceramic. Cobalt is also used to promote the adherence of enamel to steel in appliances, and also of steel to rubber for 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 1100°C, highest for any metal. It is used in manufacturing of Alnico magnets, recording tapes, 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.

**Table-1 : Reserves/Resources of Cobalt ore as on 1.4.2005
(By Grades/States)**

(In million tonnes)

Grade/State	Reserves total (A)	Remaining resources				Total (B)	Total Resources (A+B)
		Measured STD331	Indicated STD332	Inferred STD333	Reconnaissance STD334		
All India	-	30.63	2	2.78	9.50	44.91	44.91
Jharkhand	-	-	2	-	7	9	9
Nagaland	-	-	-	2.50	2.50	5	5
Orissa	-	30.63	-	0.28	-	30.91	30.91

RESEARCH & DEVELOPMENT

National Metallurgical Laboratory, Jamshedpur has developed a process route comprising reductive roast and ammonia leaching for the extraction of these strategically important metals from the sea nodules. Due to various reasons, the Co recovery was never more than 60% though Cu and Ni extractions were more than 90% in this process. Laboratory scale experiments have shown that cobalt recovery can be improved with certain additives during leaching. Some of them were found to be effective in enhancing cobalt recovery, without affecting Cu and Ni recovery.

IMMT (formerly RRL), Bhubaneswar is engaged in extraction of cobalt along with nickel from lateritic nickel/chromite overburden of Orissa through microbial route using acidophilic micro-organism. Up to 35% Ni and 50% Co recovery was achieved. In a span of 60 days, 70% Ni and 60% Co was recovered. The technology is to be scaled up to 10 tonnes with support from OMC.

INDUSTRY & PRODUCTION

Presently, there is no production of cobalt in the country from indigenous ores. The refined production of cobalt is reported to be around 1,220 tonnes in 2005, 1,184 tonnes in 2006 and 980 tonnes in 2007 from imported feed material. The remaining demand of cobalt is met through imports.

Refining capacity of cobalt in India is estimated at about 1,560 tonnes per year. In 2005-06, an additional refining capacity of 1,000 tonnes cobalt per year is reported to have come on stream. Another cobalt refinery, Conic Metals, that closed operations in 2001 reportedly remained closed. Plantwise cobalt refining capacity is given in Table-2.

**Table - 2 : Cobalt Refining Capacity
(By Plants)**

Plant	Capacity (tpy)
Nicomet (Cuncolim, Goa)	1000
Rubamin (Baroda, Gujarat)	500
Others	60
Total	1560

The refiners source the heterogeneous-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.

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-base 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 a third of cobalt is replaced by cobalt-manganese-nickel in lithium-iron batteries.

TRADE POLICY

As per the Foreign Trade Policy 2004-09 amended with effect from 1.4.2008, imports of cobalt ores & concentrates and cobalt alloys & its products are allowed freely except cobalt waste & scrap which are restricted.

WORLD REVIEW

The world cobalt resources are estimated at 13 million tonnes of metal content. Cobalt resources are mainly in Democratic Rep. of Congo (DRC) which contributes 36% to the total reserve base. Besides, major resources are located in Australia, Cuba, New Caledonia, USA and Zambia. The majority of these resources 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 resources of cobalt are given in Table-3.

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**Table - 3 : World Resources of Cobalt
(By Principal Countries)**

(In '000 tonnes of metal content)

Country	Reserve base
World : Total	13000
Australia	1700
Brazil	40
Canada	350
China	470
Congo, Dem. Rep. of (Kinshasa)	4700
Cuba	1800
Morocco	NA
New Caledonia	860
Russia	350
USA	860
Zambia	680
Other countries	1100

Source: Mineral Commodity Summaries, 2008.

The world mine production of cobalt in terms of metal content decreased to 61,000 tonnes in 2007 from 63,000 tonnes in the previous year. Democratic Republic of Congo (DRC) was the principal producer, contributing about 41%, followed by Canada (14%), Australia (9%), Brazil, Zambia and Cuba (7% each) and Russia (6%) (Table-4).

World cobalt production arises mainly from nickel industry (48%), copper industry & others (37%) and primary cobalt operations (15%).

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

(In tonnes of metal Content)

Country	2005	2006	2007
World : Total	61000	63000	61000
Australia	5198	5700 ^(e)	5600 ^(e)
Brazil ^(e)	4300	4300	4300
Canada	5767	7115	8261
China	2104	1840	2000 ^(e)
Congo, Dem. P. R. ^(e)	24500	27100	25300
Cuba ^(e)	3768	4000	4000
Morocco	1600	300	200
New Caledonia	1769	1629	1620
Russia	4748	4759	3587
Zambia	5472	4648	4229
Other countries	1774	1609	1903

Source: World Mineral Production, 2003-2007.

FOREIGN TRADE

Exports

In 2007-08, about 451 tonnes of cobalt ores & concentrates were exported mainly to China. Exports of cobalt & alloys including waste & scrap decreased to 371 tonnes in 2007-08 as against 476 tonnes in the previous year. Out of total alloys and scrap exported in 2007-08, cobalt & alloys exports were 331 tonnes and cobalt waste & scrap 40 tonnes. Exports were mainly to Netherlands (19%), Belgium (16%), USA (15%), Japan (12%) and UK (7%) (Tables - 5 to 8).

Imports

Imports of cobalt ores & concentrates increased to 9,953 tonnes in 2007-08 from 9,473 tonnes in the previous year. Imports were mainly from People's Rep. of Congo (56%) and Republic of Zaire/Democratic Rep. of Congo (36%). Imports of cobalt and alloys including waste & scrap increased to 599 tonnes in 2007-08 from 492 tonnes in the previous year. Imports in 2007-08 were mainly from USA (29%), Canada and Belgium (13% each), Japan (12%) and Zambia, Switzerland and UK (7% each) (Tables - 9 to 12).

**Table - 5 : Exports of Cobalt Ores & Conc.
(By Countries)**

Country	2006-07		2007-08	
	Qty. (t)	Value (Rs. '000)	Qty. (t)	Value (Rs. '000)
All Countries	-	-	451	105482
China	-	-	450	105477
Ethiopia	-	-	1	5

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**Table - 6 : Exports of Cobalt & Alloys
(Incl. Waste and Scrap)
(By Countries)**

Country	2006-07		2007-08	
	Qty. (t)	Value (Rs. '000)	Qty. (t)	Value (Rs. '000)
All Countries	476	560860	371	678587
Belgium	86	112462	60	211502
Netherlands	160	244621	72	173504
Japan	5	8971	45	111323
France	20	48239	14	39162
Switzerland	-	-	10	26976
USA	103	41522	56	26658
Korea, Rep. of	11	18889	5	14826
UK	38	13388	26	10915
Hong Kong	23	32281	-	-
Romania	11	24435	-	-
Other countries	19	16052	83	63721

**Table - 7: Exports of Cobalt & Alloys
(By Countries)**

Country	2006-07		2007-08	
	Qty. (t)	Value (Rs. '000)	Qty. (t)	Value (Rs. '000)
All Countries	415	544086	331	666072
Belgium	86	112462	60	211502
Netherlands	160	244621	72	173504
Japan	5	8971	45	111323
France	20	48239	14	39162
Switzerland	-	-	10	26976
USA	50	26635	39	23621
China	10	6173	45	17252
Korea, Rep. of	11	18889	5	14826
Hong Kong	23	32281	-	-
Romania	11	24435	-	-
Other countries	39	21380	41	47906

**Table - 8: Exports of Cobalt & Scrap
(By Countries)**

Country	2006-07		2007-08	
	Qty. (t)	Value (Rs. '000)	Qty. (t)	Value (Rs. '000)
All Countries	61	16774	40	12515
UK	4	1317	23	9478
USA	53	14887	17	3037
Chinese Taipei/ Taiwan	4	570	-	-

**Table - 9 : Imports of Cobalt Ores & Conc.
(By Countries)**

Country	2006-07		2007-08	
	Qty. (t)	Value (Rs. '000)	Qty. (t)	Value (Rs. '000)
All Countries	9473	1250815	9953	1940501
Congo, P. Rep.	3914	868860	5575	1287879
Zaire Rep/Congo Democratic Rep.	4768	279922	3584	469525
Uganda	-	-	107	67336
Tanzania	17	16348	388	61056
Belgium	-	-	99	18433
Germany	-	-	6	9830
Japan	-	-	46	7823
South Africa	193	39957	-	-
UAE	149	11267	-	-
Unspecified	299	28369	-	-
Other countries	133	6092	148	18619

**Table - 10 : Imports of Cobalt & Alloys
(Incl. Waste and Scrap)
(By Countries)**

Country	2006-07		2007-08	
	Qty. (t)	Value (Rs. '000)	Qty. (t)	Value (Rs. '000)
All Countries	492	829505	599	1166258
Belgium	70	159775	75	206147
Canada	90	145227	76	201660
USA	65	105718	171	150346
Switzerland	++	7	40	107289
UK	21	47080	39	101540
Japan	87	76437	69	100598
Zambia	50	77858	41	76407
France	19	51337	18	71558
China	24	49003	8	26022
Norway	30	51782	-	-
Other countries	36	65281	62	124691

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**Table - 11 : Imports of Cobalt & Alloys
(By Countries)**

Country	2006-07		2007-08	
	Qty. (t)	Value (Rs. '000)	Qty. (t)	Value (Rs. '000)
All Countries	492	829449	599	1166258
Belgium	70	159775	75	206147
Canada	90	145227	76	201660
USA	65	105662	171	150346
Switzerland	++	7	40	107289
UK	21	47080	39	101540
Japan	87	76437	69	100598
Zambia	50	77858	41	76407
France	19	51337	18	71558
China	24	49003	8	26022
Norway	30	51782	-	-
Other countries	36	65281	62	124691

**Table - 12 : Imports of Cobalt & Scrap
(By Countries)**

Country	2006-07		2007-08	
	Qty. (t)	Value (Rs. '000)	Qty. (t)	Value (Rs. '000)
All Countries	++	56	-	-
USA	++	56	-	-

FUTURE OUTLOOK

Due to specialised nature of applications and difficulty in substitution, the future demand of 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. During past 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 the cutting tools and as an alloy in permanent magnets. Cobalt powder demand will continue to grow for bonded tools in diamond industry.

India does not have any primary cobalt resources. Two possible secondary sources are nickel - bearing laterite deposits in Orissa 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 was also carried out as a regular source of cobalt though these were mostly recycled. Hence, until recently, primary cobalt consumers in India had to depend on imports of cobalt metal or salts. 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.