Indian Minerals Yearbook 2015

(Part- II : Metals & Alloys)

54th Edition

VANADIUM

(FINAL RELEASE)

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

July, 2017

19 Vanadium

Vanadium, a scarce element, is a hard, silvery grey, ductile and malleable transition metal with good structural strength. It occurs naturally in about 65 different minerals among which are patronite, vanadinite, roscoelite and carnotite. It is also present in bauxite and in fossil fuel deposits. It occurs in association with titaniferous magnetite and is recovered as a by-product during iron & steel manufacture. Vanadium is also concentrated in many end-products of organic material including coal, crude oil, oil shale and tar sands. It is also found in small percentages in meteorites. In addition, vanadium present in bauxite can also be recovered as vanadium sludge from red mud during the production of alumina. Vanadium is widely used in green technology applications, especially in battery technology.

RESOURCES

In India, vanadium is associated with titaniferous magnetite which contains 0.8 to 3% V_2O_5. It also occurs in significant amounts in association with chromite, laterite, bauxite and ferromagnesian-rich rocks, such as, pyroxenite, anorthosite and gabbro.

As per UNFC system, the total estimated resources of vanadium ore as on 1.4.2013 are placed at 24.63 million tonnes with an estimated V_2O_5 content of 64,594 tonnes. As on 1.4.2013, entire resources of vanadium, 24.63 million tonnes having 64,594 tonnes of V_2O_5 content are placed under remaining resources category only (Table-1).

PRODUCTION

Vanadium is recovered from slag that is collected from the processing of vanadiferous magnetite ore where iron and steel are the principal products. The processing of gas and petroleum products is also an important source of vanadium, which is recovered both from the raw material and from the recycling of vanadium-bearing catalyst.

Vanadium sludge is separated as a by-product during the Bayer process for production of alumina hydrate. NALCO has completed lab-scale studies to recover vanadium sludge from various Bayer Liquors. Lanjigarh Alumina has developed an in-house process for extraction of V_2O_5 (vanadium pentoxide) present in the bauxite involving simple operations with very low energy consumption. Thus, it is considered as innovative cost effective and environment friendly besides ensuring optimum utilisation of natural resources. This project was taken up as a part of Vedanta's ambitious project of Zero Discharge and Zero Waste Alumina Refinery. Vanadium recovery makes the country self-sufficient in meeting demand of vanadium as most of these raw materials is imported to make ferro vanadium. Vanadium recovery projects helps in additional generation of revenue. The vanadium sludge obtained at BALCO's Korba plant contains 6 to 10% V_2O_5, Hindalco's Renukoot plant 18.2% V_2O_5 and Muri and Belgaum plants 6 to 20% V_2O_5.

Table – 1 : Reserves/Resources of Vanadium as on 1.4.2013 (By Grades/States)

(In tonnes)

Grade / State	Reserves				Remaining resources								Total resources (A+B)
	Proved STD111	Probable STD121	Probable STD122	Total (A)	Feasibility STD211	Pre-feasibility STD221	Pre-feasibility STD222	Measured STD331	Indicated STD332	Inferred STD333	Reconnaissance STD334	Total (B)	
All India : Total													
By Grades													
Ore	**0**	**0**	**0**	**0**	**276530**	**1720000**	**4108100**	**0**	**232000**	**18297225**	**0**	**24633855**	**24633855**
Contained V_2O_5	**0**	**0**	**0**	**0**	**1106.12**	**2835**	**6032.4**	**0**	**487.2**	**54133.29**	**0**	**64594.01**	**64594.01**
By States													
Karnataka													
Ore	0	0	0	0	0	500000	4000000	0	0	14884430	0	19384430	19384430
Contained V_2O_5	0	0	0	0	0	700	5600	0	0	43197.55	0	49497.55	49497.55
Maharashtra													
Ore	0	0	0	0	276530	0	108100	0	0	0	0	384630	384630
Contained V_2O_5	0	0	0	0	1106.12	0	432.4	0	0	0	0	1538.52	1538.52
Odisha													
Ore	0	0	0	0	0	1220000	0	0	232000	3412795	0	4864795	4864795
Contained V_2O_5	0	0	0	0	0	2135	0	0	487.2	10935.74	0	13557.94	13557.94

Figures rounded off.

USES

Vanadium is used primarily as an alloying element in Iron & Steel Industry and to some extent as a stabiliser in titanium and aluminium alloys which are used in aerospace applications. It imparts toughness and strength to steel, alloys and also acts as scavenger for oxygen. Vanadium is consumed in the Steel Industry in the manufacture of wide range of products, from low carbon flat rolled steels, high strength plates & structural steels to pipes, reinforcing bars, forging steels, rail steels and tool steels. Vanadium (about 80%) is mostly used in the form of ferro vanadium as a means of introduce vanadium into steel. The content of vanadium in ferro vanadium varies from 45 to 50% and sometimes it is up to 80%, depending upon the demand. The 45 to 50% grade is produced from slag and other vanadium containing material by silicothermic reduction of vanadium pentoxide (V_2O_5) in presence of steel scrap or by direct reduction in an electric arc furnace. The resultant vanadium steels can be divided into micro-alloy or low-alloy steels with less than 0.15% vanadium and high-alloy steels with up to 5% vanadium. Non-metallurgical applications include its use as catalyst and in ceramic, chemical, pigments, health preparations and electronic industries. It is also used to produce a super conductive magnet with a field of 1,75,000 gauss. The most common oxide of vanadium i.e., vanadium pentoxide (V_2O_5) is used as a catalyst in manufacturing sulphuric acid. In biological context, vanadium is a micro-nutrient found naturally in mushroom, shellfish, black pepper, parsley dill, grain and grain products. It exists as both vanadyl sulphate, the form most commonly used in food supplements and vanadale.

Modern applications of vanadium include its use as vanadium secondary batteries for power plants and rechargeable vanadium redox battery (VRB) for commercial applications. The main advantages of VRB are that it can offer almost unlimited capacity simply by using sequentially larger storage tanks; can be left completely discharged for long periods of time with no ill effects; can be recharged by replacing the electrolyte if no power source is available to charge it; and suffers no permanent damage if the electrolytes are accidentally mixed. The VRB has also been shown to have the least ecological impact of all energy storage technologies.

SUBSTITUTES

Substitution of vanadium in steel by niobium, chromium, titanium, manganese, molybdenum and tungsten is possible although at higher cost or with lower performance. Heat-treated carbon steels can replace vanadium steels in some applications. Platinum and nickel can be used in some catalytic processes but at higher cost. Presently, there is no acceptable substitute for vanadium in aerospace titanium alloys.

CONSUMPTION

Ferro vanadium producing units in India consume either imported V_2O_5 concentrates or indigenous vanadium sludge. The domestic availability of vanadium sludge from Aluminium Industry is limited and insufficient for ferro vanadium production and the gap is met by imports. The consumption of ferro vanadium during 2012-13 to 2014-15 by various units in the Organised Sector is given in (Table-2).

Table –2 : Consumption *of Ferro vanadium, 2012-13 to 2014-15 (By Industries)

(In tonnes)

Industry	2012-13	2013-14(R)	2014-15(P)
All Industries	**1111**	**1110**	**1110**
Alloy steel	26 (5)	26 (5)	26 (5)
Electrode	2 (1)	1 (1)	1 (1)
Foundry	4 (1)	4 (1)	4 (1)
Iron & steel	1079 (11)	1079 (11)	1079 (11)

Figures in parentheses denote the number of units in organised sector.

**Paucity of data, hence consumption may not be complete.*

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

(In '000 tonnes of vanadium content)

Country	Reserves
World: Total (rounded)	**15000**
Australia	1800
China	5100
Russia	5000
South Africa	3500
USA	45
Other countries	NA

***Source:** Mineral Commodity Summaries,2016.*

WORLD REVIEW

The world reserves of vanadium in 2015 were about 15 million tonnes of metal located mainly in China, Russia, South Africa, Australia and the USA and are expected to last till next century at the current rate of consumption (Table-3). Titaniferous magnetite is the most important source accounting about 85% of current world V_2O_5 production from which vanadium could be extracted as a by-product of iron. The resources are also available in crude oil (in Caribbean basin, parts of Middle East and Russia), tar sands, (in Western Canada), phosphate rock, uraniferous sandstone and siltstone. In all these cases, extraction depends on economic recovery of the product.

The world production of vanadium in 2014 was at about 68 thousand tonnes which decreased substantially ,as compared to 70 thousand tonnes during last year. This excludes vanadium recovered as by-product from refining and burning of heavy oils. Major producing countries were China (60%), Russia (22%) and South Africa (15%) (Table-4).

Nearly all the world's vanadium supply originates from primary sources. Five countries recovered vanadium from ores, concentrates, slag or petroleum residues. Japan and the United States of America are probably the only countries to recover significant quantities of vanadium from petroleum residues.

Australia

Atlantic Ltd announced that due to substantial fire at the benefication plant of its Windimurra Vanadium Project (Perth, Western Australia), the production of vanadium was suspended. The beneficiation plant was undergoing planned maintenance and was not operating at the time of fire.

Brazil

First production at Largo Resources Ltd (Toranto, Ontario, Canada) Maracas Menchen Mine commenced in August 2014. According to the company, the vanadium is contained within a massive titaniferous magnetite deposit that has much higher grades in both V_2O_5 and iron than any other vanadium project in the world. Largo has an offtake agreement with Glencore International Plc for 100% of its material for the first 6 years. Average annual production was estimated at 11,400 tonnes of V_2O_5 equivalent through its 29-year mine life.

Canada

Vanadium Corp. Resource Inc. announced that an updated technical resource estimate for its Lac Dore Project (Northern Quebec). The inferred resource estimate was 111.9 million tonnes grading 0.42% of V_2O_5.

Russia

The Vanady Tula (200 km south of Moscow) has an annual capacity of 5,000 tonnes FeV and 7,350 tonnes V_2O_5 in its electrometallurgical and hydrometallurgical plants. It produced 7,309 tonnes of V_2O_5 in 2014 as compared to 7,352 tonnes in 2013. Of this production 2,755 tonnes further process into FeV at EVRAZ Vanady Tula and 3,538 consumed in EVRAZ Nikom. The balance was sold to a third party.

China

Pangang Group Vanadium Titanium and Resources Co. Ltd located in Panzhihua, Sichuan Province has a production capacity of 260,000 tonnes of vanadium slag, 22,000 tonnes of vanadium, 16,000 tonnes of FeV and 4,000 tonnes of vanadium nitrogen alloy. China's Xichang Steel and Vanadium Co. Ltd, a wholly owned subsidiary of Pangang Group Co. Ltd, announced that it produced a record-high level of 116,900 tonnes of vanadium slag.

Table – 4: World Mine Production of Vanadium (By Principal Countries)

(In tonnes of metal content)

Country	2012	2013	2014
World: Total (rounded)	**74919**	**70993**	**68157**
Brazil	-	-	1032
China[e]	39000	41000	41000
Kazakhstan[e]	1000	1000	1000
Russia[e]	14856	14402	15125
South Africa	19957	14000	10000(e)
USA	106	591	-

Source: *World Mineral production, 2010-2014.*

Note: *Include vanadium in slag product but exclude vanadium recovered as a by-product of refining and burning of heavy oil.*

FOREIGN TRADE

No exports and imports of vanadium & scrap were reported in 2014-15. Exports of vanadium ores & concentrates decreased sharply to 2 tonnes only in 2013-14 from 178 tonnes in the previous years (Table-5). On the other hand, imports of vanadium ores and concentrates decreased to 19 tonnes in 2014-15 from 61 tonne in the previous year (Table-6).

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

Country	2013-14		2014-15(P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**2**	**7386**	-	-
China	2	7386	-	-

Table – 6 : Imports of Vanadium Ores & Conc. (By Countries)

Country	2013-14		2014-15(P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**61**	**8674**	**19**	**1378**
Netherlands	-	-	19	1378
Other countries	61	8674	-	-

FUTURE OUTLOOK

The worldwide demand for vanadium is directly related to the demand for steel specially with demands of high-strength steel. In vanadium batteries, the consumption may increase in future.

The Indian alumina plants, which are mostly based on East Coast bauxite and that which have very low content of vanadium may not be able to generate adequate quantity of vanadium sludge to meet the internal demand. On the other hand, with growth of Automobile and Casting Sectors, demand for ferro vanadium is expected to increase and this will have to be met by imports. The accelerated growth in the Forging Industry and increased demand for die steels and tool steel too, have paved way for increased vanadium consumption. Imperatives for utilisation of the huge vanadium-bearing titaniferous ores available in the States viz, Karnataka, Maharashtra and Odisha, through R&D efforts will have to be initiated to meet the domestic demand of vanadium pentoxide and ferro vanadium.