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NICKEL RESOURCES IN INDIA AND THEIR EXPLOITATION (*)

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Nickel is an important stratagic alloying element and is being increasingly consumed in this modern era. The present world production of nickel has well exceeded 4000,000 tonnes and is likely to increase further with new plants coming up. With the depilation of high grade resources considerable attention is being paid for production of nickel from the low-grade ores and a world-wide search for such ores is continuing. India's nickel requirement is met by imports for which 18.5 million rupees worth of foreign exchange is annually required which is likely to increase with production of alloy steels. Owing to the strategic importance of nickel and the foreign exchange required for its import, the production of nickel from indigenous lean ores is highly desirable and G.S.I. has been carrying out extensive survey of the nickel deposits in the country.

Indigenous Resources:

Several low-grade nickeliferous deposits have been discovered in India. These ores are serpentinous, lateritic or sulphidic in nature. Nickel bearing serpentines occur in Assam and Rajasthan, while over 7.9 million tonnes of lateritic nickel ores containing upto 1.8% NiO have been located in the chrome ore belt of Sukinda, Orissa, as well as in the Badampahar area of Orissa. The copper ore belt of Singhbhum, Bihar contains nickel in the ore body which may provide 1000 tons of nickel annually. Besides the several ores,

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the copper tailings and anode sludge of the I.C.C. plant at Ghatsila might also prove to be an important source of nickel.

Methods for treatment of lowgrade ores:

Commercial exploitations of the low grade silicate, lateritic and sulphidic ores are well established. The sulphidic ores are upgraded by mineral dressing while the silicate and lateritic ores are not ammenable to usual ore dressing techniques. The principal methods available for treatment of lean oxidic and silicate ores include a) matee smelting, b) Smelting to ferro-nickel and c)hydrometallurgical treatment.

Matte smelting is practised in New Caledonia, Japan and U.S.S.R. The method comprises of smelting the silicate ore with a suphidising agent like gypsum, pyrite, or a sulphidic nickel concentrate and restricted amount of coke to obtain a lowgrade nickel matte. The primary matte is blown in a converter to oxidise and slag off iron, resulting in a high grade nickel sulphide matte, which is subsequently calcined to nickel oxide, and then reduced to metallic nickel, and refined electrolytically.

Smelting of silicate ores with coke in an electric furnace, produces ferro-nickel containing 20% - 30% nickel, which is subsequently desulphurised and refined in converters to remove S, P, C, and Si. Such a process is used in New Caledonia, Japan, Brizil and Greece. A modified Ugine process involving ferrosilicon reduction has been followed to treat the lateritic ores of Riddle, by the Hanna Nickel Smelting Co., Oregon. to get a ferro-nickel containing 48% Ni.

Hydrometallurgical processes involve ammoniacal leaching, at atmospheric pressure, of the reduced oxidic nickel ore as employed at Nicaro, or sulphuric acid leaching under pressure as followed by the Free Port Sulphur Co, for MaO Bay lateritic nickel ores.

The smelting processes for production of matte ferro-nickel are not suitable in case of the Indian ores containing 0.2 to 1.4% Ni, because of the extremely low nickel contents and a relatively high Fe/Ni ratio. A combined pyro-hydrometallurgical process for treating both lateritic and serpentinous ores have been investigated at the National Metallurgical Labotatory.

The lean Cu-Ni Sulphidic ores are treated in Canada by a hydro-metallurgical process where the nickel concentrate is pressure leached with ammoniacal ammonium sulphate to yield soluble ammines of Cu, Ni and Co. The leach liquor is purified and the respective metal powders are obtained from the solution by hydrogen reduction under pressure. Work is under progress at the National Metallurgical Laboratory for aqueous, acid and ammoniacal leaching of the Nickel concentrate from the Singhbhum belt, containing copper, nickel and molybdenum.

<u>Results of Laboratory scale studies:</u>

(a) <u>Oxidic Ores:</u>

Laboratory scale investigation have been completed at the National Metallurgical Laboratory to treat the serpentinous and lateritic nickeliferrous ores from Assam, Orissa, and Rajasthan. The process studied consisted of solid state roast reduction followed by ammoniacal leaching since the ores are not ammenable to physical methods of beneficiation. The ores contained 0.26% to 1.4% nickel.

Reduction of nickel ores were studies with coke, hydrogen and coke oven gas and it was observed that coke was the least effective while hydrogen was found to be the most efficient. The maximum nickel recoveries from the Assam serpentine were 15%, 50.7% and 67.4% using coke, coke-oven gas and hydrogen respectively for reduction.

The effect of temperature on reduction of different silicate and lateritic ores by hydrogen was found to be critical for each ore. The increase in reduction temperature raises the extraction efficiency till a maxime is reached beyond which the nickel extraction is lowered due to alloying of nickel with iron. The optimum temperature of reduction varied within 600°C to 750°C for the ores studied. The reduction efficiency of nickel ores depends on the physical nature as much as chemical composition.

Reduction studies with different particle sizes of ores indicated that lateritic ores from Sukinda could be treated effectively at -25 and -100 mesh (B.S.S.) sizes depending on whether the ore is porous or dense to recover 80.8% and 70.4% nickel respectively. The lateritic ore from Badam Pahar gave 50.6% nickel recovery at -170 mesh (B.S.S) size; while the silicate ores from Assam and Rajasthan needed grinding to -200 mesh (B.S.S) to give 70% and 44% nickel recoveries respectively.

The kinetics of reduction of nickel in different ores were studied under optimum conditions of reduction. The ores, in general, were reduced almost completely within 1 to $1\frac{1}{2}$ hours. The lateritic ores were found to be more readily reducible than the silicate ores. It was, however, noted that the maximum nickel recoveries are independent of the mineralogy of the ore. The higher the nickel content of the ore, the higher is the maximum nickel recovery recorded.

The reduced ores containing appreciable amounts of metallic iron required a pre-treatment of aquous oxidation before leaching. During the pre-treatment the reduced iron is convented to hydrated iron oxide and is easily separated from the ore matrix, helping nickel dissolution in a subsequent stage. Aqueous oxidation during this process was carried out in a thick slurry consistency using 20% ammonium carbonate in ammonium hydroxide. The kinetics of iron oxidation and nickel dissolution have been studied for different reduced ores and it was observed that almost all the iron was oxidised within 30 minutes while nickel dissolution was restricted to only 10% during the pre-treatment. The pre-conditioned slurry

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was leached in presence of oxygen under atmospheric pressure and temperature with a leachant consistency of 7.5% ammonium carbonate and 7.5% ammonium hydroxide, the solid/liquid ratio being maintained 1:8. The kinetics of leaching studies for the different ores indicated that leaching is complete within six hours in all cases.

The leach liquor containing nickel ammine complex precipitated basic nickel carbonate on boiling the solution. A complete nickel recovery was obtained during precipitation. The basic nickel carbonate could be easily calcined to nickel oxide which could be briquetted with coke and heated to reduce the oxide to metallic state..

Investigation have also been made to precipitate metallic nickel from the ammoniacal solution by reduction with hydrogen under pressure, and nickel recoveries of above 99% have been obtained.

Sulphation and chlorination studies were also carried out at the National Metallurgical Laboratory to extract nickel from oxidic ores, and good metal recoveries were obtained.

(b) <u>Sulphide Ore:</u>

Nickel sulphide concentrate from the U.C.I. Plant at Jadugoda are being examined at N.M.L. for extraction of nickel, copper, and molybdenum. Different methods are under investigation including roasting and leaching under atmospheric as well as ammoniacal leachants. Encouraging results have been obtained which indicate the feasibility of extraction of over 80% nickel and over 90% molybdenum from these concentrates.

<u>Nickel Recovery from wastes:</u>

Nickel can be profitably extracted from numerous metallurgical and chemical industry wastes, e.g. anode sludge of copper refineries, spent nickel catalysts as well as swarfs and scraps from heat resistant, electrical resistance and chemical corrosion resistant alloys. The possibility of nickel extraction from the anode sludge from copper refineries have been found by investigation at N.M.L. Other wastes can also be treated suitably.

Conclusion:

A keen competion is observed in the world today to utilise whatever nickel resources are available India has struck up her own nickel reserves, however low it may be. It is desirable to commence nickel extraction from these ores which can be supplemented by imported raw-materials if future demands warrant. An optimistic attitude will be helpful in this regard.