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9 December 1993
ORIGINAL: ENGLISH

SUPPORT TO COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH,
NEW DELHI
SI/IND/92/801/11-51 + 11-52
INDIA

TECHNICAL REPORT : FIRST MISSION OF CONSULTANT*

Prepared for the Government of India
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of V. Herrera Juver
Consultant

Backstopping Officer : M. Nogueira Da Silva, UNIDO

United Nations Industrial Development Organization
Vienna

*This document has not been edited.

ABSTRACT:

TITLE: Assessment of a Nickel Process for Sukinda Ore

PROJECT: SI/IND/92/801

In a one month mission to India, the consultant was expected to assess the process designed by the Council of Scientific and Industrial Research (CSIR), developed at the Regional Research Laboratory (RRL), at Bhubaneswar, and on the Techno-Economic Feasibility Report (TEFR), prepared by MECON. Detailed technical discussions were held with RRL staff on every stage of the process: ore characterization, beneficiation, dewatering, drying, agglomeration, reduction roasting, leaching, solid liquid separation, solvent extraction - electrowinning, environmental impact, waste utilization and conceptual engineering.

For each stage of the process, advises and detailed informations were given to RRL staff, according to the well established Ammonia Leaching Processes in Cuba. The consultant gave also many corrections and suggestions to the five volumes (III, IV, V, VI, VII) report prepared by MECON.

As an additional task, the consultant made a preliminary assessment on the possibility of using the acid leaching process to treat the chromite overburden and the Kansa ore.

The consultant concluded that using the chromite overburden (COB), in the wet beneficiation for the production of nickel in India, is not economic.

There are two possibilities left:

(i) to treat the COB through roasting. This could be pilot-tested abroad, in a continuous running plant, such as the Moa Bay plant in Cuba;

(ii) to use the Kansa ore, rather than the COB, for nickel production. Here, there are two processes that should be pilot-tested: ammonia leaching or acid leaching.

The consultant also mentioned that the environmental impacts caused by nickel processing are great and should be seriously considered while designing the processes.

EXPLANATORY NOTES

RATE OF EXCHANGE :

CSIR	:	Council of Scientific & Industrial Research
RRL-B	:	Regional Research Laboratory, Bhubaneswar
MECON	:	Metallurgical and Engineering Consultants Ltd. (India)
IICT	:	Indian Institute of Chemical Technology, Hyderabad
TEFR	:	Techno-Economic Feasibility Report
TISCO	:	Tata Iron & Steel Company
OMC	:	Orissa Mining Corporation
COB	:	Chromite Overburden
ROM	:	Run of Mine Ore
MHF	:	Multiple Hearth Furnace
ESP	:	Electrostatic Separator
CCD	:	Counter Current Decantation
BNC	:	Basic Nickel Carbonate
SX-EW	:	Solvent Extraction - Electrowinning
HCL	:	Hindustan Copper Ltd.

I. INTRODUCTION

Nickel is one of the strategic metals in the development of several industries. Its major consumption is in the steel industry for production of stainless steel and other corrosion resistant alloys, nickel cadmium batteries, food processing and the chemical industry.

The consumption of nickel metal in India (1983-84) was about 10,000 tonnes and is projected to reach over 20,000 tonnes by the end of the century. Presently, the entire demand of nickel in the country is met through imports, as primary refined metal, secondary nickel, charge nickel (75-90% Ni) and ferronickel (20-50% Ni).

Two alternate sources of nickel ores are available in India : Kansa Mine in Sukinda Valley and overburden from chromite mines (COB).

The Council of Scientific and Industrial Research (CSIR) has been entrusted with the responsibility by the Government of India for development of the technology and preparation of the Techno-Economic Feasibility Report for a 10,000 t/yr plant based on national ore resources from the Sukinda deposits.

The Regional Research Laboratory located at Bhubaneswar in the State of Orissa, a branch of CSIR, has carried out extensive research and finally developed a technology to produce 10,000 t/yr Ni from chromite overburden ore. With the data obtained in RRL, MECON has prepared the Feasibility Report.

The tasks included in the Job Description (Annex-I) started in November 14, 1993 and will last for one month.

The objectives of the consultant was to assess the process designed by CSIR-RRL for extraction of nickel from chromite overburden using the Reduction Roasting - Ammonia Leaching process. The objectives where revised to include a Preliminary Appraisal of the possible utilization of the Acid Leaching Process (MOA Bay Plant, Cuba) to treat the Indian ores . All the objectives were attained.

This report was written by Dr. Ventura Herrera Juver for Project SI/IND/92/801.

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2. NICKEL RESOURCES IN INDIA

The nickel resources of India are located at the Sukinda valley, State of Orissa. There are two types of ore. Kansa laterite ore with estimated reserves of 40.9 million tons (0.5 cut off grade) of which 16.7 millions are proven reserves containing 1.0-1.06% Ni and 0.09% Co. Chromite overburden from a chromite operating plant has an stockpile of about 30 million tons increasing annually by 7.5 million tons. The average content of this overburden is 0.6% Ni and 0.06% Co. An upgrading technology has been developed by RRL to increase the Ni content to 1.1% and the cobalt content to 0.08%. The chemical composition of these ores are shown in Annex-III.

3. GENERAL DESCRIPTION OF CSIR-RRL TECHNOLOGY

The process technology includes beneficiation of COB from 0.6 Ni to 1.1 Ni and processing of concentrate by Caron Process, viz., Drying, Reduction Roasting, Leaching, Nickel Carbonate Precipitation, Calcination of part of the carbonate to NiO and Solvent Extraction plus Electrowinning to produce electrolytic Ni from the rest of the carbonate.

To produce 10,000 t Ni/year 4,0 million tons of COB have to be processed with an overall recovery of 51% Ni and 22% Co.

4. ORE CHARACTERISATION

The main minerals present in the chromite overburden are : Goethite (80%), hematite + quartz + chromite + talc (20%). The size analysis is :

+30 mm	13%
-30+0.1mm	52%
-0.1-0.05mm	5%
-0.05mm	30%

50% of the Ni is locked in the goethite crystal and the rest is associated with the hydrated iron oxides. The presence of Ni in the goethite crystal is a peculiar characteristic of this ore. The Cuban ore deposits are totally different. Near the top of the deposit iron-rich mineralization occurs (hematite); associated nickel content is less than 1%. Near the bottom of the deposit, minerals rich in magnesium and silicates occur (serpentine) with 1.5-2.0 Ni content. In between is an ore zone rich in limonite with average content of 1.1 to 1.2 % Ni.

In other economically exploited ores nickel is associated with sulphides (Canada), silicates (Indonesia, Greece, New Caledonia).

5. BENEFICIATION OF COB

The beneficiation stage of the CSIR-RRL technology comprises:

Screening
Crushing
Wet Scrubbing
Conditioning
Froth Flotation
Thickening
Dewatering

To produce 10,000 t Ni/year, this plant has to process 4.0 million tons ore (0.6% Ni) and deliver 1.5 million tons/year (1.1% Ni) to the reduction-roasting stage. Nickel recovery is only 69.7% and grade or ROM is also low.

My comments on this stage of the technology are :-

Rejects from the beneficiation plant (2.5 million tors/year, containing 0.2 % Ni and small amounts of chemical reagents used in flotation) does not solve the pollution impact of the actual overburden piles.

Dewatering 5000 t/day ore is a very expensive operation.

MY SUGGESTION :

Run some tests to determine the possibility of dry classification of the COB to increase its Ni grade. RRL staff agrees to this point.

6. AGGLOMERATION

CSIR-RRL have done some pelletizing tests with the COB concentrate due to its extremely fine particle size. No binder was used to maintain the necessary pososity for the gas reduction step. Finally they just let the material to agglomerate by itself in the upper hearths of the furnace and in this way reduce to minimum the amount of unreduced ore coming out of the MHF . My comment at this point is that ore has not to be agglomerated when using a 17 hearth furnace. You will get better contact between the solid and gas phases improving NiO reduction. If the amount of dust coming out of the furnace is too large, the solution will be to design the adequte cyclone and electrostatic separator system.

7. REDUCTION ROASTING

Long discussions were held on this stage of the process due to its importance in Nickel recovery. The MHF at RRL has the following characteristics :

Diameter	:	1.1m
Height	:	3.1m
No. of Hearth	:	7
Burners location	:	Hearths Nos.2,4 and 6
Gas outlets	:	Hearths No.1,3 and 5
Diesel consumption	:	18 litres/hr (for heating)
Reducing gas	:	27% CO, 4% CO_2
Gas atmosphere	:	11% CO, 8% CO_2
Rake Arms	:	2 per hearth
Feed rate	:	10 K/hr (COB concentrate)
Retention time	:	90 minutes

In the above mentioned conditions, the % Ni reduced determined by an ammonia leaching test is 80%. The same sample reduced in a laboratory furnace shows 90% Ni is reduced.

At this point I made a thorough explanation of the differences between their MHF and the ones used at Nicaro, Punta Gorda and Las Camariocas Nickel Plants in Cuba. Such differences are :

Diameter	:	4-5 M
Height	:	21 M
No. of Hearths	:	17
Burner locations	:	2 each at hearths 6,8,10,12,14,15
Gas outlet	:	Hearth No.0
Fuel oil consumption	:	55 K/t dry ore burned at 60% stoichiometric air
Reducing gas (producer gas)	:	135 M^3/t ore, 28% CO, 15% H_2, 4% CO_2
Gas atmosphere inside the MHF	:	12% CO, 9.5% H2, 8.9% CO2
Rake arms	:	4 per hearth
CO_2/CO at hearth 10	:	1,2-1,3
Feed rate	:	16-19 t dry ore/hr
Retention time	:	90 minutes
Maximum temperature	:	730°C at hearth No.15.

In a (Cuban) Pilot Plant test processing 150 t of ore containing 1.14% Ni and 45% Fe (similar to Kansa ore), the % Ni reduced was 89%, Co reduction 65%. At this point, I made the following suggestions :

Install retention rings in alternated hearths so feed rate can be increased and Ni reduction increased.

Install four rake arms at each hearth, one of them with teeth inclined angles opposite to the other three.

Change diesel burners to fuel oil burners

Increase H_2 content of furnace atmosphere by introduction of reducing gas containing H_2
Gas outlet from MHF at hearth 0 or 1.

Reducing gas inlet at the lower hearth of the furnace to aid cooling the reduced ore.

Control of the CO_2/CO ratio at the Hearth where goethite ore is broken down.

I also pointed out that cooling of the reduced ore in a 17 hearth furnace is done in three stages : by introducing reducing gas in hearth 16, transporting the reduced ore by means of a screw conveyor cooled by water sprays and finally in a drum cooler immersed in water.

I recommended to run a continuous pilot plant test in a 17 hearth furnace using Kansa ore to obtain reliable data for the project. I propose running such test at the Laterite Research Centre built with UNDP cooperation at Punta Goroa plant.

8. AMMONIA LEACHING

The technology developed by CSIR-RRL for ammonia leaching of reduced ore comprises:

Quenching
Oxidative ammoniacal leaching
Counter current decantation

At quenching the reduced ore at 200°C is mixed with part of the liquor from the leaching step cooled through heat exchangers to 38°C. The % solids in the slurry is 14% and the temperature 44°C. Leaching is carried out in closed vessels where oxygen is sparged at 15 psig. Retention time is 30 minutes and final temperature of leached slurry is 60°C. The leach liquor contains 37 grams per liter CO_2 and 90 grams per liter total ammonia. Washing is carried out in a five stages CCD system where fresh ammonia liquor is introduced in the last stage. Solid liquid separation is carried out in thickeners with an underflow concentration of 50% solids (using flocculants). Overall Ni recovery in the leaching and washing system is 93%.

At this point, I made the following suggestions :

Evaluate the reduction in investment produced by improving kinetics in the leaching stage versus operation costs by using oxygen.

Using Air in leaching and leach liquor containing 65 gpl total NH3, CO2
35 gpl (Nicaro practice) ammonia losses will be very low (6-8 kg/t ore

overall losses including leaching, product liquor and tailings distillation, etc.)

I also made the following recommendations :

Magnetic flocculation of the slurry coming out of the leaching stage will eliminate the use of flocculants and increase % solids in thickener underflows from 50 to 55%.

When fuel oil is used in the drying and reduction roasting stages, all the sulfur contained in the fuel oil will react with the iron oxides in the ore to form sulfides. The sulfides will be oxidized in the leaching stage to non-saturated sulfur salts [$NH_2S_2O_3$, $NH_2SO_3NH_4$, tetrathionates, etc.]. These salts will partially precipitate with the $NiCO_3$ in the distillation stages and the rest will be carried out in the distillation mother liquor causing Ni and NH3 losses as well as a pollution problem. To avoid these problems, the product liquor has to be oxidized at higher temperatures and pressure to convert all non-saturated sulfur salts to the sulfate form. Addition of Na_2CO_3 to the oxidized product liquor will decontaminate the BNC and the mother liquor will contain only Na_2SO_4.

A low pressure swing (molecular sieve) plant is recommended if oxygen is to be used in the leaching stage.

9. SOLVENT EXTRACTION AND ELECTROWINNING

RRL technology comprises the following operations :

Centrifuging of BNC thickener underflow to 45% H_2O BNC Cake

Drying and pelletizing of BNC cake

Dissolution in expent electrolyte

Filtration

Extraction of Ni in mixer-settlers

Stripping of organic phase

Treatment in activated carbon columns

Electrowinning to produce cathode nickel

Production of $NiSO_4$ for recycling.

This Laboratory has a bench scale SX-EW unit where they have tested the standard technology used elsewhere. The data obtained is reliable. In their scheme Cyanex-272 and tributyl phosphate are used to extract Ni in the organic phase leaving Co, Cu and Zn in the water phase. Nickel recovery will be 99.9%.

My comments of these operations are :

BNC thickens to 20% solids. In our practice we do not use centrifuges but vacuum rotary drum filters and final % H2O in BNC cake is 70%, I am not sure that by centrifuging the moisture will be 45%.

In the calcination of BNC to NiO there is no need for pelletizing. Agglomeration cccurs in the rotary calciner producing nodular reen NiO. If sulfur is not removed from product liquor the BNC will contain 2.3% S (dry basis) and during calcination SO_2 will come up in the outgoing gases.

I also recommend to treat the water phase in the SX-EW circuit which contains Co, Cu and Zn with Na_2CO_3 to precipitate a mixed carbonate cake. The solid/liquid separation of this precipitate will depend on the temperature, the velocity of addition of the Na_2CO_3 solution and the mixing velocity. The idea is to produce basic cobalt, zinc and copper carbonates with minimum of hydroxides.

10. ENVIRONMENTAL IMPACT AND WASTE UTILIZATION

The way CSIR-RRL technology as now designed, produce the following pollution impact problems :

Stream No.	Product	Quantity	Proposed utilization (RRL)
1.	Beneficiation rejects	$2.5x10^6$ t/y	Back filling of mines
2.	Tailings from ammonia leaching	$1.2x10^6$ t/y	Tailings pond
3.	Filtrate from BNC	$2.1x10^6$ m^3/y	No treatment is given
4.	Water phase from SX-EW plant	-	Treat with NaOH to obtain a mixed Co,Cu Zn hydroxide

My comments on these problems are :

STREAM-1 :

Beneficiation rejects contains 50% of the Ni originally contained in COB plus traces of chemicals used in flotation stage.

STREAM-2 :

A low grade magnetite concentrate can be obtained using a magnetic separation scheme. This has to be tested and according to results find a market for the concentrate.

STREAM-3 :

Unless proper treatment is provided, this stream will be highly contaminating since it will contain several ammonium salts and soluble nickel. In a previous chapter I suggested adding Na_2CO_3 to the oxidized product liquor going to the BNC stills.

STREAM-4 :

After proposed treatment with NaOH or Na_2CO_3 the liquor will contain Na_2SO_4.

11. CONCEPTUAL ENGINEERING

My remarks have been given in the previous chapter.

I may add the following comments and suggestions.

Consider having one extra drier (standby). Final moisture of dry ore should be 4-5%.

The size and number of the MHF could not have been calculated from the RRL MHF, so I suppose it is an inferred figure. Feed rate and size of the furnaces must be obtained from pilot tests using 17 Hearth Furnace.

A water cooled screw conveyor has to be considered for transportating reduced ore from MHF to drum coolers.

Consider having two CCD lines to treat leached slurry with smaller size thickeners

A polishing filter (closed leaf filter) is needed prior to product liquor distillation.

The fuel oil consumption in the driers is too high (50K/t ore) because the high % H_2O in dewatered COB concentrate. If oil used in MHF and other uses are added, total consumption will be 25.6 t fuel oil/t Ni produced.

Temperature for calcining BNC to NiO is 1100°C (MECON gives 1350°C)

Nitrogen gas is not necessary in the drum coolers.

12. ECONOMICS

MECON has worked out a detailed economic analysis of the technology proposed using Indian indexes for which I have no comments. The figures in MECON's report shows the following operating costs :

Production cost	*Cost/t metal US $*
Excluding depreciation and interest	*8262*
Including depreciation and interest	*15576*
Price of Ni in Indian market	*10469*

Actual prices of Ni are in the order of 4500 US $/t and it is expected to rise to 6000-7000 US $/t in the next 3 years.

I totally agree with MECON's recommendations :

Contribution of beneficiation plant towards over all capital cost is substantial.

It is noteworthy that the plant is not economically viable at the selling prices assumed. MECON's report also recommentds the set up of a nickel extraction facility for producing 200 t/y Ni on Kansa ore as feed material. My comments on this point are:

* *The production figure proposed will cover only 20% of actual India's needs and 10% of the planned needs in year 2000.*
* *The proposal is considered by MECON as an experimentation semi-industrial facility.*
* *I will recommend to run a pilot plant test with the adequate equipment and from the data obtained, work out a project for the 10,000 t Ni/year plant.*

13. ACID LEACHING OF INDIAN ORES

This task was not included in the terms of reference (Annex-I)

In the discussions with RRL staff, they asked me to give them a general description of the acid leach process operating since 1962 at Moa Bay, Cuba and my opinion on the possibility of processing Indian ores using such technology.

Taking into consideration the chemical composition of the ores (Annex-III), my preliminary opinions are :

COB and COB concentrate do not seem suitable for acid leaching because of their high MgO and CaO content. RRL had carried out batch laboratory tests using those materials and acid consumpion was almost double of MOA's practice.

Kansa ore, considering only the average chemical composition given, seems suitable for acid leaching.

In the MOA's acid leaching process the heat balance is round up with heat generated in a sulfuric acid plant located inside the metallurgical plant. If sulfuric acid is obtained in the national market, extra fuel oil has to be used to make up the energy balance.

Acid leaching produces a polluting stream containing Mn, Mg, Ni, free sulfuric acid whose treatment greatly increases production costs.

Tailings from the acid leaching process are composed mainly by hydrated iron oxides and basic iron and aluminium sulfates, so they cannot be treated by magnetic concentration scheme.

14. CONCLUSIONS

[1] Nickel production in India using chromite overburden and technology developed by CSIR is not economically feasible primarily because of wet beneficiation. In the wet beneficiation stage of the process 30% of the nickel is lost in rejects while in the reduction roasting - ammonia leaching stage another 19% of the nickel is lost. So overall nickel recovery is only 51%. Cobalt recovery have not been studied in detail. With the figure given for cobalt recovery (22%) the nickel oxide product will contain more than 1% Co which makes it unusable for the manufacture of certain alloys.

[2] It is likely that COB, and the concentrate will give higher recovereis during roasting in a 17-hearth Multiple Hearth Furnace as used in commercial plant. However, this needs to be ascertained through pilot testing.

[3] The ore from Kansa mine seems suitable for nickel production by either the ammonia or the acid leaching process with possible overall nickel recovery of 80-92% and cobalt recovery of 55-89%.

[4] Processing Kansa ore using the ammonia leaching process (80% Ni recovery) the mineral resources of that mine will sustain a 10,000 t Ni/y plant for over 14 years. If a cobalt separation stage is included, a 55% recovery can be expected. The tailings from this process can be upgraded by magnetic separation to produce a concentrate containing over 60% Fe. Acid leaching of Kansa ore will give higher Ni and CO recoveries but pollution impact will not be easily solved due to location of the mine and metallurgical plant. Tailings cannot be upgraded by magnetic separation.

15. RECOMMENDATIONS

[1]

As an alternative to the wet beneficiation technology developed by CSIR, a dry classification route shall be explored by RRL to upgrade the chromite overburden.

[2]

Carry out additional research work on the reduction roasting - ammonia leach process of Indian Ores in a Pilot Plant provided with a 17 MHF and leaching circuit working in a continuous base. CSIR could coordinate these tests with reliable foreign institutions. This will be a more realistic approach to decide the construction of the industrial scale plant than the proposal of constructing a semi-industrial plant (2000 t Ni/yr) as an experimental unit.

[3]

After a preliminary assessment of the possibility of acid leaching of Indian ores, CSIR could coordinate bench scale tests with reliable institutions.

16. LIST OF ANNEXES

Annex-I	:	Job Descriptions
Annex-II	:	Persons Met
Annex-III	:	Chemical Composition of Indian Ores
Annex-IV	:	Evaluation of Expert's Report

ANNEX-I

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

JOB DESCRIPTION

SI/IND/92/801/11-51

J13207

***

Post Title: Consultant in nickel processing.

Duration: 1.0 M/M

Date required:

Duty Station: New Delhi/Calcutta, with travel within India.

Purpose of project: To assess the process designed by CSIR for the extraction of nickel.

Duties: The consultant is expected to (1) advise the CSIR on the technology for processing nickel ores; (2) assess the process designed by CSIR for the extraction of nickel from the Sukinda ore deposit; (3) to perform tasks I, II, III, IV and V of the attached work plan; (4) to write the report with findings and recommendations, in cooperation with the other consultant and the study tour team.

Qualifications: Highly qualified metallurgical or chemical engineer with industrial experience in nickel processing.

Language: English

Background information:

India imports more than 10,000 tons of nickel metal, equivalent to more than 70 million dollars annually. After identifying nickel reserves in its own territory, the Government of India decided to exploit them through the installation of a metal smelter.

The Council of Scientific and Industrial Research (CSIR), India has been entrusted with the responsibility by the Government of India for development of technology and preparation of Techno-Economic Feasibility Report (TEFR) for a 10,000 tonnes per annum nickel plant, based on the lateritic nickel deposits of the Sukinda region. The plant will produce both class I Nickel (Nickel Cathodes) and Class II Nickel (Nickel oxide sinter).

The project involves a number of National Laboratories in India, namely Regional Research Laboratory, Bhubaneswar; National Metallurgical Laboratory, Jamshedpur; India Institute of Chemical Technology, Hyderabad, Central Electrochemical Research Institute, Karaikudi and BARC, Hyderabad. MECON, Ranchi has been appointed as Indian Consultant whose job is the preparation of Techno-Economic Feasibility Report (TEFR) based on the process know-how/data to be furnished by CSIR/Foreign Consultant appointed by CSIR.

Nickel ore deposits in India are confined to the Sukinda area in Cuttack district of Orissa in Eastern India. The deposits are lateritic and the main deposit is in the Kansa area having an estimated ore reserve of about 46 million tonnes of 0.94% nickel. In addition to this, nickel is also present in the overburden of the nearby chromite mines as lateritic nickel. The reserves are estimated at over 150 million tonnes, containing approximately 0.5% which is amenable to beneficiation to around 1.1%.

The nickel extraction process to be adopted has the following operations:

- ore beneficiation
- reduction roasting
- ammoniacal leaching
- calcination into oxide (5,000 tpy)
- dissolution in acid
- solvent extraction
- electrowinning into nickel (5,000 tpy).

The technology development will be based on lateritic nickel ore of the Kansa area and overburden of nearby chromite mines in the Sukinda region, Orissa (India).

A feasibility study is being prepared by the Indian engineering consultancy company MECON and is due to be completed in 1992. The output of this proposed project is expected to be used for the preparation of the feasibility study.

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

JOB DESCRIPTION

SI/IND/92/801/11-52

J13207

***

Post Title: Consultant in nickel-ammonia leaching.

Duration: 1.0 M/M

Date required:

Duty Station: New Delhi/Calcutta, with travel within India.

Purpose of project: To assess the process designed by CSIR for the extraction of nickel.

Duties: The consultant is expected to (1) advise the CSIR on the technology for processing nickel ores; (2) assess the process designed by CSIR for the extraction of nickel from the Sukinda ore deposit; (3) to perform tasks VI, VII, VIII, IX and X of the attached work plan; (4) to write a report with findings and recommendations, in cooperation with the other consultant and the study tour team.

Qualifications: Highly qualified metallurgical or chemical engineer with industrial experience in nickel processing.

Language: English

Background information:

India imports more than 10,000 tons of nickel metal, equivalent to more than 70 million dollars annually. After identifying nickel reserves in its own territory, the Government of India decided to exploit them through the installation of a metal smelter.

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ANNEX

PROGRAMME OF WORK

TASK 1 ORE CHARACTERISATION

Mineralogical characterisation already carried out on samples representing wide cross section of entire chromite overburden from different quarries in Sukinda area indicate that the majority of nickel is associated with amorphous materials of hydrated iron oxide as well as with crystal lattice and absorbed on its surface. A typical analysis of Kansa ore is given in Table-I.

The consultant will correlate results of these studies with similar ore from other parts of the world and advise whatever further mineralogical investigations are necessary.

TASK II BENEFICIATION

Beneficiation studies using classification and classification-flotation techniques which have already been carried out indicate that the overburden material can be beneficiated from 0.4 to 1.1% nickel with more than 70% recovery.

TASK III DEWATERING, DRYING AND FLOWABILITY

Data are being generated with respect to overburden samples on dewatering, drying and flowability. Dewatering of concentrates has shown a minimum free moisture content of 30%. The consultant will correlate these data with similar ore from other parts of the world.

TASK IV AGGLOMERATION

Cold bonded pellets have been prepared in a disc pelletiser using powedered ore with the required binder. The consultant will be required to advise on the utility of such pellets.

TASK V REDUCTION-ROASTING

Reduction-roasting studies on overburden material in a Multi-Hearth-Furnace (MHF) have shown more than 75% recovery results. Tests on the reduction roasting in a rotary kiln will also be carried out. The consultant will advise on the use of such kilns for reduction of lateritic nickel ore.

TASK VI LEACHING

Leaching studies are being carried out to recover maximum reduced nickel and cobalt. Studies already carried out on material roasted in a furnace show leaching of more than 75% nickel. The consultant would be required to advise for standardisation of leaching parameters and recycling of leach liquors, so that nickel content in leach liquor can be upgraded.

TASK VII SOLID-LIQUID SEPARATION

The consultant would be required to advise on settling and filtration tests on leached slurry as well as dewatering tests on flotation production.

TASK VIII SOLVENT EXTRACTION-ELECTROWINNING (SX-EW)

Extensive studies on SX-EW of nickel bearing solution from lateritic nickel ore have already been carried out. The consultant will advise and suggest to develop the SX-EW process package for nickel from Sukinda belt.

TASK IX ENVIRONMENTAL IMPACT STUDIES

Environmental impact studies with respect to the different activities of the proposed nickel plant have been carried out. The consultant would be required to advise on identification of procedures for relevant environmental tests, standardisation of test procedures, identification and checking of parameters.

TASK X WASTE UTILISATION

Wastes generated in the process are to be utilised. Consultant would advise particularly on physical/chemical beneficiation of tailings.

TASK XI CONCEPTUAL ENGINEERING

Taking into account all the steps in the process package, the consultant would be required to advise on:

(i) energy and material balance studies on all process steps,
(ii) development of equipment flow diagrams for the process,
(iii) development of models for all critical process steps,
(iv) preparation of basic process package.

Persons met :

Mr. Vinay Kumar, UNIDO, Delhi
Mr. Lasse Moller, Programme Officer, UNIDO, Delhi
Dr. H.S. Ray, Director, RRL
Dr. R.P. Das, Leader, Nickel Project, RRL
Mr. J.R. Sahu, Head, Planning, Information, Library & Computer Division, RRL
Mr. D.N. Dey, Head, Pyrometallurgy, RRL
Mr. A.K. Jouhari, Scientist, Pyrometallurgy, RRL
Dr. A.K. Tripathy, Scientist, Pyrometallurgy, RRL
Shri Balbir Singh, Executive Director, Hindustan Copper Ltd.
Dr. K. Sarveswara Rao, Scientist, Hydrometallurgy
Dr. (Mrs.) S. Anand, Scientist, Hydrometallurgy, RRL
Mr. Gautam Kr. Das, Fellow, Hydrometallurgy
Mr. Birendra Kumar Das, Research Asst., Hydrometallurgy, RRL
Shri Rajeswar Rao, Scientist, IICT
Shri Kulkarni, Scientist, IICT.
Mr. A.K. Mukerjee, General Manager, MECON
Mr. R.K. Sharma, Chief Design Engineer, MECON
Mr. S.K. Khurma, Commercial Director, MECON
Mr. A.K. Ghosh, Assistant Manager, HCL

ANNEX-III

CHEMICAL COMPOSITION OF INDIAN ORES

Day basis	Chromite OB	Chromite OB conc.	Kasa
%Ni	0.6	1.1	1.06
%CO	0.06	0.08	0.09
$\%Fe_2O_3$	34.3	70.0	64.0
%Fe	24.0	49.6	44.8
$\%SiO_2$	49.9	9.0	3.0
%MgO	2.0	0.4	0.6
%CaO		2.6	
$\%Al_2O_3$	1.5	1.5	
$\%Cr_2O_3$	2.4	3.4	2.0
%Mn	7		0.8
LOI	6.2	7.0	

ANNEX-IV

M. Nogueira da Silva/ecz
14 April 1994

EVALUATION OF EXPERT'S REPORT

SI/IND/92/801/11-51 + 11-52

Assessment of a Nickel Process for Sukinda Ore

Prepared by Backstopping Officer: M. Nogueira da Silva

This evaluation refers to the mission report submitted on 9 December 1993, by Mr. V. Herrera Juver, consultant in: nickel processing, and nickel-ammonia leaching.

I. Purpose of Mission:

The consultant was expected to: (1) advise the Council of Scientific and Industrial Research (CSIR), on the technology for processing nickel ores; (2) assess the process designed by CSIR for the extraction of nickel from the Sukinda ore deposit; (3) perform tasks of the attached work plan; (4) write the report with findings and recommendations, in cooperation with the other consultant and the study tour team.

II. The Expert's Report:

In a one month mission to India, the consultant was expected to assess the process designed by the Council of Scientific and Industrial Research (CSIR), developed at the Regional Research Laboratory (RRL), at Bhubaneswar, and on the Techno-Economic Feasibility Report (TEFR), prepared by MECON. Detailed technical discussions were held with RRL staff on every stage of the process: ore characterization, beneficiation, dewatering, drying, agglomeration, reduction roasting, leaching, solid liquid separation, solvent extraction - electrowinning, environmental impact, waste utilization and conceptual engineering.

For each stage of the process, advises and detailed informations were given to RRL staff, according to the well established Ammonia Leaching Processes in Cuba. The consultant gave also many corrections and suggestions to the five volumes (III, IV, V, VI, VII) report prepared by MECON.

As an additional task, the consultant made a preliminary assessment on the possibility of using the acid leaching process to treat the chromite overburden and the Kansa ore.

III. The Recommendations:

The consultant concluded that using the chromite overburden (COB), in the wet beneficiation for the production of nickel in India, is not economic.

There are two possibilities left:

(i) to treat the COB through roasting. This could be pilot-tested abroad, in a continuous running plant, such as the Moa Bay plant in Cuba;

(ii) to use the Kansa ore, rather than the COB, for nickel production. Here, there are two processes that should be pilot-tested: ammonia leaching or acid leaching.

The consultant also mentioned that the environmental impacts caused by nickel processing are great and should be seriously considered while designing the processes.