NML
Annual Report
1981-82

NATIONAL METALLURGICAL LABORATORY
JAMSHEDPUR, INDIA

ANNUAL REPORT
1981-82

NATIONAL METALLURGICAL LABORATORY
COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH
JAMSHEDPUR, INDIA.

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INTRODUCTION

The R & D activities of the Laboratory have resulted in the utilisation and potential application of some of the products and processes developed. Consultancy assignment and a large number of sponsored projects have been assigned to the Laboratory.

The Laboratory developed the technology for the production of aluminium-5 percent magnesium welding filler wire according to specification B.S. 2901-1970-NG6. This type of filler wire, which is now imported, is used for welding of sheet metal components in manufacture and repair welding of aero engine components. The NML produced welding filler wire has been used by M/s Hindustan Aeronautics Ltd. Engine Division, Bangalore, who found it quite suitable for the purpose. It has been approved by M/s. Hindustan Aeronautics Ltd, for use in their engine division.

In this connection excerpts from a communication from M/s. Hindustan Aeronautics Ltd. Engine Division, Bangalore is reproduced below.

"In an effort to locate an indigenous source for these filler wires, M/s. National Metallurgical Laboratory, Council of Scientific and Industrial Research, Jamshedpur-831007, have developed the subject material and the sample/trial batch material has been tried by us and found suitable. In view of the above it has been approved for use in our Division."

The NML Madras Unit was entrusted to undertake detailed investigation by MECON, the Technical Consultant of the pelletization plant of Kudremukh Iron Ore Company, to establish the parameters for the production of direct reduction/blast furnace quality iron ore pellets from Kudremukh iron ore concentrate. Investigations were carried out as per the specified test schedules. The consultant were provided with the results of the exhaustive studies conducted on characteristics of the concentrate, the pelletization procedure, physical tests on green and hardened pellets etc., which will form the basis for design of the proposed plant.

The Laboratory has also conducted a number of sponsored investigations on beneficiation and agglomeration studies of low grade ores and minerals.

The Laboratory has developed a process for the recovery of tin from tin slag. Technology has also been developed for recovering tin from sponge tin which is a bye-product obtained from detinning operation. The processes developed are under negotiation for commercial utilization.

The Laboratory has developed nickel free creep resistant austenitic steel for application in automotive exhaust valve. NML's experimental alloy has been evaluated by M/s TELCO and the results are very encouraging.

Large scale industrial production of wire rods made from high strength medium conductivity aluminium alloy, designated as NML-PM 215, has been made at M/s. Bharat Aluminium Co. Ltd., Korba. There wire rods are

Ambassadors from some Asian countries, during their visit, observing some permanent magnetic materials developed at National Metallurgical Laboratory.

being processed for the multistrand overhead conductors for defence requirements. The wire is also being processed for applications of catenary overhead traction wire for use by the Railways.

NML Pyroloy 1000-a heat resistant cast iron alloy—is undergoing industrial evaluation trials for various applications such as carrier blade castings for reheating furnace, element pins for electric heat treatment furnace, grillage line castings for walking beam furnace, spacer castings for gas carburising etc. The evaluation trials have given very encouraging results and various firms are interested in the products.

The Laboratory is offering its service to various thermal power plants of the country by carrying out investigations on prematurely failed components and advising the reasons for failure and remedial measures, quality assurance of creep quality steels, estimation of residual life of used components etc.

The Laboratory has conducted investigations on the amenability of Chikla manganese ore for the production of electrolytic manganese metal and electrolytic manganese-dioxide on behalf of M/s. Manganese Ore of India Ltd. Based on the investigations the firm proposes to set up commercial plants for production of electrolytic manganese metal and electrolytic manganese dioxide.

The United Nations Industrial Development Organisation, Vienna ; held a Workshop at National Metallurgical Laboratory on "Regional Project for Co-operative Research Among Metallurgical Research and Development Centres in Asia and the Pacific" in December 1981, which was attended by 28 participants from ten different countries. Prof. V. A. Altekar, Director, NML ; was elected the Chairman of the Workshop, Dr. B. R. Nijhawan (Ex-Director, NML), and now senior Inter-regional Adviser, Metallurgical Section, UNIDO, was the Leader of the UNIDO team.

Dr. Rajendra Kumar, Scientist in the grade of Director, has been assigned as Project Co-ordinatior of the project "Boiler Tube failures in Thermal Power Station" of the Central Board of Irrigation & Power for a period of three years 1982-85.

Shri D. D. Akerkar, Scientist, has received the 'Indranil Award' for metallurgy for the year 1980-81, by Mining, Geological & Metallurgical Institute of India, Calcutta.

A brief resume of the various R & D projects and other activities are furnished in the different chapters of the report.

PROJECT HIGHLIGHTS

A. ORE DRESSING & MINERAL BENEFICIATION

1. **Beneficiation and Sintering Studies on Iron Ore from Gua, Mixed with Dump fines.** *Sponsored by M/s. Indian Iron & Steel Co.*

Detailed large scale sintering studies were carried out on fines arising out of beneficiation of Gua iron ore mixed with dumped fines at different proportions. The test results indicated that dumped fines could be mixed with the beneficiated fines for making good quality sinter without appreciably altering the sintering characteristics.

2. **Further Sintering Studies on Composite Iron Ore Fines from Bailadila Deposits 4 & 5 Employing Machkotteria Dolomite.** *Sponsored by M/s. Vishakapatam Steel Project.*

Further large scale sintering tests were carried out employing Machkot Teria dolomite in place of Khammam dolomites, without altering the other variables. It was observed from the results of sintering studies, that Khammam dolomite could be successfully substituted with Machkot Teria dolomite, without considerable difference in the yield and quality of the sinter produced.

3. **Beneficiation of Slime Samples.** *Sponsored by M/s. Mineral Development Board.*

M/s. Mineral Development Board sponsored detailed beneficiation studies of four different iron ore slimes. Scientists from NML, Regional Research Laboratory Bhubaneshwar ; and representatives from MDB visited some of the mines and washing plants and arrived at certain conclusions regarding collection of the slime samples for beneficiation studies. Accordingly, one slime sample obtained by washing of Gua iron Ore, crushed to-50 mm size was received and exhaustive large scale studies are in progress.

4. **Beneficiation of Limestone Samples from Chopan Area, Mirzapur District.** *Sponsored by M/s. Cement Corporation of India.*

Approximately 8 tons of limestone sample from Chopan area were received for detailed beneficiation studies for producing cement grade concentrate employing dry process only. Earlier, scientists from NML visited the mine area and discussed with the representatives of M/s. CCI, regarding the nature of limestone available in the area. It was observed shale is the major gangue associated with the limestone and work has been initiated for removing the shale.

5. **Beneficiation Studies of Low Grade Kyanite Samples UDK-1 & UDK-2.** *Sponsored by Director of Mining & Geology, Udaipur, Rajasthan.*

The kyanite samples as received assayed between 40-42% Al_2O_3. Beneficiation by gravity concentration methods including agglomeration, tabling etc. are in progress.

6. Beneficiation Studies of Sivaganga Graphite. *Sponsored by M/s. Tamilnad Mineral Ltd.*

M/s. Tamilnad Minerals Ltd. (TAMIN) is proposing to set up a beneficiation plant for processing their graphite deposits at Sivaganaga, Ramnad Dist. Discussions were held between M/s. TAMIN and NML and these were further followed by a visit to their graphite mines by NML Scientists for field studies and suggestions for collection of 50 tonnes of representatives sample for bench and pilot plant studies. Preliminary studies on a few hand-picked samples from the area, indicated the amenability to beneficiation. The flotation concentrate assayed over 90% fixed carbon with less than 3% ash free from mica and with high carbon recovery. The bulk sample of 50 tonnes had been received for detailed beneficiation studies. TAMIN have also shown interest to assign the full consultancy for the project to NML.

7. Explanatory Studies for Producing Bulk Concentrates for Market Evaluation Trials from Kyanite Samples from Pardi Mines. *Sponsored by Maharashtra Minerals Corporation.*

Explanatory studies were conducted on 100 kg. of kyanite sample from Pardi mines with the object of producing bulk quantities of tourmaline-free kyanite concentrates for further market evaluation studies. Accordingly, bulk quantities of kyanite concentrates were produced by employing gravity methods. The concentrates were found to assay 59-60% Al_2O_3 mostly free from tourmaline (less than 3%) with high P.C.E. values. Approx 50 kg. each of these products have been handed over to M/s. MMC for further evaluation studies at M/s. A.C.C. Belpahar refractories Ltd. After receiving feed back information about the behaviour of the supplied concentrates, further exhaustive studies on a 200 kg of tourmaline rich kyanite sample from the same area have been undertaken for supplying bulk quantities and for further consultancy work for the kyanite project with the sponsors.

8. Petrological & DTA studies on Ores & Minerals.

Detailed petrological and differential thermal analysis studies were conducted on various samples of ores and minerals received for investigational work, as well as the products produced during investigations.

B. REFRACTORY TECHNOLOGY

1. Evaluation and Characterization of Indian Fireclays. *All India Co-Ordinated Project.*

The P.C.E. of 14 samples of clay were determined. Bars of size 6″×1″×1″ were hand tamped in brass mould. These bars were dried and fired at different temperatures and the dry shrinkage and fired shrinkage were determined. Bulk density, apparent porosity and modulus of rigidity of these fired specimens are being studied.

2. Development of Graphite-Silicon Carbide Crucible.

The samples of large size crucibles which were sent for industrial trials did not give expected results of life. So fresh trials are being planned.

3. Suitability of Indian Sea-water Magnesia for Refractory Use.

In continuation of the earlier work, one tonne sample of sea water magnesia was received from CSMCRI, Bhavnagar. The received one tonne materials has been sampled and being analysed. 30 mm. dia. sample specimens were pressed at different pressures with as received sample. Some sample specimens with the admixture of calcined sea water magnesia were also prepared. The samples will be subjected to firing at high temperature.

4. Development of Dense High Purity Alumina Grains from Technical Alumina.

During the period under review, raw technical alumina was chemically analysed and its particle size analysis was carried out. To reduce the alkalies content to minimum, it was leached with hot conc. HCl followed by hot distilled water leaching. Its chemical analysis was again carried out. Few buttons of 2″ dia were hydraulically pressed from three more selected batch compositions with varying amount of sintering aids and their green bulk densities were determined. The samples were sintered in a high temperature gas fired furnace at different temperatures and for different soaking periods. Their bulk density, apparent porosity, percent linear shrinkage, percent water absorption, etc. are being evaluated.

5. Utilization of Concentrate from Low Grade Magnesite for Refractory Purpose.

The objective of the project is to utilise concentrates from low grade magnesite for refractory purposes. About 1 tonne sample of beneficiated Salem magnesite was obtained. Sample specimens of 30 mm. dia. were prepared at different pressures for firing at different temperatures.

6. Studies on the Reactivity of Indian Dolomite and Magnesite for the Development of Dolomite-Magnesite Composition for Oxygen Converter.

Four samples of dolomite and two samples of magnesite were obtained. They were crushed and graded for carrying out the reactivity studies.

7. Development of Low Density Low Iron Insulation Bricks from Alumino-silicate Aggregates.

Trials were made to develop foam insulation refractories from kyanite and fireclay which are low in iron content. The alumino silicates gave encouraging results showing porosity 80-83%, bulk density 0.47-0.54 and cold crushing strength 11 to 27 Kg/cm^2.

8. Studies on the Development of High Temperature Castables for 1500°-1700°C using Fused Alumina as Aggregate and NML CA Cement.

It was observed during in-plant trails that castable produced could be used safely upto 1500°C. At 1600°C and above the liquid formation and volume shrinkage was more. Hence, further work to make high temperature castables suitable upto 1650°C was taken up by using fused alumina grains as aggregate and NML made high alumina cement as binder.

Physical properties of the aggregate as well as high alumina cement used were studied. Six different batch compositions with varying cement content and rest fused alumina grains were made and pressed in the form of 2' dia buttons. These buttons were heat treated at different temperatures and soaking period. The study of physical properties is in progress.

9. Studies on the Development and Production of Carbon Bricks and Blocks.

Procurement of raw materials such as calcined petroleum coke, pitch and tar for making dense carbon aggregate is under progress.

10. Studies on Hindustan Electrographite Fines to make Carbon Bricks for Chemical Industry. *Sponsored by M/s. Hindustan Electrographite.*

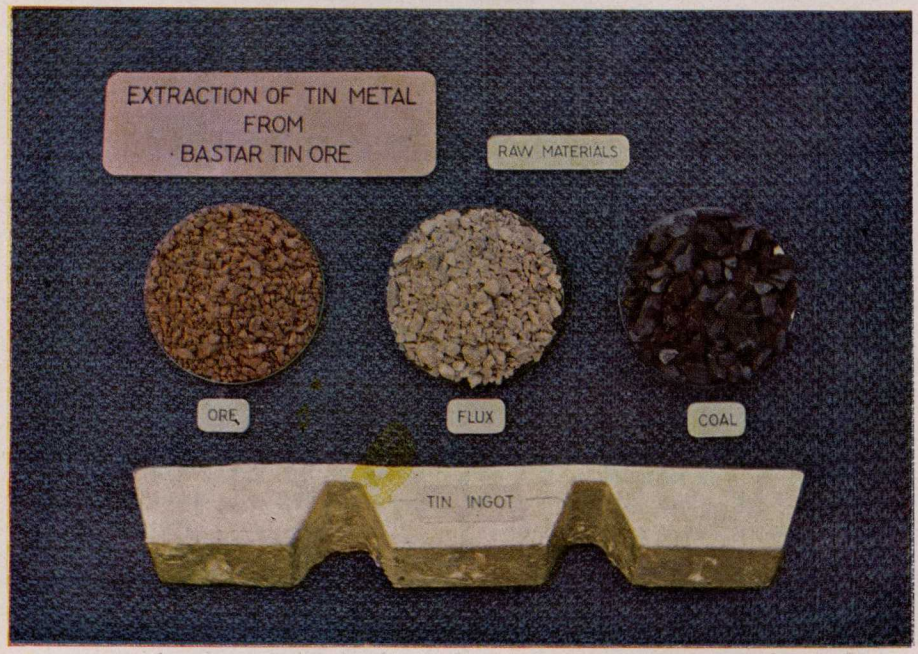
M/s. Hindustan Electrographite sent 250 kg of graphite powder to determine its suitability for making carbon bricks either as a whole or in part, Physical properties of the raw materials were determined. Six batch compositions were made by incorporating HEC fines, dense carbon aggregate and calcined petroleum coke, using pitch as binder. Compacts were made in the form of 2" dia buttons and fired under reducing conditions. Different properties of the fired compacts were determined and the report has been submitted to the party.

11. Studies on Petroleum Cokes. *Sponsored by M/s. Engineers India Ltd.*

The project was taken up is to find out the feasibility of making petroleum coke from crude petroleum obtained in the Bombay-High region. For this purpose, crude petroleum cokes were processed in a variety of way at I.I.P., Dehradun. Two such samples from Bombay-High processed at I.I.P., Dehradun, were taken up for investigation. The raw samples were calcined in a gas fired furnace. Physical properties like true specific gravity, electrical resistivity, bulk density and proximate analysis of all the samples were determined. Further work is in progress.

12. Testing of Acid Resistance Bricks. *Sponsored by M/s. Uranium Corporation of India, Jadugoda.*

Six different samples from U.C.I.L. were received for acid resistance studies. Physical properties such as bulk density, apparent porosity and cold crushing strength are under progress.



Tin produced from Bastar tin ore at National Metallurgical Laboratory.

C. EXTRACTION & CHEMICAL METALLURGY

1. Large scale Testing of NML Process of Extraction and Recovery of Nickel from Lateritic Nickel Ores. *All India Co-ordinated Project between NML and Regional Research Laboratory, Bhubaneswar.*

The bench scale trials on the roast reduction of overburden material of Sukeranji and Soyuabil Mines is in progress. Also arrangement is being made to procure the overburden materials of the chromite mines of Sukeranji and Sayuabil in Orissa.

2. Extraction of Tin from Bastar Tin concentrate.

For large scale trials, a new electric furnace has been installed and commissioned. Trials to be conducted soon.

3. Recovery of Tin from Sponge Dross, Sludge and other Waste Materials, (Secondaries).

Investigation has been carried out on recovery of tin metal from secondary sources obtained from electrolytic detinning of tin plate scraps and used tin cans. A private firms has shown interest in setting up a plant with NML consultancy. Bench Scale explotatory experiments have been conducted for recovery of tin from tin dross obtained during tin coating of wires. Bench scale exploratory experiments have been conducted for recovery of tin from tin sludge of a electrolytic tin plating plant.

4. Recovery of Lead from Battery Scrap.

One tonne of battery scrap has been received from a private firm for conducting (large scale trials) in a rotary furnace.

5. Recovery of Vanadium Pentoxide from Vanadium bearing Slag of VISL.

Bench scale investigations are over. Large scale roasting and leaching trials are in progress.

6. Recovery of Nickel from Nickel Ash (Spent Catalyst).

Spent nickel catalyst is an important source of nickel and nickel chemicals. Preliminary exploratory experiments were conducted by pyro as well as by hydrometallurgical routes for the recovery of nickel. Both routes have yielded encouraging results. It is now planned to do a semi large scale trial by one of the promising pyro route for recovery of nickel. Larger quantity of the nickel ash for conducting pilot trials are being obtained to study the effect of scale up factors.

7. Development of Indigenous Solvent Extraction Reagents. *Inter-Laboratory Project between NML & National Chemical Laboratory, Pune.*

The samples sent by NCL (NX_1 and NX_2) were tested and evaluated. One of the sample has shown encouraging results.

8. Treatment of Complex Sulphide Ores for the Recovery of Copper, Zinc, Lead and Sulphur Values.

Several tests were conducted on roasting Ambamata concentrates in the fluidised bed reactor. Subsequent leaching and solid separation were also carried out. The copper-zinc solution was treated by solvent extraction to recover copper. Studies are also carried out to remove iron by Jarosite process. Copper was recovered from sulphate by stripping with sulfuric acid. Electrowining experiments are planned to recover copper and zinc from the sulphate solutions.

9. Electric Smelting of Dolomite for Extraction of Magnesia.

Instrument panel board, electrical connections for the unit are being established. The rotary air lock to be used for charging the furnace has been procured.

10. Purification of Molybdenite Concentrate suitable for Making Ferro-molybdenum.

M/s. Uranium corporation of India Ltd. had sent three type of concentrates for studying & finding out their suitability of adoptation of the processs developed at the NML. Detailed investigation in one sample has been undertaken and semi-large scale trials are underway.

11. Extraction and Recovery of Lead and Zinc from Oxidized Ore from Chakula, Bhutan. *Sponsored by Geological Survey of India, Bhutan Circle.*

The work on the average grade sample on leaching and recycling of spent leach liquor is nearly completed and the investigation report is being finalized.

12. Recovery of Ammonia Chloride and V_2O_5 from Effluents of the Plant Recovering V_2O_5 from Vanadium bearing Sludges. *Sponsored by M/s. Rare Metal & Chemicals, Ranchi.*

Experiments were complete for recovery of NH_3 or NH_4 Cl from the effluent of the plant of M/s. Rare Metals and Chemicals, Ranchi. The design of the ammonia/ammonium chloride recovery unit has been made and given to the licencee for setting up in the V_2O_5 plant.

13. Roasting Studies on the Zinc Sulphide Concentrates of M/s. Hindustan Zinc Limited in Fluidised Bed Reactor. *Sponsored by M/s. Hindustan Zinc Ltd.*

Series of experiments were conducted to ascertain the roasting characteristics of the HZL concentrates of Zinc sulphide.

14. Recovery of Non-ferrous Metals and Elemental Sulphur from Complex Sulphide Mineral concentrates by Hydro and Electro-metallurgical Techniques.

90% Zinc, 97% copper and almost all the lead and silver present in Ambamata complex sulphide concentrate were recovered by leaching the ash eceived concentrate in ferric chloride solution. Grinding of the concentrate and further leaching in ferric chloride raised the recoveries to 94% zinc and 98% copper.

15. Utilization of Ferrous Sulphate for Production of Pigment Grade Ferric Oxide.

Ferric oxide prepared by thermal decomposition of the bye product green vitriol, from Iron & Steel Industry, was evaluated by a leading paint manufacturer and found to confirm to ISC-445 (Venetian Red). Another grade developed by the same technique but under different parameters, has been found visually to match with the colour of ISC-473 (Gulf Red Pigment). ½kg. of this sample has been sent to National Test House, Calcutta for its evaluation as pigment grade.

16. Processing of Sulphide Concentrates.

Based on the developed and patented know-how for treatment of complex and lean grade sulphide concentrates, copper-nickel concentrates from Uranium Corporation of India Ltd, copper concentrates from Sikkim, and copper ash from non-ferrous foundry waste were examined and optimum parameters for these concentrates were established.

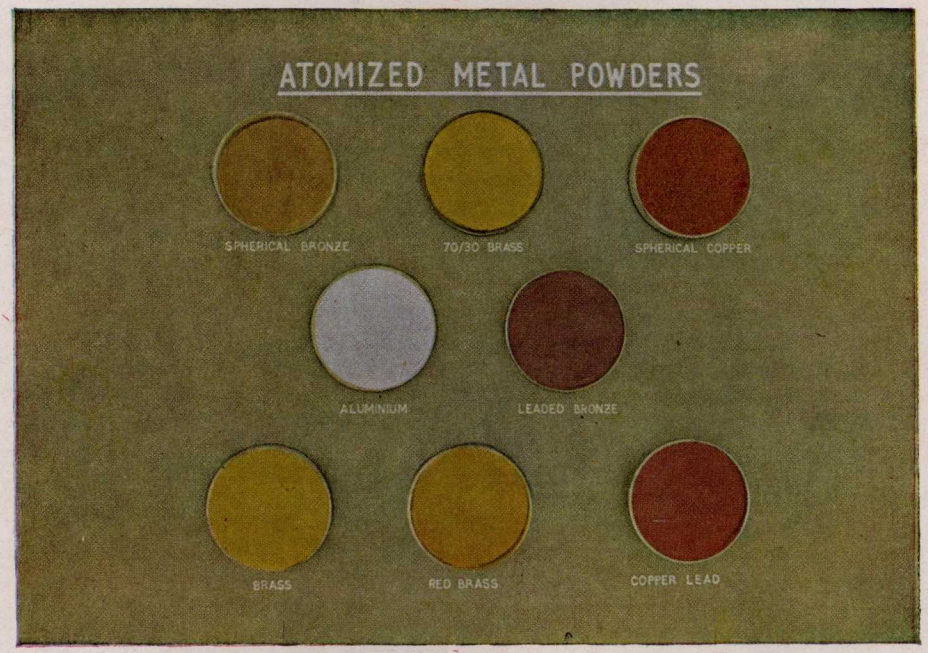
17. Development of New Electrodes for Electrolytic Manganese Dioxide Process.

Adherence of the EMD deposit with various types of surface preparation of the titanium anodes was examined. Under the optimum electrolytic conditions established with lead-antimony anodes, excellent deposits of EMD was obtained on titanium anodes as well, after preparation of surface according to the specified manner. The EMD obtained contained 93-94% MnO_2 with a battery activity index of 71.6.

18. Large Scale Electro-Metallurgical Facility—Production of Electrolytic Manganese Metal and Dioxide.

The Chilka manganese ore of M/s. Manganese Ore (India) Ltd. was evaluated for production of electrolytic manganese metal and dioxide. The reduction of manganese ore was over 90% with current efficiencies of the order of 95% for EMD on electrolysis of solutions obtained by leaching the reduced ore in spent electrolyte and purification.

Studies on the removal of certain impurities in the manganese ore which build up in the electrolyte during processing and enter into the deposited EMD on electrolysis were conducted. Based on the work, the firm proposes to set up commercial plants.



Different types of metal powders produced at National Metallurgical Laboratory.

19. Activated Manganese Dioxide.

Two high grade ores of M/s. Manganese Ore (India) Ltd. were studied to develop a method for activation of Indian manganese ores to a higher battery activity so that they can be used efficiently as a depolarrizer in dry cells. It has been possible to increase the activity index from 27 to 55. Optimum condition of the different variables of the process are being determined.

20. Prepartion of Fluorine Chemicals/Synthetic Crytolite.

The procss is now at the transfer of technolgy stage. Large scale cyclic experiments for the production of cryolite at 100 kg per batch scale with a view to improve upon the fluorine recoveries and reduce the raw material consumption were carried out.

21. Production of Microfine Silver Powder for use in Powder Metallurgy, Conductive Cooling etc.

Simultaneous oxidation and reduction of silver in aqueous electrolytic bath was carried out to produce silver powder of desired fineness. They yield obtained in the initial experiments was over 90% with a current efficiency of 97%. 98.2% of the production passes through 325 mesh and its purity is 99.99% in Ag. content. A scheme is being prepared to develop the process on large continuous scale.

22. Production of Metal Powders.

(*a*) *Gas-atomized Metal Powder*

"The Project Consultants M/s Micrometal Sen Ltd. appointed by NML licencee for air-atomized metal powders were assisted in preparing the plant and equipment specifications as well as in finalizing plant layouts. Pertinent design drawings were vetted and assistance also rendered in floating enquiries and recommending equipment selection. The plant is actively under erection at Jassidih. A new licencee for air-atmozed metal powders, M/s Fort William of Calcutta, was given the process technology manual as part of the technology transfer package.

A potential licencee—M/s Zinc Products of Patna was assisted in prepering project profiles for the production of distilled zinc dust.

(*b*) *Water Atomized Metal Powder*

Some progress was made in the installation and energizing of the 80 HP high-pressure high thruput triplex pump and commissioning trials are underway. The first trial heats for producing water-atomized aluminium powders to start with are expected to take place shortly."

23. Bio-hydrometallurgical Metal Powder

A cementation cell and electrolytic cell of advanced designs specifically for dilute solutions such as those obtained by microbial leaching were

designed and fabrication is under way. Meanwhile, 25 liters of microbial copper leach liquor have been obtained from the MACS Research Institute, Pune for preliminary evaluation.

24. Large Scale Multi-purpose Testing Facilities for Non-Ferrous Metals Extraction (Hydro-Electrometallurgy Project.)

The proposal for the establishment of a Large Scale Multi-Purpose Tecting Facility for the Extraction of Non-Ferrous Metals was re-vamped and approved by the Governing Body of CSIR at a cost of approximately Rs. 4.5 crores for implementation during a seven year period 1981 to 1987 with the assistance of an appropriate project consultancy firm.

D. Iron & Steel Technology

1. High Strength Low Alloy Steels.

Charpy V notch impact specimens were prepared from the as rolled 170 mm $\times$20 mm flat bars of high strength low alloy steels made at Visvesvaraya Iron & Steel Ltd., Bhadravati, during the industrial scale demonstration trials and room temperature and sub-zero temperature impact tests were carried out on the specimens.

2. External Dephosphorization of Hot Metal

From the trials carried out it was possible to reduce the phosphorus content of the cast iron containing above 0.9% Si up to 30-40% (initial P-0.22 to 0.27%) without any appreciable loss of carbon. Further work will be carried out to see how far the dephosphorization can proceed when the opening Si-content is decreased and also to devise ways for higher dephosphorization of hot metal containing silicon from 0.85% to 1.3%.

E. ALUMINIUM TECHNOLOGY

1. Development of High Strength Aluminium Alloy Conductor.

Large Scale industrial production of wire rods made from high strength medium conductivity aluminium alloy designated NML-PM215 has been made at Bharat Aluminium Co. Ltd., Korba. About 400 kg from this wire rod are being processed for the manufacture of multistrand over-head conductor for defence requirement at M/s India Cable Co., Jamshedpur. Further quantities of the wire rod will be processed for applications of (i) catenary wire in Railways and for (ii) composite conductor along with NML-PM2 for overhead application in coastal areas of Gujarat.

2. Development of Aluminium Alloy Electrode Wire.

The Laboratory has developed the production technology of the aluminium alloy filler wire corresponding to BS 2901 NG 6 and IS 1278. 1971 NG 6 specifications. Although the nominal composition is described in the various national standards, their production technology required development to suit the indigenous resources. The technology includes

the melting, solidification and processing and the filler wires have been designated as NML-PM6. Fairly large quantities of NML-PM6 filler wires in different gauge diameters were suppled to M/s. Hindustan Aeronautics Limited, Bangalore for evaluation. M/s. Hindustan Aeronautics have stated that the material was found suitable and has been approved for use in their engine division. The production technology is now ready for commercial utilization.

3. Studies on High Strength Weldable Al-Zn-Mg Alloy.

Four sets of four point bending test apparatus for stress corrosion testing of high strength aluminium alloy have been fabricated. A number of heats of Al-Zn-Mg alloy with and without NML reactive filter were made and processed in the form of sheet. To study the effect of alloy addition and duplex heat treatment on the stress corrosion resistance of the alloy, samples were exposed for the test.

4. Non-Corrosive, Non-Polluting Degassing of Liquid Aluminium.

Some heats on fumeless degassing of aluminium melt were made with simultaneous use of NML Reactive Filter and varying amounts of degassing media. Metallographic studies of these samples are in progress.

5. Development of Filler Wire for MIG Welding of High Strength Aluminium Alloys.

Priliminary work is in progress.

6. Development of Aluminium base Bearing Alloys.

An Al base bearing alloy containing Pb (PM401) for floating bush type applications has been developed as substitute material for conventional class IV bronze bushes. The solidification technology for this alloy has been optimised on the laboratory scale production. The wear characteristic have also been studied. These bushes were fitted to Loco engines by RDSO, Lucknow; and the results have indicated that the performance is superior to the bronze bushes. RDSO has now evinced interest to produce this alloy on larger scale. Apart from floating bush this alloy may find other bearing applications as well. The process is ready for commercialisation.

F. MAGNETIC MATERIALS

1. Effect of Alloy Additions on the Stability and Magnetic Properties of Hard Mn-Al-C Alloys.

Study on Mn-Al-C alloys had indicated that good permanent magnet properties (isotropic) could be obtained in this system by suitable heat-treatment. However, the alloys were found to be very brittle and unstable. In order to overcome these difficulties, it was felt necessary to study the effect of alloying elements such as iron, cobalt and nickel on the stability and magnetic properties of these alloy. Work was conducted in this

direction and the alloy containing about 1.5 wt% iron was found to be quite stable as compared to the alloy containing no iron. Further work to improve the stability and magnetic properties is in progress.

2. Low Cobalt Magnetic Alloys.

During the period under review, a few heats of Fe-Cr-Co were homogenised at above 1200°C. The alloy samples were quenched and given thermomagnetic treatment and step tempering treatments for different durations. The alloys developed permanent magnet properties with remanence 3000 gauss and coercive force 550 Oe. Efforts are now being made to improve the properties, particularly the remanence by suitable heat treatment. Efforts are also being made for developing anisotropy in these alloys by deformation aging instead of the thermomagnetic treatment.

3. Manganese-Aluminium-Iron Alloys.

In order to scale up the technology for the production of soft Mn-Al-Fe alloys, a few 10 kg. heats were made. They were then hot forged, and hot rolled, suitably heat treated and tested for their electrical and magnetic properties.

This alloy was found to have low coercive force, high permeability and high resistivity and, therefore, can be used for both d.c. and a.c. applications in relay and transformer cores in place of soft magnetic iron and silicon steel.

4. Low Carbon Soft Magnetic Iron.

65 mm. square billets of soft iron, produced and processed in the industry as per NML's Know-how were supplied to Indian Railways & M/s Bharat Heavy Electricals Ltd. Bhopal; to meet their requirement.

G. HIGH TEMPERATURE CREEP RESISTANT STEELS.

1. Development and Testing of Creep Resistant Steels Produced Indigeneously for Thermal Power Plant Applications.

Sponsored by M/s Bharat Heavy Electrical Ltd.

A number of creep resistant steels produced indigenously for the first time in the country by several steel manufacturers for thermal power plant application are being investigated for high temperature creep behaviour with the ultimate objective of the substitution of imported grades of such steels. Currently, the following grades of steels are under long-term evaluation :—

Sponsor & Steel Grade	*No. of casts being tested*	*Producer*
BHEL (R & D)		
Bolting Steel		
1Cr-1Mo-$\frac{1}{4}$V (DIN-17240)	3	MUSCO
Superheater Tubing Steel		
(i) $1\frac{1}{4}$Cr-1Mo	6	MUSCO & ASP
(ii) $1\frac{1}{4}$Cr-$\frac{1}{2}$Mo	3	MUSCO (ASP)
(iii) 1Cr-$\frac{1}{2}$Mo	2	VISL
Casting and Forging		
(i) 1Cr-1Mo-$\frac{1}{4}$V (FOV)	9	CFFP (BHEL)
(ii) $\frac{1}{2}$Cr-$\frac{1}{2}$Mo (0.5 FO)	3	,,
(iii) 1.4Cr-1Mo-$\frac{1}{4}$V Forging	1	,,
(iv) 15 XM, 1Cr-$\frac{1}{2}$Mo	1	,,
(v) FOVD 8811	2	,,
(vi) 17Cr MoV 511	2	,,
(vii) 18Cr-Mo 910	1	,,
(viii) GS 22 Mo4	1	,,

As decided by the Indian Creep Panel, who is co-ordinating the various activities in this developmental work, top-most priority has been accorded to the evaluation of superheater tubing steel. On each of the grade of steel, the aim is to generate the data upto 33,000 hour for obtaining 100,000 hr. designed data by extrapolation. Indian Creep Panel has rationlized in total 21 grades of creep resistant steel so far which have to be evaluated.

2. Development of Nickel-free Creep Resistant Austenitic Steel.

Exhaust valves manufactured by M/s Engine Valves Ltd. Madras from NML's experimental alloys have been evaluated at M/s TELCO and the test results are very much encouraging. This has prompted to go for production of the steel at commercial/semi-commercial scale from which exhaust valves of different specifications will be manufactured for further trial by respective user. Arrangements are being made for making the commercial heat.

3. Steels for Short-term Evaluation.

During the period the following samples were received from different organisations for determining the specific properties:

Material	*Nature of investigation*	*Sponsor*	*Status*
(a) Air exhaust valves.	To determine creep properties under different test condition.	M/s DLW Varanasi.	Test completed and the report submitted.
(b) Boiler Plate	Metallurgical test as per Indian Boiler Regulation	S.B. Rice & Atta Mills, Kamrup, Assam	-do-
(c) Boiler tubes	-do-	M/s TISCO	-do-
(d) Welding Electrodes	Tensile and creep rupture tests.	M/s Advani-Oerlikon.	-do-

4. Estimation of Residual Creep Life of Thermal Power Plant Components.

NML has developed experimental technique for determining the residual creep life of components which has already undergone service life. The method is now increasingly used by the thermal power plant engineers and a number of investigations are currently in hand. The following samples are under investigation :—

(i) Steam pipe line which has already undergone a service life of 100,000 h-2 samples from Boiler No. 2 & 3 of Thermal power station, Neyveli Lignite Corporation.

(ii) Reheater tubes with running life of 40.000 h, Koradi Thermal Power Station, Maharashtra State Electricity Board.

(iii) Superheater tubes which has rendered service life for 100,000 h— Indian Oil Corpn. Gauhati.

(iv) Superheater tubes of Unit No. 5(50 MW) from Barauni Thermal Power Station, Bihar State Electricity Board, BSEB.

H. METALLURGICAL INVESTIGATION STUDIES ON FAILURE OF METALS & ALLOYS

	Name of the Project	*Sponsor*
1.	Metallographic Examination of stainless steel valves.	Shama Engine Valves Ltd., Bhopal.
2.	Metallurgical Examintion of CDS Tubes & Couplings.	Geological Survey of India, Calcutta.
3.	Failure of ID Fan of Tomlinson Recovery Boiler.	Bengal Paper Mills Ltd., Raniganj.

4.	Failure of Rotors.	Ukkai Thermal Power Station, Gujarat Electricity Board.
5.	Failure of Boiler Quality Plates.	ACC Vickers-Babcock Ltd., Durgapur.
6.	Failure of Angle Beam and Shackles.	National Hydro-Electric Power Corporation, New Delhi.
7.	Failure of Socket Clevis.	-do-
8.	Metallurgical Examination of Socket Clevis.	Electrical Manufacturing Co., Calcutta.
9.	Metallurgical Examination of Cement Mill Liner.	Satna Cement Steel Works, M.P.
10.	Metallographic Examination of Copper Rods.	Hindustan Transmission Products Ltd., Bombay.
11.	Failure of Condenser Tube.	Patratu Thermal Power Station.
12.	Metallurgical Investigation on the Failure of Heater Tube.	Indian Oil Corporation, Barauni.
13.	Metallurgical Examination of Gyratory Crusher.	Equipment & Sales Ltd., New Delhi.
14.	Failure of Reformer ID Fan Coupling.	Sri Ram Fertilizer & Chemicals, Kota.
15.	Super heater tubes (7 no.) from various zones from two boilers.	Patratu Thermal Power Station, Bihar State Electricity Board.
16.	Development of Coal Crushing Hammers.	Hariyana State Electricity Board.
17.	Failure of 32 MW Turbo Generator.	Panki Thermal Power Station, Kanpur.
18.	Metallurgical Examination of Hammer bits for Crushing Coal.	Barauni Thermal Power Station.

I. MECHANICAL WORKING & TESTING

1. Stainless Steel Clad Aluminium Sheet

A cladding process is being developed in which a thin stainless steel sheet could be roll-bonded to aluminium sheet with very little deformation of stainless steel layer thus providing the composite clad sheet adequate ductility. Optimisation of process parameters and standardisation are in progress

2. Development of Duplex Shear Blade

A thin layer of tool steel/high speed steel is bonded surface to surface with a thicker mild steel plate, the thin tool steel layer acts as a cutting edge after heat-treatment, sharpening and finishing and the mild steel portion as a backing supporting plate. This duplex shear blade is economical as very little quantity of costly steel is used for its manufacture.

Some more heats of Fe-Cr-V, Fe-Cr-V-Mo and high carbon steel were made, rolled to thin sheets and finally roll-cladded to thicker plate. The appropriate heat-treatment schedule for the composite has been developed. The process is being standardised and samples for industrial trials are under preparation.

3. Forging of Ferrous Powder Metallurgy Parts

Several green compacts of different sizes were made with the compaction pressure as standardised in earlier experiments. The compacts were then sintered under controlled atmosphere and then forged. Deformation of about 40-50% was given during forging. The hardness and the tensile properties of the products were determined and the results were found within the acceptable range. Parts like cylindrical bushes were made, sintered and forged, utilising the standard techniques.

4. Production Technology of Electrical Contact Materials.

Contact materials containing cadmium upto 10% were completed earlier. To develop contact materials having 12 and 15% Cd, several heats were made. The cast slabs were rolled to different thickness. Internal oxidation heat-treatment schedule was studied and standardised on small samples cut from rolled sheets.

Further work on incorporation of thin layer of pure silver on the one surface of silver cadmium alloy sheet is in progress.

Several heats containing different proportions of silver, copper, cadmium, zinc and nickel were made. The cast slabs were subjected to heat treatment prior to rolling. The slabs were reduced to different gauges as per standard specification.

5. Development of Silver base Brazing Alloys. *Sponsored by Mls. Laxmi Traders, Calcutta.*

Work was undertaken to develop 14 alloy compositions needed by the party. Two compositions have been produced and the alloys have been used for joining contacts to the contact assemblies.

6. Development of Silver base Contact Materials. *Sponsored by M/s. Laxmi Traders, Calcutta.*

The firm desires to develop various silver base contact materials such as Ag-Ni (four compositions), Ag-W (three compositions), Ag-Mo (three

composition) and Ag-graphite (three compositions) by powder metallurgy and mechanical working technique.

Work has been started with silver-nickel group. The important parameters like compacting load, sintering temperature to achieve the specified conductivity have been established for two compositions. Work on other compositions is in progress.

7. Development of Ni-Cr and Ni-Cr-Fe Alloys. *Sponsored by M/s. Fort Williams, Ltd. Calcutta.*

Work has been started with Ni-Cr-Fe alloy. Few heats were made. The ingots were dressed and forged to 1″ square bar. Further work is in progress.

8. Mechanical Working & Testing Facilities

Tensile, compression, Olsen ductility, torsion, load elongation, hardness, Charpy impact and calibration tests of Universal Testing Machine were carried out for the Laboratory as well as for the outside parties.

The machanical working facilities namely rolling, forging, extrusion and wire drawing were extended to the various projects of the Laboratory. Different sections, of the aluminium-magnesium alloy and magnesium base alloy were extruded for Indian Space Research Organisation.

J. FOUNDRY TECHNOLOGY

1. Product Substitution with NML Pyroloy 1000.

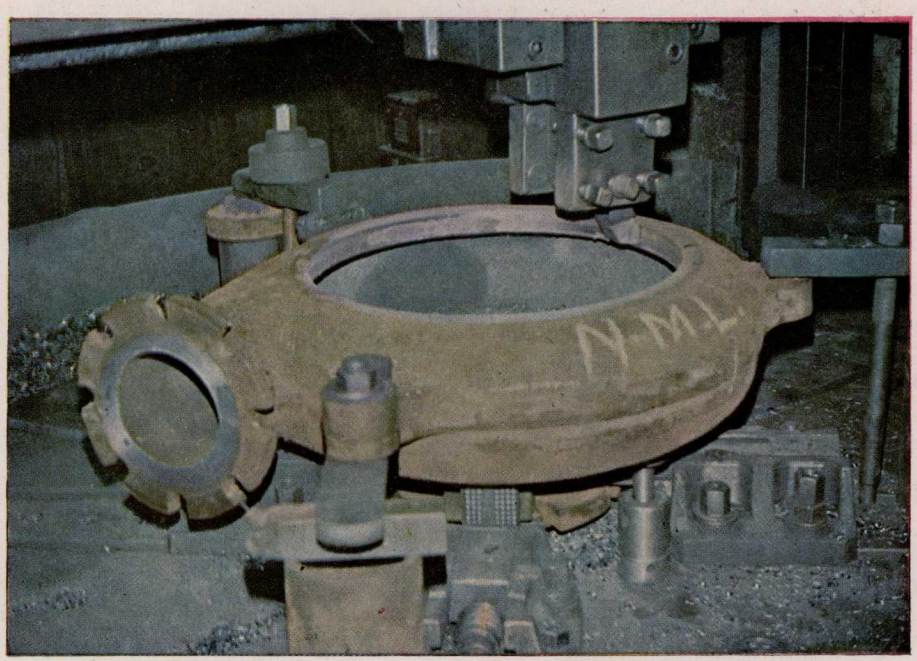
NML Pyroloy-1000 is undergoing industrial evaluation trials for various applications mentioned below :

(*i*) *Carrier Blade Castings for Reheating Furnaces*

Carrier blade castings are employed in the sheet bar reheating furnaces at Tisco Ltd. in their sheet mill. 500 no. of such castings made with NML-Pyroloy-1000 were installed in their reheating furnace for full scale evaluation test. These castings were fitted on 20th Sept. 80. About 200 carrier blade castings of NML-Pyroloy 1000 were removed after one year of service and are being evaluated. These 200 castings were in good condition after the trials.

(*ii*) *Element Pins for Electric Heat Treatment Furnaces*

Element pins made from NML-Pyroloy-1000 were fitted in the GEC electric heating furnace No. C and No. A at the Field Gun Factory, Kanpur. It was reported that NML-Pyroloy-1000 pins are giving excellent service and are in good condition under continuous use.



Slurry pump casing made from 'NML WEAR-NOT' under machining at Mining & Allied Machinery Corporation, Durgapur; for evaluation trials.

(*iii*) *Grillage Link Castings for Walking Beam Furnace*

Twelve no. of Grillage Link castings were sent to Rourkela Steel Plant for industrial evaluation trials. 6 no. of the castings were put for trials in the stationary hearth area of the ESM Walking Beam Furnace. The castings were found in very good condition and free from any scale after six months of use at 850°C. Now it is proposed to continue the trials in the moving hearth area of the furnace at 950°C for evaluation.

(*iv*) *Spacer Castings for Gas Carburising*

In plant trials of spacer castings of different designs and sizes for gas carburising at 920°C of automotive components are being carried out at M/s. Telco Ltd., Pune in their heat treatment shop. M/s. Telco have reported that NML-Pyroloy 1000 spacers are giving very satisfactory service and they are interested in carrying trials with heavier castings.

(*v*) *Finger Castings for Pipe Normalising Furnace*

Seven finger castings eash weighing 7 kg. made from NML-Pyroloy-1000 were fitted in the pipe normalising furnace at IISCO-Stanton Ltd., Ujjain, for inplant trials. It has been reported that NML-Pyroloy-1000 finger castings are giving excellent service compared to Cr/Ni alloy fingers. M/s. IISCO-Stanton Ltd., are showing keen interest in NML-Pyroloy-1000 and evaluation trials are being continued.

2. Coke-less Cupola

To substitute foundry grade coke normally used for cupola by other fuels like pulverised coal, blast furnace gas, natural gas etc., a small 8″ internal dia. cupola was designed and fabricated for cokeless operation. The cupola was successfully operated in several experimental trials. Foundrymen are showing keen interest and it is proposed to scale up the coke-less cupola to pilot plant size for further studies.

3. Development of Know-how regarding Special Casting Methods

Preparation of silca sol, which is used as a binder for the preparation of slurry for investment castings is proposed to be tried employing ion exchange techniques. This involves standardising the conditions of the process for large scale production of silica sol.

4. Wear & Abrasion Resistant Cast Iron

Further to the discussions on evaluation trials of NML-WEARNOT at Mining & Allied Machinery Corporation Ltd., (MAMC) Durgapur ; the following castings were made at MAMC steel foundry, from heats in their 4 ton electric arc furnace.

(i) Parts of slurry pump.
(ii) Parts of hydrocyclone
(iii) Peripheral liner for coal mill exhauster.

The following observations were made—

(1) NML-WEARNOT can be easily melted in an electric arc furnace to achieve desired composition and temperature control.

(2) The casting characteristics of the alloy are satisfactory providing good flowability and surface finish.

(3) The castings of the alloy also have as cast hardness suitable for machining as required for some of the components of slurry pump.

(4) The alloy possess high hardness suitable for wear resistant materials.

Some of the components cast with the NML alloy are with MAMC Durgapur and some were sent to Chandrapura Thermal Power Station, DVC, Chandrapura; for performance evaluation.

K. CORROSION STUDIES ON METALS & ALLOYS

1. Studies on Atmospheric Corrosion of Metals and Alloys : An International Project between N.M.L. and N.R.I.M., Tokyo

During period under review, the properties of rust developed on plain carbon and low alloy steels after the exposure period of one year have been studied. X-ray diffraction analysis and the examination of the rust through scanning electron microscopy has revealed growth morphology of the rust formed on mild steel and low alloy steel surface. Corrosion rates of the various metals have also been determined. Metals exposed in coastal environment showed greater rate of corrosion.

2. Studies on Inhibitor for Continuous Pickling Operation.

Steel plants having continuous pickling line use higher concentration of acids and greater temperature for quick pickling process matching with the speed of operation. Suitable inhibitors for such operation are not available and at present proprietory imported compounds, meant for lower concentration and temperature of pickling solutions, are only used. Studies on this line have been initiated at the N.M.L. and a suitable formulation has been developed. The developed formulation has shown inhibitor efficiency of 95 to 98% for pickling of steels in 25% H_2SO_4 solution and at temperatures upto 110°C.

3. Effect of Cold Work on Hydrogen Absorption.

Hydrogen absorption in steel during pickling in acid solutions has been studied and the results reported earlier. During the period under review, influence of plastic deformation on hydrogen absorption in acid solutions at various temperatures have been studied. It has been noted that with the increase in temperature concentration of acids and plastic deformation, hydrogen pick up in steel also increases with abrupt rise above 40% C.R. It has been noted that di-phenyl-thiourea being a good inhibitor is not effective to reduce hydrogen pickup.

L. SURFACE COATING ON METALS

1. Development and Performance Evaluation of Diffusion Treated Steels in Fertilizer Chemical Industries (*Collaborative Project between NML and Fertilizer (P & D) India Limited, Sindri*).

The collaborative project was undertaken with a view to evaluate the performance of aluminium diffusion treated M.S. tube materials as heat exchangers with special reference to sulphuric acid plants. Such diffusion treated steel tubes are being used in sulphuric acid plants abroad and it is reported that the service life of such tubes is increased by a factor of atleast 10 compared to plain carbon steel tubes.

NML had supplied in the first phase of the programme tube sections calorized as desired by Fertilizer (P & D) India Limited, Sindri; for evaluation, in actual service conditions. The diffusion treated steel tube sections have a coating thickness of about 100μ with an average Al-concentration of 40% approximately. The samples were placed in the stream of oil burnt gases containing SO_2 and it was reported by F.P.D.I. that the diffusion treated steels are about ten times more corrosion resistant than plain carbon steel under the same conditions.

A number of experiments were carried subsequently with a view to evaluate the effect of temperature and composition of the pack mixture on the coating uniformity and texture of coated samples. It was observed that an active pack containing aluminium and ceramic grog brings considerable dimensional changes in the samples which is not desirable in the case of tubes. Hence, experiments were conducted using iron-aluminium alloy of optimum composition so as to yield satisfactory thickness of diffusion zone and adequate Al-concentration. Experiments are in progress and another batch of samples are planned for evaluation under actual plant conditions.

2. Silver Plating from Non-cyanide Bath

Experiments carried in non-cyanide silver plating revealed the possibility of depositing silver in an acceptable form from non-cyanide baths ranging in PH 4.5. to 5.5. The process has a good potential in replacing the toxic conventional cyanide baths.

3. Electrolytic Colouring of Aluminium and its Alloys.

Commercially availably aluminium and some of its alloys like Al (2S) and Al(3S) were electrolytically coloured by a two stage process, i.e. D.C. anodizing and A.C. colouring in various salt solutions. The resultant colours are fast and resistant to sunlight. They vary from yellow, pink, green, deep red to black. Such coloured aluminium and aluminium alloy products have a potential in the field of architecture, industry and utulization of solar energy. Further experiments are being planned for exposure of coloured panels under actual atmospheric conditions.

4. Hard Chrome Plating.

Work is under progress in optimizing the conditions for obtaining very hard chromium deposits on steel with good cathode efficiency using especially low concentration baths.

M. STANDARD REFERENCE MATERIALS & ANALYTICAL WORK

1. Preparation of Standard Reference Materials.

Replenishment of plain carbon steel samples was taken up. A set of eight samples of different compositions were melted and composition of each melt was determined. Further work on homogenising treatment is underway.

Preparation of Low alloy steel samples was completed and ready for sale.

2. Analytical Work

(*i*) *Chemical Analysis*—1594 samples were analysed for 5540 radicals.

(*ii*) *Spectrographic Analysis*—125 samples were completely analysed.

(*iii*) *X-ray Fluorescence Spectrometry*—509 samples were analysed for 998 radicals.

(*iv*) *Analysis of Gases in Metals*—123 samples were analysed for 404 radicals.

N. APPLIED BASIC PROJECTS

1. Solidification from Two Phase Field of Aluminium alloys.

In continuation of the previous report the studies have revealed that

(i) The precipitation kinetics of Al-Cu and Al-Zn-Mg alloys solidified from the two phase field show accelerated ageing behaviour as compared to identical alloys cast in conventional manner.

(ii) The ingot produced by two phase solidification has finer equiaxed grain structure.

(iii) Uniform dispersion of Pb, graphite and SiC in the matrix of Al-Si and Al-Si-Cu-Ni-Mg bearing alloys can be obtained. The alloys so produced were found to have better wear resistance and thermal expansion characteristics as compared to the normal alloys and therefore would be suitable for bearing applications. This project is complete.

2. Grain Refinement of Wrought Aluminium Alloys.

Further studies on recrystallization kinetics were carried out on Al-1.25% alloy plates subjected to modified heat treatment schedules. Metallographic

studies are in progress. Metallographic studies to determine factors limiting high temperature plasticity in Al-Cu-Zr alloy are in progress.

3. Fracture Studies on High Strength Aluminium Alloys.

Fracture toughnesses of a number of Al-Cu & Al-Zn-Mg alloys containing Li with graphite dispersion were studied using 3 point bend specimens. The experimental results indicated that fracture toughness of graphite dispersed alloys are better and that the values depend on grain size. The project is basically aimed at understanding the fracture behaviour of Al alloys. The project is complete.

4. Effect of Super Saturation on Structure and Properties of Aluminium Alloys Containing Mn, Mg, Zn etc.

A cooling technique has been developed by adopting which primary super saturated solid solution upto 60% Mn, in Al could be attained.

On reducing the cooling rate solid solubility proportionality decreased until an equilibrium state that is an alloy containing Mn upto 100% in solid solution is attained.

Structural stability on annealing indicates that the single phase alloy containing solute more than equilibrium concentration is stable upto 350°C producing greater strengthening properties. Precipitation kinetics of the secondary phase is under study by point counting and X-ray quantitative analysis techniques besides hardness measurement.

5. Structure of Extracted Inter-metallic Phases formed during Thermal Conditions in Aluminium Alloys Containing Mn, Fe, Si.

Six alloys with different Fe, and Si percentage to Al-Mn systems were made. These were chill cast, furnace cooled and splat cooled conditions i.e. at three different cooling rates.

Phases were extracted electrolytically in oxime bath. Extracted phases thus obtained are being identified by X-ray diffraction techniques. Metallographic study is also in progress.

6. Studies on the Corrosion Inhibition Mechanism using Radioactive Tracers.

During the period under review, the studies on the effect of borate on the inhibition efficiency of chromate were completed using a new radiotracer technique developed.

The studies on film growth on mild steel immersed in the mixture of inactive and active Na_2CrO_4 solutions containing different proportions of Na_2CrO_4 and borate saturated with purified nitrogen at 30°C, were carried out for different immersion periods.

Variation in open circuit potential of mild steel with time in the same Na_2CrO_4 solutions containing different proportions of Na_2CrO_4 and borate, was also recorded to throw light on the behaviour of oxide film formation on mild steel surface.

Using the same developed technique further work on the project—Studies on the effect of polyphosphate, silicate, nitrite and Zn^{++} on Cr-film growth on mild steel is in progress.

NML UNIT IN CSIR COMPLEX, MADRAS

The unit completed successfully several important sponsored investigations such as, pelletisation studies on Kudremukh iron ore concentrate ; beneficiation studies on tourmaline-kyanite sample from Maharashtra Minerals Corpn., studies on silica sand from Aroor Udyog ; bench scale beneficiation on coal samples from Ennore Thermal Power Station ; grindability studies on abrasive samples from Cutfast Abrasive Tools (F) Ltd., bench scale beneficiation studies on a low grade graphite sample from Sivaganga ; investigation on ferrous sulphate treatment procedure as related to protection of condenser tubes etc. The NML Madras Centre has undertaken chemical analysis, metallographic, mineralogical studies on various samples received from outside paeties as also for the R & D programmes.

Exposure studies of samples received from Japan under the project of NML-NRIM Collaboration on atmospheric corrosion are continuing.

A brief resume of the various projects and activities is furnished below.

1. Pelletisation Studies on Kudremukh Iron Ore Concentrate

Detailed pelletisation studies, as per the guidelines given by MECON, were conducted on Kudremukh iron ore concentrate at the instance of Kudremukh Iron Ore Company Limited and MECON. The work involved bench scale pelletisation tests and heat hardening trials at different variables as well as large scale pelletisation at selected parameters and heat hardening trials in pot grate furnace. Heat hardening and reducibility tests and swelling indices and porosity measurements were conducted on Kudremukh iron ore concentrates.

2. Beneficiation of Silica Sand. *Sponsored by M/s. Aroor Udyog, Mangalore.*

A silica sand sample assaying 96% SiO_2, 0.5% Fe_2O_3, 0.35%, TiO_2 and 2.45% Al_2O_3 was received for making it suitable for glass manufacture. A final product analysing 98.3% SiO_2, 0.011% Fe_2O_3, 0.06% TiO_2 and 1.56% Al_2O_3 was obtained through beneficiation studies. This product conformed to grade specifications for Grade I glass manufacture as per IS 488-1963.

3. Grindability Studies on Three Abrasive Samples. *Sponsored by M/s. Cutfast Abrasive Tools (P) Ltd., Madras.*

Three abrasive samples were received for determination of their grindability characteristics. The tests were conducted as per the procedure developed by Denver Equipment Company, Colorado, U.S.A. The results were furnished to the party.

4. Beneficiation of Coal from Ennore Thermal Power Station.

Bench scale beneficiation studies were conducted on coal samples (lumps as well as pulverised) from ETPS with a view to bringing down their ash contents. The lump sample as received assayed 34.6% Fixed Carbon, 27.09% ash and 32.7% V.M. whereas pulverised coal which is the actual feed to boilers assayed 26.01% F.C., 40.88% ash and 29.44% V.M.

Studies on lump sample showed that gravity method could not be adopted for beneficiating the sample and that the sample had to be ground to fine size for flotation. Subsequent flotation trials on pulverised coal yielded a concentrate analysing 41.32% F.C., 22.05% ash and 33.12% V.M. representing a recovery of 87.4% F.C. in it.

5. Bench & Pilot Plant scale Beneficiation Studies on a Low Grade Graphite from Sivaganga, Tamil Nadu. *Sponsored by M/s. Tamil Nadu Minerals.*

At the instance of Tamil Nadu Minerals Ltd. (TAMIN) bench scale beneficiation studies were made on graphite sample from Sivaganga area of Ramnad Dist., Tamil Nadu. The sample as received assayed 13.5% F.C. A final graphite concentrate analysing 87% F.C. with a recovery of 81% F.C. in it was obtained. This product fulfilled the grade requirements for crucible manufacture.

Consequent on the successful conclusion of the bench scale beneficiation studies on a 300 Kg graphite sample M/s. TAMIN has sponsored a pilot plant scale investigation on a 50 tonne sample. The work on the same is in progress. Based on the recommendations M/s. TAMIN is planning to set up a 100 TPD plant at Sivaganga.

6. Beneficiation Studies on a Tourmaline - Kyanite Sample. *Sponsored by M/s. Maharashtra Minerals Corpn. Ltd., Bombay.*

Beneficiation studies were conducted on a tourmeline-kyanite sample from M/s. Maharashtra Minerals Corporation Ltd., to reduce its tourmaline content. The sample contained 75% Kyanite, 10% tourmaline and 10% micas. A 1st grade concentrate assaying 2-3% tourmaline and 95% Kyanite with a weight recovery of 51.4% and a 2nd grade concentrate assaying 4-5% tourmaline and 90% Kyanite with an additional weight recovery of 14.3% were obtained. High intensity magnetic separation of the concentrate (2-3% tourmaline) yielded a product almost completely free from tourmaline.

7. Recovery of Mineral Values from Slimes and Flotation Tailings.

(*i*) *Studies on Copper Tailings from M/s. Hindustan Copper Ltd.*

Tests were performed using mixture of anionic collectors, under hot conditions for flotation of chlorite and other oxide copper minerals present if any.

Tests were also performed in which the primary tailing was agitated with HCL, slime removed and the sand was subjected to froth flotation using oleic acid-sulphonate for flotation of chlorite, followed by xanthate for sulphide flotation.

(*ii*) *Studies on Carbon-cryolite Dust Sample from HINDALCO*

Flotation tests were completed.

(*iii*) *Studies on Magnesite Fines*

Magnesite fines of Salem analysing less than 3% SiO_2 were subjected to agglomeration techniques using pelletisation to produce agglomerates of suitable size and strength for dead burning. Starch, dextrin and molasses were experimented as binder and the pellets produced using dextrin yielded best results. Light calcination studies were conducted on pellets in a muffle furnace and the pellets produced retained their shape and were free from cracks.

15 Kg of magnesite pellets were made and despatched to Belpahar Refractories, Salem, to study their behaviour in a rotary kiln.

8. Extraction of Copper from Chitradurga Copper Concentrate. *Sponsored by M/s. Chitradurga Copper Corpn., Karnataka.*

Acid pressure leaching of chalcopyrite with oxygen was investigated at the instance of Chitradurga Copper Corpn., Karnataka. Various factors such as oxygen pressure, temperature, time, excess concentrate over stoichiometric acid requirement etc were studied. A shorter leaching cycle of 4 hr with excess concentrate and recovering the excess concentrate by flotation for recycle is being attempted. Recovery of elemental sulphur either by hot filtration or dissolution using organic solvents is also being investigated.

9. Development of a Fluosolid Reactor for the Calcination of Limestone.

As a preliminary step a fluid bed dryer to dry washed sands has been designed and given for fabrication. Trials will be commenced when the dryer is received after fabrication. Detailed drawing of the perspex model of multistage calciner is being made to study the flow of the materials.

10. Studies on Samples of Sand for their Suitability for Glass Making and Foundry Moulding Purposes. *Sponsored by M/s. Maharashtra Minerals Corpn., Ltd., Bombay.*

After the preliminary studies on 6 selected samples 3 samples were taken up for detailed studies for their suitability for glass making and foundry moulding purposes. Eventhough the silica content of the samples were of glass grade, the sieve analysis was found to vary slightly from that of the glassgrade. Also, blending studies were conducted on these samples to suit the specification requirements of certain consumers using the material in bulk quantities. The different blended fractions are being

studied for their silica content, specific surface area and coefficient of angularity.

11. Dry Scrubber for Sand Reclamation. Inter-Laborotory Project.

Based on the work conducted on the core scrap samples of M/s. Ennore Foundries Limited, Madras, the Inter-Unit project with MERADO for the fabrication of the prototype dry scrubber has made progress by way of the fabrication of the rotating table, impeller, bearing housing, barrier plate and stationary teeth which is completed. The assemply of the scrubber is underway and is expected to be completed soon for trials.

12. NML—NRIM Japan, Atmospheric Corrosion Collaborative Project

Results of 2nd year exposure tests of NRIM samples are under evaluation. The performance of the samples was in general the same as reported during the first year. Metereological and atmospheric pollution data were continuously recorded. Assessment of the Indian samples is under progress.

13. Studies on Ferrous Sulphate Injection for Prevention of Corrosion of Condenser Tubes in Ennore Thermal Power Station, Madras.

The study covers effect of P , temperature, amount of ferrous sulphate to be added and frequency of closing. An electrochemical set up was made to study the corrosion behaviour of Al-brass condenser tubes by potentiostatic polarisation method.

Preliminary studies indicate that the general corrosion of Al-brass was little high due to polluted sea water. Presence of excessive solids and deposits contributed to the pitting type of attack. The effect of ferrous sulphate in reducing the local corrosion by way of film formation is under study.

14. Chelating Agents as Collectors for Sulphide Minerals.

The reaction between the chelating agents and the mineral surface was studied by using spectrophotometric methods, by measuring heats of adsorption and by calculating free energy of adsorption from adsorption data for both $CuFeS_2$—oxine and $CuFeS_2$—Cupferron systems. A measured quantity of chalcopyrite mineral was treated with the reagent solution, filtered dried and this mineral was again treated with chloroform, where the metal reagent complexes will dissolve and give definite colours and these colours were compared with the bulk complexes dissolved in the same solvent. The extracted compound U.V. and visible spectrum was in close agreement with the bulk complex spectrum. For this, surace extracted compound IR spectra was also drawn and observed the absorption band at 9.0 microns which is a characteristic band for metal oxine chelates.

15. Zeta Potential and its Correlation to Floatability of Sulfide and Oxide Minerals

The work is primarily a study of flotation of fine particles of sulfide and oxide minerals with different collectors including a chelating agent, oxine. Zeta potential measurements were found to have an excellent correlation with flotation studies, for the various P_H and concentration values studied. In the present work chalcopyrite and magnesite were tried with various collectors.

16. Electroflotation of Chalcopyrite Fines

In continuation of the earlier work on electro-flotation of chalcopyrite fines with the reagents potassium ethyl xanthate and sodium diethyl dithiocarbonate, basic work like examining the surface products, collector adsorption on the surface of the mineral was studied.

17. Studies on Leaching of Chalcopyrite with Potassium Persulphate as a Leachant

The leaching of chalcopyrite concentrate with potassium persulphate was studied both in the absence and in the presence of solvent for sulphur. The effect of variables on the rate of reaction was studied and analysed kinetically. From the kinetic results, the activation energies, and the order of the reactions were calculated. Mathematical model was developed to explain the mechanism of the reaction.

18. Heat treatment, Metallographic Studies, Mineralogical Studies, Analysis, Calibration of Thermocouples, Refractory Testing Etc.

The unit conducted the above work on behalf various industrial units and organisation. Mineralogical studies were conducted on samples of ores and minerals received for beneficiation investigation. 47 ferrous and non-ferrous alloys were studied evaluating their micro-structure. 43 cases of failure of metal components during service or processing were investigated. 45 Cr/Al thermocouples were tested for this accuracy and test certificates furnished to concerned parties. 517 samples for 2008 radicals were analysed for various industries and units R & D programme. Refractory tests were conducted on behalf of two firms.

NML FIELD STATIONS AT HOWRAH, BATALA & AHMEDABAD

During the period under review, the Field Stations had rendered technical services to the engineering and foundry industries in and around their respective locations.

These services comprised of mechanical testing and chemical analysis (both qualitative and quantitative) of various metals and alloys as well as minerals, testing of foundry moulding sands and bonding clays, etc. on the spot study of foundry shop floor problems on various types of products and their remedial measures, improvement in quality according to the stringent specifications and export purposes etc.

A comprehensive statement of the work done by the three field stations during the period is furnished below.

	Howrah	*Batala*	*Ahmedabad*
I. *Chem. Analysis*			
(a) No. of samples	650	151	437
(b) No. of radicals	1937	370	1378
II. *Mech. Testing*			
(a) No. of samples	335	13	—
(b) No. of tests	335	13	—
III. *No. of Tech. enquiries*	48	210	19
IV. *No. of Foundry visits*	12	117	—

In addition to the above, the Howrah F/s had conducted two metallographic tests on two samples and the Batala F/s conducted eight metalllographic tests on eight samples.

The Batala F/s had conducted 65 investigational work on sand and four tests on four sand samples.

The Ahmedabad F/s had conducted three tests on two sand samples.

DESIGN ENGINEERING

Design work undertaken during the period related to :

1. Design of an atomizer for water atomization of molten metals.

2. Design of an absorption tower for ammonia recovery for a licencee at Ranchi.

3. Design of apparatus for preparation of thin films for examination in the scanning election microscope.

In addition to design work, the design office also provides tracing and reprographic services for the Laboratory.

MECHANICAL ENGINEERING

The workshop provides services for fabrication of appratrus and equipment for metallurgical research, preparation of test specimens, mechanical maintenance of equipment, patterns and other wooden equipment and maintenance of vehicles.

ELECTRONICS ENGINEERING

A. Instrumentation of projects :

(*i*) *Mineral Processing*

Two temperature recorders, one flow recorder and one P_h meter were serviced, repaired and recommissioned.

(*ii*) *Sponge Iron*

One thermocouple test set, six temperature indicating controllers were repaired and recommissioned.

(*iii*) *Instrumental Analysis*

Pye Unicam Atomic Absorption Spectrophotometer, Philips X-ray fluorescence Spectrometer and Carl Zeiss Spectrophotometer were serviced, repaired and recommissioned.

(*iv*) *Hydro-electrometallurgy* (*HEMP*)

AIMIL gas chromatograph was serviced and recommissioned.

B. General Maintenance, Installation, Calibration and Testing Jobs Completed (Major Jobs) :

1. Philips Electron Microscope EM 400
2. Derivatograph (DTA equipment)
3. Gas Chromatograph
4. Proportional Counting System
5. X-ray Diffractometer
6. X-ray Recorder
7. Potentiometric Recorders (15 Nos.)
8. Temperature Controllers (30 Nos.)
9. Potentiostat
10. Vibrophore

ELECTRICAL ENGINEERING

A. Development Work

(*i*) *Development of Arc Plasma Technique for use in various Metallurgical Processes.*

A fully stabilized a.c. arc plasma of 50 KW was produced in an indirect arc furnace available in the Laboratory. Plasma zone of 150 mm was obtained with the flow of 10-15 litre argon per minute. Behaviour of voltage—current characteristic of the plasma was studied and saving of power and electrode in plasma melting was established. Design parameters for an appropriate plasma reactor were assessed. Design of a reactor was carried out and its fabrication is under progress.

(*ii*) *Design and Building of 3-Zone Isothermal Electric Resistance Furnaces for Creep Testing Machines.*

Refractory tubes, insulating materials, stainless steel sheets were procured. Twenty-furnace shells of stainless steel with Syndanyo board-end covers were fabricated. Durable and reliable power terminals with suitable covers were also fabricated. Insulating material granules were graded. Further wo k is in progress.

(*iii*) *Extraction of Magnesium in a Single Electrode Electric furnace.*

High current and low voltage bus bar system and central power control system were designed and their installations were carried out.

B. Establishment of Special Facility for Melting and Smelting.

Installation of a 350 KW—graphite rod resistor furnace was carried out. The furnace was commissioned. Trial melts of 750 Kg each were conducted in order to assess the performance of the furnace.

C. Design of Power Distribution Systems, Preparation of Detailed Specifications and Layout, Installation and Commissioning.

Design of power distribution system and control system in respect of the following major jobs were carried out. Their detailed specifications and layouts were performed. Execution of installation and commissioning were planned.

(i) Installation of power supply system of Magnesium furnace.

(ii) Electrical installation of roll crusher, ball mill etc.

(iii) Installation of power supply system of water pumps split furnace, air conditioning blower etc.

(iv) Installation of power and lighting distribution boards in the Main Building.

(v) Design of distribution panel with multitier units for the Creep Laboratory power supply system.

(vi) Electrical installation of Jigger Jolley, air compressor, hot mixer at Dense Carbon Pilot plant.

(vii) Providing earthing stations for the sub-station equipments and neutral earthing of transformers.

(viii) Dismantling and re-installation of 450 KW Bastain Allen Electrode Boiler.

(ix) Rewiring after dismantling of old unserviceable wirings of type IV quarters at Tuilandurgi.

(x) Rewiring after dismantling of old unserviceable wiring of Type IV flats and C Type bungalow at Pipe Line road.

D. Preventive Maintenance and Break down Repairs.

Scheduled preventive maintenance and replacements, planning and execution of proper inspection and monitoring of various critical components while in service and fault shooting and repairing were carried out for the electrical equipment of the laboratory, its pilot plants and residential areas, comprising of high frequency furnace, resistance furnaces, rectifiers, electric motors and their control centres, temperature and humidity control equipment etc. Some of the major jobs are enumerated below ;

(i) Modification of rolling mill control system with a view to use indigenous parts as the original imported ones have become unserviceable.

(ii) Rectification of defect in closing mechanism of 6600 volts oil circuit breaker of 500 KVA ferro alloy furnace.

(iii) Preventive maintenance and rectification of troubles in automatic-on-mains failure diesel generator set.

(iv) Testing of dielectric of oil of various power transformers and tapping of oil to the required level.

(v) Preventive maintenance of 6600 volt oil circuit breakers and control panels of 500 KVA direct arc furnace.

(vi) Scheduled preventive maintenance of electric drives and control gears of various central air conditioning plants.

E. Forecasting and Procurement of Spare Parts.

Forecasting and procurement of spare parts with regard to power distribution systems, temperature and humidity control systems, melting facilities, metal testing facilities, pilot plants etc. were carried out.

CIVIL ENGINEERING

Work Completed

1. Providing new service lines and replacement of damaged service lines at various places at NML.

2. Removal and replacement of toilet and bath room fitting etc. at NML.

3. Re-Painting of road surface in pilot plants, FPTD, MBPP.

4. Modification of drainage system at terrace of NML.

5. Replacement of broken glass pans in NML Building and its pilot plant.

6. Construction of overhead watertank at Dense carbon plant.

7. Replacement of damaged doors at Foundry Field Station.

8. Painting of gas main line and supporting structures.

9. Painting white washing etc. of NML Building.

10. Protection against corrosion of M.S. Reinforcement in RCC Roof of NML Buildings.

11. Periodical painting and white washing of type 'IV' Qrts. at Pipe Line.

12. Raising the compound wall at back of New 'D' type Qrts. at Agrico.

13. Construction of drain in front of NML Flats at Pipe Line Road.

14. Making brick tree guards at Tuiladungri and Agrico Colony, NML.

15. Replacement of damaged rain water/soil pipes and fittings for staff Qrts.

16. Periodical Painting and white washing of 8 No. Staff. Qrts. at MCRS.

17. Construction of Cycle shed and improvement in the 42 No. type I Staff Qrts. at Tuiladungri.

Annual Plan 1982-83

The Annual Plan for 1982-83 comprising Revised Budget Estimates for 1981-82 and Budget Estimates for 1982-83 was formulated on the basis of the requirements under ongoing and new research projects, international collaborative projects, pilot plant studies, institutional programmes, infra-structural facilities, etc.

The document includes a brief review of the achievements during 1980-81, major accomplishments expected in 1981-82, areas of major thrusts planned in 1982-83, etc.

Sixth Five Year Plan Projection

Project-wise planning and programming of Research and Development work and the inputs that would be required during the Sixth Five Year Plan covering the period of five years from 1980-81 to 1984-85, have been reflected in the document.

The major thrust in the sixth Five Year Plan projection would continue to be on the proposals as given below :

(i) Mineral Beneficiation.

(ii) Development, Testing and Evaluation of High Temperature Creep resistant steels;

(iii) Extraction of Non-Ferrous metals and Minerals;

(iv) Development and Testing of Refractories;

(v) Development of Aluminium and Light alloys technology;

(vi) Melting and Metal Working Facilities for steels and special steels etc.

The proposals envisage foreign/U.N.D.P. assistance in some of the areas.

Research Appraisal Activities

The Research Advisory Council at its meeting held on 1st and 2nd Sept. '81 reviewed the recommendations of the various Research Advisory Panels which were constituted with experts to make in-depth study of the R&D programme under each discipline.

Based on the final review by the R.A.C. the necessary follow-up actions have been initiated.

Collaboration with SAIL

The Laboratory was represented on a number of working Group meetings to identify projects for collaboration between NML and SAIL under the CSIR—SAIL collaborative Programme. Several Projects have been identified for interaction with SAIL.

Co-ordination Council Meetings of the Engineering Group of Laboratories

During the period four meetings were held under the Chairmanship of Prof. V. A. Altekar Director, at NML; CSIR, New Delhi; NAL, Bangalore and C.B.R.I.—Roorkee.

The Co-Ordination Council Meeting held at CSIR was addressed by Prof. Nurul Hasan, Vice-President, CSIR. The C.C. meeting held at NAL, Bangalore, was addressed by Dr. G. S. Sidhu, D.G., SIR and Dr. C. V. S. Ratnam, Expert in Technology Transfer & Counterpart Administrator, Regional Centre for ESCAP.

During the addresses, the importance of collaborative programmes and the role and functions of the Engineering Group of Laboratories were stressed.

Projects of national importance were reviewed and new proposals were identified for collaboration among the engineering group of laboratories taking into consideration the resources available in various laboratories. Besides inter-lab collaboration, inter-agency collaborative projects were also identified for inter-action with agencies outside the CSIR organisation.

Transfer of Know-how

A. The following technology transfer was effected

1. Process know-how on production of air atomised extra fine non-ferrous metal Powders (Process released through NRDC)	M/s. Fort William Co. Ltd., Calcutta	The Process Know-how document has been given. Demonstration cum training is to be implemented

Lumpsum premium : Rs. 5,000/-
Recurring Royalty : Rs. 100/- tonne
Nature of licence : Non-exclusive
Period of licence : 14 Years.

2. Blue prints of the design of equi-blast cum balanced blast cupola, as designed by NML, were given to the following three parties. Fees charged Rs. 250/- each party.

1. M/s. Saraswathi Foundry Works, Saharsa, Bihar.
2. M/s. Sorath Industries, Rajkot-2.
3. M/s. Ganpule Metal Corpn., Morvi.

3. Assistance was rendered to M/s Patna State Super Graphite Products, Titilagarh; the sponsor of production of clay graphite stopper heads which are hitherto being imported.

B. Process Released through NRDC

Process/Products	*Party*	*Terms*
1. Production of refractory cement (Cement foundutype) by sintering technique.	M/s. Vijaya Magnesite Ltd., Ghaziabad.	L.P. Rs. 7,500/- RR: 2% on sales; Period : 10 Years, Nature : Non-Ex.

2. The consortium for the setting up of the commercial plant on electrolytic manganese dioxide by the joint venture of Orissa State Govt. and Electrochem (Orissa) Ltd., to whom the licence has been given by NRDC, is under formation and is under active progress with the single joint responsibility of NRDC.

C. Technology Ready for Commercial utilisation

Production technology of aluminium alloy filler wire/rods designated as NML-PM6, (Corresponding to BS 290, NG6 and IS 1278:1972) suitable for TIG and MIG welding of aluminium alloy.

PATENTS

A. Sealed

I.P.	*Title*	*Inventors*
I. 148202	An improved process for desulphurization of ferrous melts in the iron and steel industry	D. J. Chakrabarti S. K. Biswas and V. A. Altekar
II. 147948	A process for simultaneous electrolytic production of Zinc metal and manganese dioxide from zinc sulphide concentrates and manganese ore	V. A. Altekar A. M. Pandey K. N. Gupta
III. 148140	A process for Production of austenitic stainless steel free of nitrogen	S. S. Bhatnagar B. K. Guha R. K. Sinha

B. Filed

1.	Improved process for casting of aluminium or aluminium alloys to obtain fine grain refining thereof	Rajendra Kumar C. S. Sivaramakrishnan R. K. Mahanti

UNIDO Workshop on Regional Project for the Co-operative Research Among Metallurgical Research and Development Centres in Asia and the Pacific.

United Nations Industrial Development Organisation, Vienna, Austria; held the above Workshop at National Metallurgical Laboratory, Jamshedpur, from 7th to 11th December 1981.

The Workshop was attended by 28 participants from different countries e.g. People's Republic of China, Czechoslovakia, Egypt, India, Korea, Nigeria, Pakistan, Philippines, Sri Lanka, Thailand, Turkey and Yugoslavia. The UNIDO team was led by Dr. B. R. Nijhawan, Senior Inter-regional Adviser, Metallurgical Industries Section, UNIDO, Vienna.

Dr. G. S. Sidhu, Director-General, C.S.I.R., New Delhi, who was to inaugurate the Workshop could not attend due to pre-occupation. Prof. V. A. Altekar, Director, National Metallurgical Laboratory, was elected as the Chairman of the entire session of the Workshop and Prof. Chang-Xu-Shih, Director, Institute of Metal Research, Academia Sinica, Shenyang, People's Republic of China, acted as Vice-Chairman.

Prof. Altekar, the Chairman of the Workshop, after welcoming the participants gave an account of UNIDO's technical assistance to National Metallurgical Laboratory. He mentioned about the Central Creep Testing Facility set up at N.M.L. with the assistance of UNDP and UNIDO. This facility has developed and developing indigenous high temperature creep resistant steels for power plants, atomic research centre etc. He invited the participants to present their views on the subject of Co-operative Research work and their written contributions.

Dr. B. R. Nijhawan, Senior Inter-regional Adviser, UNIDO; explained at length the objectives of the Workshop and outlined the activities of UNIDO in general and of the Metallurgical Industries Section in particular vis-a-vis the objectives of the Workshop and plans and projections on the subject of Co-operative Research and Development Work. He outlined the activities of UNIDO on regional projects covering metallurgical industries including iron and steel, standardization in general and standardization of iron and steel products etc. He also outlined the work undertaken at the 15 metallurgical research and development centres which have been established and are operating through the technical assistance programme of UNIDO/UNDP in different developing countries of the world and other pipe line projects.

Dr. Nijhawan explained to the participants possible courses of action to promote co-operation among Metallurgical Research and Development Centres in ESCAP countries. He outlined the following possibilities/ potentialities for promoting co-operative research among metallurgical research and development centres in Asia and the Pacific.

Prof. V. A. Altekar, Director, NML & Chairman of the UNIDO Workshop session, addressing the participants from different countries on the opening day of the Workshop. Dr. B. R. Nijhawan, Leader of the UNIDO Team, Vienna; is on the left of Prof. Altekar and next is Prof. Chang-Xu-Shih, Director, Institute of Metals Research, Academia Sinica, People's Republic of China; the Vice Chairman of the Session.

(i) Exchange of technical publications, documentation, (Classified and unclassified).

(ii) Possibilities of forming joint research teams from different research and development centres on joint project to be identified as a result of the activities at one or more of the existing centres of metallurgical research and development.

(iii) Formation of a nucleus at an existing centre of metallurgical research and development in the ESCAP countries.

(iv) On an ultimate long range basis, during or after the work and activities as indicated have been successfully completed, the U.N. may consider establishing a new Regional Centre with its own building, well equipped and well staffed at a commonly accepted location/country.

During the course of presentation of written contributions by the participants, references and cross references were made to the objectives of the Workshop and possible means and modes of their implementation.

In the light of the various important aspects enumerated in the discussions, the participants concluded that the establishment of a regional centre for co-operative research and development on metallurgy was highly desirable. The implementation of the proposed scheme should be given high priority.

DISSEMINATION OF INFORMATION

NML Technical Journal

The issues of Vol. 23,1981 were edited and published.

Leading abstracting services like Metal Abstracts, Chemical Abstracts etc., report the abstracts of papers published on the journal.

Documented Survey on Metallurgical Development

The issues of this publication were brought out.

Monograph on Indian Ores & Minerals

Volume 1 of the Monograph on "Ores & Minerals of India—Beneficiation & Agglomeration Technique for Industrial & Economic Exploitation" was released by Shrimati Indira Gandhi, Prime Minister & President of CSIR at Director's Conference in April 1981. Vol. 2, edited and under publication.

NML News Letter

The issue of the NML News Letter were brought out.

News Paper Clipping Service

Daily newspapers including commercial and business papers were scanned and items of importance covering news on metallurgical and allied industries R & D work ; Govt. industrial policy, new & scientific and industrial innovations etc. were classified and departmentally circulated.

Annual Report

Annual Report of the Laboratory for the year 1980-81, was prepared and under publications.

Monthly Report

Monthly Reports covering new specific contribution of the Laboratory were prepared.

Publicity of Processes & Products

Periodic publicity was given about NML activities, processes and technologies ready for commercial utilization through brochures, articles, newspapers, broadcast talk etc.

Papers Published

76 Papers were published, presented/communicated. Details furnished in Appendix I.

Investigation & Research Reports Prepared

38 Investigation & Research Reports were prepared. Details furnished in Appendix II.

DEPUTATION & TRAINING

Prof. V. A. Altekar Director	(1) Visited Bulgaria under CSIR-Bulgaria Science & Technology Programme as Leader of the Indian delegation for finalising programme of bilateral R & D work. (2) Visited Vienna, Austria ; to discuss and finalise the details with UNIDO for grant of Creep testing equipment to N.M.L. (3) Visited Cairo, under Indo-ARE Academy of Scientific Research & Technology Programme.
Shri G. P. Mathur Scientist F	Taken up an assignment at Nigeria as UNIDO expert for establishing mineral processing facilities at Nigeria.
Dr. Venkatesh Rao Scientist	Deputed to France under CSIR-CNRS exchange of Scientist Programme to study (i) fundamental and applied aspects of rare earth-transition metal alloys and their hydrides and (ii) the techniques of preparation of amorphous materials, their characterization and the method of evaluating their proportion.
Shri S. N. Sinha S.L.A.	Deputed to a training course on 'Industrial Metal finishing' organised by Electro-Chemical Society of India, Bangalore.

Shri D. D. Akerkar, Scientist, has been awarded the Indranil Award for Metallurgy for the year 1980-81 by Mining, Geological & Metallurgical Institute of India.

Shri H. Singh, Scientist & Prof. V. A. Altekar, Director, were awarded Certificate of Merit by Institution of Engineers (India) for the joint paper "Studies on effects of furnace design on electro-thermal smelting of lead concentrates" published in the Journal of Inst. of Engineers, pt. MM2, Nov. 1980.

CHAIRMANSHIP, MEMBERSHIP ETC. OF NML STAFF ON OUTSIDE BODIES

Prof. V. A. Altekar	Director	Adityapur Industrial Area Development Authority, Govt. of Bihar.
	Director	Brindaban Alloys Ltd, Bangalore (a constituent of Industrial Finance Corporation of India, Bombay).
	Member	Advisory Committee of CSIR Polytechnology Transfer Centre, Patna.
Dr. R. Kumar Scientist in the grade of Director	Chairman	Institute of Engineers, Jamshedpur Centre.
	Chairman	SMDC 10 of ISI.
	Member	Panki Thermal Power Station Enquiry Committee constituted by Govt. of India.
	Member	Expert Group to review the environmental issues related to metallurgical industry of Dept. of Science & Technology
	Project Co-ordinator	Project Boiler Tube Failures in Thermal Power Station of Central Board of Irrigation & Power.

APPENDIX I

Papers Published, Communicated and Presented

1. Thermodynamic analysis of Al-Zn alloys from calorimetric measurements—A. K. Nayak, NML Technical Journal, V. 23(1 & 2), 1981.

2. Modern concepts in solidification and structure of cast iron—C. S. Sivaramakrishnan; Same as Sl. No. 1.

3. Oxygen enriched hot air blast cupola iron melting—R. Santokh Singh & P. S. Virdhi; same as Sl. No. 1.

4. Rapid indirect volumetric method for determination of molybdenum in ferro-molybdenum—M. R. Pramanik, R. Ganesh & L. P. Pandy; Same as Sl. No. 1.

5. Embrittlement of high carbon steel in sulphuric acid containing thiocompounds—A. K. Dey, Inder Singh & V. A. Altekar; NML Technical Journal, V. 23 (3 & 4), 1981.

6. Development of clad metals for various applications—V. A. Altekar, S. K. Banerjee, B. N. Ghose & J. Bhattacharya; same as Sl. No. 5.

7. Dephosphorisation of hot metal—A review;—S. K. Tiwary; same as Sl. No. 5.

8. Development of alumina foam insulation refractories—A. K. Bose & M. R. K. Rao; same as Sl. No. 5.

9. Use of X-rays in chemical analysis—L. P. Pandey; same as Sl. No. 5.

10. The influence of pseudosurfaces on solidification of aluminium alloys—R. Kumar & C. S. Sivaramakrishnan; presented at the International Conference on "Thermodynamics & Kinetics of Metallurgical processes" Bangalore, July 181.

11. Impact of research at NML on the aluminium technology in India—R. Kumar; same as Sl. No. 10.

12. Thermodynamics and structure of aluminium alloys—R. Kumar & C. S. Sivaramakrishnan; same as Sl. No. 10.

13. NML—PM2 electric grade aluminium alloy conductor—potential advantages in power metallurgy—R. Kumar; presented and published in the Proceedings of 48th Annual Research Session of Central Board of Irrigation & Power, Sept. 1981.

14. Industry Oriented R&D on aluminium technology at NML—R. Kumar; B. K. Saxena & Kishori Lal; presented at the All India Seminar on "Small Scale Metallurgical Industries, in India—Scope & Development in Technique, & Processes", Sept. 1981.

15. Development of aluminium alloys for conductor grade applications—R. Kumar; presented at the Seminar on 'Advances in Cable Technology', Sept. 1981.

16. Aluminium—status & prospects in India—R. Kumar; presented at the Workshop on "Futurology relating to Mineral & Metal based Industries", convened by Dept. of Science & Technology & Regional Research Laboratory, Bhubaneswar, January 1982.

17. Effect of two phase solidification on fracture toughness of aluminium alloys—N. K. Das, P. K. Mahanty & R. Kumar; communicated to Indian Journal of Technology.

18. Study of grain refinement of aluminium by NML—PM122—C. S. Sivaramakrishnan, R. K. Mahanty & R. Kumar; same as Sl. No. 17.

19. An indigenous filler wire for welding aircraft components—R. Kumar, B. K. Saxena & G. D. Sani—presented at the Seminar on 'Aerospace Alloys and Fabrication Technology', Organised by Indian Inst. of Metals, Bangalore Chapter & Indian Inst, of Science; December 1981.

20. Development of a melting and solidification technology for the production of light alloys—C. S. Sivaramakrishnan, M. K. Mahanti & R. Kumar; same as Sl. No. 19.

21. The bench scale to industrial concentrator—the story of 500 tonnes/day fluorspar project—M. V. Ranganathan, G. P. Mathur & V. A. Altekar; communicated to International Mineral Processing Congress, Toranto, Canada; Sept.-Oct. 1981.

22. Beneficiation of some industrial minerals for the manufacture of basic refractories—P. D. Prasada Rao, A. Peravadhanulu, N. Chakraborty, S. K. Banerjee & G. P. Mathur ; presented at the seminar on "Basic Refractories for Steel Making" organised by Indian Ceramic Society, Jamshedpur Chapter, January 1982.

23. Use of MgO-Carbon refractories in electric arc furnace—K. K. Singh & M. R. K. Rao; same as Sl. No. 22.

24. Indian dolomites and their uses in basic oxygen furnace lining—K. C. Roy, P. C. Sen & M. R. K. Rao; same as Sl. No. 22.

25. A correlation of chrome ores grain size and properties of chrome-magnesite refractories—N. N. Mathur, M. R. K. Rao & P. C. Sen; same as Sl. No. 22.

26. Biohydrometallurgy in India—M. J. Shahani; Hydrometallurgy International (Amsterdam), October, 1981.

27. Process parameters of zinc dust production and applications technology—G. Basak, R. N. Lahiri & M. J. Shahani; Presented at

the Seminar on 'Lead, Zinc & Cadmium—Retrospect & Prospect' organised Indian Lead-Zinc Information Centre, November, 1981.

28. Recovery of cadmium from spray booth powder—G. Basak & M. J. Shahani; same as Sl. No. 27.

29. Cemented, reduced, electrolytic and atomized metal powder—a value engineering analysis—T. V. K. Das, S. Prasad, G. Paras Nath & M. J. Shahani; presented at the Silver Jubilee Seminar of Ind. Inst. of Technology, Kharagpur, December, 1981.

30. Whither the Indian powder metallurgy industry—Retrospect & prospect —M. J. Shahani; Key not address at National Powder Metallurgy Conference, Hyderabad, March, 1982.

31. Modern trends on direct smelting of lead—V. A. Altekar & Narinder Singh; presented at the Seminar on 'Lead, Zinc & Cadmium—Retrospect & Prospect organised by Indian Lead-Zinc Information Centre, November, 1981.

32. Metallothermic smelting of Indian lead concentrate—V. A. Altekar, Narinder Singh & S. B. Mathur; same on Sl. No. 31.

33. A process for extraction and recovery of lead-zinc and cadmium from mixed oxide and silicate type ores—D. D. Akerkar, M. S. Mahanty, M. Yaseem & M. G. Bodas; same as Sl. No. 31.

34. Process for leaching and electrolytic recovery of zinc from lean oxidized ores—D. D. Akerkar & M. G. Bodas, presented at the Indo-US Workshop on Mineral Processing and Chemical Metallurgy, December, 1981.

35. Process for purification and enrichment of low-grade molybdenite concentrates—D. D. Akerkar, A. K. Saha, S. R. Srinivasan & V. A. Altekar; same as Sl. No. 34.

36. Recovery of cobalt from lateritic nickel cobalt ores with special reference to Sukinda Ultramafic field—A. K. Saha, M. S. Mahanty, D. D. Akerkar & V. A. Altekar; Communicated to the International Conference on "Cobalt Metallurgy and Uses," held at Brussels; Belgium, November, 1981.

37. Electrophoretic deposition of silicon carbide—A. K. Sinha Mahapatra & N. Dhananjayan; Trans. Ind. Inst. of Metals, Vol. 34(6), Dec. 1981.

38. Emerging technologies in the hydro and electro-metallurgical extraction of lead and zinc from complex sulphide ores—P. K. Sinha, G. Basu, S. C. Aush, N. Dhananjayan & V. A. Altekar; presented at the Seminar on "Lead-Zinc and Cadmium—Restrospect & Prospect" Organised by Indian Lead-Zinc Information Centre, November, 1981.

39. Roasting of copper sulphide concentrate with reduced energy consumption under controlled pollution—P. K. Som & S. K. Roy

Chowdhury; Presented at the 35th Annual Technical Meeting of Ind. Inst. of Metals, November, 1981.

40. Studies on lime-roast back technique of treating chalcopyrite concentrate—P. K. Som & S. K. Roy Chowdhury; Communicated to Trans. Ind. Inst. of Metals.

41. Special ceramic filter for aluminium alloys—C. S. Sivaramakrishnan, R. K. Mahanti & R. Kumar; Trans. Ind. Cer. Soc. July-Aug., 1981.

42. Amorphous soft magnetic alloys produced by splat cooling—V. V. Rao & R. Kumar; Trans. Magnetic Society of India 1979, (published in 1981).

43. Kinked hysterisis loop in 36% Ni-Fe alloys—Ved Prakash, C. R. Tewari & D. Bandhyapadhya; Ind. J. Pure & Applied Physics, Vol. 19 (1981).

44. Studies on manganese-aluminium-carbon alloys—Ved Prakash, C. R. Tewari, V. Rao, S. Pramanik, D. Bandhyopadhya & S. P. Narayan—Communicated to Trans. Magnetic Society of India.

45. Problem of overheating in a power boiler—R. Singh & R. Kumar, presented at the seminar on "Failure Analysis" Organised by Ind. Inst. of Metals, Jamshedpur Chapter, August, 1981.

46. Creep strain measurement with LVDT transducers—L. N. Das; presented at the 4th All India Symp. on "Instrumentation" Organised by IIST (India) & Madhav Institute of Technology, Gwalior, October, 1981.

47. Roll cladding of copper on aluminium and development of a continuous annealing schedule—J. Bhattacharya, B. N. Ghose & S. K. Banerjee; Communicated to Sheet Metal Industries (U.K.)

48. Heating elements for electrical applications—R. K. Dubey, S. K. Chaudhury & P. Basak; Communicated to Journal of Engineers.

49. Heat treatment of tool steels—R. K. Dubey & S. P. Chakraborty; Proc. of All India Seminar on "Small Scale Metallurgical Industries in India", New Delhi, 1981.

50. Experiments with cokeless cupola—G. N. Rao, S. S. Dhanjal & C. A. N. Rao; presented at the 31st Annual Convention of Ind. Inst. of Foundrymen & published in the Proceedings.

51. Present state of development of the fluid sand process at NML—T. A. Beck, G. N. Rao, S. Ghosh, R. R. Dash & S. K. Sinha; same as Sl. No. 50.

52. Electric smelting by mini steel plants—R. D. Gupta; presented at the International Conference on "Electric Furnace Steel Making Eighties" Organised by Steel Furnace Association of India, at Bangalore, January, 1982.

53. Refractories in basic electric steel making—R. D. Gupta; presented at the seminar on Basic Refractories on Steel making" Organised by Ind. Cer. Society, January, 1982.

54. Effect of plastic deformation on corrosion rate and hydrogen absorption in inhibited acid solution—M. K. Banerjee, Inder Singh & P. K. Dey; presented at the Seminar on 'Corrosion and its Control' Organised by I.I.T., Bombay, CTDT, Bombay, SAEST, Bombay Chapter, July, 1981.

55. Failure of metals in service due to stress corrosion cracking—K. P. Mukherjee & V. A. Altekar; same as Sl. No. 54.

56. Hydrogen absorbtion index and input hydrogen fugacity—V. A. Altekar, Inder Singh & M. K. Banerjee; presented at the 3rd International Congress "Hydrogen Embrittlement of Metals".

57. Diffusion coating of saddle casing and spacers—P. Prabhakaram, A. N. Mukherjee, A. K. Dey & B. K. Guha; Trans. Ind. Inst. of Metals, Vol. 34(6).

58. Pre-Coated metals—P. Prabhakaram; Communicated to Second National Conference on "Electroplating & Metal finishing" Organised by SAEST, March-April, 1981.

59. Future trends in electroplating and metal finishing—S. K. Narang; Communicated to Symp. on" Futuristic aspects of Electro-Chemical Science & Technology" Organised by SAEST., Karaikudi; October, 1981.

60. Studies on atomic absorption sensitivities of trivalent and hexavalent chromium—L. P. Pandey, K. K. Gupta, P. Dasgupta, S. N. Jha and N. N. Chatterjee, Jr. Inst. Chemists India, 1981, 53(60).

61. Separation and estimation of cadmium and zinc in their alloys—S. N. Jha, A. C. Biswas and L. P. Pandey, Jr. Inst. Chemist (India), 1981, 53 (20)

62. Recent developments in atomic absorption spectrophotometry—A. P. Choudhury and L. P. Pandey; Presented in World Instrumentation Symposium held in Bombay in April, 1981.

63. The successive determination of aluminium and titanium in ferrotitanium by complexometric titration—B. C. Bose, M. N.Choudhury and L. P. Pandey.

64. Antipyrylazo III and thymolphthalexon as indicators for the complexometric determination of calcium and manganesium in lime stones—N. C. Mukherjee, N. N. Ganguly, V. N. Choudhury and L. P. Pandey.

65. Determination of manganese in Steel by atomic absorption spectrophotometry—L. P. Pandey, P. Dasgupta, N. N. Chatterjee and S. N. Jha.

66. Use of tannin as a colorimetric reagent for the estimation of tantalum—L. P. Pandey, B. Singh and K. K. Padhi.

67. Spectrophotometric determination of vanadium in steel with chromotropic acid—L. P. Pandey, B. Singh and K. K. Padhi.

68. Spectrochemical analysis of solver in Copper Concentrate—M. K. Ghosh.

69. X-ray spectrometric analysis of rock phosphate—M. K. Ghosh, Rajeev, S. C. Srivastava and N. Ghosh. (Paper Nos. 63 to 69 were presented at the Symposium on "Metallurgical Analysis", held at Calcutta in August, 1981.)

70. 1-Amino-2naphthal-4-sulphonic Acid as a colorimetric reagent for vanadium—L. P. Pandey, B. Singh & K. K. Padhi; Communicated to National Symposium on "Current Activities in Analytical Chemistry", Allahabad, November 27-29, 1981.

71. Spectrophotometric determination of vanadium in steel by O-dianisidine —L. P. Pandey, B. Singh, K. K. Padhi; Presented at Annual convention of Chemists at Madras December, 1981.

72. Estimation of sulphur in pyrites-pyrrhotite ores by X-ray fluorescence spectrometry—S. C. Srivastava, N. Ghosh, Rajeev and M. K. Ghosh; Presented at Annual Convention of Chemists, Dec. 1981 at Madras.

73. Liberation analysis and release analysis—P. R. Khangaonkar, & C. Satyanarayana; Trans. Inst. Min. Metall (Sect, C; Mineral Process Extr. Metall), 90 Sept. 1981.

74. Flotation adsorption of chalcopyrite with Cupferron—S. Prabhakar and P. R. Khangaonkar; International Jr. of Mineral Processing; The Netherlands, Vol. No. 9, Issue No. 1, 1982.

75. Electro-flotation of chalcopyrite fines—G. Bhaskar Raju and P. R. Khangaonkar; International Jr. of Mineral Processing. The Netherlands, Vol. 9, Issue No. 2, 1982.

76. Technical development in electric steelmaking—S. S. Bhatnagar; presented at the International Conference on "Electric Steel Making in the Eighties," Bangalore, January, 1982.

APPENDIX II

Research & Investigations Completed and Reports Prepared

1. Beneficiation of a nickel chromium bearing magnetic sample from Nagaland—T. C. De, S. K. Sil, N. Chakraborty & G. P. Mathur, (IR 1081/81).

2. Bench Scale beneficiation studies on three low grade graphite sample from Khepchisi mine, Bhutan received from M/s Industrial Development Corpn., Royal Government of Bhutan—P. N. Pathak, M. V. Rangathan, N. Chakraborty & G. P. Mathur, (IR 1082/81).

3. Exploratory studies on the evaluation of some of the Indigenous reagents designated "Chemiflocs" received from M/s G. C. I. Chemical Nagpur for use as floculants—S. K. Sil, M. V. Ranganathan, & S. K. Banerjee (IR 1083/81).

4. Studies on calcination characteristics of Kuteshwar limestone (M.P.) received from M/s Bokaro Steel Plant—K. C. Roy, P. C. Sen, & M. R. K. Rao, (IR 1084/81).

5. Bench Scale beneficiation studies on two low grade samples from "Rakha and "Santoshi" mines of Karara deposit in Rajasthan for R. S. N. D. Corpn., Udaipur—S. N. Prasad, K. K. Bhattacharya, M. V. Ranganathan, S. K. Banerjee & G. P. Mathur, (IR 1086/81).

6. Beneficiation of a low grade silliminite sample from Maharashtra state Mining Corporation Ltd., T. C. De, S. K. Sengupta, S. K. Sil, N. Chakraborty & G. P. Mathur, (IR 1087/81).

7. Report on failure of (i) water wall tube, (ii) wall superheater Tube, (iii) ceiling superheater tube, and (iv) Condenser Tube of Unit No. 8 Patratu Thermal Power Station, Hazaribagh—R. Kumar & R. Singh, (IR 1088/81).

8. Sampling, Chemical and Sieve Analysis of Iron Ore, Coal and Limestone samples from M/s. Ganesh Scientific Research foundation, New Delhi—K. Vijayaraghvan, V. Mohan, R. Gopalkrishnan & P. R. Khangaonkar, (IR 1089/81).

9. Studies on Hindustan Electro Graphite lines to make carbon bricks for chemical industry, (IR 1090/81).

10. Report on Failure of 1. Economiser Tubes of unit No. 2 and superheater Tube of unit No. 4 and 111. Superheater of unit No. 5 M/s. Barauni Thermal Power Station, B. S. K. B-R. Singh, K. Prasad & R. Kumar, (IR 1091/81).

11. Pelletisation studies on Kudremukh Iron Ore concentrate (IR 1092/81).

12. Grindability studies on three abrasive samples from M/s. Cutfast Abrasives, Madras—K. Vijayaraghvan, P. R. Khangaonkar, (IR 1093/81).

13. Evaluation of Iron Ore Sample of Jhinkpany longalata mines of Barajamda sector of Orissa state received from M/s. M.M.T.C., New Delhi for gas based direct reduction processes (Midrex), (IR 1094/81).

14. Evaluation of Iron Ore sample of Jhinkpany longalata mines Barajamda sector of Orissa state received from M/s. M.M.T.C., New Delhi for gas based direct reduction processes (Hyl), (IR 1095/81).

15. Evaluation of Iron Ore sample of Gadigi Mines of the Bellary Hospet area of Karnataka State received from M.M.T.C., New Delhi for gas based direction processes (Midrex process), (IR 1096/81).

16. Evaluation of Iron Ore Sample of Gadigi Mines of the Bellary Hospet area of Karnataka state received from M/s. M.M.T.C., New Delhi for gas based direct reduction processes (Hyl), (IR 1097/81).

17. Beneficiation studies on "A tourmuline Kyanite Sample" from Maharastra Minerals Corporation Ltd., Bombay—C. Satyanarayan & P. R. Khangaokar, (IR 1098/81).

18. Studies on Silica sand from M/s. Arror Udyog (P) Ltd., Mangalore, Karnataka—K. S. Vijayanarayan, C. Sankaran & P. R. Khangaonkar, (IR 1099/81).

19. Investigation on yellow and white duptrine received from T.E.I.G. Ltd., Jamshedpur—S. K. Sinha, T. A. Back & G. N. Rao, (IR 1100/81).

20. Sintering tests on composite iron ores from Bailadila Deposit 4 & 5 employing Machkot Tiria Dolomite for Vishakhapatam steel project—R. K. Kunwar, A. K. P. Srivastava, J. S. Padan, & S. K. Banerjee, (IR 1101/81).

21. Grain size and mineralogy of raw and fined dolomite samples from TISCO—V. N. Mathur & M. R. K. Rao, (IR 1102/81).

22. Bench scale studies on Chikla Manganese ore for production of electrolytic manganese dioxide and evolytic managese metal—P. L. Sengupta & N. Dhananjain, (IR 1103/81).

23. Estimation of residual life of the steam line pipe of Boiler No. 1 received from Neyveli Lignite Corporation Ltd., Neyveli, T. Nadu—R. Kumar & R. Singh, (IR 1104/82).

24. Bench Scale Beneficiation studies on a low grade graphite samples from Sivaganga Ramnad Dist. (T.N.) by Tamil Nadu minerals Ltd., Madras—K. Vijayaraghvan, V. Mohan & P. R. Khangaonkar, (IR 1105/82).

25. Beneficiation and sintering studies of Iron Ore Mixed with dumped fines from M/s. Indian Iron & Steel Co.,—R. K. Kunwar, J. S. Padan, N. Chakraborty, S. K. Banerjee & G. P. Mathur, (IR 1106/82).

26. Determination of Reduction Degradation Index of N.M.D.C. Iron Ores, Hyderabad—A. K. S. Mahapatra, & K. N. Gupta, (IR 1107/82).

27. Metallurgical investigation on "the failure of catenary wire"; Divisional Manager (Tv.D.) Chakradharpur—S. E. Rly., A. K. Bhattamishra, G. G. Nair, Kishorilal & R. Veeman, (IR 1108/82).

28. Development and Testing of Creep Resistant Steels, (IR 1109/82).

29. Determination of Physical Characteristics and free silica content in a limestone sample from Cheltinad Cement Corpn. Ltd., received from M/s. Mcnally Bharat Engg. Co. Ltd.,—S. Sivaih, S. K. Sengupta, Bhaskar Banerjee, M. V. Ranganathan, A. Peravadhanulu, D. M. Chakraborty, S. K. Banerjee, (IR 1110/82).

30. Exploratory studies on a pyrite sample from Amjhore for M/s. Pyrites Phosphates and Chemicals Ltd.,—S. N. Prasad, M. V. Ranganathan, N. Chakraborty & S. K. Banerjee, (IR 1111/82).

31. Development of indigenous technology of the manufacture of the alloy AK_1 sponsored by HAL Koraput—R. Kumar, G. D. Sani, B. K. Saxena, C. S. Sivaramakrishnan, R. K. Mahanti & P. K. De, (RR 400/81).

32. Studies on recovering of metal values from complex zinc—lead ore of Chakula, Bhutan—S. K. Roychowdhary & P. K. Som, (RR 401/81).

33. Treatment of copper ash from Non-ferrous Foundry work—S. K. Roychowdhary & P. K. Som, (RR 402/81).

34. Studies on extraction of nickel and cobalt from the lateritic nickeliferrous ore of Kansa area of Sukinda, Orissa—M. S. Mahanty, B. N. Singh, M. Yaseen, D. D. Akarkar & V. A. Altekar, (RR 403/81).

35. Extraction of nickel from the nickeliferrous ores from the Wampahar area—B. N. Singh, M. S. Mahanty, D. D. Akarkar & V. A. Altekar, (RR 404/81).

36. Purification and enrichment of low grade molybdenite concentrates by desilication and chloridising roasting—A. K. Saha, S. R. Srinivasan, D. D. Akarkar & V. A. Altekar, (RR 405/81).

37. Processing of the bulk copper nickel sulphide concentrates of the V.C.I.L. through electro-thermal smelting and matte leaching—D. S. R Murthy, N. Subrahmin & D. D. Akarkar, (RR 406/81).

38. Combination process for purification and enrichment of low grade molybdenite concentrates by acid heat-treatment—A. K. Saha, S. R. Srinivasan, D. D. Akarkar & V. A. Altekar, (RR 407/81).