NML Annual Report

1980-81

NATIONAL METALLURGICAL LABORATORY
JAMSHEDPUR, INDIA

ANNUAL REPORT

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

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INTRODUCTION

The multidisciplinary activities of the laboratory have brought rich dividends in the form of sponsored projects/investigations, consultancy assignment, transfer of technologies. The laboratory has carried out large number of sponsored work, in plant and field trials, large scale trials.

During the period, seventeen products/processes have been established as a result of R & D efforts which are under various stages of evaluation. Three products/processes have gone into production for the first time and thirteen product/processes which are in continuous production are progressing well. The total product value is around Rs. 50 million during 1980-81.

A project on the modernization of the Durgapur Steel Plant was taken up in collaboration with British Steel Corporation (Overseas service). Over 100 tonnes of run-of-mine ore sample from M/s Bolani Ore Ltd. were received and detailed large scale studies were successfully completed. The report has been furnished to the sponsors. Detailed bench and pilot plant studies on a low grade pyrite-pyrrhotite sample from Saladipura were conducted on behalf of M/s Pyrites, Phosphates & Chemicals Ltd. who are setting up beneficiation plant for the recovery of sulphur. In this connection Shri G. P. Mathur, Scientist F, visited Lurgi Laboratory on behalf of M/s P.P.C.L. to study the bench scale results on the sample also carried out by the firm.

The international assignment on the beneficiation and agglomeration studies on pilot plant scale on two low grade iron ore samples from Syria, obtained through MECON, was completed. The results of the work has formed the basis for the preparation of the feasibility report by MECON for Govt. of Syria towards the establishment of an iron and steel complex at Syria.

To counteract problems of severe corrosion in the coastal regions, the Gujarat Steel Electricity Board installed two types of conductors made of the versatile electric grade aluminium alloy NML PM2. Encouraged by the good performance of the conductor, Gujarat State Electricity Board and the Central Board of Irrigation & Power jointly convened a Conference at Baroda in April 1981 of representatives of all the State Electricity Boards having coastal regions to serve and decision was taken for wider trials with ACC NML PM215 conductor in the coastal region.

The Gujarat State Electricity Board has also shown interest in the use of NML-PM53, which is a medium strength medium conductivity aluminium alloy conductor in the coastal region.

Research Design & Standards Organization, Lucknow, Ministry of Railways, Govt. of India; have shown interest in the use of NML-PM215 as catenary conductor in the Railway Electrification Project. The Laboratory has developed PM 401 aluminium alloy bearing bushes as a substitute of bronze bearing and supplied to Research, Design & Standards Organization, for evaluation. RDSO fitted these bushes into steam locomotives. The

Prof. Nurul Hasan, Vice-President, CSIR (extreme right), during his visit to NML, being shown round by Prof. V. A. Altekar, Director (centre).

performance was evaluated under actual running condition and was found satisfactory. Large diameter bushes have been sent to RDSO for further field trials.

The Laboratory has established the production technology of the aluminium alloy welding filler wire corresponding the BS2901 NG6, and IS1278 : 1972NG6 specification. Fairly large quantities of NML-PM16 filler wire in different gauges have been supplied to M/s Hindustan Aeronautics Ltd. Bangalore for evaluation. As a result of increased demand for NML Reactive filter, M/s Bhaskar Stonewere Pipes (P) Ltd. who are producing the material as licencee, are increasing their production capacity. A foreign firm in U.K. is interested in taking up the technology of Reactive filter and it is being processed by National Research Development Corporation. To minimize the rejection rate in aluminium utensil manufacture by small scale utensil industries in Bihar, the Laboratory has rendered its expertise and consultancy. With the assistance of the Laboratory, the rejection rate was brought down to 5-7% from 25-35 percent. A Workshop-cum-Get-Together was organized at Patna in November 1980, where NML developed technology was demonstrated.

Under a collaborative programme of work with M/s. Visvesvaraya Iron & Steel Ltd. on process standardization of high strength low alloy steels, industrial scale heats of niobium and niobium-vanadium steels were made in a 12 ton L.D. converter. These steels find use in the construction of ships, bridges, buildings, pressure vessels, transmission towers, wagon, pipe lines, reinforcement rods etc. It is an import substitution product and country is meeting its demand partially through import.

NML has accepted a package deal for setting up a one tonne per day pilot plant for production of ferro-tungsten by alumino-thermic reaction for the Central Research Organization, Rangoon. The assignment is through CSIR/NRDC under the Govt. of India's assistance to Govt. of Burma under Indian Technical & Economic Co-operation Programme.

The Laboratory has developed technique for assessing the extent of accumulation of creep damage through accelerated stress rupture tests. This technique has already been used to predict the state of condition of the tubes from Central Electricity Board (for Badarpur Thermal Power Station) and Neyveli Lignite Corporation Thermal Power Plant.

The Laboratory has developed expertise on the cause of failure of engineering metal components in construction materials. This expertise is in large demand by thermal and hydro-electric power plants, oil refineries, petro-chemical complex, iron & steel industry, coal washeries, mining, cement, textile, paper industry etc. A large number of sponsored investigations including on the spot study have been conducted and the causes of failure were ascertained and remedial measures advised.

The technology of aluminium base 'SUPERAL' anode for cathodic protection of ships and harbour structure was released to M/s Aluminium Manufacturing Co, Calcutta ; who have started its production and supplying to various dockyards.

Dr. A. R. Kidwai, Governor of Bihar (2nd from right), observing some NML developed refractory products.

The NML Pyroloy-1000—a heat resistant cast iron developed in the laboratory, has found its application in another new item in replacing nickel-chrome finger castings used in pipe normalising furnace. Finger castings made in the laboratory with NML Pyroloy 1000, were used by Indian Iron & Steel Co's Stanton Pipe Foundry at Ujjain, and was found superior to nickel-chrome castings.

An International Symposium on "Modern Developments in Steel Making" was held from Feb, 15-17 1981 ; in collaboration with M/s Tata Iron & Steel Co. Ltd ; Steel Authority of India Ltd. & Indian Institute of Metals. The Symposium was attended by 350 delegates from India and 80 foreign delegates from 20 countries of the world. Representative from United Nations Industrial Development Organization, Vienna ; also participated in the Symposium.

The volume 1 of the Monograph on "Ores & Minerals of India-Beneficiation & Agglomeration Techniques for Industrial & Economic Exploitation" was published and released by the Prime Minister & President of CSIR, Shrimati Indira Gandhi.

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

PROJECT HIGHLIGHTS

A. ORE DRESSING & MINERAL BENEFICIATION

1. Large Scale Beneficiation & Agglomeration Studies on Low Grade Oolitic Iron Ores from Syria. *Sponsored by MECON.*

For the establishment of an iron & steel complex at Syria, large scale investigations were conducted on tonnage scale Syrian iron ore samples received through MECON, who are entrusted with the consultancy work by Govt. of Syria.

Two low grade samples containing 32.8% Fe and 26.8% Fe were received. These were subjected to various treatments to obtain a economically viable high grade product and sinters suitable for smelting purpose. The detailed report with the operational parameters which will form the basis of the proposed plant, have been furnished to MECON.

2. Large Scale Beneficiation Studies on Iron Ore Samples from Bolani for Modernisation of Durgapur Steel Plant. *Sponsored by SAIL.*

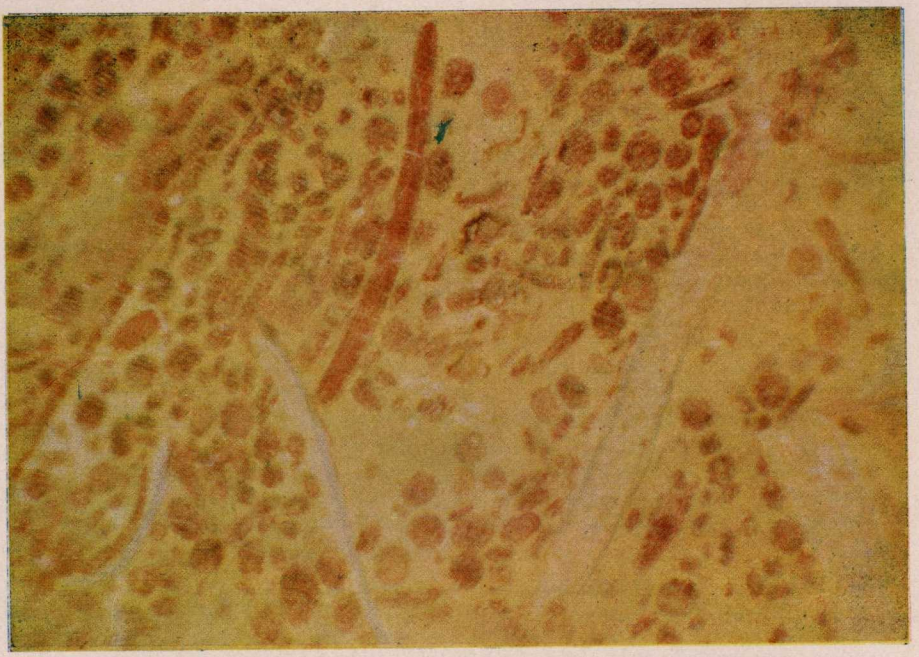
Tonnage quantities of iron ore sample assaying 61.0% Fe, 3.8% Al_2O_3, 2.5% SiO_2 ; were investigated for the washing characteristics in connection with the modernisation programme of Durgapur Steel Plant in collaboration with British Steel Corporation (Overseas Service). The final beneficiated product assayed 63.2% Fe, 1.6% SiO_2 & 2.8% Al_2O_3. The findings will form the basis for iron ore washing plants needed for modernisation of Durgapur Steel Plant.

3. Bench and Large Scale Studies on a Low-grade Pyrite-Pyrrhotite Sample from Saladipura, Rajasthan. *Sponsored by M/s. Pyrites, Phosphates & Chemical Ltd.*

Bench and large scale studies were conducted for the purpose of generating parameters in connection with setting up a sulphur beneficiation plant from low grade pyrite-pyrrhotite deposit of Saladipura for sulphuric acid manufacture. The low-grade sample containing sulphur was treated through various beneficiation routes and a concentrate assaying about 40% S with a recovery of 90% S was produced. The work done will form the basis for setting up a beneficiation plant at Saladipura for the treatment of low grade pyrite-pyrrhotite deposit.

4. Large Scale Beneficiation and Sintering Studies on Gua Iron Ore. *Sponsored by M/s. Indian Iron & Steel Co. Ltd.*

Tonnage scale beneficiation and sintering investigations conducted on the iron ore sample assaying 62.4% Fe, 2.3% SiO_2 and 3.5% Al_2O_3, yielded, satisfactory results.



Cut section of oolitic iron ore from Syria showing calcareous shells with oolites in a limonitic base.

Oolite concentrates of Syrian iron Ore after beneficiation.

5. Bench Scale Beneficiation Studies on Three Ferruginous Manganese Ore Samples. *Sponsored by M/s. Tata Iron & Steel Co. Ltd.*

Bench scale investigations were conducted on three low-grade ferruginous manganese Ores with a view to improve their Mn : Fe ratio to make them suitable for manufacture of ferro-manganese.

The first sample assayed 18.1% Mn and 31.6% Fe and was beneficiated to yield a concentrate assaying 48.2% Mn and a Mn/Fe ratio of 6.3.

The second sample assayed 26.9% Mn and 27.7% Fe and was beneficiated to 53.3% Mn with a Mn/Fe ratio of 7.0. The third sample assayed 37.5% Mn and 13.6% Fe and was beneficiated to 51.6% Mn with a Mn/Fe ratio of 8.7. Samples were beneficiated to meet the grade suitable for ferro-manganese manufacture.

6. Bench Scale Beneficiation Studies on Low Grade Chromite 'Ganga Pit Sample.' *Sponsored by M/s. Ferro-Alloy Corporation.*

Investigation was conducted to improve the Cr/Fe ratio of a low grade chromite assaying 39.9% Cr_2O_3 & 14.1% FeO, so as to make it suitable for ferro-chrome manufacture having a Cr/Fe ratio of 3 and Cr_2O_3 48.0% minimum. Studies conducted produced a concentrate 52.7% Cr_2O_3 but the Cr/Fe ratio could not be improved more than 2.58, which is low for standard ferro-chrome manufacture, due to presence of iron in chemical combination with chromite mineral.

7. Bench Scale Beneficiation Studies on a Chromite Sample of Singhbhum Area. *Sponsored by M/s. Hyderabad Asbestos Ltd.*

A chromite sample assaying 10.7% Cr_2O_3 was investigated to make it suitable for market acceptability containing a minimum of 44% Cr_2O_3. The sample was treated through different routes and a concentrate assaying 46.2% Cr_2O_3 could be obtained.

8. Bench Scale Beneficiation Studies on an Iron-bearing Rock Phosphate Sample from Beldi Mines, Purulia-District. *Sponsored by M/s. West Bengal Mineral Development & Trading Corporation.*

To produce a concentrate suitable for fertilizer having 36% P_2O_5, low iron content and P_2O_5 : Fe ratio over 20 ; beneficiation studies were conducted on sample containing 31.0% P_2O_5 and 3.7% Fe. A concentrate suitable for fertilizer containing 39.7% P_2O_5 and 1.6% Fe was produced.

9. Bench Scale Beneficiation Studies on Three Low Grade Graphite Samples from Khepchishi Hills, Bhutan. *Sponsored by M/s. Industrial Development Corporation, Royal Govt. of Bhutan.*

Three low grade graphite samples. A, B & C were investigated to study their amenability to beneficiation for producing high grade concentrate for

industrial use and subsequently setting up a beneficiation plant with NML's assistance.

Samples A & B assayed 6.2% and 6.4% F.C. with ash content varying between 89 and 90%. Sample C assayed 11.8% F.C., and 70.5% ash. The concentrates produced assayed between 77.3% to 81.1% F.C. with ash content varying between 15 to 18%. The recovery was, however, poor due to the extremely fine dissemination of the graphite particles with associated gangue minerals.

10. Study on Physical Characteristics of Limestone and Dolomite Samples. *Sponsored by Durgapur Steel Plant of SAIL.*

Shatter index hardness, compressive strength, Bond's work index of lime stone and dolomite samples from Birmitrapur, Karanpura, Chopra, Obera and Hyariti were determined. These wil be used as fluxing materials in the sinter plant of Durgapur Steel Plant.

11. Petrological & DTA Studies on Ores & Minerals.

Detailed petrological studies and determination of differential thermal analysis on a large number of ores and mineral samples received from various organizations for investigations were done.

B. REFRACTORY TECHNOLOGY

1. Development of Synthetic Carbonaceous Product as a Substitute of Petroleum Coke and Anthracite.

Salient feature of the work on the project during the period, relate to calcination of compositions made from coke samples received from Central Fuel Research Institute and samples of coal from Bhowrah colliery and from Assam. Properties of the calcined samples were determined.

2. Carbon Refractories—Testing of Binders.

The properties e.g. solvent extraction, proximate analysis of the binders were determined. Arrangements for making different composition of carbon bricks with the use of dense carbon aggregate as base material and various indigenous binders are in progress.

3. Carbon Bricks for Chemical Industry.

Out of two selected composition about 100 full size carbon bricks were made and fired to 1300°C. Physical properties of these two types of bricks were studied. One type of bricks has been lined in a reactor vessel to see the effect of acid slurry in the reactor vessel.

4. Development of Low Density and Low Iron Insulating Bricks.

The objective of the project is to develop a suitable technology for foam insulation refractories. Technical alumina was taken as the base

material. Laboratory scale production of alumina foam insulation was made. Dozens of foam alumina insulation bricks were also successfully made.

5. Development of Graphite—Silicon Carbide Crucible.

New compositions were made for carbon bonded graphite-silicon carbide crucible and size 40 crucibles were pressed and fired under NML guidance in the factory of one of the licensees. The sampes have been sent for industrial evaluation.

6. Evaluation and Characterization of Indian Fireclays. *All India Co-ordinated Project in Collaboration with Geological Survey of India and Central Glass & Ceramic Research Institute.*

The objective of the project is to carry out systematic studies on physico-chemical and physico-thermal properties of Indian fireclays and to prepare a monograph to characterize fireclays of potential reserves. Some samples have been received. These were crushed and ground and plasticity index was determined. Work is in progress on the determination of other properties.

7. Suitability of Indian Sea Water Magnesia for Refractory Use.

The preliminary exploratory work carried out on a sample of 50 kg. sea water magnesia supplied by Central Salt and Marine Chemicals Research Institute, Bhavnagar, showed an encouraging result. A bulk density and porosity of 3.43 gm/cc and 2.37% had been achieved after firing the briquette at 1800°C. Recently a bulk sample of a tonne sea water magnesia from CSMCRI was received. Systematic studies for sintering and making refractory grains are under progress.

8. Studies on High Temperature Castables Suitable for 1450°-1650°C.

Attempts have been made to make high temperature castable suitable for 1450 to 1650°C using natural corundum as agreegate and NML made calcium aluminate cement. Physical properties of natural corundum and NML made CA cement were studied. Different batch composition were made comprising the above two and pressed into 2" dia. buttons. These buttons were fired to different temperatures with 2 hours soaking and their physical properties were studied.

Based upon the above properties, burner blocks were made and put under actual inplant trials in a strip mill for evaluation. It was observed that corundum base castables can be used upto 1500°C safely but at 1600°C and above liquid formation and volume shrinkage is more which makes it unsuitable for use at 1600°C and above. Further trials have been initiated using fused alumina as aggregate.

9. Development of Dense High purity Alumina Grains from Technical Alumina.

The objective is to develop dense high-purity alumina grains similar to imported 'tabular alumina' from technical alumina i.e. Bayer's alumina.

A detailed literature review was carried out with a view to collect some relevant informations on the topic. Raw Bayer's alumina was procured and its properties are being evaluated. The technical alumina was ground for different periods in the pot-mill in order to obtain very fine particle size. The determination of overall particle size analysis is in progress. Few buttons of 2″ dia were hydraulically pressed from a selected batch composition and their green bulk densities were determined. These samples are to be sintered in a gas fired furnace for further developmental work.

10. Development of Submerged Arc Welding Fluxes.

Fluxes for hard facing of steels by the submerged arc welding process were developed which when used with ordinary mild steel wires gave hardness values ranging from 220 to 650 BHN. Some agglomerated flux compositions were also developed which may be suitable for S-A welding of mild and low alloy steels.

C. EXTRACTION & CHEMICAL METALLURGY

1. Extraction of Nickel and Cobalt from Lateritic Nickel Ores of Sukinda—Large Scale Testing (Roast Reduction and Ammonical Leaching Part). *All India Co-Ordinated Project between NML & Regional Research Laboratory, Bhubaneswar.*

a. Roast Reduction & Ammonia Leaching

Large scale trials were conducted with Kansa Ore in the vertical reduction furnace, using Talcher type coal for roast reduction. The leachability tests were conducted in ammonia-ammonium carbonate solution. Over 90% nickel and about 60-65% cobalt was recovered in solution. The feasibility of the process has been established on large scale.

b. Leaching, Solvent Extraction and Electrowinning

Large quantities of roast reduced pellets were ground and leached with ammonia-ammonium carbonate solution to recover nickel and cobalt in solution. About 150 litres of the leach liquor containing 5.3 gpl nickel and 0.13 gpl cobalt, was taken to RRL (B) where continuous solvent extraction electrowinning experiments were carried out to produce nickel cathodes. This entire programme has proved the feasibility of the entire process on large scale testing.

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

Preliminary trials with Ambamata concentrates received from the pilot plant of GMDC, were carried out. Leaching and solvent extraction studies with Lix-64N for copper and zinc recoveries are in progress.

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

Considerable work was done on leaching and recycling of spent liquor on fresh average grade representative sample.

4. Recovery of Ammonium Chloride and Vanadium Pentoxide from Effluents of the Plant Recovering Vanadium Pentoxide from Vanadium bearing sludges in Alumina Production.

The vanadium pentoxide plant of M/s. Rare Metals and Chemicals is producing the vanadium pentoxide of ISI grade. Experiments were conducted to recover NH_4Cl from effluent of the plant. The design for setting up the absorption tower for recovery of NH_4Cl at the Licencee's plant, is in progress.

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

The samples sent by NCL in September 1980 were tested and was found that the extraction recoveries were poor compared to the previous samples and therefore NCL has been suggested to prepare the reagents separately and send without mixing for testing, so that tests could be done with different compositions of the mixed reagents.

6. Extraction of Tin from Bastar Tin Concentrate.

Fresh sample of one tonne tin concentrate was received for large scale trials. In addition to tin, the sample also contains niobium and tantalum. Some bench scale experiments with the sample were conducted to verify the previous results. Large scale trials will be taken up.

7. Recovery of Lead from Battery Scrap.

Laboratory scale studies for the recovery of lead from the battery scrap were carried out and various parameters established for large scale trials in rotary furnace. Arrangement is being made to procure a tonne each of the grey and brown powders for carrying out experiments in rotary furnace.

8. Recovery of Vanadium Pentoxide from Vanadium Bearing Slag of M/s. VISL, Bhadravati.

Additional trials on further recovery of vanadium pentoxide from once roasted slag is in progress and also the detailed project report is under preparation.

9. Recovery of Copper, Nickel, Lead, Zinc and Elemental Sulphur from Complex Sulphide Mineral Complex.

The adaptability of bulk complex lead, zinc copper concentrate from Ambamata, to the flow sheet developed on ferric chloride leaching process,

was systematically examined. Leaching the as received concentrate with ferric chloride solution gave a recovery of 84% copper, 80% zinc and 100%. lead under optimum conditions established.

10. Processing of Sulphide Concentrates.

Utilisaton of low and complex copper sulphide concentrates from Sikkim was examined on the basis of the know how developed. Pretreatment and selective leaching were successfully carried out to remove certain impurities viz. Pb, Zn, As, Sb, Bi along with alkaline earth metals. Selective sulphation technique was attempted to recover the copper values from a copper ash sample. Copper recovery to the extent of 88% was achieved by selective sulphation with additives and aqueous leaching. Further work is under progress.

11. Preparation of Fluorine Chemicals.

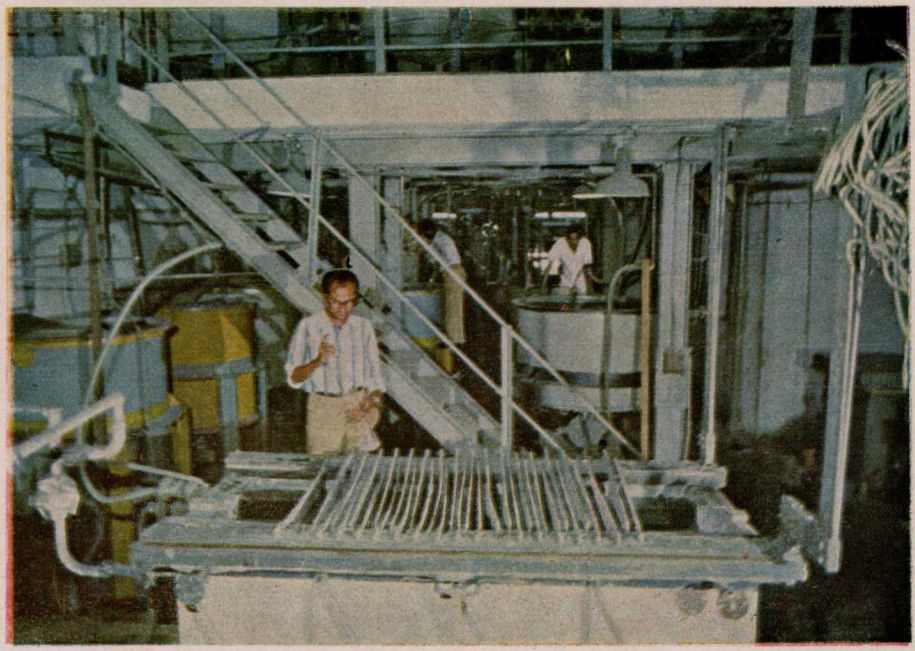
A process for the production of synthetic cryolite from fluorspar has been developed upto 100 kg. cryolite per batch scale. The process has been assessed by a consulting engineering firm and found to be technically sound and economically viable. The cryolite obtained by this process was also tested in the aluminium production cells by carrying out in plant trials at the Indian Aluminium Company's Hirakud works and found to be suitable for use in the aluminium industry. M/s. Indian Aluminium Co., have shown interest in the utilization of the cryolite process technology. The matter is under consideration of the company.

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

A process flow sheet for the production of red ferric oxide at 100 gm ferric oxide/batch scale from ferrous sulphate hepta-hydrate by thermal decomposition technique has been developed. The ferric oxide sample obtained from bench scale studies was sent to a reputed laboratory and a leading paint manufacturing firm for product evaluation. The reports indicated that the NML ferric oxide sample is high grade, has good oil absorption properties and matches the pigment colour ISC 445. Studies for the preparation of pigment grade yellow ferric oxide are under progress.

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

After examining titanium anodes with different surface conditions which gave excellent deposits of EMD with 93-94% MnO_2 and a battery activity index of 71.6%, silicon iron anode was tried as a substitute anode material. The deposited EMD contained 0.198% iron, contaminated from the electrode surface above the solution level. Further trials with this electrode covering the susceptible exposed surface with acid resistant coating are in progress.



Production of electrolytic manganese dioxide in the NML plant.

14. Large scale Electro-Metallurgical Facility. (Production of Electrolytic Manganese Metal and Dioxide)

M/s. Electro-Chem (Orissa) Ltd. a Joint Sector Company formed by Industrial Promotion & Investment Corporation of Orissa Ltd. & M/s. Rungta & Sons Pvt. Ltd., desire to set up 3000 tonnes per annum electrolytic manganese dioxide plant at Remuli Joda Road, Keonjhar District, based on NML technology. The project report has been prepared.

M/s. Manganese Ore (India) Ltd, intend to set up a 2500 tonnes per annum electrolytic manganese dioxide and 1000 tonnes per annum electrolytic manganese metal complex at Dongri Buzurg based on NML technology, and have sponsored investigations to examine the suitability of the ore fines at Dongri Burzurg for production of EMD and EMM. The investigation is under progress.

15. Production of Metal Powder : Gas-atomized Metal Powders.

M/s. Nalco Metal Powder Ltd. a licencee of NML developed technology, has started commercial production of zinc powder which was tested and found to be of good quality. The firm will soon start to produce aluminium powder on NML technology.

M/s. Micro-Metal Sen Ltd. another licencee of NML technology of metal powder production, is setting up a 700 tonnes/year plant to produce aluminium and zinc powder.

A few more firms are negotiating for the license to produce the metal powder based on NML technology.

16. Large Scale Multipurpose Testing Facilities for Non-ferrous Metal Extraction (Hydro-Electro Metallurgical Project.

The revised proposal has been approved by Governing Body of CSIR for implementation covering a seven year period from 1981-1987 with the assistance of a suitable project consultancy firm.

D. IRON & STEEL TECHNOLOGY

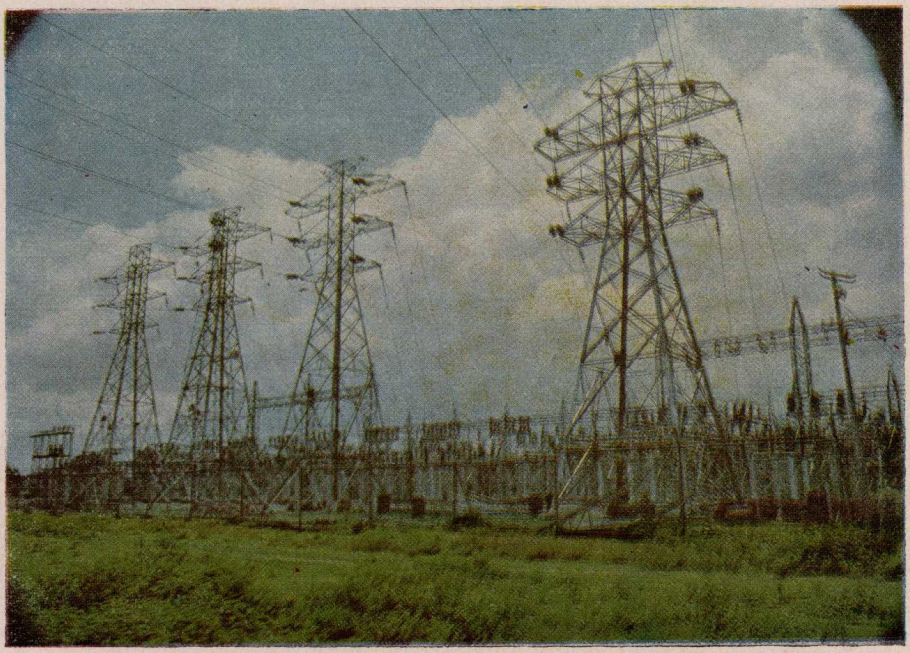
1. High Strength Low Alloy Steel.

Under collaborative programme of work with M/s. Visvesvaraya Iron & Steel Ltd., Bhadravati, Karnataka, industrial scale heats of niobium and niobium-vanadium steel were made in a 12 ton L.D. converter to standardize the large scale production process.

E. ALUMINIUM TECHNOLOGY

1. Development of Aluminium Cables & Conductors—Electric Grade Aluminium Alloy.

The NML-Gujarat State Electricity Board collaboration for the use of NML-PM2 in overhead conductors has met with commendable success.



NML marches ahead with R & D contribution to the energy sector.

In order to combat problems of severe corrosion in the coastal regions, the Gujarat State Electricity Board (GSEB) installed two types of conductors made from the versatile electric grade aluminium alloy 'NML-PM2'. Encouraged by the good performance of the conductor the GSEB and the Central Board of Irrigation and Power Jointly convened a conference at Baroda of all the State Electricity Boards having coastal regions to serve and a decision has been taken for wider trials with a composite AAC-NML-PM2 and PM 215 conductor in the coastal regions. NML-PM 215 is a high strength (30 kg/mm^2) and medium conductivity (53% IACS) alloy in advanced stages of development.

The Gujarat State Electricity Board has shown interest in the use of NML-PM 53 which is a medium strength medium conductivity aluminium alloy conductor in the coastal region and is in correspondence with NRDC, (to whom the technology has been transferred) for undertaking field evaluation of NML-PM 53 conductor jointly.

The Research, Deisgn & Standard Organization, Ministry of Railways, has shown interest in the development of NML-PM 215 and it is likely that the railway Board will be interested in putting up trial lengths of catenary conductors from NML-PM 215.

2. Development of Aluminium Alloy Electrode Wires.

Based upon the R & D work, the Laboratory has established the production technology of the aluminium alloy filler wire corresponding to BS 2901 NG 6, and IS 1278 : 1972 NG 6 specification. Although the nominal composition of the filler wire is described in the various national standards, their production technology required development to suit the indigenous resources. The technology includes the melting, solidification, and the processing and the filler wires have formally been designated as NML-PM 6. Fairly large quantities of NML-PM 6 filler wires in different gauge diameters have been supplied to M/s. Hindustan Aircraft Ltd. Bangalore ; for evaluation and to meet their requirements. The technology is now ready for commercial exploitation.

3. Development of High Strength Aluminium Alloy Conductor.

A high strength medium conductivity aluminium alloy designated NML-PM 215 has been developed which meets the potential for making catenary conductor and grooved contact wire. The welding trials of NML-PM 215 extruded rod by resistance butt welding have been carried out at U.K. The welded joints were then tested for various mechanical properties which have been reported to be satisfactory. Industrial trials are under way for making catenary conductor for railways from NML-PM 215 aluminium alloy.

4. Studies on High Strength Weldable Al-Zn-Mg Alloys.

Four point bending test apparatus for stress corrosion testing of high strength aluminium alloys have been fabricated as per ASTM. A number of heats were made in the form of plates from Al-Zn-Mg alloys with varying alloying additions. To study the effect of duplex aging on the stress corrosion

life of Al-Zn-Mg (4 Zn, 2 Mg) samples have been exposed in the above SCC test.

5. Filtration of Aluminium Alloys.

The development of NML reactive filter medium and its transfer of technology to M/s. Bhaskar Stoneware pipes Ltd. Delhi have been reported earlier. Since then the commercial production of the filter medium is going on and the demand by the aluminium industries is increasing. NML licencee has increased the production capacity to meet the demand. The user industries have stated the following important advantages of the NML reactive filter.

(*i*) Reduction in sodium levels in the filtered metal.
(*ii*) Reduction in oxide levels.
(*iii*) Uniformity of grain size.
(*iv*) Improvement in the yield in casting and extrusion shops.
(*v*) Reduction in the quality of fluxes to be used.

Foreign firms has shown interest in the commercialisation of NML reactive filter in their country.

6. Development of Inoculant (wire form) for Aluminium/ Aluminium Alloys.

Some aspects on optimization of the inoculant NML PM 122 from fundamental considerations of solidification were carried out with a view to study the fading out effect and optimum quantity of inoculants required for effective grain refinement. The technology for the production of NML PM 122 has been assigned to NRDC for commercial exploitation.

7. Development of Aluminium base Bearing Alloys.

Field trials of aluminium alloy bushes are in progress. Based on the results so far obtained some modification of alloy composition and processing parameters have been introduced to improve the casting characteristics. Ageing response and mechanical properties of modified alloy have been determined. Larger diameter bushes, stress relieved at ordnance factory Jabalpur, have been sent to Research, Design & Standards Organization, Ministry of Railways ; for field trials in large locomotives. It is also proposed to carry out trials of bushes made of the modified alloy at M/s. Escorts limited for use in hydraulic pumps.

8. Fracture Studies in High Strength Aluminium Alloys.

The fracture behaviour of aluminium alloy samples are being investigated by fracturing in three point bend test. The effect of alloying element, heat-treatment, dispersion of graphite particles in the matrix by modified solidification techniques are studied.

9. Defects in Aluminium Utensils manufactured by Small Scale Industries. *Sponsored by Govt. of Bihar.*

Based on investigational work, a viable technology was recommended for the improvement in productivity and quality control for the production of aluminium utensils in small scale industries in Bihar. It was successfully demonstrated through extensive in-plant trials at leading aluminium utensil manufacturing unit in Bihar where the rejection rate of the utensils particularly made by two or more spinning operations has been reduced down to 5-7% as compared to 30-35% of the existing practice. In the first week of November, 1980, a Workshop on "Improvements in aluminium utensil processing" was held at Patna, organised by Polytechnology Centre, CSIR, Patna, NML & Govt. of Bihar in order to disseminate the technological inputs recommended by NML to small scale aluminium utensil units in Bihar.

The technology for the melting of aluminium scrap for further processing into utensils has won acclaim from the Utensils Manufacturers Association of Bihar and the Development Commissioner, Small Scale Industries, Govt. of India has advised other regional centres to organise specific conferences to bring this development to the notice of small scale manufacturers in their regions. NML also attended a Workshop held at Trichur on similar type of problems of small scale aluminium foundries and a good response has been received from the small scale aluminium industry from that region.

F. DEVELOPMENT OF MAGNETIC MATERIALS

1. Development of High Permeability Nickel-Iron Alloys.

Sponsored by M/s. Guest, Keen & Williams Ltd.

Nickel-iron alloys are widely used in special type of transformers, inductors, magnetic amplifiers, switch cores, magnetic shields, tape recording heads and memory storage. These alloys are not manufactured in the country and the entire need of the country is met through import. The project was taken up on behalf of M/s. GKW to develop indigenous know-how for their manufacture. M/s. GKW had approached NML to develop four nickel-iron alloys having properties similar to those of (1) Mu metal, (2) Radio Metal, (3) Rho metal and (4) HCR alloys. The melting, rolling and heat treatment schedules for these alloys were developed successfully to give magnetic properties as per the specification of the sponsoring authority. Some of the alloys even showed better properties. The results of investigations have been made available to M/s. GKW for commercial production.

2. Structural, Magnetic and Deformation Characteristics of Mn-Al system.

The work on this project was taken up in the following stages.

(*i*) Preparation of Mn-Al-C alloys and the study of the structural aspects of the alloy from x-ray diffraction and metallographic analyses.
(*ii*) Suitable heat treatment of the alloys for developing optimum magnetic properties.

The work on the above stages has been completed.

3. Low Cobalt Magnetic Alloys.

The work was taken up to develop low cobalt Fe-Cr-Co permanent magnet alloys as substitute for alnicos and ferrites. A few 2 kg. heats of Fe-Cr-Co alloys with 15% to 23% cobalt were made in air induction furnace. The alloy after homogenisation treatment was quenched in water. The quenched alloy was given thermomagnetic treatment. The alloy was found to show permanent magnet characteristics. Further work to improve the magnetic properties is in progress.

4. Effect of Alloying Additions on the Stability and Magnetic Properties of Mn-Al-C alloys.

Work was taken up to develop stable and high energy product Mn-Al-C alloy containing small amount of alloying elements such as iron, cobalt and nickel. A few 2 kg. heat of Mn-Al-C alloy with small additions of iron, nickel were made in air induction furnace. Study of stability of the alloys after giving suitable heat treatment is in progress.

5. Low Carbon Soft Magnetic Iron.

16 mm dia. rods of soft iron manufactured & processed in the industry under NML supervision were supplied to a signal relay manufacturing unit of Indian Railways against their urgent requirements. Purchase orders to meet the urgent requirements of Indian Railways & Bharat Heavy Electricals Ltd. for 65 mm sq. soft iron billets were also received which are being processed for execution.

G. HIGH TEMPERATURE CREEP RESISTANT STEELS.

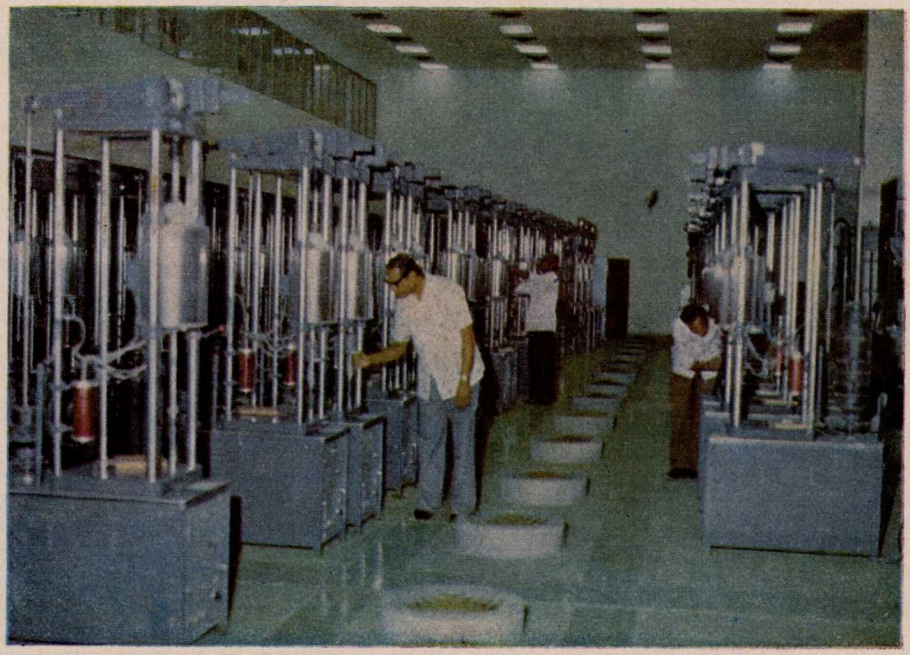
1. Development & Testing of Creep Resistant Steels. *Sponsored by M/s. Bharat Heavy Electricals Ltd.*

A number of creep resistant steels produced indigenously for thermal plant applications are being studied for high temperature creep behaviour with the ultimate objective of substitution of imported grades of steels.

Long term evaluation is in progress on the following steels.

(*i*) Bolting Steel—1 Cr-1Mo-$\frac{1}{4}$v (DIN 17240-21 CrMov 57).
(*ii*) Tubing Steel— (*a*) $2\frac{1}{4}$ Cr-1 Mo
(*b*) $1\frac{1}{4}$ Cr-$\frac{1}{2}$ Mo
(*c*) 1 Cr-$\frac{1}{2}$ Mo
(*iii*) Casting & forging steel :—
(*a*) 1Cr-1Mo-$\frac{1}{4}$v (FOV)—Casting
(*b*) $\frac{1}{2}$ Cr-$\frac{1}{2}$ Mo (O. 5 FO) castings
(*c*) 1.4Cr-1Mo-$\frac{1}{4}$v (1.4 FOV) Forging
(*d*) 1Fo4/15XM (1 Cr-1Mo) Forging

Investigations have been completed on the following grades of steel.
(*i*) $1\frac{1}{2}$ Cr-1Mo $\frac{3}{4}$ VT-B—for application in steam turbine bolting steel.
(*ii*) $1\frac{1}{2}$ Cr-$\frac{1}{4}$ Mo (En-20B)— -do-



Development and testing of creep resistant steels at NML.

Necessary data Viz. creep, stress-ruptures and stress relaxation up to 30,000 hr. have been generated for these steels.

2. Creep Rupture Testing of AIS-316 Stainless Steel. *Sponsored by Reactor Research Centre, Department of Atomic Energy, Kalpakkam.*

Creep and stress-rupture data at 550°C and 600°C upto 40,00 hr. on over 60 samples drawn from several plates/heats were generated and the report submitted to RRC.

3. Development of Nickel-free Creep Resistant Austenitic Steels.

Automotive exhaust valves were successfully manufactured by M/s. Engine Valves Ltd., Madras ; from NML's experimental alloys. The valves are now under accelerated performance test at M/s. TELCO and M/s. Simpson Co., Madras.

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

Thermal power plant components often experience temperature and pressure beyond the specified limit, resulting in premature creep failure of the components. Power plant engineers are confronted with the problem of taking decision about replacement of the component at a correct and convenient stage which ultimately affects the proper utilization of installed power generation capacity. To solve this problem, NML has developed experimental technique for assessing the extent of accumulation of creep damage i.e. the residual creep life of the components. The technique has already been used to predict the remaining lives of tubes/steam pipe received from Central Electricity Authority, (Badarpur Thermal Power Stations). Investigation is in progress on the following two samples.

(*a*) Superheater tube which has already completed the designed life i.e. 100,000 hr. sponsored by SAIL (R & D).

(*b*) Main Steam Line Boiler No. 1, after completion of the designed life i.e. 100,000 hr. sponsored by Neyveli Lignite Corporation, Neyveli, Tamil Nadu.

5. Steel for Short-term Evaluation.

During the period, the following steel samples were received for determining some specific properties.

Material	*Nature of Investigation*	*Sponsor*	*Status*
(a) Samples of castings produced by UNIABEX Alloy product, Thane.	Hot tensile & stress rupture tests.	M/s UNIABEX	Test completed and report submitted.
(b) 2¼Cr-1Mo forgings for seamless tubes.	Tensile & creep test.	SAIL (R & D) Ranchi.	Completed.
(c) Welding Electrodes.	Tensile & Creep rupture test.	D & H Secheron & Advani Oerlikon.	Completed.
(d) Pre-stressed concrete wire (P. C. wire).	Stress relaxation testing (1000 h)	ISI	Completed.
(e) Samples of castings for Indian Oil Co.	Stress-rupture test.	M/s Shivananda	Completed.

H. METALLURGICAL INVESTIGATION STUDIES ON FAILURE OF METALS & ALLOYS.

The following investigations on causes of failures and their remedial measures were conducted on behalf of the various sponsoring organizations and reports made available to them. Metallographic examinations were also conducted on samples received from various organizations.

1. Failure of Water Wall Tube of Boiler. *Sponsored by Patratu Thermal Power Station, Bihar State Electricity Board.*

2. Failure of Reheater Tube of Boiler. *Sponsored by Patratu Thermal Power Station, Bihar State Electricity Board.*

3. Failure of Economizer Tube of Boiler. *Sponsored by Barauni Thermal Power Station, Bihar State Electricity Board.*

4. Failure of Reheater tubes of Boiler. *Sponsored by Barauni Thermal Power Station, Bihar State Electricity Board.*

5. Failure of Secondary Super heater Tube, Boiler No. 7. *Sponsored by Bokaro Thermal Power Station, D.V.C.*

6. Failure of Ball Pin in Disc Insulators. *Sponsored by M/s Jayashree Insulators, Calcutta.*

7. Failure of Chlorine Cylinder Valve. *Sponsored by M/s Vanaz Engineers (P) Ltd. Pune.*

8. Failure of CDS Tube. *Sponsored by M/s Mining & Allied Machinery Co. Ltd. Durgapur.*

9. Failure of I.D. fan of Tomlinson Recovery Boiler. *Sponsored by M/s Bengal Paper Mill Co. Ltd., Raniganj.*

10. Failure of Rotors. *Sponsored by Ukai Thermal Power Station, Gujarat State Electricity Board.*

11. Failure of Boiler Quality Plates. *Sponsored by M/s ACC-Babcock Ltd., Durgapur.*

12. Failure of Angle Beam and Shackles. *Sponsored by National Hydro-electric Power Corporation, Allahabad.*

13. Failure of Socket Clevis. *Sponsored by National Hydro-Electric Power Corporation, Allahabad.*

14. Failure of Condenser Tube. *Sponsored by Patratu Thermal Power Station, Bihar State Electricity Board.*

15. Failure of Heater Tube. *Sponsored by M/s Indian Oil Corporation, Barauni.*

16. Metallurgical Examination of Steel Rods. *Sponsored by M/s Steel India (P) Ltd, Aurangabad.*

17. Metallographic Examination of Steel Samples. *Sponsored by M/s Steel India (P) Ltd. Aurangabad.*

18. Metallurgical Examination of Stainless Steel Valves. *Sponsored by M/s Shama Engine Valves Ltd. Bhopal.*

19. Metallurgical Examination of CDS Tubes and Couplings. *Sponsored by G.S.I., Calcutta.*

20. Development of Hammer Bits for Coal Crushing. *Sponsored by Faridabad Thermal Power Station.*

21. Metallurgical Examination of Cement Mill Liner. *Sponsored by M/s Satna Cement Steel Works Foundry, M.P.*

22. Metallographic Examination of Copper Rods. *Sponsored by M/s Hindustan Transmission products Ltd., Bombay.*

23. Metallurgical Testing of Socket-Clevis. *Sponsored by M/s EMC, Calcutta.*

I. MECHANICAL WORKING & TESTING

1. Development of Copper Clad Steel.

The technology developed is ready for commercial exploitation. The product fulfils all required properties of standard specification.

2. Production Technology of High Sensitive Thermostatic Bi-metal.

The technology developed is ready for commercial exploitation. The product developed fulfils the required properties of standard specification.

3. Stainless Steel Clad Aluminium Sheet.

A specialised rolling technique has been developed which will control the deformation of stainless steel but allow the aluminium to flow freely while rolling. Several roll bonding experiments were carried out with this technique and the properties studied. Further work is in progress to standardise the optimum reduction and the rolling technique.

4. Development of Duplex Shear Blade.

Few heats of tool steel and high carbon steel were made, hot worked and hot roll-bonded with thicker mild steel backing plate to get the duplex shear blade. Other methods of getting the duplex properties at the two opposite surface were tried. Heat-treatment schedule and properties evaluation of both the processes are being studied.

5. Production Technology of Electrical Contact Materials.

(*i*) *Silver-Cadmium and Silver-Cadmium Oxide Contacts*

Several heats of silver and cadmium containing 5 and 10% cadmium were made. The castings were done in metal mould in the form of slab. The slabs were then subsequently rolled to different thickness. Small samples were cut form the rolled sheets and subjected to internal oxidation heat-treatment. Heat-treatment schedule has been standardised and required electrical conductivity and hardness were obtained. Further work on silver-cadmium alloy containing 12 and 15% cadmium is in progress.

(*ii*) *Silver Brazing Alloy*

Few heats were made with silver, copper, cadmium and zinc. Casting was done in the form of slab and rod. Subsequently the slabs and rods were further reduced by rolling and wire drawing process. Further work on other compositions of the silver brazing alloys are in progress.

(*iii*) *Copper-Chromium Alloy*

The production technology of the copper-chromium alloy containing upto 1% chromium has been developed. All the required properties mainly electrical conductivity, resistance to wear hardness etc. were studied and compared with the standard specifications. This alloy is mainly used as an electrode for seam welding and as a contact material.

6. Forging of Powder Metallurgy Parts.

The objective of this project is to study the forging characteristics of iron powder preforms to get the properties associated with the wrought

components and to develop a technical know how for industrial exploitation.

It was experimentally observed that the maximum density of the green compacts is obtained at a pressure of 20 tons load. The compacts made were sintered at various temperatures, under controlled atmosphere. The sintered products were forged and reduced to different thickness and the density and the hardness of the forged products were observed. The maximum hardness obtained was between 225-235 VPN. Further work to study the different aspects of forging and sintering characteristics of the green compacts is in progress.

7. Mechanical Testing & Working Facility.

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 mechanical working facilities, namely rolling, forging, extrusion and wire drawing were extended to the various projects of the Laboratory. Various sections of the aluminium-magnesium alloy and magnesium base alloy were extruded for Indian Sapce Research Organization.

J. FOUNDRY TECHNOLOGY

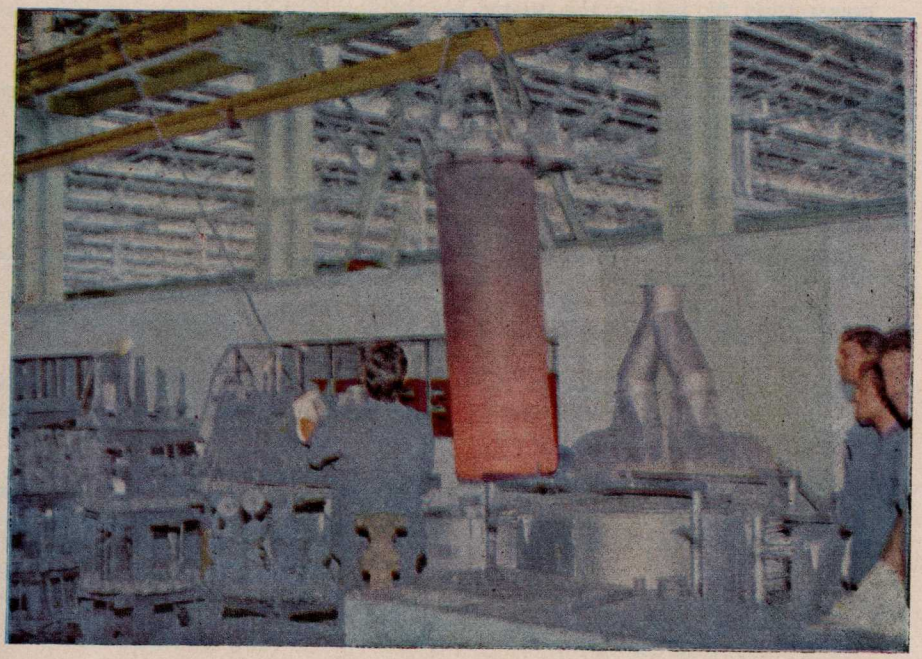
1. Product Development with Heat Resistant Cast Iron (NML-Pyroloy 1000).

NML-Pyroloy-1000 is undergoing industrial evaluation trial for various applications in carrier blade castings for sheet for reheating furnaces. Nearly 500 carrier blade castings were made at the Tool Steel Plant, Tisco ; using a $\frac{1}{2}$ ton induction furnace. 480 numbers of carrier blade castings were put in the reheating furnace of Tisco's sheet mill for full scale evaluation test. More than 200 carrier blade castings are still in very good condition after nearly eight months of service at a service temperature of 900°C.

Element pins made of NML-Pyroloy-1000 were fitted in M/s. GEC Electric heating furnace and are under trials since more than a year at the Field Gun Factory, Kanpur. It is reported that these NML-Pyroloy pins are giving highly satisfactory service and are still in very good condition and giving continued service.

Grillage link castings for walking beam furnace is yet another high temperature application, where NML-Pyroloy-1000 has been put for industrial evaluation trials at the Rourkela Steel Plant. These were found to be in good condition even after eight months service at 900°C. Rourkela Steel Plant is eager to replace Ni-Cr castings by NML-Pyroloy-1000.

NML-Pyroloy-1000 spacer castings of different designs and sizes for gas-carburising of automobile components are being evaluated in heat-treatment shop at M/s Telco Ltd., Pune. It has been reported by M/s. Telco, Pune ; that these spacer castings are still in good condition and are giving satisfactory service even after more than six months of continuous use.



NML Pyroloy spacer castings undergoing in-plant trial inside the hot retort containing automobile parts at Telco heat treatment shop, Pune.

2. Wear and Abrasion Resistant Cast Iron. (NML-WARNOT).

Industrial trial of 'NML-WEARNOT' is being planned at M/s. Mining & Allied Machinery Corporation Ltd., Durgapur. Detailed discussions have been held in this connection. The items selected for trials are (i) parts of hydrocyclone, (ii) parts of slurry pumps and (ii) periferial liner used in coal mill exhauster.

3. Development Self-setting and Fluid Sand Process.

Several alterations such as ferrochrome slag, modified ferrochrome slag, portland cement, fast setting cement etc. were tried. Some additions are being tried to reduce the water percentage in both cement bonded and sodium silicate bonded sand.

4. Development of Know-how regarding Special Castings Method.

Preparation of stucco material, used in investment castings, from indigenous raw material has been taken up. The process parameters were worked out on a laboratory scale for its production. Preparation, of silica sol, binder used in investment casting has also been taken up. The parameter for its production have also been standardised.

K. CORROSION STUDIES ON METALS & ALLOYS

1. Studies on Atmospheric Corrosion of Metals and Alloys.

International Collaborative Project with National Research Institute for Metals, Tokyo, Japan.

Exposure studies with the different structural materials sent from Japan have been started at three different sites namely Jamshedpur, Madras and Digha. A preliminary report on performance of the various samples at the initial stages has been made. It has been observed that' Marine Steel' supplied from Japan remained bright in all the atmospheric condition of the exposure sites whereas different conventional high alloy steels started corroding.

For comparative evaluation, a separate batch of Indian samples having similar composition has been exposed at Jamshedpur in Sept., 1980. Regular measurement of pollution humidity, temperature, rainfall, V.V. Energy, etc., of the atmosphere are being carried out.

2. Development of 'Backfill' material for 'SUPERAL' Anode (Aluminium base Sacrifical Anode).

Several chemical compositions to be used as 'backfill' materials for cathodic protection of metals have been tested in combination with 'SUPERAL' anode in soils having varied resistivity ranging from 300 ohm cm to 2000 ohm cm.

Two formulation were found to maintain the performance of SUPERAL anode to protect the steel samples at potentials of—1020 to —1040 mv in soils having resistivities of 300-500 ohm cm. Pilot plant scale trials on buried

pipe line with some of these 'back fill' chemicals and SUPERAL anode is being planned.

3. Studies on Stress Corrosion Cracking of Metals.

The various metallurgical and environmental parameters on the initiation and propagation of stress corrosion cracking of mild steel, brass and stainless steels were studied. An interesting phenomenon has been observed that irrespective of metal environment combination, stress corrosion cracking initiates on metal surface with the development of a series of pits in specific pattern.

4. Studies on Hydrogen Embrittlement of Steel in Aqueous System.

It has been observed that cold rolled mild steel also gets embrittled in sulphuric acid under the influence of constant hydrogen charging (cathodic charging).

Different organic chemicals known as inhibitors have been tried in acid pickling solutions. Some of these chemicals could effectively reduce the dissolution rates as hydrogen pick-up by the steel. Based on the data, a suitable formulation has been made which gives 90-92% inhibition efficiency in 2-5N H_2SO_4 at 40-70°C and could check hydrogen pick up by the steel effectively. The work is completed.

5. Evaluation of Inhibitors for Corrosion Control in Recirculating Cooling Water System.

One formulation based on non-chromate chemicals has been developed. The evaluation of the inhibitor under dynamic conditions will be done in the available existing cooling tower at the NML. The work is completed.

L. SURFACE COATING ON METALS

1. Development and Performance Evaluation of Diffusion Treated Steel in Fertiliser and Chemical Industry. *Collaborative Project with M/s Fertiliser (P & D), India Ltd., Sindri.*

A collaborative project between NML and Fertiliser (P & D) India Limited, Sindri ; has been undertaken with the object of aluminium coating of mild steel tube by diffusion treatment for utilisation in heat exchangers of sulphuric acid plants. This heat exchanger tubes also finds application in petrochemical and other industries. Work on this project has started recently.

2. Development of Alkali Silicate-Zinc Dust Coatings.

Successful primers based on alkali silicate and zinc dust were developed and the performance of the primer under atmospheric exposure condition for the past 20 years at Jamshedpur, Digha & Madras was found excellent. The work is completed.

3. Chromizing and Calorizing of Low Alloy Steel Parts for High Temperature Service.

Calorized saddle castings were found to possess enhanced oxidation resistance, about 20 to 30 times, more than the base metal. Work is completed.

4. Electro-galvanizing Steel Wires from Fluoborate Bath.

The brightener developed for electrogalvanizing of steel wires from fluoborate bath was found to be quite stable even at high current densities. Work is completed.

5. Zinc rich Primers based on Organic Silicates.

Exploratory work on development of zinc rich primers based on organic silicates was undertaken for corrosion protection of steel with special reference to marine applications. Some experiments were carried on the controlled hydrolysis of ethyl silicate-40, using polyhydric alcohols and different solvents with a view to obtain a suitable vehicle for zinc rich primer.

6. Silver Plating from Non-cyanide Bath.

The project was taken up on an exploratory basis. It was found possible to get silver electrolytically deposited in an acceptable form from non-cyanide bath. Work is in progress to optimize the conditions and make the solution more stable.

7. Development of Electrolytic Process for Colouring Aluminium Alloys.

Work was carried on integral colouring of aluminium alloy (A12s) and commercial aluminium electrolytically. A number of colours ranging from yellow, deep red to black, resistant to sunlight could be produced. Work is under progress for optimizing conditions for getting more shades and subsequently scaling up the process.

M. STANDARD REFERENCE MATERIALS & ANALYTICAL WORK

1. Preparation of Standard Reference Materials.

Standard samples are of vital importance to metallurgical and mineral industries for rapid and accurate analysis of the raw materials and finished products. Standard sample of cast iron was prepared. Replenishment of 0.4% Carbon steel and nickel steel was done. 61 kg. of chemical standards were sold worth Rs. 1.25 lakhs.

Standardisation work of low alloy steel spectrographic standard was completed.

2. Analytical Work.

(*i*) Chemical and Instrumental Analysis—2691 samples for 8001 radicals were analysed.

(*ii*) Analysis of Gases in Metals—101 Samples for 352 radicals were analysis.

(*iii*) Spectrographic Analysis—1350 Samples for 1861 radical were analysed. Complete qualitative analysis was done for 150 samples.

N. APPLIED BASIC PROJECTS

1. Solidification of Two Phase Field of Aluminium Alloys.

More alloys of 2014 and 7075 types were prepared with varying Mg and Li contents. Work on ageing kinetics as reported in the last report were carried out upto 500 hours. These alloy were cast from the two phase field after stirring. The effects of alloying elements and solidification techniques on the ageing behaviour have been studied. It was observed that presence of Li produced accelerated ageing on two phase solidification. Wear resistant of these alloys were also studied in the Amsler wear testing machine and the results indicated that alloys produced by two phase solidification have better wear resistance.

2. Grain Refinement of Wrought Aluminium Alloys.

(a) Studies of the Effect of Six different pre-treatment schedules on the recrystallization kinetics of direct chill cast Al-1.25 Mn alloy were completed. Studies of the effects of the above pre-treatments and heating rate on the extent of recrystallization was also completed. Further work is in progress.

(b) Al-Cu-Zn alloys was subjected to different thermo-mechanical treatments to achieve fine grain size and to develop super-plasticity. So far about 200% elongation could be obtained in tensile specimens. Further work to improve the properties is in progress.

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

During the period, studies on the effect of pH on the inhibition efficiency of chromate were completed using a new radiotracer technique developed in the Laboratory.

EXTENSION UNIT

NML UNIT IN CSIR COMPLEX, MADRAS

The NML Unit, during the period, has laid emphasis on R & D projects in various disciplines in addition to rendering technical services to public and private sector organisations. The construction of the Technological Bays is complete and equipment and machinery of scaled up ore-testing facility have been installed. Several important sponsored projects are underway such as pelletisation of Kudremukh Iron ore concentrate sponsored by MECON ; beneficiation of silica sand from Arror Udyog, Mangalore. Sand and kyanite samples from Maharashtra Minerals Corporation, Bombay etc. Calcination studies on two limestone samples from Syria have been completed. The semi-automatic carbon analyser for rapid and efficient analysis of carbon, developed by the NML Unit, Madras ; has been assigned by NRDC for commercial exploitation to another firm M/s. Equipment Sales and Service Corpn., Madras.

Exposure studies of sampled received from Japan under the project of NML-NRIM collaboration on atmospheric corrosion were started in March 1980 and continued during the year 1980-81.

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

1. Studies on Copper Tailings from Mosabani, Hindustan Copper Ltd.

Gravity method of concentration employing tablingdid not yield a product preferentially rich in copper. However, the table tailings assayed 0.097% Cu. Some other methods applied did not give encouraging results. Work is continued to determine whether the grade can be improved.

2. Studies on Carbon/Cryolite Dust Sample from M/s. HINDALCO, Renukot.

The sample of carbon-cryolite skimmings as received analysed 43.8% cryolite and 10.25% C. Preliminary flotation tests after grading the sample to 65 mesh indicated that most of the carbon could be floated leaving cryolite in the tailings. Further tests are in progress.

3. Development of a Fluo-solid Reactor for the Calcination of Limestone.

As a preliminary effort, a single stage dryer (capacity 250 kg/ hr)to dry wash sands from 5% to 0.1% or less has been designed. All the design parameters have been worked out and the drawings are being made. The reactor will be given for fabrication shortly.

A multistage fluo-solid calciner model made of parpex 150 mm size dia is being fabricated. The study of fluidisation and flow characteristics in the model will enable collection of useful data for further work on high temperature calciner.

4. Dry Scrubber for Sand Reclamation. *Inter-Laboratory Project.*

Based on the work conducted by the unit on the core scrap samples of M/s. Ennore Foundries Ltd., Madras, the Inter-Unit project started by MERADO for the manufacture of the prototype dry scrubber has made progress by way of fabrication of the rotating table, impeller, bearing housing, barrier plate, stationary teeth etc. at the MERADO Workshop.

5. Studies on Two Limestone Samples from Syria.

As a part of the larger NML project of iron ores and other raw materials from Syria, studies were undertaken on two samples of limestone designated as 'K' and 'T' from Syria. The work involved complete chemical analysis of both the samples as received as well as the screened lumps after crushing to certain stipulated sizes, determination of amount of fines generated during crushing, bulk densities of the samples, as received, as well as the crushed and screened products of which calcination characteristics were to be studied. Cold crushing strength, true and apparent porosity, specific gravity, hardness on Moh's scale, tumbler and abrasion indicese etc are also to be determined. Mineralogical characteristics of both the samples (as received) and calcination characteristics of crushed and screened lumps viz. 160-80 mm and—55—20 mm of both the samples K and T also were studied.

6. Sampling, Chemical and Sieve Analysis of Six Iron Ores, Six Coals and Two Limestone Samples from Ganesh Scientific Research Foundation, New Delhi.

About one tonne each of six iron ore fines, six coals and two limestone samples reported to be collected from various mines in India were received. The work involved drawing representative samples and sieve and complete chemical analysis on each sample.

7. Pelletisation Studies on Kudremukh Iron Ore Concentrates.

Batch pelletisation trials were carried out to determine the various variables. Based on the batch test results, large scale pelletising and heta-hardening trials were conducted at selected variables as suggested by MECON. Collection of additional data is in progress. Gukushin reducibility tests and swelling index measurements were also carried out on pellet samples.

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

Tabling of the washed sand after desliming, yielded a sand fraction, assaying 98.2% SiO_2, 0.11% Fe_2O_3 and 0.1% TiO_2. Efforts are being made to further bring down the Fe_2O_3 contents in the concentrate so as to make it suitable for glass making.

9. Beneficiation Studies on Kyanite Sample. *Sponsored by M/s. Maharashtra Mineral Corporation, Bombay.*

Tabling tests were conducted after classification and desliming. Hindered settling classification trials and air classification studies were also conducted. The original feed contained 10% tourmaline. The table concentrates contained only 1 to 2% tourmaline. Further tests on 60 mesh material is in progress.

10. Calcination Studies on Two Samples for Syria.

Two limestone samples from Syria designated K and T were studied for their calcination characteristics and reactivity to optimise the parameters of size of limestone for calcination and temperature of calcination. In all 20 calcination experiments were carried out at temperatures of 950°C to 1200°C. The burnt lime produced in these tests were subjected to disintegration and reactivity studies.

11. Studies on Reduction Disintegration Index of Two Samples of Donimalia Iron Ore.

Two samples of Donimalai iron ore were tested for their reduction disintegration index in the Gakushin reducibility apparatus for M/s. Minerals and Metals Trading Corporation.

12. Determination of Alumina Minerals in HINDALCO Bauxites.

The various alumina bearing minerals present in HINDALCO bauxite were determined quantitatively and conveyed to the party.

13. Acid Pressure Leaching of Chalcopyrite Concentrates. *Sponsored by M/s. Chitradurga Copper Co.*

The investigation on the acid pressure leaching of copper concentrates with the object of recovering the copper values as copper sulphate and sulphur values as elemental sulphur was taken up. About 16-20 tests are proposed to be conducted in the 2 litre autoclave to optimise the parameters of temperature, oxygen pressure, acid concentration, acid to concentrate ratio and particle size. So far 4 tests have been carried out and about 35% copper has been recovered from the concentrate as copper sulphate. Further trials are under progress.

14. Studies on Foundry Sand Sample. *Sponsored by M/s. Maharashtra Minerals Corporation, Bombay.*

Eleven samples were received for evaluation of their suitability for foundry moulding and glass making purposes. Six samples were taken up initially for the studies. Work on the mechanical grading in the as-received and washed condition, estimation of clay content and grain fineness number was completed. Studies on the moulding characteristics of the samples are in progress.

15. Testing of Collapsible Agents for Carbon Dioxide Process.

Based on the results obtained from testing of collapsible agents of M/s. Texchemin Corporation, Madras, it was found that the proprietory collapsible agents, in general, work well upto a temperature of around 750°C which makes them ideally suitable for non-ferrous and other low-melting alloys.

Work was initiated to develop a collapsible agent for the CO_2 process which will work well at temperatures of over 800°C making them suitable for use in heavy grey iron and steel castings. Mixtures were prepared and their properties were evaluated after firing at different temperatures.

16. Studies on Atmospheric Corrosion of Metals. *International Collaborative Project with National Research Institute for Metals, Tokyo, Japan.*

The yearly observation report on the samples of NRIM Japan, exposed at Madras was sent to NML, Jamshedpur for a consolidated report which also includes the results of Jamshedpur and Digha.

17. Corrosion Studies on Aluminium-Brass Condenser Tube at M/s Ennore Thermal Power Station.

Some aspects of corrosion studies relating to the failure of Al-brass condenser tubes used at E.T.P.S., Madras were studied and the causes of the corrosion failure were determined.

18. Evaluation of Chromel/Alumel and Pt/Pt-Rh Thermocouples and Platinum Resistance Thermometers.

About 10 No. thermocouples received from industry were evaluated at different temperature ranges specified by them.

19. Setting up of Chemical Laboratory for Analysis.

M/s. Aroor Udyog (Mangalore), a major supplier of washed sand to a leading automobile foundry in Western India wanted to set up a Quality Control Laboratory, mainly for chemical analysis of sand. After scrutinising their requirement, the Unit undertook setting up of the Chemical laboratory. Technical assistance was provided for selection of equipment etc and technical briefing to the staff on quality control procedures.

20. Electroflotation of Chalcopyrite Fines.

Electro flotation studies were conducted on chalcopyrite fines with a modified Hallimond tube designed for electrofloating using platinum anode-copper cathode and graphite anode-copper cathode systems. Excellent possibilities of flotation of fine chalcopyrite particles with oxygen bubbles were indicated.

21. Chelating Agents as Collectors for Sulphide Minerals.

Flotation experiments were carried out in a modified Hallimond cell with a collector system of oxine and fuel oil. Reagent concentration, PH and conditioning time are the variables studied.

22. Studies on Leaching of Chalcopyrite Concentrate 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 sulfur. The effect of variables such as temperature, concentration, amount of HCL, pulp density and particle size were studied on the rate of reaction. The progress of the reaction was also studied kinetically with reference to temperature and concentration. Under the leaching conditions used, 80% extraction of copper is achieved in the presence of solvent and 60% was obtained in the absence of solvent.

23. Heat treatment, Metallographic Studies, Mechanical Testing, Analysis, Refractory Testing etc.

The Unit also carried out heat treatment, mechanical testing, metallographic studies etc. on samples received from various organizations. Under the scheme of modernization of foundries under small Industries Services Institute, a report on the modernization of Shri Andal & Co, Kumarapalayam was prepared and submitted to SISI. 432 samples for 1747 radicals were analysed for various R & D projects as well as for various industries. Refractory testing work was also done for a number of organization.

24. Design Work.

The following design assignments were completed :

(*i*) Ore bin feeder and vibratory feeder support for the scrubber.

(*ii*) Portable trolley arrangements for fixing the vibrating table.

(*iii*) Slip mould detail for the preparation of PCE test specimen.

NML FIELD STATION, HOWRAH

NML Field Station, Howrah, have continued to render services to the small scale metallurgical industries in Howrah by providing testing facilities as well as technical advice regarding quality control and product development. Number of visits have also been made to the different industries by the staff of the Field Station, for providing technical assistance on the spot.

An account of the details of the work undertaking by this centre during the review period is enumerated below :

Chemical Test—No. of Samples	606
no. of radicals	2041
Mechanical Test	397
Number of Technical Enquiries	28
Metallography	12
Visit to industries and technical advice rendered on the spot.	5

NML FIELD STATION, AHMEDABAD

The field station did the following work.

Beneficiation of Chalk Sample received from Director, Geology & Mining, Gujarat.

Bench scale beneficiation studies were conducted on a low grade chalk sample. The sample as received, analysed 45.52% CaO, 12.35% SiO_2. Concentrate assaying 53.5% CaO, 2.3% insoluble, 2.0% Fe_2O_3 with CaO recovery of about 48% was obtained.

The station conducted chemical analysis on 1168 samples for 4207 radicals on behalf of industrial organizations.

NML FIELD STATION, BATALA.

The NML Field Station, Batala, continued to assist the small scale industries of Northern Region particularly the foundry industries of Batala in the production of high duty graded cast iron castings, machine tool castings etc. by way of periodic visits and by attending to the day to day problems in moulding, core making cupola operation etc., and suggesting remedial measures for the elimination of casting defects. The Field Station is also guiding the local foundries in selection and application of proper raw materials for their day to day use by providing them analytical facilities.

During the period, the Field Station conducted the following work :

(*i*)	Total no. of foundry visits to guide them on the spot	103
(*ii*)	Total no. of technical enquiries attended through personal discussion & correspondence	185

(*iii*)	Total no. of samples tested for chemical analysis	207
(*iv*)	Total no. of radicals analysed	458
(*v*)	Total no. of Sand samples tested	5
(*vi*)	Total no. of samples tested for hardness	9
(*vii*)	Total no. of Cupola design released	16
(*viii*)	Total no. of unit served	103
(*ix*)	Total no. of unit served belonging to Registered Small Scale Units	93

ENGINEERING SERVICES

DESIGN ENGINEERING

The following design work was undertaken.

1. Development of a specimen making machine for making flat tensile specimens. The machine is under assembly.

2. Design of apparatus for testing the permeability of refractory samples.

3. Design of apparatus for testing abrasion resistance of refractories.

4. Design and fabrication of different types of apparatus, equipment and furniture required for the International Symposium on Modern Developments in Steel Making.

In addition to design of metallurgical pilot plant and testing equipment, the design office also provided services such as, preparation of display charts, reprographic services etc.

MECHANICAL ENGINEERING

The workshop provided extensive services for preparation of test specimens from alloy developed within the laboratory as well as materials received from outside, particularly for investigation on failures of metals.

Additional services provided include pattern making, and maintenance of vehicles.

ELECTRONICS ENGINEERING

A. INSTRUMENTATION OF PROJECTS

(*i*) *Mechanical Metallurgy*

Specification for thyristor control of rolling mill (to replace existing thyratron control was system) prepared.

(*ii*) *Instrumental Analysis*

Defects in Pye Unicam Atomic Absorption Spectrophotometer were rectified.

(*iii*) *Hydroelectro-metallurgy* (*HEMP*) *Project*

Steps were taken for installation of Thyristor Rectifier (0-50; VDC; 8KA).

(*iv*) *Mineral Processing*

One (German Make) temperature controller was repaired and several recorders serviced and calibrated.

B. GENERAL MAINTENANCE, INSTALLATION, TESTING AND CALIBRATION JOBS COMPLETED (MAJOR JOBS)

(i) Complete renewal of telephone cables at pilot plant site.
(ii) X-ray fluorescence spectrometer.
(iii) X-ray diffractometer.
(iv) Scanning Electron Microscope
(v) Geiger counting system.
(vi) Gas chromatograph.
(vii) Rolling Mill control.
(viii) Potentiometric Recorders (20 Nos.).
(ix) Temperature controllers (25 Nos.).
(x) X-ray Recorder.
(xi) Potentiostat.

ELECTRICAL ENGINEERING

A. DEVELOPMENT WORK

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

A 50 KVA indirect arc furnace available in the laboratory was selected to explore the feasibility of generating arc plasma using A.C. power. A partial generation of plasma could be attained by flowing optimum quantity of argon gas through the electrode holes.

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

Design for single specimen, multi specimen, multi specimen and extended zone furnaces were completed. Bill of materials and their detailed specifications were prepared. Machining and fabrication drawings for furnace shells were prepared.

B. DESIGN OF POWER DISTRIBUTION SYSTEMS, PREPARATION OF DETAILED SPECIFICATION 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 prepared. Execution of installation and commissioning were planned and implemented.

(i) Separate protected panel system for the power supply of the essential utilities of the Creep Testing Laboratory.

(ii) Electrical installation of Transmission Electron Microscope.

(iii) Electrical installation of bending strength testing and hot load testing equipment.

(iv) Power supply to Mains Frequency Induction Furnace and high capacity pump.

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

(vi) Dismantling and rewiring of the areas for protection against corrosion.

(vii) Installation of power & lighting distribution boards etc. as replacement in the Main Building.

(viii) Design & fabrication of muffle and tube furnaces upto 1000°C for various metallurgical research & development requirements.

C. PREVENTIVE MAINTENANCE AND BREAK DOWN REPAIR

Scheduled preventive maintenance and replacements, planning and execution of proper inspection and monitoring of various critical components while in service and fault shorting and repairing were carried out for the electrical equipments of the laboratory, its pilot plants and residential areas, comprising of high tension substations, electric arc furnaces, high frequency furnaces, resistance furnaces, rectifiers, electric motors and their control centres, temperature and humidity control equipment etc.

D. FORECASTING AND PROCUREMENT OF SPARE PARTS

Forecasting and procurement of spare parts for power distribution system, temperature and humidity control system, melting facilities, metal testing facilities, pilot plants etc were carried out.

E. ESTABLISHMENT OF SPECIAL FACILITY FOR MELTING AND SMELTING

Installation and commissioning of a 350 KW-graphite rod resistor furnace were planned and executed. Installation of electrical sub-station, furnace structures, bus bar, water recirculation system, fume extraction system etc. for the furnace was carried out.

CIVIL ENGINEERING

Other than the normal maintenance of gas, water and other services lines, modification at various places, installation of equipment, the following jobs were completed and in progress.

WORK COMPLETED

1. Tarflet treatment to the terrace of NML roof of eastern and western wing of NML.

2. Barbed wire fencing for residential quarters.
3. Installation of Raymond grinding Mill foundation at MBPP.
4. Periodical white washing/painting to old 'D' type bungalows.
5. Periodical white washing, painting to C/2 bungalow at Agrico.
6. Periodical painting to old 'E' type flats.
7. Construction of maintenance site office at Tuiladungri Colony.
8. Periodical painting, white washing to new 'E' type flats at Agrico.
9. Cleaning chocked gas main & branch lines at NML.
10. Annual maintenance work of NML Field Station, Howrah.
11. Modification of drainage system in the washing room of NML canteen.
12. Repairing of water tower and the damaged compound wall of railway gate of FPTD.
13. Construction of wooden cubicle at Ref. Div. in NML.
14. Construction of partition wall inside chemical store, NML.
15. Painting & repairing of the carbon plant building at NML.
16. Tarfelt treatment to some roof at NML residential quarters.
17. Construction of brick masonry tank for FPTD & MBPP (NML).
18. Covering the vacant space near D'NML Office.
19. Construction of drain between staff Quarts. and Hammer shed at NML.
20. White washing & painting of NML Guest House at CH Area.
21. Providing gate for the central school plot at Adityapur.
22. White washing, painting of New 'D' type block at Agrico.
23. Painting and white washing of residential building at C.H. Area, & Pipe Line Road.
24. Modification and renovation of toilet at NML Club.
25. Maintenance of paths in the residential Bungalow at C.H. Area, Pipe Line Road and M.S. Flat Agrico.

26. Upkeeping of the NML building.

27. Drainage system for kitchen sink for staff qrts.

28. White washing, painting of staff Quarters—Tuiladungri Flats & H type double storied quarters.

29. Construction of roof for the installation of Electron Microscope at Creep Lab.

30. Providing M.S. grill to windows of Microscope room.

31. Fencing for the cooling tank at FPTD (NML).

WORK IN PROGRESS

1. Repairing and replacement of wooden doors and windows of the staff quarter.

2. Construction of cycle shed and improvement of the 42 No. type I staff Qurts. at Tuiladungri, NML.

3. Extension of service line at NML.

4. Protection against corrosion of M.S. reinforcement in R.C.C. roof of NML Building.

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

6. Providing and replacement of toilet bath room fittings at NML.

7. Repairing of road surface in pilot plants, FPTD & MBPP.

RESEARCH PLANNING

ANNUAL PLAN 1981-82

The Annual Plan for 1981-82 comprising Revised Budget Estimates for 1980-81 and Budget Estimates for 1981-82 was formulated on the basis of the requirements under ongoing and new research projects, international collaborative projects, pilot plant studies, institutional programmes, infrastructural facilities etc.

The document includes besides a brief review of achievements during 1979-80 based on the projects completed, projects likely to be completed during 1980-81 and their terminal results expected, areas of major thrust planned in 1981-82.

SIXTH FIVE YEAR PLAN PROJECTION

Project-wise planning and programming of Research & Development work for the sixth Five Year Plan covering the period of five years from 1980-81 to 1984-85 was formulated. The projection includes on going projects as well as new R & D project proposals, institutional projects, infrastructural facilities, extension centres, etc.

The major thrust in the Sixth Five Year Plan Projection would be to augment and modernise the existing facilities in the vital areas having national importance for which demand from the industries is ever increasing. The fields include (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/UNDP assistance in some of the areas.

Efforts of planning wing were continued on the proposals to the development of instrumental analytical facilities, library, documentation and information service and other infrastructural facilities as well as adequate support to the existing Field Stations.

Adequate attention was also given to the social needs of the NML Staff in the plan proposals for construction of staff quarters, guest house, training hostels, co-operative stores, dispensaries, central school for the children of NML Staff, club house, etc. which are very much lacking.

RESEARCH APPRAISAL ACTIVITIES

The Research Advisory Council, which met on 3rd & 4th of Sep. 1980 reviewed the R & D programmes of the laboratory under various disciplines and the final R & D programme was evolved along with the required resources inputs in respect of equipment, man power and other basic infrastructural facilities.

TECHNOLOGY UTILIZATION—PATENTS & PROCESSES

Institutional Consultancy Services

The following institutional consultancy services were conducted.

	Name of the Firm	*Scope of Consultancy*
1.	Central Coalfields Ltd., Ranchi.	Preparation of Report for coal flotation plant comprising treatment flowsheet, material balance and equipment specifications.
2.	Atlanta Engineering, Calcutta.	Examination of the scheme for manufacture of auto-bearings.

Commercialization of Know-how

The following technologies which were released earlier were commercialized and production has commenced.

	Name of Process	*Name of Licencee*
1.	Atomised extrafine non-ferrous metal powders.	M/s Nalco Metal Products Pvt. Ltd., Madurai, Tamil Nadu.
2.	Production of aluminium based sacrificial anodes for cathodic protection designated 'Superal' (India Pat. No. 119958).	M/s The Aluminium Manufacturing Co. Ltd., Calcutta.
3.	Production of nickel-magnesium alloy (Trial Production has been made).	M/s ABM & Metal Alloys Shimoga, Karnataka.

Process Know-how

(a) Released through NRDC

	Name of Process	*Name of Licencee*
1.	Carbon free ferro-alloys by alumino-thermic reactions (including I.P. No. 65231—chromium-manganese master alloy).	M/s Mysore Manganese Co. Pvt. Ltd., Mangalore.
2.	Production of liquid gold.	M/s Luxmi Traders, Calcutta.

(b) Technical Know-how Through Sponsored Investigations

(*i*)	Development of flow-sheet by investigation of their raw materials viz. Oolitic iron ores, dolomites limestone etc. for setting up of iron and steel complex at Syria.	Government of Syria thro' MECON.
(ii)	Evaluation of Bolani Iron Ore Sample by beneficiation as a part of modernization of Durgapur Steel Plant.	SAIL—Durgapur Steel Plant thro' Bolani Ores Ltd.

Get-together & Exhibition

1. NML participated in the Workshop on 'Improvements in Aluminium Utensils Manufacture' in November 1980 jointly organized at Patna by NML ; Polytechnological Centre of CSIR at Patna ; and the Government of Bihar. The expertise by means of recommendations of viable technology with field demonstration were given for the benefit of small scale aluminium utensils manufacturers.

2. NML participated in the 'Workshop on Technology Transfer' organised by NRDC at New Delhi on 15th Nov. 1980. The Workshop was well attended by about 300 delegates from India and about 30 delegates from overseas especially from developing countries. The workshop enabled the delegates to know about the R & D activities of NML.

3. NML participated in the Workshop on 'Industrial Development in Bihar' organized by the Association of Indian Engineering Industry at Patna in December, 1980. The Research and Development activities of NML on ores and minerals etc were highlighted. The Bihar State Industrial Development Corpn. informed of their desire to start joint sector plants in association with industrialists/ entrepreneurs based on the raw materials available in Bihar, utilizing the viable technologies and expertise available with NML.

4. NML participated in the All India Seminar on 'India's Economy-Aluminium' organised by the primary aluminium producers in association with users at Lucknow on 6th and 7th Jan 1981 wherein a paper on 'Impact, of Research at NML on the Aluminium Technology in India by Dr Rajendra Kumar, Scientist (Director), was presented. In the Exhibition held at this time, the NML displayed its processes and products in the field of aluminium metallurgy and the expertise available were brought to the attention of the delegates/visitors.

5. NML took part in the Seminar organized by the Small Industries Service Institute, Trichur, Kerala in March 1981 by way of presenta-

tion of a technical paper on some aspects of productivity improvement and quality control in small scale aluminium foundries.

State Level RD & D (Research Development and Design) Committee for Bihar

During the period under review, two meetings of the State Level RD & D Committee for Bihar were held the 13th meeting at Ranchi on 7th and 8th July 1980 under the Chairmanship of Dr S. S. Khanna, Director, NIFFT and the 14th Meeting at Adityapur on 24 and 25th Feb 1981, under the Chairmanship of Prof. V. A. Altekar, Director, NML and Chairman of State Level RD & D Committee.

As usual, a Get-together of small scale industrialists/entrepreneurs, officials of the State Govt. and its Agencies, Scientists from CFRI, CMRS, PTC Patna representatives of HEC, Regional Development Authorities etc, was held both at Ranchi and Adityapur during each of the above meetings.

The Get-togethers were preceded by visit by the members of the Committee to a few identified small scale units both at Ranchi and Jamshedpur to acquaint themselves with the technical problems of these units as also with their present practice and working conditions. Wherever possible on the spot solution/advice was rendered and problems referred to the concerned laboratory/institute are being attended to through investigations.

Technical Aid to the Industries

Nearly three hundred enquiries were attended to on processes/products received from public/private sector industries, entrepreneurs, State and Central Govts. Departments/Undertakings, universities etc.

Collaboration with Academic Institutions/Universities

Services were provided to Indian Institute of Technology, Kanpur in Scanning Electron Microscopic analysis work.

Training

The following were given practical training during the period under review :—

Name of trainee	*Period of training*	*Field of training*
1. B. N. Sahay HMBP, HEC, Ranchi	3.11.80 to 10.11.80	Fatigue testing
2. L. B. Srivastava Shri Ram Test House, Delhi	23.2.81 to 23.3.81	Metallographic Testing

3.	C. J. Nwanko Nigerian Trainee with Bokaro Steel Plant C/o. Bokaro Steel Plant, Bokaro	11.9.80 to 13.9.80	Industrial study tour cum training on heat treatment
4.	Mat Hussain Bin Saleh UNIDO trainee from Malaysia	1.7.81 to 31.7.81	Heat treatment & Metallography

Patents

Filed

	Title	*Inventors*
1.	A process for production of iron ore concentrate from low grade iron ores having hydrated iron oxides.	N. Chakravorty B. L. Sen Gupta K. K. Bhattacharya and G. P. Mathur
2.	Improvements in or relating to roll cladding with particular reference to that of stainless steel sheet to aluminium sheet.	J. Bhattacharya B. N. Ghosh and S. K. Banerjee
3.	Improvements in or relating to production of vanadium pentoxide flakes from vanadium bearing slags.	A. K. Nayak D. Bagchi D. D. Akerkar and V. A. Altekar

PHOTOGRAPHIC, REPROGRAPHIC & PRINTING SERVICES

The photographic and reprographic services continued to be rendered regularly besides preparation of exhibits such as translites, blow-ups etc for publicity in exhibitions. Printing services were rendered for printing of various stationeries, circulars, publicity materials, reports, folders etc.

TECHNICAL CONFERENCE

An International Symposium on "Modern Developments in Steel Making" was organised by National Metallurgical Laboratory in collaboration with M/s Tata Iron & Steel Co., M/s Steel Authority of India Ltd. & Indian Institute of Metals from 15th to 17th February 1981. The symposium was inaugurated by Shri S. Samaddar, Secretary, Dept. of Steel, Ministry of Steel & Mines on behalf of Shri Pranab Mukherjee, the Hon'ble Minister of Steel & Mines, Govt. of India.

The Symposium was attended by eminent specialists and renowned authors on different area of steel making. 350 delegates from India and 80 delegates from 20 countries of the world participated. United Nations Industrial Development Organization, Vienna ; took part in the Symposium.

Over 60 papers including 8 keynote addresses were presented and discussed in 8 technical sessions, which covered *inter alia* :

1. Theoretical aspects of oxygen steel making ;
2. Design and project engineering ;
3. Raw-materials for steel making ;
4. Refractories for steel making ;
5. Operational aspects of pneumatic processes ;
6. Operational aspects of other processes ;
7. Ladle metallurgy ;
8. Deoxidation and ingot-making.

The keynote addresses provided by eminent specialists like Professor Klaus W. Lange of West Germany, Dr. M. N. Dastur of India, Mr. Neil Cherrett and Mr. R. N. Younger of U.K., Dr. I. D. Chigrai of U.S.S.R., Dr. Paul E. Nilles of Belgium, Prof. Jacques Astier of France, Dr. H. P. Haastert of West Germany and Professor Atsumi Ohno of Japan provided a lucid background to the invited papers on each theme, highlighting the progress made so far and the future trends in each discipline.

The specially organised invited lectures by Mr. S. K. Nanavati (India) on "My impressions of the Indian iron and steel industry" and by Dr. B. R. Nijhawan of UNIDO, Vienna on "Global scenario of world steel industries particularly in the developing countries" provided a proper backdrop of the status of steel industry on the Indian and global scenes.

The poster sessions proved a valuable opportunity for the participants for a good pre-view, current view and post-view of the papers presented and this contributed to a great extent the wealth of technical discussions.

A view of the audience in a Technical Session of the International Symposium on Modern Developments in Steel Making.

DISSEMINATION OF INFORMATION

N. M. L. Technical Journal

N.M.L. Technical Journal stepped into its 22nd year of publication. The issues of the Journal Vol. 22, were edited and published.

Leading abstracting services like Metal Abstracts, Chemical Abstracts, report the abstracts of the papers published in NML Technical Journal.

Documented Survey on Metallurgical Development

The issues of the publications were brought out. The documented abstracting service published by the Laboratory is well received by industrial research organization & educational institutions.

Monograph on Indian Ores & Minerals

Volume 1 of the Monograph on "Ore & Minerals of India—Beneficiation & Agglomeration Technique for Industrial & Economic Exploitation" was released by the Prime Minister & President of CSIR, Shrimati Indira Gandhi, in April, 1981.

NML News Letter

The issues of the NML News letter were brought out.

Annual Report

The Annual Report of the Laboratory for the year 1979-80 was prepared and published.

News Paper Clipping Service

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

Publicity of Processes & Products

Periodic publicity was given for the developed processes & products ready for utilizations, under commercial utilization through brochures, folders, handouts, newspapers and other media.

Broadcast Talks

Broadcast Talks through All India Radio by Director & Senior Staff Members were given to appraise the public in general, the industrial entrepreneurs etc. about R & D work of the Laboratory and the assistance that can be rendered by the Laboratory to the industrial organizations.

Papers Published

Details furnished in Appendix I.

Research & Investigation Reports Prepared

Details furnished in Appendix II.

LIBRARY & DOCUMENTATION SERVICE—BIBLIOGRAPHY AND DOCUMENTATION

Library maintained the project-oriented documentation service in full strength.

Comprehensive bibliographies were furnished to outside institutions in the following new areas.

1. Memory alloy (MARMEM) based upon. Copper-Zinc-Alloys.
2. Use of Ag-Cd, silver-gold, silver-palladium alloys as contact material.
3. Meehanite iron castings.
4. Free cutting steels.
5. Industrial screen design used for sizing and elimination.
6. Modelling on chilling, particularly on white cast iron.
7. Continuous casting of steel.

Library Extension Service

During the year, xeros copies of over 600 pages of information material were supplied, on request to outside organisations from the country and abroad.

HONOURS & AWARDS

Prof. V. A. Altekar, Director, Shri M. J. Shahani, Scientist & Shri A. K. Saha, Scientist were awarded Sir Gangaram Memorial Gold Medal by Institution of Engineers (India) for their paper "Multistage adsorption of nickel by lignite and related studies" published by Journal of Institution of Engineers, Vol. 60 Feb. 1980.

Dr. R. Kumar, Scientist in the grade of Director, has been invited to serve on the International Advisory Board of the Journal 'High Temperature Technology' brought out by IPC Science and Technology Press, Surrey, England. This is a professional recognition of the NML work in the area of high temperature materials technology.

Dr. P. R. Khangaonkar, Scientist 'F' & Shri R. Krishnamurthy Sr. Lab. Assistant, were awarded Certificate of Merit by Inst. of Engineers (India) for their paper "Reduction of leach process for chalcopyrite" published in Jr. of Institute of Engineers (Min & Met), March, 1980.

DEPUTATION & TRAINING

Prof. V. A. Altekar Director	(i) Visited Vienna, Austria; to discuss and finalise the details with UNIDO for grant of Creep testing equipment of NML. (ii) Visited Bulgaria under CSIR—Bulgarian Science & Technology Programme.
Shri G. P. Mathur Scientist 'F'	Visited Lurgi Laboratory Frankfurt W. Germany, as an expert on behalf of M/s Pyrites, Phosphates & Chemicals Ltd. to study the firm's bench scale results of Saladipura pyrite sample.
Shri K. P. Mukherjee Scientist	Visited Moscow as a Member of the Indian delegation of experts for collaborative studies on metallic corrosion, surface coating, corrosion inhibitors & fundamentals of corrosion.
Shri J. P. Srivastava Scientist	Visited Ukraine, USSR, to attend UNIDO in-plant group training for Iron & Steel Engineers.
Shri C. S. Sivaramakrishnan Scientist	(i) Completed one semester course in Metallurgical Engineering Department, I.I.T. Bombay, in Partial fulfilment of the registration for Ph.D. (ii) Attended a short-term course on mechanics of failure Analysis at Banaras Hindu University.
Shri G. Jawra Scientist	Attended a short course on "Microprocessor and their application", organised by Institution of Instrumentation Scientist and Technologists at Jamshedpur.
Shri L. N. Das Scientist	-do-
Shri A. P. Choudhory Scientist	-do-

CHAIRMANSHIP, FELLOWSHIP, MEMBERSHIP ETC. OF STAFF ON OUTSIDE BODIES

Prof. V. A. Altekar	Chairman	Co-ordination Council of Engineering Group of Laboratories of C.S.I.R.
	Member	Governing Body of C.S.I.R.
	Do	C.S.I.R. Society
Dr. Rajendra Kumar Scientist in the grade of Director	Member	Board of Governors of National Institute for Forge & Foundry Technology, Ranchi for a period of 4 years from 1981-85.
Shri M. J. Shahani Scientist	Member	Editorial Board of Hydrometallurgy International Journal.
Dr. M. R. K. Rao Scientist	Chairman	Indian Ceramic Society, Jamshedpur Chapter.
Shri G. N. Rao Scientist	Vice-Chairman	Institute of Indian Foundryman, Jamshedpur Chapter.
	Visiting Lecturer	Regional Institute of Technology, Jamshedpur.
Shri M. C. Kundra Scientist	Member	Indian Standars Institution (Castable Sub. Committee).
Shri L. P. Pandey Scientist	Guide	Ph.D. degree from Patna University in Chemistry.
Shri H. Singh Scientist	Diploma of Fellowship	Institution of Engineers (India).

APPENDIX 1

Papers Published, Presented and Communicated

1. Integral colour anodizing of aluminium and aluminium alloys in molybdate containing acidic baths—T. L. Sharma and Y. N. Trehan ; NML T.J. Vol, 22, (1 & 2), 1980.

2. Spectrochemical analysis of aluminium and steel—M. K. Ghosh ; NML T. J. Vol. 22 (1 & 2), 1980.

3. Spectrophotometric study and its application to metals and non-metals—K. K. Padhi & L. P. Pandey ; NML T. J. : Vol., 22 (1 & 2), 1980.

4. Models for metallic solutions—C. S. Sivaramakrishnan & R. Kumar ; NML T. J. Vol, 22 (1 & 2), 1980.

5. The Silico sand ratios of sodium silicate—its foundry importance—S. Ghosh, R. R. Dash & G. N. Rao ; NML T. J. Vol. 22 (3 & 4), 1980.

6. X-ray fluorescence analysis of copper, lead, zinc ores—Rajeev, S. C. Srivastava & M. K. Ghosh ; NML T. J. Vol, 22 (3 & 4), 1980.

7. Determination of molybdenum and copper in Mu metal type alloy—N. Ghosh, K. K. Padhi, (Mrs.) S. Choshal, A. C. Biswas & L. P. Pandey ; NML T. J. Vol., 22 (3 & 4), 1980.

8. Importance of quality control in steel making—a case history of two high carbon steels using sponge iron—R. D. Gupta & V. A. Altekar ; Steel Furnace Monthly, Feb, 1980.

9. The powder metallurgy industry in India—News for a National Master Plan—V. A. Altekar ; presented at the Six Annual Tech. Conference of Powder Metallurgy Association of India, Bangalore, Feb. 1980.

10. Multi-stage adsorption of nickel by lignite and related studies—A. K. Saha, M. J. Shahani & V. A. Altekar ; Journal of Institute of Engineers (I), Vol. 60, pt. CH, 2, Feb. 1980.

11. Studies on the effect of furnace design on the electro-thermal smelting of lead concentrates—H. Singh & V. A. Altekar ; Communicated to Journal of Institute of Engineers (I), Mining & Metallurgy Division.

12. Contribution of NML to the mineral industries of Gujarat—V. A. Altekar ; presented at the Seminar on "Scope for New Mineral Based Industries" Organised by GMDC, Ahmedabad, March, 1980.

13. Role of Research in ferro-alloy industry—V. A. Altekar ; Tool & Alloy Steels, Vol. 14 (4 & 5), April & May, 1980.

14. Evaluation of xanthates as corrosion inhibitors—V. A. Altekar, Inder Singh, M. K. Banarji, M. N. Singh & T. R. Soni—Proc. of the 5th European Symposium on "Corrosion Inhibitors", held at University of Ferrara, Italy, Sept. 1980.

15. Production of vanadium enriched slag from vanadium bearing titaniferrous ores at VISL—V. A. Altekar & Dasarath ; presented at the Indo-Soviet bilateral Symp. on "R & D efforts in Iron & Steel Industries", Ranchi, December, 1980.

16. Recovery of non-ferrous metal and elemental sulphur by ferric chloride leaching of sulphide concentrates—P. K. Sinha, G. Basu, S. C. Aush, N. Dhananjayan & V. A. Altekar ; Trans, Ind, Institute of Metals, Vol. 33 (6), December, 1980.

17. Foundry developments in the past decade—V. A. Altekar & G. N. Rao ; presented at the 30th Annual Convention of Ind. Institute of Foundry, Pune, Feb. 1981.

18. An efficient process for desulphurization of ferrous metals—D. J. Chakraborty, R. N. Guin & V. A. Altekar ; presented at the International Symp. on "Modern Developments in Steel Making" Jamshedpur, Feb, 1981, organised by NML. Inst. of Metal, SAIL & TISCO.

19. Beneficiation studies on graphite at NML—P. D. Prasad Rao, A. Peravadhanulu & G. P. Mathur ; presented at the Workshop on "Graphite", Rajmundry, January, 1981.

20. NML's experience in the fields of mineral beneficiation and conservations—B. L. Sengupta & G. P. Mathur ; presented at "National Mineral Convention" New Delhi, Feb, 1981, organised by F.I.M.I.

21. Mineral processing as a tool for conservation of mineral resources—B. L. Sengupta & G. P. Mathur ; presented at Seminar on "Conservation of Mineral Wealths" organised by Regional Research Laboratory, Bhubaneswar.

22. Flotation of coal fines—some aspects—B. L. Sengupta N. Chakravarty, G. P. Mathur & V. A. Altekar ; presented at the International Seminar on "Recent Advances in Mineral Beneficiation" organised by Regional Research Laboratory, Bhubaneswar, January, 1981.

23. Beneficiation of pytire-problems and methods—B. L. Sengupta, N. Chakraborty & G. P. Mathur ; same as no 22.

24. Monograph on "Indian Ores & Minerals their beneficiation and agglomeration studies", Vol. 1—A. Peravadhanulu, P. D. Prasad Rao, G. P. Mathur & V. A. Altekar ; edited by P. K. Gupta.

25. Studies on physico-chemical properties of some Indian and foreign clay-graphite stopper heads—K. K. Singh, M. R. K. Rao ; Presented

at the seminar on "Casting Pit Refractories" Organised by Ind. Cer. Society held at Calcutta, Dec. 1980.

26. Development of high alumina refractories from technical alumina and kyanite—K. K. Singh, A. V. Subrahmanyam & M. R. K. Rao ; presented at the 45th Annual Convention of Indian Ceramic Society.

27. Studies on reactivity of lime—K. C. Roy & P. C. Sen ; same as sl. no. 26.

28. Research on recovery of nickel and cobalt from various sources at NML—D. D. Akerkar, M. S. Mahanty, C. Sankaran, B. N. Singh, D. S. Murthy, Z. H. Khan, N. Subrahmanyam & V. A. Altekar ; presented at the Seminar as "Hydrometallurgical Processes", organised by Dept. of Science & Technology, Govt. of India, held at Jadugoda, Nov. 1980.

29. Hydrometallurgical processes for extraction and recovery of zinc and lead from siliceous type of ores and copper, zinc and lead from complex sulphide ores—M. G. Bodas, M. S. Mahanty, M. Yaseen & D. D. Akerkar ; same as sl. no. 28.

30. Hydrometallurgical process for recovery of vanadium pentoxide from vanadium sludge of alumina production—Narinder Singh, S. B. Mathur, D. D. Akerkar & V. A. Altekar ; same as sl. no. 28.

31. Production of zinc oxide from zinc ash/zinc hydroxide bye products—P. K. Sinha, G. Basu, S. C. Aush & N. Dhananjayan ; presented at the Seminar on "Zinc wastes & their Utilization" organised by Lead-Zinc Information Centre, at New Delhi, October, 1980.

32. Utilization of green vitriol for production of pigment grade ferric oxide—Gurdail Singh, M. L. Dey, N. Dhananjayan & V. A. Altekar ; presented at the seminar on "Prospect of Chemical and Allied Industries based on Bye-products and Wastes of Integrated Steel Plants in India" held at Rourkela, Feb, 1981.

33. Production technology of Al-Cu-Ni-Mg high strength aluminium alloys for aircraft industry—R. K. Mahanti, C. S. Sivaramakrishnan, G. D. Sani, B. K. Saxena & R. Kumar ; Presented at the Symposium on "Non-ferrous Semis & Products" organised by Ind. Inst. of Metals, Delhi Chapter, Sept, 1980.

34. Some aspects of technological inputs into the production of aluminium semis in small scale Industries—R. K. Mahanti, K. Lal & R. Kumar ; same as sl. no. 33.

35. Influence of processing variables on the stress corrosion characteristics of weldable Al-Zn-Mg alloy—R. Kumar, B. K. Saxena, K. Lal & C. S. Sivaramakrishnan ; presented at the Seminar on "Quality Assurance of Engineering Equipment for Defence", organised by Controllerate of Inspection, Dighi, Pune, Feb, 1981.

36. Status of small scale aluminium utensil industry in Bihar and technological recommendations to improve its productivity—R. Kumar, K. Lal & R. K. Mahanti ; presented at the Workshop on "Improvement in the Aluminium Utensil Processing" convened by Govt. of Bihar, Patna.

37. Grain refinement of aluminium alloy billets for production of semis—R. K. Mahanti, C. S. Sivaramakrishnan & R. Kumar ; presented at the Seminar on "Non-ferrous semis" held at New Delhi, Sept, 1980.

38. Secondary aluminium alloy for production of semis—A. N. Sinha, V. V. Rao & R. Kumar ; same as sl. no. 37.

39. Morphology and mechanical properties of vacuum solidified cast aluminium alloys—R. K. Mahanti, N. K. Das, C. S. Sivaramakrishnan & R. Kumar ; presented of National Symposium on "Aluminium Technology & Metallurgical Applications", January, 1981.

40. Correlation of structure and extrusion parameters in the processing of high strength aluminium alloy—G. D. Sani, K. Lal, B. K. Saxena & R. Kumar ; same as sl. no. 33.

41. Some aspects of productivity and quality control in aluminium foundries —K. Lal & R. Kumar ; presented in "Industry Clinic on Aluminium Castings of Moulds/Matrices for Tyre Retreading Machining" organised by S.I.S.I., Ministry of Industry, Govt. of India, Trichur ; March, 1981.

42. Structural and magnetic studies of pure and substituted gamma iron oxide—Ved Prakash, V. Rao & S. Pramanik ; Communicated to Trans. of Ind. Inst. of Metals.

43. Effect of manganese on the magnetic properties of Co-14% Al. alloys—Ved Prakash & C. R. Tiwari same as sl. no. 42.

44. Studies on manganese-aluminium-carbon alloys—Ved Prakash, C. R, Tiwari, V. Rao & S. Pramanik—Communicated for presentation at the Annual Technical Meeting of the Magnetic Society of India.

45. Problems of tube failure in processes boiler—R. Singh & R. Kumar ; presented of the Seminar on "A Study of Tube Failure in Boiler and Proposed Step to Minimise the Same"—Organised by Madhya Pradesh Electricity Board & Power Engineers Training Society, March, 1981.

46. Development of a variable inductunce type instrument transducer—G. Jaura ; J. Inst. of Engineers (India), Vol. 60, pt. E 1-3, April, 1980.

47. Production of electrical contact materials—R. K. Dubey, P. Basak & S. C. Dev ; Workshop on "Electrical Contact and Contact Materials" organised by ERDA, Vadadara, September, 1980.

48. Observation on terhmo-mechanical working of alloy steels—R. K. Dubey, S. P. Chakraborty & P. Basak ; Proc. of International Seminar

on "Metal Working Technology—Today & To-morrow" organised by NIFFT, Ranchi, April, 1980.

49. Development of orthodantic stainless steel spring wire—G. D. Sani, S. K. Chaudhary, R. K. Dubey, & V. A. Altekar ; same as sl. no. 48.

50. Cadmium—its importance and application—R. K. Dubey, P. Basak & S. C. Dev, Proc. of the Cadmium Seminar, May, 1980.

51. Foundry research and development work at NML—G. N. Rao & V. A. Altekar ; presented at the "Foundry Service" organised by I.I.F. Jamshedpur Chapters, Sept, 1980.

52. Recent foundry developments—G. N. Rao & V. A. Altekar ; Study Report on "Status of Foundry Industry in Bihar" published by Bihar Industrial & Technical Consultancy Organization.

53. Studies on the effect of temperatures on the Chromium 7 pick up on cold rolled mild steel using radio tracer—K. D. Maji, (Mrs) Aruna Bahadur & Inder Singh ; Presented at the 5th European Symp. on "Corrosion Inhibitors" held at University of Ferrara, Italy.

54. Importance of inhibitors in the prevention of corrosion—Inder Singh & V. A. Altekar ; presented at All India Symp. on "Corrosion Control" organised by Inst. of Energy Management, held at Bombay, March, 1981.

55. Cathodic and anodic protection of metals—K. P. Mukherjee & V. A. Altekar ; same as sl. no. 54.

56. Corrosion science and its different forms—A. N. Mukherjee & K. P. Mukherjee ; presented at National Productivity Seminar on "Corrosion Control", September, 1980.

57. Cathodic protection of metals from sea-water—A. N. Mukherjee & K. P. Mukherjee ; same as sl. no. 55.

58. Bright electrogalvanizing of steel wires from fluoborate bath—S. K. Narang ; presented at the Second National Conference on "Electro-plating and Metal Finishing" held at Bombay, March, 1981.

59. A simultaneous chelatometric determination of calcium and magnesium in magnesite—V. N. Choudhry, B. C. Mukherjee B. C. Bose & L. P. Pandey ; Ind. Jr. of Technology Vol. 18, 1980.

60. A simaltaneous complexometric determination of iron & calcium in phosphate rock—B. C. Bose, N. V. Choudhry & L. P. Pandey ; Ind. J. of Chemistry, Vol. 19A, 1980.

61. Atomic adsorption spectrophotometry : A potent analytical tool to metallurgical industries—L. P. Pandey ; Science Reporter, August, 1980.

62. Flotation and adsorption of chalcopyrite with cupferron—S. Prabhakar & P. R. Khangaonkar ; communicated to journal of Mineral Processing, Netherland.

63. Electro-flotation of chalcopyrite fines—G. Bhaskar Raju & P. R. Khangaonkar ; same as sl. no. 62.

64. Studies on reduction leach process for chalcopyrite—R. Krishnamurthy & P. R. Khangaonkar ; journal of Inst. of Engineers—Mining and Metallurgy, March, 1980.

65. Leaching of sphalerite in the presence of solvent—Y. Venkataswamy & P. R. Khangaonkar ; communicated to 'Hydrometallurgy', Netherland.

APPENDIX II

Research & Investigations Completed and Reports Prepared

1. Moulding Characteristics of Silipar sand received from the Directorate of geology and Mining, Lucknow (U.P.)—R. C. Arora & R. N. P. Gupta, (IR 1047/80).

2. Evaluation of corrosion resistance of austentic stainless developed by SAIL—K. P. Mukherjee, (IR 1048/80).

3. Determination of pitting potentials of feritic steels under development at SAIL—K. P. Mukherjee, (IR 1049/80).

4. Determination of the amount of zinc coatings on galvanised tube surface—A. N. Mukherjee & K. P. Mukherjee, (IR 1050/80).

5. Benificiation and sintering studies on Gua Iron Ore from M/s Indian Iron and Steel Co.,—Tirath Singh, A. K. P. Srivastava, J. S. Padan, N. Chakraborty, S. K. Bannerjee & G. P. Mathur (IR 1051/80).

6. Annodic passivation of boiler steel in sodium carbonate and hydrazinc-ammonia solution—K. P. Mukherjee, (IR 1052/80).

7. Recovery of magnetite from the heavy media contamainted with coa fines supplied by Kathara Washery, C.C.L.—K. K. Bhattacharya, T. C. De, N. Chakraborty & G. P. Mathur, (IR 1053/80).

8. Bench scale flotation studies with the coal middling of Nandan Colliery for M/s CMPDI, Ranchi—P. D. Prasad Rao, R. K. Kunwar & G. P. Mathur (IR 1054/80).

9. Reduction of ash content from the middling of Damna Colliery for M/s CMPDI, Ranchi—P. D. Prasad Rao, R. K. Kunwar & G. P. Mathur (IR 1055/80).

10. Reduction of ash content from a coal middling sample—AB inclines Damna by froth flotation for M/s CMPDI, Ranchi—R. K. Kunwar, P. D. Prasad Rao, M. V. Ranganathan & G. P. Mathur, (IR 1056/80).

11. Investigation on the defects in semi continuous direct chill cast billets of Al-Mg-Si alloy from Bihar Extrusion Co., Gamharia—B. K. Saxena, Kishorilal & A. B. Bhatta Mishra, (IR 1057/80).

12. Removal of sand from coal samples from south Balander of Jagannath mines, received from M/s. Central Mine Planning & Design Institute, Ranchi—R. K. Kunwar, D. M. Chakraborty, S. K. Banerjee & G. P. Mathur, (IR 1058/80).

13. Study of some physical characteristics of lime stone and dolomite samples received from D.S.P., Durgapur—P. N. Pathak, B. Banerjee,

A. Peravadhanlu, B. L. Sengupta, S. K. Banerjee & G. P. Mathur, (IR 1059/80).

14. Bench scale benificiation studies on three manganese ore samples from M/s TISCO Ltd.,—S. N. Prasad, S. Rafiuddin, N. Chakraborty & G. P. Mathur, (IR 1060/80).

15. Bench Scale Benificiation studies on low grade chromite marked "Ganga Pit Sample" from M/s Ferro Alloy Corpn., Ltd., Sreeramnagar (A.P.)—S. K. Sil, M. V. Ranganathan, S. K. Banerjee & G. P. Mathur (IR 1061/80).

16. Physical, petrological, chemical and DTA studies on Kuteshwar limestone (M.P.) from Bokaro Steel Plant—S. K. Biswas, B. Banerjee, P. K. Sinha, S. R. Joti, A. Peravadhanulu & S. K. Banerjee, (IR 1062/80).

17. Pilot plant benificiation and agglomeration studies on low grade iron ores from seyna—G. D. (IR 1063/80).

18. Studies on raw material evaluation and sintering characteristics of Hesse & Jargara dolomite from Syria—(IR 1064/80).

19. Physical, chemical, metallurgical and calcination studies on two lime stone samples from Syria—K. Vijayraghavan, P. V. Viswanathan, V. Mohan, C. Satyanarayan, C. Sankaran & P. R. Khangaonkar, (IR 1065/80).

20. Pilot plant benificiation studies on iron ore sample from Bolani for modernisation programme of DSP—O. D. Division, (IR 1066/80).

21. Investigation report on failure of a platen superheater header of Boiler of unit no. 8 Patratu Thermal Power Station (DTPS) Extension stage III (2×110 Mw.)—MSD (IR 1067/80).

22. Metallurgical investigation of superheater tube of unit no. 1 of extension stage III (2×110 Mw)—(IR 1068/80).

23. Failure investigation of water wall tubes of unit no. 3 at Durgapur Thermal Power Station (DTPS) Damodar Valley Corpn., —R. Kumar & R. Singh (IR 1069/80).

24. Moulding characteristics of sand sample no. 3 from the Directorate of Geology and Mining, Lucknow (U.P.)—H. P. Singh & R. N. P. Gupta (IR 1070/80).

25. Moulding characteristics of Gulalia sand from the Directorate of geology and Mining, Lucknow (U.P.)—R. C. Arora & R. N. P. Gupta (IR 1071/80).

26. Bench scale beneficiation studies on a chromite sample of Singhbhum area received from M/s. Hyderabad Asbestos Ltd.,—S. K. Sil, S. C. Maulik, N. Chakraborty, S. K. Banerjee & G. P. Mathur (IR 1072/80).

27. Investigation on defects in aluminium utensils sponsored by Govt of Bihar, Patna—R. Kumar, Kishori Lal, R. Mahanty & P. K. Ghosh, (IR 1073/80).

28. Report on the inplant evaluation of the NML Technology of the manufacture of aluminium utensils in the small scale sector with existing equipments—R. Kumar, Kishori Lal & R. K. Mahanti, (IR 1073/80 Part II).

29. Bench scale beneficiation studies on an iron bearing rock phasphate sample from Beldih mines, Purulia Dist for M/s. W. B. M. Dev. & T. Co. Ltd.,—K. K. Bhattacharya, M. V. Ranganathan, S. K. Banerjee & G. P. Mathur, (IR 1074/80).

30. Mineralogical and DTA studies on laterite chromite and ultrabasic rock samples of Syria received from M/s. MECON, Ranchi—Bhaskar Banerjee, A. Peravadhanalu & S. K. Banerjee, (IR 1075/80).

31. Beneficiation of chalk samples received from Director of Geology & Mining (Gujarat)—Joga Singh & R. Ganesh. (IR 1076/80).

32. Some studies relating to corrosion of condenser tubes at Ennore Thermal Power Station, Madras—S. Rao Addanki & P. R. Khangaonkar, (IR 1077/81).

33. Studies on physical characteristics of limestone samples rfom Kuteswar mines for Bokaro Steel Plant—U. S. Chatterjee, S. K. Biswas, S. R. Soni, P. K. Sinha, B. L. Sengupta & G. P. Mathur, (IR 1078/81).

34. Bench & pilot plant studies on a low grade pyrite- pyrrohotite sample from Saladupira, Rajasthan, (IR 1079/81).

35. Determination of some physical characteristics and free silica content in limestone sample of M/s. Chettinand Cements Corp, Ltd., Received from M/s. Mcnally Bharat Engineering Co. Ltd.,—P. N. Pathak, M. V. Ranganathan, & A. Peravadhanalu, (IR 1080/81).

36. Determination of Bonds work index of a vanadium rich slag from VISL—K. Vijayragham & P. R. Khangaonkar (RR 396/80).

37. Lime concentrate roast leach for recovery of copper—S. K. Roy Chowdhury, P. K. Som & V. A. Altekar (RR 397/80).

38. Development of high alumina refractories from Technical alumina and kyanite—K. K. Singh, A. V. Subrahmanyam & M. R. K. Rao (RR 398/81).

39. Studies on reactivity of lime—K. C. Ray, P. C. Sen & M. R. K. Rao (RR 399/81).