NATIONAL METALLURGICAL LABORATORY

By
V. A. Altekar*

Introduction

"I do believe that there can be no real progress either in this country or any other part of the world without it being founded and based on science, on the scientific application to many things in life and, if I may say further, on the scientific temper of the mind of the people—" thus said the late Pandit Jawaharlal Nehru, former Prime Minister, while inaugurating the National Metallurgical Laboratory on 26th November 1950.

The National Metallurgical Laboratory followed this dictum and formulated its research programme having definite applied value and application in the industry and at the same time placing a high premium on ingenuity in basic research as applied to development projects.

The advent of the Five Year Plans, shortly after Independence, laid stress on the establishment of basic industries and utilisation of indigenous raw materials. In this context, the Laboratory's research and development programme was oriented to suit the requirements of dynamic growth and expansion of Indian mineral and metal industries under the impact of successive Five Year Plans. The discoveries of new deposits of virgin raw materials and the dearth of foreign exchange placed additional responsibility on the laboratory to find out ways and means for the utilisation of available products to minimise and eliminate as far as practicable imported metals, alloys and minerals.

There was, thus, need for expansion of the Laboratory to cope with the increased quantum of work in multifarious fields of metallurgical science and technology. The Laboratory was, therefore, progressively equipped on modern lines to undertake planned research and development projects in the context of the country's industrialisation programme.

Growth & Development

It became imperative in pursuing various applied projects to study on pilot plant scale trials, potential practical themes so as to determine their suitabilities for commercial exploitation under Indian raw material conditions. This resulted in the progressive establishment of various pilot plants. Many of these pilot plants and precision equipment were designed and fabricated by the Laboratory.

The research and development work of the National Metallurgical Laboratory, during the last decade, have been geared to generate a continuous dialogue between

* Prof. Altekar is Director of National Metallurgical Laboratory

the researchers, planners, users and industries for identification and solution of problems pertaining to various disciplines of metallurgy against the background of industrial and national needs. This has resulted in winning the confidence of the industries and forging close links with them. The metal and mineral industries, both in the public and the private sector, are showing keen interest in the processes and products developed by the Laboratory to whom they refer their problems and sponsoring projects in ever-increasing numbers.

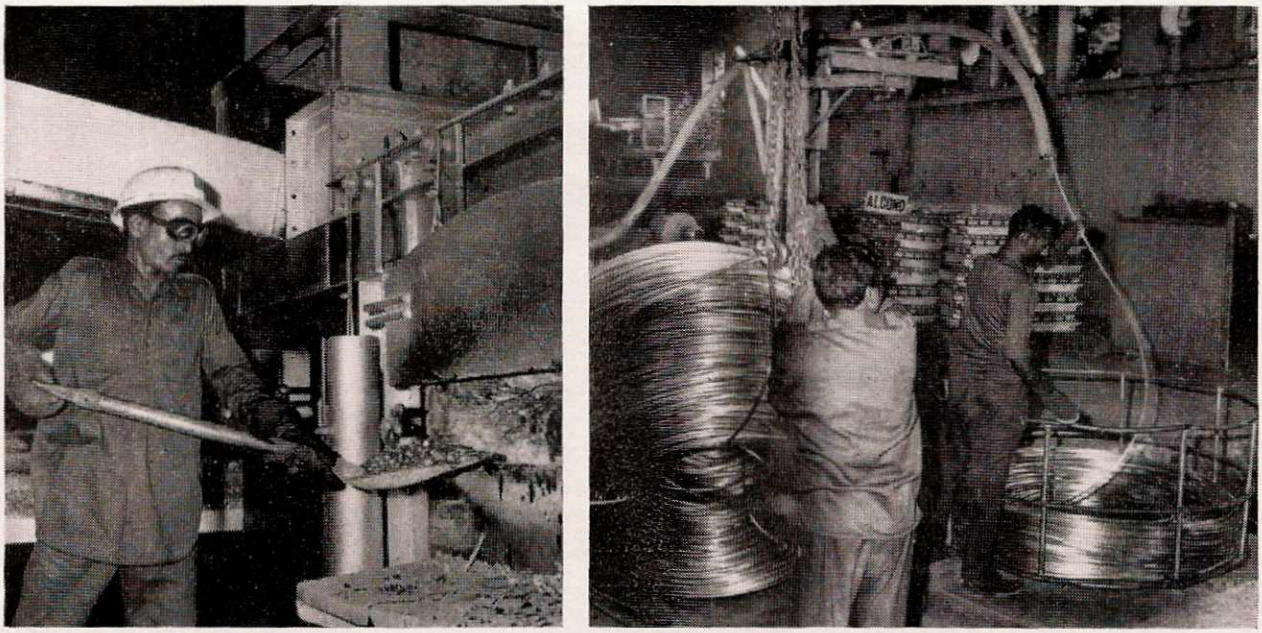
The National Metallurgical Laboratory has also set up large-scale investigations and testing facilities for product evaluation work, development of new technologies, etc. Notable amongst these are Creep Testing Facilities which have been set up with the assistance of UNDP with 150 test points having provision to instal 400 test points. This facility is now utilised by Bharat Heavy Electricals, Reactor Research Centre, etc., for the development and testing of high temperature creep resistant steels for use in pressure vessels, power plants, etc. In the Mineral Beneficiation Large-scale testing plant which can treat up to 5 tonnes of ore per hour, more than 500 samples of low-grade iron ores, copper ores, lead ores, zinc ores, complex multimetal sulphide ores, fluorspar, graphite, magnesite, pyrite, apatite, etc., have been investigated and evaluated. Large-scale testing plants have also been set up for the production of dense carbon aggregates, electrolytic manganese metal and manganese dioxide. A large-scale facility for hydro and electro-metallurgical technique is now under installation. Large-scale investigations conducted in these facilities are used for finalising design data of major inputs before setting up commercial plants.

Besides the large-scale investigation and testing facilities, the Laboratory has installed and procured many precision scientific equipment like Scanning Electron Microscope, X-ray Fluorescence Spectrometer, Atomic Absorption Spectrophotometer, Autrometer, transmission electron microscope, etc., for various investigational studies on crystallography, metal phases, X-ray diffraction, accurate analysis, etc.

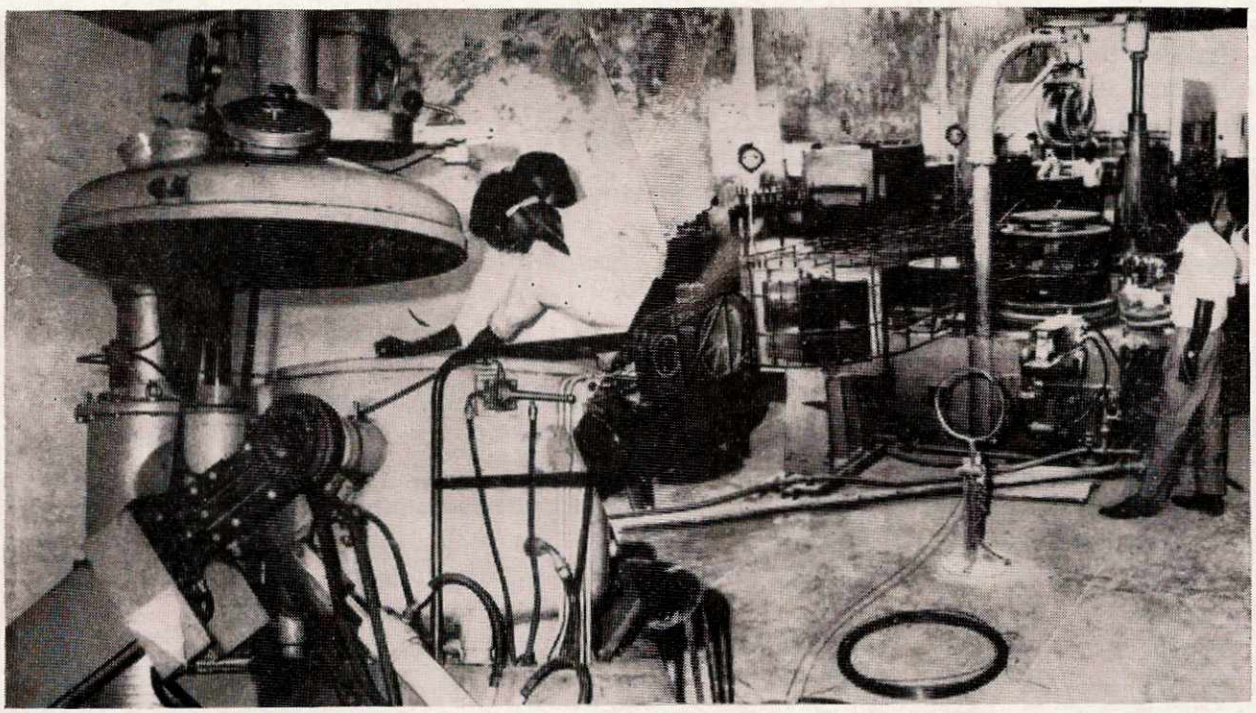
Expertise and Consultancy

The National Metallurgical Laboratory has developed expertise in many disciplines such as mineral processing, alloy development, metal extraction, metal working, metal casting, corrosion problems, refractories, etc., which are utilised by industrial and other organisations both at the national and the international level. NML Scientists have also been called upon to render assistance and expertise for other developing countries through UN agencies.

The commercial production and utilisation of NML products and technologies have helped in the generation of employment, saving in foreign exchange and utilisation of indigenous talent and raw materials. NML has not stopped at conducting laboratory or pilot plant scale developmental work but it has actively participated in the planning, in the designing of industrial projects as well as in the implementation of technologies in the factories. It has also participated in eliminating trouble-shooting operations, incraasing production, improving efficiency and advising on better methods and materials. NML Scientists have further assisted in the preparation



Production of Electrical Resistance Alloy by Cable Works (India) Ltd. Faridabad, based on NML technology



Production of Electrical Conductor from NML-PM2 Alloy Aluminium by Alcond (P) Ltd., Calcutta, based on NML technology

of feasibility reports, designing of plant layout, drawing up of specifications, installing and commissioning of plants.

R&D CONTRIBUTIONS

Ore Dressing & Mineral Beneficiation

During the last three decades of its existence, the Mineral Processing Division of the Laboratory has made significant contributions to the rapid growth of mineral based industries and has helped in designing flow-sheets for the treatment of low grade ores and in the utilisation of potential resources which would have otherwise gone waste.

It is well known that the mechanised mining operations in the iron ore mining centres, particularly in the Bihar, Orissa, and Madhya Pradesh regions have resulted in the generation and accumulation of large stocks of iron ore fines amounting to millions of tonnes. Although these iron ore fines contained a high percentage of iron, they were not being used because of their fine size as also because of the high alumina and silica content. The National Metallurgical Laboratory continued to tackle this problem sponsored by a number of projects and agencies such as Hindustan Steel Ltd., Bokaro Steel Ltd., Visveswaraya Iron & Steel Ltd., National Mineral Development Corporation, TISCO as also a number of iron ore producers in the Goa region. Processes have now been developed for utilisation of the iron ore fines to produce fluxed sinters of good physical and chemical characteristics. The significance of the Laboratory's contribution can be guaged by the fact that the quantum of product value based at full capacity of production will be about Rs. 300-400 crores per year. NML is closely collaborating with the Consulting Engineering firms for setting up beneficiation and pelletising plants, for example, with MECON for a central pelletisation plant for utilising the iron ore fines of Orissa and Bihar sectors. The proposed plant will have a capacity of one million tonnes per year and its contribution to GNP will amount to Rs. 200 million per year. Based on the results of the tests and the technological data prepared by NML, detailed project reports have been prepared for two iron ore pelletisation plants of NMDC, each having a capacity of two million tonnes per year.

NML has been the process consultants for Hindustan Copper Limited for undertaking exhaustive pilot plant tests and the development of flow-sheet for the Rakha Copper Project which went into operation towards the end of 1975. NML has also evolved processes for the beneficiation of low-grade copper ores from Mosabani in Bihar, Khetri and Kolihan in Rajasthan which have resulted in setting up a copper smelting plant at Khetri and a copper concentration plant at Mosabani.

Earlier, NML had carried out extensive investigations on the Malajkhand copper ore of M.P. and a flow-sheet has been evolved and finalised with the approval of the Soviet Project Consultants. A 90-crore rupee project, based on this flow-sheet, is now coming up at Malajkhand. This will process about a million tonnes of copper ore per year and the concentrates produced here will be fed to the smelter at Khetri.

India is predominantly agricultural and naturally the requirements of fertilisers assume the highest priority. Earlier, the country was importing all its requirements of rock phosphate used by fertiliser plants to produce phosphatic fertilisers. Several extensive investigations on low grade rock phosphates including those on the recently discovered deposits of Rajasthan and Mussorie area were successfully undertaken. Plans are now afoot to establish processing plants based on NML developed flow-sheets. NML's expertise of beneficiation of graphite has been well recognised. A graphite plant with a capacity to process 24 tonnes of ore per day is being installed in Udaipur under the Laboratory's consultancy assignment. Similar projects for a few more graphite beneficiation plants are under negotiation.

Another notable contribution of the laboratory in the field of mineral conservation is being made in the area of coal. It is well known that scores of coal washing plants are producing millions of tonnes of coal middlings and rejects per year and these have accummulated over the years into huge heaps amounting to several million tonnes. The National Metallurgical Laboratory realising the potential of obtaining high grade coal concentrates from these wasted heaps of coal middlings and rejects, obtained samples and demonstrated the techno-economic feasibility of processing them to extract a further amount of high grade coal matter. In fact, some of the results have shown convincingly that middlings and rejects having as high as 39-45% ash in them can be up-graded into lower ash coal concentrates with ash content from 11 to 16% and weight recoveries ranging from 50 to 70 %. On behalf of Central Coal Fields Ltd., Ranchi, NML has successfully conducted large-scale trials on 200 tonnes of high ash coal fines.

Extensive studies have been conducted on pyrites from Amjhore in Bihar and Saladipura in Rajasthan. The Sindri Fertiliser Plant has been getting its pyrite from Amjhore and the supply has not always been up to the desired quality which has necessitated the use of imported sulphur to make up for the low quality. NML, through extensive pilot plant trials and demonstrations, has established the techno-economic feasibility of upgrading the Amjhore pyrites to a consistently high level, which will do away with the import of sulphur and give a consistently high quality of pyrites to the fertiliser plant.

The 500-ton per day beneficiation plant set up at Ambadunagar in the Baroda district of Gujarat for the beneficiation of low-grade fluorspar deserves special mention. This was the first project in the country, where entirely indigenous know-how developed by NML along with indigenous engineering consultancy and engineering fabrication capacity was utilised to put up this first ever fluorspar beneficiation plant in India. The plant has a capacity to produce both metallurgical and chemical grades of fluorspar with an annual turn-over of over Rs. 2 crores.

For the first time in the country, deposits of cassiterite have been found in the Bastar district of M.P. The tin content of the ore is as low as 0.4 %. The Laboratory has developed a flow-sheet for producing a concentrate analysing over 60 % tin with high recoveries.

Extraction & Chemical Metallurgy

In the field of Extraction Metallurgy, a significant contribution of NML was in developing and implementing the technologies for recovery and production of vanadium in the country. Earlier, the country imported 100 per cent of its requirements of vanadium and vanadium rich slags. In a two run attack, NML developed two processes for extraction of vanadium from iron ores as well as from the sludge obtained from alumina plants treating bauxite. The technology for extraction of vanadium was implemented at VISL at Bhadravati. This plant happened to have all those equipment which were essential for this process. It was doubly lucky to have vanadium bearing iron ore in the vicinity. NML did not have much difficulty in convincing the management to try out the process which was successfully demonstrated in their plant at Bhadravati by the concerted efforts of half a dozen scientists of NML. The technology has been well established, and VISL is now setting up a 100-tonne per annum ferro-vanadium plant to implement commercially the NML-developed technology.

Similarly, a process for the extraction of vanadium from bauxite was successfully developed and has been licensed to a number of small-scale industries; one of them has already started production and another firm is setting up this plant. It is hoped that within the Sixth Five Year Plan period, the country will turn into an exporter of vanadium from its Fifth Five Year Plan period position of total importer.

Another very interesting contribution of NML came into being when the project for production of 1000 tonnes of electrolytic manganese dioxide per year built up by T. K. Chemicals Limited at Trivandrum went into production a couple of years ago. The EMD produced by the plant will be worth 11 million rupees per year. Two more plants based on NML technology are under active negotiation. The Laboratory has also exported the technology to the Government of Burma, who have set up a 50 kg. per day pilot plant with NML assistance.

For the manufacture of alloy, tool and special steels, special types of ferro-alloys are needed which are imported. NML has developed know-how for the production of some special types of ferro-alloys which are now commercially produced by a number of firms which have resulted in reducing and eliminating their imports.

NML Scientists have developed a novel method of extraction of lead from lead concentrates by a simple single step process, which is applicable in the small-scale sector also. The process avoids pollution of atmosphere and not only extracts high purity metal with high recoveries but also recovers the sulphur as a sulphide, which can be subsequently processed for generation of either pure sulphur dioxide or hydrogen sulphide. The process has been tried out on pilot plant scale producing over 10 tonnes of lead metal in continuous operation which have given reliable data on the cost of manufacture which is comparable to the cost as obtained in large industrial plants. A proposal is being submitted to the Ministry for a demonstration unit using the lead concentrates being produced in their concentrator in Andhra Pradesh.

High Temperature & Creep Resistant Steel

The Division of Material Science and Technology of the National Metallurgical Laboratory has also made some very significant contributions towards the industrial growth of the country. One of the most noteworthy amongst these is the development and testing of high temperature and creep resistant materials for the various thermal power plants, nuclear power plants, fertiliser and chemical plants, etc. These types of sophisticated steels used to be wholly imported into the country but after the establishment of a National Creep Testing Facility with the assistance of UNDP, the Laboratory has helped the local manufacturers of alloy steels to produce and test high temperature and creep resistant steels in close association with Bharat Heavy Electricals, who are the major user of such steels. Already, four grades of such steels have been tested and developed and considered as acceptable in lieu of the imported grades. Trial orders have been placed by BHEL with indigenous manufacturers and the estimated saving in foreign exchange will be about Rs. 20 lakhs. NML is also assisting the Reactor Research Centre, Kalpakkam, in the development and testing of high temperature steels for use in the reactor. Incidentally, NML is playing an ever increasing role in investigation failures and rendering advice to the thermal power plants and several other types of industries. Such advice has resulted in decreasing the rates of failures and increase in the efficiency and equipment availability.

Alloy Development

A very significant aluminium alloy electrical conductor designated as "NML PM-2" has been developed and commercialised for production by a number of conductor manufacturers in the country. These include one in Calcutta, one in Hyderabad and one in Delhi. The conductor has better conductivity than the E.C. grade aluminium and has much more ductility to resist breakage either during manufacture or during its use. The same group is now busy developing another aluminium alloy for catenary wires required for electrification of Railways. The materials have already been tested and approved by the Railways and will undergo actual field trials on tracks between Kanpur and Delhi.

The Laboratory's scientists have developed a very interesting high temperature heat resistant cast iron alloy which, in actual plant trials in Tisco, has been successfully used at 1000°c for over 5 months. The nature of the duty calls for alternate heating and cooling of this alloy component under which condition, the costly and conventional high alloy stainless steels started flaking away and became useless in much less time. This heat resistant cast alloy designated as 'NML-Pyroloy-1000' will be half as costly as the heat resistant stainless steel. The Tata Iron and Steel Company are now commercialising for their captive use NML-Pyroloy-1000 for carrier blade in the sheet mill re-heating furnace.

Similarly, NML has also developed a wear and abrasion resistant cast iron in close cooperation with Telco who wanted to find a substitute for the imported impeller blade in the centrifugal shot blasting machine. The service life of the NML alloy 'Wear-not' has surpassed the service life of the imported components.

Another group of scientists of NML has developed a lost cost low alloy high strength weldable steel, which has been commercially tested and produced on a commercial scale. The steel has a high yield strength of 55 kg^2 mm^2 and has an added property of high ductility at sub-zero temperatures of-40°C. The production of this steel has been successfully demonstrated in inplant trials as an integrated steel plant where subsequently about 3000 tonnes of this steel were produced, valued at about Rs. 35 lakhs. Reinforcement rods commercially produced out of this steel have indicated a saving in the requirement of steel to the extent of 30% over ordinary steels. This steel can be used also for pressure vessels, high strength containers, bridges, transmission towers, carriage frames and for high altitude sub-zero conditions.

NML has also produced a number of other industrial and consumer alloys, such as, electrical resistance alloy for use in heating elements used for furnaces, ovens, electric irons, etc. This has been in commercial production and has been licensed to a number of parties. The production technology of aluminium alloy, welding filler wires, corresponding to NG-6, BS-2901 specification has been developed. Large quantities have been supplied to Hindustan Aeronautics Ltd. and the Ordnance Factory to meet their requirements in place of the imported product. The technology is available for commercial implementation. Inoculants for refinement of grain-size in aluminium and a series of aluminium-silicon alloys were developed. These inoculants are found to be more efficient than commercially available ones.

A dental amalgam alloy needed for filling up dental cavities has also been developed in close collaboration with dentists of local hospitals. This has been licensed for commercial production since the last two years. There are several other alloys which this Laboratory has developed and these are under various stages of implementation-cum-production.

To assist the foundries, the Laboratory has investigated a large number of foundry moulding sands and bonding clays and has determined their suitabilities for different casting purposes. This has helped the foundry industries in selecting the proper types of foundry raw materials and also setting up sand processing units. A large number of industrial foundry problems have been successfully solved and the foundries concerned have been furnished with findings followed by a practical demonstration of the operations involved. An equi-blast-cum-balanced blast cupola developed by the Laboratory has been set up in a number of foundries in the Punjab and Haryana Regions.

Magnetic Materials

A group of scientists has developed soft magnetic irons, which are required by the Railways for their signalling equipment. NML has been supplying this material to the Railways for the past few years. Recently, industrial heats were made and rolled to exacting specifications and supplied to the railways.

Several industries have sponsored developmental programmes at NML. One such firm has sponsored a developmental programme for the production of high permeability magnetic alloys, such as, Mu metal, Rho metal, Radio metal, etc. The

Laboratory's scientists have developed these materials to meet the specifications of the market.

Powder Metallurgy

NML has an active group for the production of metal powders for various applications. This group has developed bimetallic powders, such as copper-lead and leaded bronze, which are required for the manufacture of sintered bearings. The technology has been licensed for commercial production. Similarly, zinc dust is needed to the extent of about 5000 tonnes per year. The Laboratory has developed a process for the manufacture of fine dust from fine metal or zinc dross and this technology has also been licensed to a party in Calcutta.

Non-Metallics

The Laboratory has done considerable work in the field of non-metallics also. The hard ferrites developed have been successfully tested for magnets by a leading scooter producer of the country and the transfer of technology of the hard ferrite is now under negotiation.

Refractories

NML has an active Refractories division. One of the most significant recent contributions of this Division has been the development of technology for the production of clay-graphite stopper heads under a sponsored programme. The objective of this programme was to develop know-how for the production of stopper heads needed in the steel plants for pouring hot metal into moulds. The challenge was to produce stopper heads of the same quality as that of the imported ones using indigenous raw materials and this has been amply achieved and has been demonstrated by inplant trials, in an integrated steel plant. The commercial production of the stopper heads based on the NML technology is soon going to be started. This Division has also developed know-how for the production of a substitute material for imported anthracite coal. Known as dense carbon aggregate, it is produced from locally available raw petroleum coke and can be processed into soderberg pastes, which are used by aluminium industries as well as in the ferro-alloy furnaces. Firms are now producing carbon and clay bonded graphite crucibles based on the NML developed technology which are widely used by ferrous and non-ferrous foundries in place of imported crucibles. For special welding purpose, the Laboratory has developed sub-merged arc welding flux which was earlier imported. This flux is now commercially produced in the country.

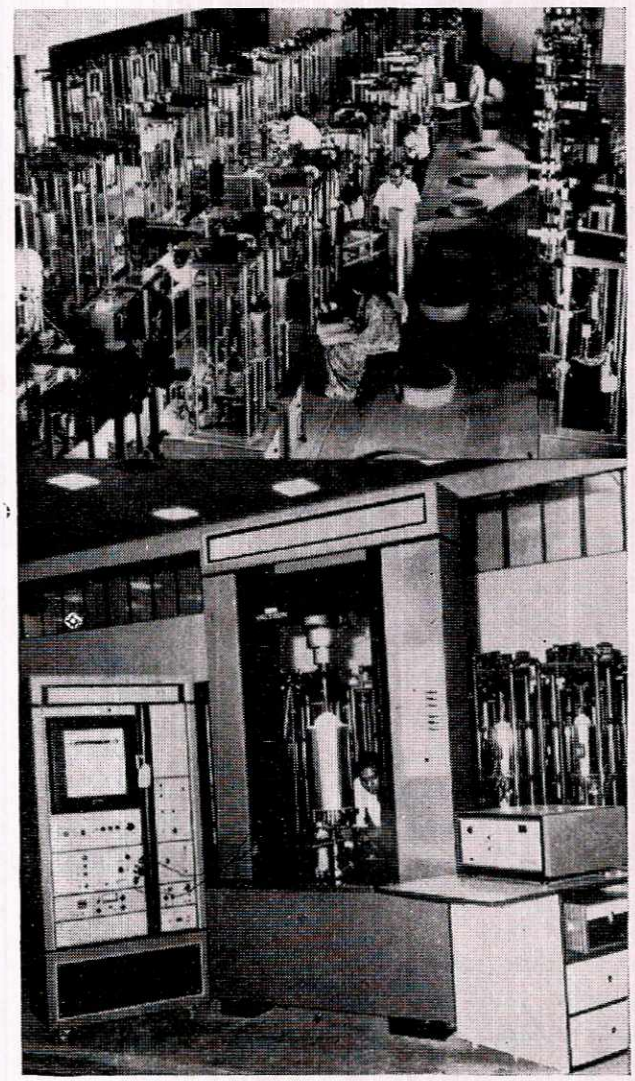
A ceramic filter has been developed for filtering molten aluminium alloys to get a clean melt free from oxide and dross inclusions. These filters have been successfully tried on a commercial scale and are now under industrial production.

Corrosion Studies on Metals & Alloys

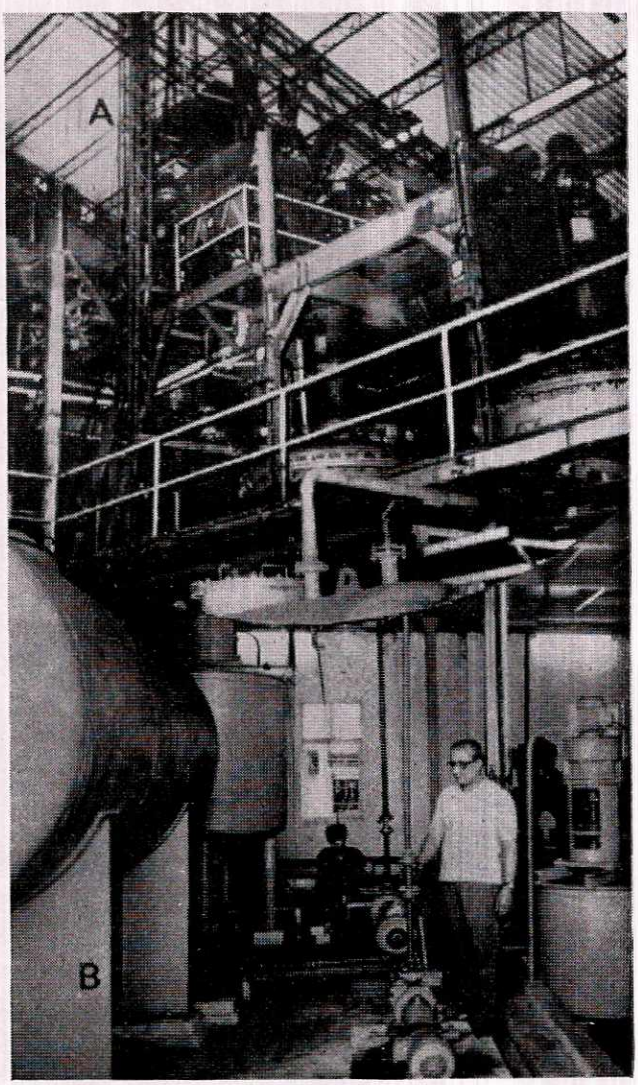
The Laboratory has conducted extensive investigations on corrosion of metals and alloys in industrial plants, equipment, buildings, water pipe line, air-conditioning

units, etc., and have identified the causes of corrosion and suggested their preventive measures. This has resulted in minimising and eliminating corrosion thereby deriving a huge benefit by way of increased plant life and production. Besides, comprehensive studies have been conducted on the atmospheric corrosion of various metals and alloys under industrial and marine atmospheres.

NML has developed an aluminium base sacrifical anode designated as 'Superal' for cathodic protection of ship hull and other submerged structures. In collaboration with the National Institute of Oceanography, Goa, their seagoing vessel was fitted



Creep Testing Facility at NML



Electrolytic Manganese Dioxide Plant (A) installed by T K Chemicals, (B) set up at CRO, Burma, with NML technology and assistance

with NML anodes and the performance was found superior to other types of aluminium anodes. Industrial scale production trials of this alloy, from melting and casting to finishing stage, was successful. The technology is in the process of being released for commercial production.

Electroplating

A number of novel electroplating techniques have been developed which can replace the conventional, hazardous plating operations using cyanide baths. Besides, the Laboratory has produced electroplating salts which are at present imported. Some of the electroplating salts like bright nickel plating salts developed are used by Dunlops for plating cycle-rims. A number of cycle and other industries are interested in using the various types of electroplating salts developed by the Laboratory which can dispense with the proprietory imported products.

Standard Reference Materials

The Laboratory has initiated a project on the production of standard reference materials needed for chemical and spectrographic analysis which are required to be imported. The standard reference materials produced and supplied by NML to various research, educational and industrial organisations have saved foreign exhange worth Rs. 3.5 lakhs during the last few years.

Basic Studies

Basic studies in various metallurgical phenomena as well as on allied disciplines were conducted for the advancement of knowledge and its application in practical aspects, postulation of theories, etc. Studies thus made have been published in renowned scientific Indian and foreign journals and have won international recognition. Some of the important work done during the period relate to structure of liquid metals of various systems, e.g. cadmium-antimony, aluminium-silicon, cadmium-zinc, etc., studies on liquid metal and alloys; preferred orientation in extruded rods, grain size control of non-ferrous metals and alloys; liquids and phase equilibrium studies on high alumina slags; kinetics and mechanism of alkali attack on alumina-silicate refractories; structure of rapidly solidified aluminium alloys from the liquid state, study of physical and mechanical properties of splat cooled aluminium alloys; fundamental studies on bentonites, etc.

Design & Fabrication

Design and fabrication of a large number of apparatus and pilot plants were carried out. These include precision apparatus, pilot plant machineries, etc. The work of Design, Mechnanical, Electronics and Electrical engineering sections have resulted in saving the Laboratory's expenditure including foreign exchange component to the tune of nearly two million rupees. Besides, the Civil Engineering section has conducted many of the civil works relating to the installation of pilot plants, laying of water and gas lines, construction of bays, residential quarters, etc.

Field Stations

The Laboratory has established a number of field stations to inter-act with regional and local industries, particularly the small and medium-scale industries. The Laboratory has established Field stations at Batala, Madras and Howrah. These regional stations look into the needs of the local foundry and other metallurgical industries and assist them in solving their problems, testing their materials.

NML has set up a unit in the CSIR Complex at Madras to assist the industries in the Southern region. The activities of this unit cover investigation of Ore-dressing, chemical metallurgy, failure study, consultancy work as well as R&D work.

A Marine Corrosion Research Station has been set up at Digha on the coast of the Bay of Bengal in West Bengal. This station is conducting corrosion studies of metals and alloys under marine atmosphere which are of considerable importance to ship builders, structural engineers, etc.

A Regional Liaison Centre has been set up at Calcutta to appraise the industries and business entrepreneurs, the scope and assistance NML can offer for setting up mineral and metal based industries. This centre also appraises the industries, new products, processes and technologies developed by NML and maintain a close liaison with them for commercial implementation.

International Assignments

The R&D activities of the Laboratory have crossed the frontiers of the country. In recent years, the following international assignments were conducted and undertaken.

1. Laboratory & Pilot Plant Scale Studies on Asswan Iron Ores-Project of United Arab Republic (Egypt) on behalf of UNIDO:

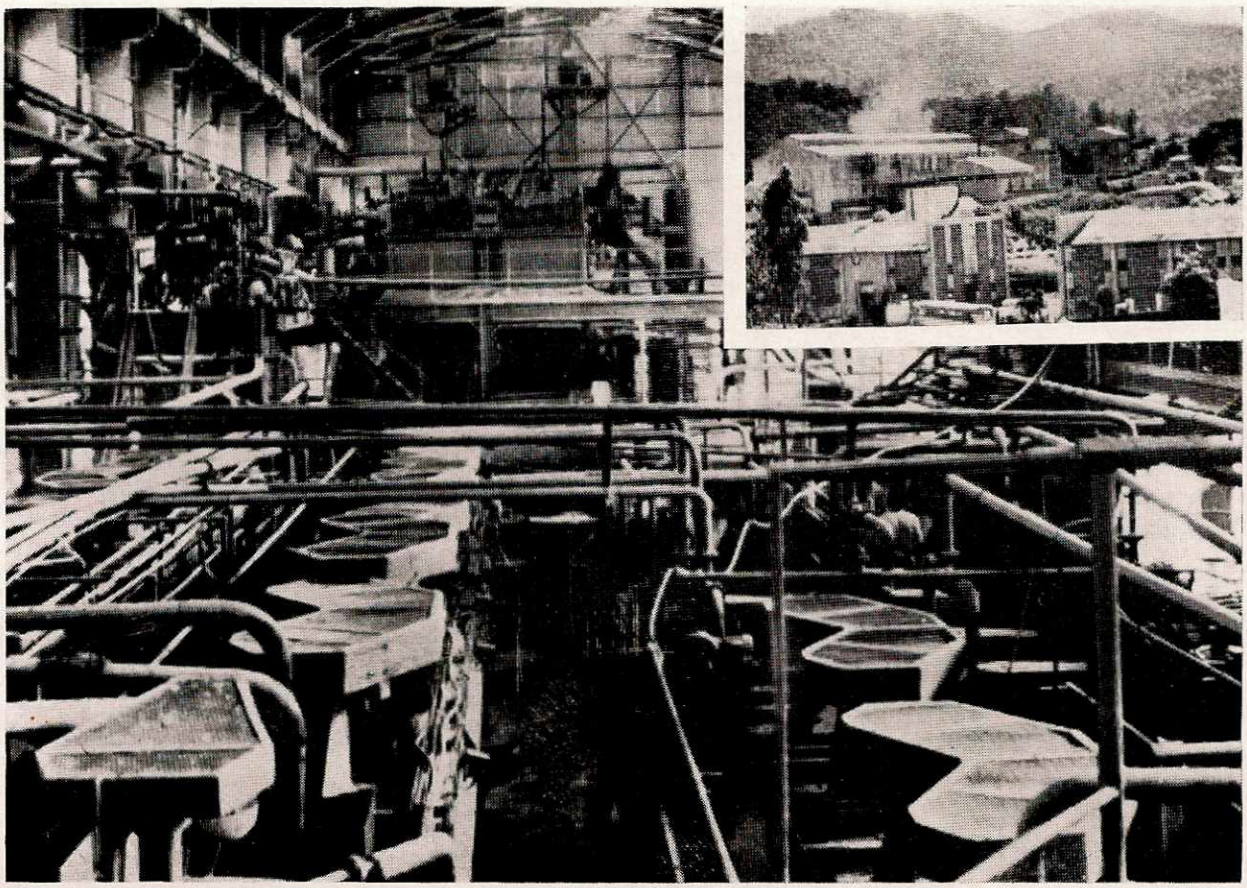
The National Metallurgical Laboratory entered in a contract with the United Nations Industrial Development Organisation (UNIDO) to undertake laboratory and pilot plant scale studies on the suitability of Asswan Iron Ores, from the Arab Republic of Egypt, for iron making.

The final report, submitted as per terms of the contract, contains a detailed description of:

(a) Petrological and DTA studies;

(b) Laboratory scale trials on the beneficiation of the ores, for the formulation of a flow-sheet for optimum and economic upgrading to yield the highest possible iron recovery consistent with high quality concentrate;

(c) Extensive pilot plant scale trials to obtain requisite data for industrial scale implementation of the recommended beneficiation flow-sheat, based on laboratory scale trials;



A 500-tonne per day Fluorspar Beneficiation Plant of Gujarat Mineral Development Corporation installed and commissioned with NML technology and consultancy

(d) Comprehensive tests on sintering and large scale pelletization of the concentrate for industrial scale implementation;

(e) Pilot Plant scale trials on pre-reduction of the pellets;

(f) Smelting of pre-reduced pellets in an electric arc furnace for pig iron making;

(g) Techno-economic assessment of each stage of the process, including crushing, grinding, beneficiation, agglomeration, pre-reduction and smelting.

2. Beneficiation of Iron Ore from Syria:

To assist the Govt. of Syria in setting up an iron & steel plant, the Laboratory, through MECON, undertook a challenging assignment of beneficiating on bench and semi-large scale low grade colitic iron ores from Syria. The studies carried out have established the technical feasibility of beneficiating the ore by more routes than one.

3. Setting up and commissioning a Pilot Plant for the production of Electrolytic Manganese Dioxide on behalf of the Govt. of Burma:

An electrolytic manganese dioxide pilot plant of 50-kg a day based on NML know-how has been set up at Rangoon by the Central Research Organisation, Burma, under the Govt. of India assistance to the Govt. of Burma through CSIR NRDC. The NML Scientist was deputed to assist in setting up and commissioning the plant in May 1979 and also in training the Burmese engineers to operate the plant. The product produced at this plant has been tested by the user viz. Heavy Industries Corporation, Burma, who have been producing the dry cell batteries with foreign collaboration, using imported electrolytic manganese dioxide and natural manganese dioxide. The manganese dioxide produced in this pilot plant is of superior grade comparable to the variety imported hitherto by them.

4. Corrosion of Metals & Alloys—Collaborative project with the National Research Institute of Metal, Tokyo, Japan.

A collaborative project on 'Atmospheric corrosion of metals and alloys' with National Research Institute of Metal (NRIM), Tokyo, Japan, has been initiated. The project is to run initially for a period of three years, comprising exposure tests with different metals and protective coatings as well as laboratory studies on different aspects of atmospheric corrosion in both India and Japan, under identical climatic conditions.

5. Preparation of Standard Reference Materials for 'National Bureau of Standards, U.S.A.'

The Laboratory has prepared standard reference samples (a) high carbon ferro-manganese, (b) low carbon ferro-manganese and (c) ferro-titanium as per the requirement of National Bureau of Standards, U.S.A., and supplied them the required quantities.

Dissemination of Information

In the field of dissemination of scientific and technical information, the Laboratory has made a very significant contribution. It brings out its own journal 'NML Technical Journal' containing R&D work of the Laboratory as well as from elsewhere. NML Technical Journal has attained a standard at par with the leading metallurgical journals of the world. The Laboratory organises Symposia and Seminars on subjects of topical interest covering various disciplines of metallurgy which act as valuable media for exchange of information and generation of original thoughts. Proceedings of symposia and seminars, monographs, bibliographies on specialised subjects are other important publications of the Laboratory.

The Laboratory organises periodic 'get-togethers' where industrialists, business entrepreneurs, technologists and scientists meet and exchange views relating to NML developed products and processes. NML also takes part in various national and international Trade Exhibitions and exhibits the product, technologies, service facilities, expertise available with NML.

Library & Documentation

The Library and documentation services of the National Metallurgica lLaboratory with their project-oriented documentation and pin-pointed system of information retrieval play a key role in facilitating R&D work. The Library also gives service to outside organisations. The NML Library has been recognised as a potent inspection centre. The Library prepares bibliographies on subjects of R&D interest. The holdings of the Library comprising books, journals, specifications, etc., exceed 50,000. The Library receives 600 periodicals monthly.

Social Activities

The National Metallurgical Laboratory encourages the social activities of the staff. The NML club organises various outdoor and indoor games for the staff and their families.

The NML staff take part in the annual Sir Shanti Swaroop Bhatnagar Memorial Tournament arranged amongst CSIR Laboratories in cricket, badminton, table-tennis, volley-ball, cards, etc. This year, the Laboratory won the championship in bridge and were runners-up in volley-ball in Bhatnagar Memorial Tournament. Annual sports are organised amongst the NML staff and their families.

Kindergartens are run in the residential colonies of the NML staff. Besides, NML is keenly pursuing for the establishment of a High School under the Central School System of the Govt. of India. Cultural classes like dance, music, arts and crafts are held in the colony.

Residential colonies have been built for the NML staff at Golmuri and Agrico areas. Recently, two new multi-storeyed buildings, each comprising 12 floors and containing 48 flats have been constructed at Agrico. In addition, 42 flats have been constructed at the Golmuri area. Medical dispensaries are run at residential areas for minor treatment and ailment of the staff members and their families. Efforts are being made to obtain sanction for the longstanding needs of a hostel, regular building for schools, dispensaries and accommodation for new staff.

For facilitating banking and postal work, a branch of the State Bank of India functions within the Laboratory premises. A post office is also located within the Laboratory.

NML canteen provides tea, snacks and lunch to staff members at reasonable rates. NML Staff Co-operative Credit Society handles a transaction of nearly three lakhs of rupees annually.

The NML staff members respond to relief activities conducted during natural calamities like flood, drought, etc.

Commercial production of V_2O_5 by Rare Chemicals Ltd. Ranchi, with NML know-how and consultancy

The staff members organise various cultural shows. Religious functions are held within the colony premises.

Conclusion

The National Metallurgical Laboratory is a firm believer in the ingenuity of Indian research scientists, engineers and technologists. Discoveries, inventions and breakthroughs are not monopolies of any particular nation—these come to those who deserve and who believe in the motto of 'Self-help'. Indian scientists need the support of the industry whether it is in the public or the private sector. It is the unceasing application of new ideas and newer innovations on an industrial scale that fertilise the scientist's research ingenuity to search and research, to explore and forge ahead, to beneficiate his technical 'know-how', upgrade the economics of his technical operations. The scientists in India, as elsewhere, can hardly thrive in isolation. Ceaseless applications of his embryonic ideas and techniques generate a cycle of all-round multiple growth; it is such chain reactions, the growth of original research effort and its applications that lead to the intandem mutual progress of both.