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STRENGTHENING METALLURGICAL RESEARCH AND DEVELOPMENT COMPETENCY OF DEVELOPING COUNTRIES*

Prepared by
the UNIDO Secretariat

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For introducing and applying indigenous metalllurgical R and D know-how developing countries have three basic options:

(i) transfer and adaptation of technology from industrialized countries in well defined areas, with appropriate adaptation to available local raw material, equipment, human resources, and other specific conditions (e.g. scale of operation or market);
(ii) transfer and adaptation of (appropriate) technology from another developing country, therefore decreasing or minimizing the problems of technology transfer;
(iii) development of indigenous R and D activities, with requisite supporting services and institutional arrangements for transfer to industry

As a matter of fact, without transfer and adaptation of technology and R and D know-how consistent and balanced, industrial development is unimaginable even in the most developed industrialized countries and it is an absolute pre-condition for developing countries. It is evident that if we make a distinction between absolute and relative underdevelopment, the transfer and adaptation of technology and know-how will address the problem of relative underdevelopment only. To decrease the absolute underdevelopment, indigenous capabilities of development of technologies and R and D know-how are to be created at least in selected spheres of technology and science.

Establishment and operation of R and D centres, laboratories, institutes, pilot and demonstration units in selected fields of industrial development is the main instrument to both transfer and adapation of existing and also development of new achievements and capabilities. This is the reason that, while UNIDO is providing technical assistance to developing countries in all of the above areas, item (iii) receives UNIDO's particular attention also in the field of metallurgy. These Centres for Metallurgical Technology are created or supported by UNIDO's technical co-operation programme to try to effectively promote first of all the adaptation and modification of proven

processes and products and later, relying on the accumulated knowledge and experience to develop new processes and products most suited to the prevailing conditions.

Such Centres may cover broad sectors of metallurgical industries, or be limited to a specific branch, e.g. iron and steel or aluminium. Areas covered usually include ore beneficiation, metal extraction, refining, transformation, surface protection and also application of metals and alloys in various shapes and forms, standardization, fuel and energy conservation, environmental aspects and diverse consultancy work for local clients.

Centres would also undertake such activities as cataloguing and dissemination of technical information and documentation, evaluation, testing of metallurgical raw materials, preparation of feasibility studies, market surveys and project reports, providing technical training for industry and research personnel, arranging the exchange of personnel for on-the-spot studies - as well as other activities to promote the growth and expansion of the metallurgical sector in a given country or region.

The forms of UNIDO's technical assistance inputs to the establishment of Metallurgical R and D Centres are essentially one or the combination of more, of the following:

Engagement of individual experts or consulting firm by contracting;

Procurement and putting in operation of laboratory and plot plant equipment for analytical, testing and demonstration purposes;

Arrangement of individual fellowship training programmes, group training programmes and study tours, seminars and workshops;

Since its inception in 1967 UNIDO has assisted more than 30 developing countries, through about 50 projects, in the establishment and/or

strengthening of Metallurgical R and D Institutes, Laboratories or Centres. A list of projects provided in Annex I shows 10 projects undertaken in Africa and Arab States, 19 in Asia, 9 in Latin America and 8 in Europe - a total of 46 projects of R and D and pilot and demonstration units in developing countries.

In the present paper we have selected some examples of UNIDO's technical assistance projects in the non-ferrous metals field, and these are presented as follows:

ALUMINIUM INDUSTRY PROGRAMME:

JAMAICA - Upgrading of the scientific and technological capabilities of the Jamaica Bauxite Institute - Establishment of a Bayer process pilot plant for alumina production

The Bayer alumina pilot plant, established under a UNIDO technical assistance project from 1981 to 1985 is a complete closed circuit Bayer process loop embracing the unit operations of an industrial scale Bayer alumina plant up to the alumina hydrate stage.

It was designed, developed and constructed by JBI staff working closely with UNIDO consultants and local contractors. The plant is capable of refining bauxite to alumina hydrate at a minimum rate of 10 kg/hr, of alumina hydrate. Up to 20 tonnes of bauxite can be processed in the plant in a one month period. The plant is of critical importance because the data generated from its use can be extrapolated to an industrial scale alumina plant with much greater accuracy and confidence than laboratory tests so as to enable determination whether new technology is economically justified and should be implemented. The design mode of the pilot plant enables its operation on a continuous or batchwise basis and allows to process all types of bauxites and also tests with flocculants, disperants, coagulants and liquor purification agents. Plant features include:

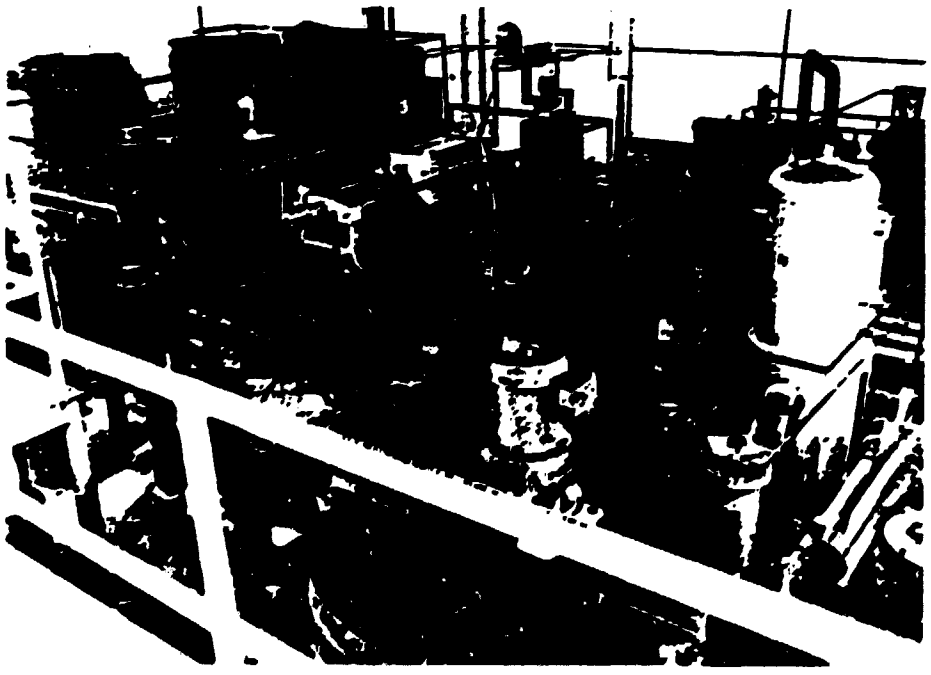
Wet Grinding of bauxite
Low and high temperature digestions

Controlled counter-current bauxite slurry
Continuous counter-current mud washing and decantation
Control filtration
Alumina hydrate precipitation under a great variety of carefully and accurately controlled conditions

JBI can also offer training of personnel in Bayer process operations and management. Apart from bauxite processing, JBI deals with bauxite exploration, red mud utilization and economic and strategic planning for Jamaican bauxite/alumina industry. The analytical laboratories are well equipped with modern facilities enabling routine analytical and research tasks on a variety of inorganic based samples for industry and agriculture.

The pilot plant project was financed from the United Nations System for Science and Technology for Development, with an input of about $ 1.1 million, and was implemented by UNIDO. The UNIDO project arranged for training scientists, engineers and technicians (about 25 fellowship training programmes and study tours), procured and installed new equipment (e.g. scanning electron microscope, X-ray spectrometry and commissioned the laboratory and pilot plant. It was inaugurated in June 1985. At that occasion JBI held a Demonstration Workshop on Laboratory and Pilot Scale Bauxite Processing, with international participation. More information on the Pilot Plant can be found in the Report of the Workshop (Symbol no. ID/WG.446/7) which may be obtained from UNIDO free of charge.

General view of the pilot plant



YUGOSLAVIA: Establishment of an Aluminium Institute for R and D in Titograde

UNIDO is active in Yugoslavia where it assists a UNDP financed project with an input of about $ 650,000, related to the establishment of an Aluminium Institute for R and D in Titograde, with the provision of sophisticated R and D equipment, e.g. universal testing machine, computer system, X-ray and texture diffractometer, scanning electron microscope, X-ray spectrometer, laboratory furnaces, etc.) and elaboration of R and D programmes ranging from investigation of bauxite and alumina up to development of aluminium semi-finished products. Within this project new research methods have been developed particularly with regard to optical microscopy and casting technology for aluminium alloys, phase identification by X-ray diffraction technological treatment and product quality of aluminium alloys and many more.

INDIA: Establishment of an Aluminium Research, Development and Design Centre

A detailed preparatory report was prepared and completed in 1983 incorporating in-depth elaborations on the suggested organization and management structure, leand, buildings, equipment, manpower and training requirements, capital recurring expenditures and suggested phasing for establishing the Centre which is now in the planning stage. Approval by UNDP to provide an input to the project of about $ 5 million is expected soon. This will cover the cost of about 150 m/m of international expert and consultants services, about 50 m/m of fellowship training abroad, the services of an international consulting firm and procurement of sophisticated laboratory R and D equipment and instruments. The project will be implemented by UNIDO and is envisaged to include at full development an Alumina Production Research Department; Aluminium Electrolysis Department; Analytical Research Department; General Services, Instrumentation and Control Department; General Administration Department incl. Workshop and Maintenance Sections.

The Centre is designed so as to develop capability of carrying out the following main functions:

(a) Assimilation and adaptation of available technologies for the production of alumina and aluminium. Development of local know-how and basic engineering packages for future alumina and aluminium plants to be set up in the country based on indigenous raw materials and natural resources; carrying out laboratory research work ensuring background for the industrial research.

(b) Providing recommendations and ad hoc services to local industries in particular regarding improvements in the existing technological processes in the field of alumina and aluminium production and to assist in the transfer of technology from know-how suppliers; Undertaking research programmes specifically oriented towards reduction of energy and material consumptions. Carrying out research work for new prospective processes;

(c) Setting up and operating of a data bank with all the available information on the latest developments in alumina/aluminium production technologies.

(d) Providing training of Indian engineers employed in the alumina/aluminium industry (R and D staff) in relevant specialized fields of alumina/ aluminium production through the organization of workshops, group training programmes and acceptance of individual fellowship training, as need may be.

PEOPLE'S REPUBLIC OF CHINA: Assitance to the Zheng Zhou Light Metals Research Institute in Alumina and Aluminium Production

UNIDO rendered UNDP financed assistance (about $ 470,000) in the modernization and expansion of the research capabilities of the Zheng Zhou Light Metals Research Institute by providing an international sub-contactor, sophisticated laboratory equipment (including electron microscope, a differential thermal analyser, an infrared absorption spectrometer an X-ray diffractometer and a particle size distribution analyser) and training programmes for Chinese nationals, thereby strengthening the Institute's capability to carry out mineralogical and technological investigations of bauxite.

The institute can provide technical services and supply new technologies for development and extraction of alumina from aluminium mineral sources (for metallurgical and other applications) and for recovery of gallium through the new technology of comprehensive utilization, energy saving of aluminium production, super purity aluminium production, research on magnesium metallurgy, etc.

A 6 weeks group training on alumina production and aluminium electrolysis was organized at the Zheng Zhou Institute in 1984, within the framework of the Joint UNIDO/Hungary Aluminium Industry Programme, with 7 Hungarian experts lecturing to a Group of 32 Chinese participants.

Experimental tube digestion of bauxite

Also in the People's Rep. of China, UNIDO is presently engaged in preparing design documentation and to assit in the actual establishment of an industrial experimental tube preheating/digestion unit to be established in the Zheng Zhou aluminium complex for processing diasporic bauxites, providing sufficient data and experience which would permit the construction and successful operation of new tube digestion units in China.

VIETNAM:Technical assistance for the establishment and operation of a laboratory for bauxite processing technology in Vietnam

A $ 1.1 million project is presently implemented by UNIDO in Vietnam, assisting the country in establishing a bauxite testing laboratory suitable for undertaking geological exploration and ore evaluations as well as elaborating alternatives of industrial processing technology.

Project activities cover fielding of about 45 m/m of international experts, about 43 m/m of training of fellowships and study tours abroad and the provision of laboratory equipment which will, among others, cover atomic absorption spectrometer, thermobalance, X-ray diffractometer, Gamma-ray model settler and the UNIDO COMPAR feasibility calculation system. The holding of a group training programme on evaluation of bauxites and alumina production for about 25 participants is envisaged for early 1988. The project is expected to be implemented by end 1988.

Organization of Group Training Programmes on Alumina Production

Within the framework of the Joint UNIDO Hungary Programme for Co-operation in the aluminium Industry Field, the first 3 months international Group Training was held in Budapest in 1979 and was successfully repated in 1983. Subsequently, the desire was expressed by a number of participating countries to have such group trainings on a national basis to give more national participants the opportunity to profit from the lectures and demonstrations. The first national Group Training Programme has held at the Zheng Zhou Light Metals Research Institute in China in 1984 when 32 participants listened to the lectures of 7 Hungarian experts and took part in practical demonstrations. Another such Group Training is in the planning stage for Vietnam for 1988. Interest was also expressed at various times by Indian experts.

OTHER NON-FERROUS METALS PROGRAMME:

PAKISTAN: Establishment of a Development Centre for Silicon Technology:

The first phase of this project with an input of $ 1.3 million by the UNFSSTD is presently under completion.

The Government of Pakistan has initiated a programme aimed at harnessing solar energy as one method for electric power production for small rural communities. A parallel programme was introduced to establish two energy centres to provide electricity from photovoltaic solar cells for lighting, water pumping and TV.

Since there are extensive deposits of silica sands in Pakistan and the demand for silicon photovoltaic cells for rural electrification is expected to increase, the Government has taken the step to establish a Silicon Technology Development Centre to bridge the gap between supply and demand for semi-conductor devices with a facility which will provide indigenous technological capability for silicon production.

Under the project UNIDO procured equipment to the order of $ 0.9 million. Project activities included (a) the transfer of technology for testing, qualifying and producing high quality silicon, electronic grade polysilicon, single crystal silicon, silicon solar cells and solar cell modules, using indigenous materials; (b) the acquisition of indigenous skills and information to support the development of silicon solar cells and semi-conductor technologies; (c) the development of technical capability to prepare silicon-based materials photovoltaic colar cells and cell modules through different routes based on current and future technologies and (d) the setting up of institutional facilities to cater for R and D and training requirements for creating a pool of highly skilled manpower which could serve an expanded local silicon-based industry.

CHILE: Establishment of a Mineral and Metallurgical Research Centre

In Chile, UNIDO assisted in the establishment of a Mineral and Metallurgical Research Centre (now Centro de Investigaciones Minero-Metalurgicas - CIMM) in two phases between 1971 and 1978. The UNDP

input to the project was about $ 2 million. During the second Phase of the project about 190 man-months of international expertise was provided, constituting the largest part of project inputs. The Centre mainly serves the copper industry of the country and deals with all aspects of mining exploitation, ventilation, rock mechanics, mine models and simulation, mineral processing, extractive metallurgy, pyro- and hydrometallurgy, hydraulic transport of solids, environmental control, quality control, minerals characterization and water analysis.

The nucleus of CIMM is a pilot plant covering all aspects of mining, milling and metallurgy, from primary crushing, grinding and flotation through refining to casting. A tailings dump ensured pollution-free operation of the unit.

CUBA: Establishment of a Mineral Beneficiation Pilot Plant

The first phase of this UNDP financed projects counted with an input of $1.15 million. Project activities mainly covered the establishment of the pilot plant including procurement and installation of technological equipment for ore crusing and grinding, ore classification, attrition and flotation as well as laboratory instruments. Constructions of buildings and other facilities was provided as part of the Government contribution.

Under Phase II, which started in 1987, with an expected completion time in 5 years, the laboratories will be established and brought to full operation. They will include

i. A mineralogy laboratory to determine the characteristics of ores of zinc, lead, cadmium, barite, gold, silver, copper, manganese, chromium, bauxite, zeolite, bentonite, silica sand, feldspar, kaolin, pyrite, magnesite, dolomite, phosphate rock, calcium carbonate and gypsum.

ii. A bacterial leaching laboratory to study application for ores, mining waste and sulphide, oxide and arsenical residues of copper, gold, silver and zinc.

iii. Assembly and installation in the newly established pilot plant of research units for gravity concentration, magnetic and electrostatic separation, hydrometallurgy and solvent extraction including transfer of technology for the design and selection of equipment for the research units.

The second Phase of this project is being implemented with 8.5 man-month of UNIDO Chief Technical Adviser, about 30 m/m training programme abroad, with the larger part of the project constituing equipment procurement for the laboratories and pilot plant units (e.g. microscopes, image and X-ray analysers, pumps, thermometers, etc.

When fully operational, the Centre will cater for Cuban needs to promote R and D in exploiting non-ferrous and non-metallic minerals beginning with lead, zinc, cadmium, barite, gold, silver and copper and to identify alternative technologies for processing, e.g. bacterial leaching of complex ores. It will also provide training to local personnel in these fields and will thus make a significant contribution to increasing Cuba's self-sufficiency in technical and research capacity in this field through transfer of technology.

PAKISTAN: Assistance for the Establishment of a Multiputpose Ore Beneficiation Pilot Plant

Alike Cuba, UNIDO is assisting the Pakistan Council of Scientific and Industrial Research to establish a multipurpose ore beneficiation pilot plant for undertaking mineral processing research work of indigenous ores and minerals. UNIDO project activities started in 1986 after PCSIR had already completed an appreciable part of its charteres responsibilities. The project is scheduled to be completed by end 1987. The UNDP input to the project is about $ 400,000 covering 20 man-months of consultants, 18 man-months of study tours abroad and procurement of laboratory equipment such as filter station, jaw and cone crusher, ball mill, hydrosizer, etc.

Once fully operational, the mineral beneficiation pilot plant will be able to formulate optimum beneficiation techniques and flow sheets for undertaking mineral beneficiation tests on low grade ores and mineral deposits and will serve the local industry in this field.

PERU - Establishment of a Centre for Metallurgical Technology

In Peru, UNIDO is assisting in the establishment of a Centre for Metallurgical Technology. The project is supported by a large cost-sharing component by INTINTEC and SIDERPERU. It is aimed to increase the effectiveness of industrial metallurgical operations and to improve the quality control of primary materials and products of local origin and imported ones through inspection and standardization. Equipment procured for the Centre covers instruments for chemical and metallographic laboratories, mechanical testing, moulding sand laboratory etx. When fully operational the centre will provide services related to treatment and processing of metals, production of ferrous and non-ferrous metals and alloys, design engineering and technical advisory services.

As can be seen from these examples of UNIDO's technical assistance activities, we are promoting the establishment of Centres for Metallurgical Technology. The strengthening or establishment of a local nucleus for metallurgical technology in any developing country with mining/metallurgical activities is of vital importance in the industrialization process. When introducing new metal products, their application and quality requirements call for the attention of teams of specialized metallurgists backed up by adequate applied R and D facilities, including pilot plants. Within the contest of a dynamic economy chiefly based on industrial development, the industries which are dependent upon metals for their operations and products are expanding in many different fields. The correct and optimum utilization of the various types of metals and alloys call for continuous and trained expert assistance.

Thus, Centres for Metallurgical Technology play an active part in the transfer and adaptation of metallurgical technology to suit the conditions and requirements of the country and, in addition, promote technical co-operation.

This multiple approach and collaborative functioning of Metallurgical R and D Centres amply justify their establishment, as a nucleus of know-how, not only for solving existing metallurgical problems, but also for implementing the more important long-term plans and objectives of the metallurgical industries in developing countries and to carry out cost and market oriented research and development work.

Just as it is virtually impossible for any country to continue exporting ores and concentrates indefinitely and, at the same time, to satisfy the domestic demand for primary metals through imports, so it is equally inadmissable for a country to depend permanently on foreign institutions for the transfer of industrial metallurgical technology. There comes a time when the country has to establish its own R and D centre to be able to locally investigate ores and raw materials and to promote the adaptation of existing processes and products, along with the development of new ones better suited to local conditions.

Annex I

METALLURGICAL RESEARCH AND DEVELOPMENT PROJECTS INCLUDING DEMONSTRATION UNITS IMPLEMENTED OR UNDER IMPLEMENTATION BY THE METALLURGICAL INDUSTRIES BRANCH OF UNIDO

Country	Project Title
AFRICA	
Nigeria	Establishment of a Central Metallurgical R and D Institute - Phase I
Mozambique	Report on the establishment of a technological semi-industrial metallurgical and non-metallic testing and development laboratory
Niger	Creation of a foundry and forge installation for production and demonstration
Senegal	Establishment of a Foundry Development Centre
Somalia	Establishment of a Foundry and Mechanical Workshop in Mogadiscio.
ASIA	
China, Peoples Rep. of	Assistance to the Chemical Reaction Engineering Laboratory for Extractive Metallurgy
	Strengthening of the Institute of Metal Research in the Field of Materials Science
	Assistance to the Zheng Zhou Light Metals Research Institute in bauxite/alumina investigations
	Establishment of an experimental tube digestion unit for bauxite processing
Hongkong	Assistance to the Hong Kong Productivity Centre related to heat treatment
India	Establishment of a Central Creep Testing Unit at the National Metallurgical Laboratory, Jamshedpur
	Establishment of a Demonstration Plant for the Production of Spone Iron at Kothagudem, Andhra Pradesh
	Establishment of a National Welding Research Institute at Tiruchirapalli
	Preparatory assistance related to the future establishment of an Aluminium Research and Design Centre

Country	Project Title
Iran	Assistance to the Aluminium Raw Materials Programme in establishing R and D facilities for bauxite and alunite processing for aluminium production
Rep. of Korea	Establishment of a Surface Treatment Centre
Malaysia	Assistance to the Metal Industries Development Centre
Nepal	Establishment of a Pilot and Demonstration Foundry
Pakistan	Establishment of Metals Advisory Services
	Establishment of a Development Centre for Silicon Technology
	Assistance for the establishment of a multi-purpose ore beneficiation pilot plant
Regional Asia	Workshop on the Regional Project for Co-operative Research among Metallurgical R and D Centres in Asia and the Pacific
Regional Asia	Assistance to the Southeast Asia Iron and Steel Institute
Vietnam	Technical assistance for the establishment and operation of a laboratory for bauxite processing technology
LATIN AMERICA	
Argentina	Integrated assistance to the Development of the Iron and Steel Industry - Assistance to the Argentine Iron and Steel Institute
Brazil	Assistance in the field of standardization, quality control and quality certification of iron and steel
Chile	Establishment of a Mineral and Metallurgical Research Centre, Phase I and II
Cuba	Establishment of a Mineral Beneficiation Pilot Plant
Jamaica	Upgrading the scientific and technological capabilities of the Jamaica Bauxite Institute
Mexico	Technical assistance to the Mexican Iron and Steel Research Centre
Paraguay	Technological strengthening of the metallurgical industry

Country	Project Title
Paraguay	Establishment of a Centre for personnel training for the production of charcoal for iron and steel industry
Peru	Prepratory assistance for the Centre for Metallurgical Technology
EUROPE	
Czechoslovakia	Establishment of a consultancy and training centre on managed maintenance in metallurgical industries
Hungary	Complex utilization of low grade and secondary raw materials for metallurgical and coal sorts of low calorific value
	Development of technologies for low scale utilization of metallurgical and other industrial wastes as secondary raw materials
Iceland	Strengthening of the Industrial Research Institute
Romania	Assistance to the Research and Design Centre for tubular and drawn products in rehabilitation and commissioning of materials testing system equipment
Turkey	Assistance to the Marmara Scientific and Industrial Research Institute, Gebze
Yugoslavia	Mastering modern technologies in the iron and steel industry - technical assistance to the Metallurgical Institute "Hasan Brkic", Zenica
	Establishment of an Aluminium Institute for Research and Development, Titograde
ARAB COUNTRIES	
Egypt	Establishment of a Central Metallurgical R and D Institute
Egypt	Intercountry programme (creation of a centre) for managed maintenance systems in metallurgical industries for African countries
Morocco	Assistance to the Foundry Sector
Sudan	Assistance in the establishment of Khartoum Central Foundry (for demonstration purposes)
Regional Arab	Regional programme for the Development of the Arab Iron and Steel Industry - Establishment of computerized information systems at the Arab Iron and Steel Union.