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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

ID/103
(ID/WG.110/17)

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

CREATION AND TRANSFER OF METALLURGICAL KNOW-HOW

Report of a Workshop
Jamshedpur, India
7–11 December 1971

Including a summary of lectures
presented to the Workshop

I. ORGANIZATION OF THE WORKSHOP

The participants in the Workshop came from 11 developing and industrialized countries. They elected L. Takats (Hungary) as Chairman, M. K. Hussein (Egypt) as Vice-Chairman, and H. I. Martin (United States of America) as Discussion Leader. V. A. Altekar (India) was the Rapporteur. The UNIDO secretariat was represented by the Chief of the Metallurgical Industries Section and the Senior Interregional Adviser.

The participants discussed a number of papers prepared for the Workshop, summaries of which are given in part two of this report.

The participants visited the National Metallurgical Laboratory and its pilot plants and the Central Engineering and Design Bureau, Hindustan Steel Ltd.

II. SUMMARY OF THE DISCUSSION

The papers prepared by experts for the Workshop were circulated in advance to the participants. They were the basis for the discussions, in which attention was directed to the matters mentioned below.

The two steps necessary for the success and permanence of technology transfer from the industrialized countries to the developing countries were the transfer of know-how and the generation of indigenous know-how that would provide a basis for subsequent development and independent growth. The transfer of know-how had usually been based on bilateral agreements. Often in those agreements, the specifications of engineering components and materials were in the terms of the standards and materials of the donor country. Thus the receiver was permanently dependent on that country for spare parts and maintenance and could not seek replacements on a competitive basis on the world market.

Since the technology of industrialized countries was rapidly being improved, some of the transferred know-how, equipment and components could be obsolete in the donor country and the recipient would not be able to fully use them. The generation of indigenous know-how and expertise would reduce the frequency of those situations. Therefore, indigenous research and management techniques should be developed at the same time that know-how was being imported.

Since no general method for the creation and transfer of know-how was applicable in all developing countries, each country should establish its national goals and priorities for determining the areas in which foreign collaboration was desirable. Although both industrialized and developing countries purchased know-how, the developing countries must be careful that only essential know-how was imported on a selective basis.

Perhaps the most effective and rapid method of technology transfer was a result of a partnership with a foreign company. The branch of the company located in the developing country would be subject to its domestic laws and could become a source of great economic strength to the developing country. The assignment of personnel from the developing country to other branches of the company for additional training would be desirable, since they could possibly assume some duties of the foreign experts upon their return home. The agreements for all joint ventures should include long-term guarantees and servicing of engineering equipment.

Thorough knowledge of the existing infrastructure in a developing country was vital for the successful installation of metallurgical plants. Conditions varied, and many problems could arise from inadequate infrastructure. A developing country that had effectively solved similar problems could possibly provide the necessary technical assistance rather than a highly industrialized country where other conditions and problems were prevalent.

Since preliminary studies and feasibility reports provided vital information that influenced the decision to begin a project, extreme care should be taken in the selection of a technical consultant. Therefore, an atmosphere of mutual confidence between an industrialized country and a developing country was essential.

The experience and background knowledge of the industry that were required to plan project and feasibility reports were not readily available in developing countries. A team consisting of two technicians and an economist could be recruited for overseas training in the methods of preparing feasibility studies.

After the feasibility studies had been completed, data on process technology and the problems faced by other consultancy agencies should be collected. The detailed project study could be prepared in one of the following alternative ways:

(a) The preparation of general specifications for over-all plant design, the issuance of tenders and the award of the detailed engineering design and responsibility for commissioning the plant to a contractor;

(b) The complete preparation of the detailed engineering design locally.

The first method differed from a turn-key project in which the contractor was responsible for the working of the complete plant because the responsibility of the contractor was limited to supervision and erection of supplied machinery. The second alternative required an efficient organization with co-ordination of the activities of its departments as well as with those of the manufacturer.

The need for the establishment of research and development laboratories in developing countries was recognized. The laboratories should pursue applied research, maintain contacts with industry and increase the market potential of the end-products. Essential policies for implementation of applied research and development programmes would include adequate salary scales, administrative autonomy, the availability of technical and economic data, and meaningful market research programmes.

Specialized national metallurgical research and development centres should concentrate on ferrous and non-ferrous technology. The centres should provide the necessary know-how and data for the design institutes and should have close ties with metallurgical plants especially during the start-up period of new equipment or technology. The exchange of experienced personnel would be beneficial to both the centres and the plants.

When a certain technological level was reached in a developing country, it must set up its own technical design organization. The decision required courage, sound technical leadership and enlightened national policies. The following tasks were the responsibilities of the design organization: general plant layout, plant and equipment specifications, detailed design of the equipment for manufacturing processes, and detailed civil and structural design including electrical design as a part of the infrastructure.

The design of metallurgical plant and equipment generally involved consideration of the product mix and output requirements and the derivation of basic parameters for suitable machine capacities, the development of the basic design for the equipment from the parameters obtained and the production of detailed manufacturing drawings from the basic design. Most developing countries would be dependent upon imported know-how for those tasks. Since the plant and equipment costs in a metallurgical industry was 50 per cent of the total capital investment, it was desirable that a developing country used the maximum possible indigenous contribution. However, the planning of the maximum local manufacture of a metallurgical plant should be based on horizontal isolation rather than in terms of vertical isolation of basic equipment.

The estimates for the following five groups of personnel and their duties in a design engineering organization were discussed in detail:

Civil engineering group (25 per cent) track rods, foundations, structures, sewage and water supply

Electrical engineering group (20 per cent) supply, distribution, control, equipment and communications

Mechanical engineering group (20 per cent) machinery layout, piping and material handling

Technology group (25 per cent) combustion (energy and economy), instrumentation, refractories and facilities for maintenance and service

Support group (10 per cent) economists for control of finance and cost accounting, administration and project implementation

Processes used in the manufacture of metallurgical equipment included fabrication, iron and steel castings, forging, heat treatment, machining and assembly. Among those processes, the technique of fabrication could be developed in a short time. Casting, forging, heat treatment and machining could also be developed reasonably quickly within limited size ranges. Facilities required for assembling such equipment could be established fairly easily in any developing country. Therefore, before importing equipment, consideration should be given to the facilities available in the developing country.

In some countries, the immediate need was the co-ordination of research and development programmes and the establishment of a sound machinery for the management of research. Industrial concerns in both the private and public sectors should contribute to the establishment and overhead costs of centralized agencies similar to the British Non-Ferrous Metals Research Association and the British Iron and Steel Research Association.

The creation of indigenous know-how gradually reduced the need for imported know-how. The feedback aspect of the creative process was emphasized; channels for effective communication between industry and the research centres could increase the rate of accumulation of know-how.

The urgent need for educational facilities and programmes for technical training on all levels was stressed. It was essential for the success of metallurgical projects in developing countries that local engineers, technicians, artisans and draughtsmen were able to actively participate in the use of imported know-how.

Long-range educational policies for increasing the training potentialities for a greater number of technical personnel should be evaluated and if necessary revised. When appropriate provisions had been included in the contracts for pilot plants, they could be useful training centres. Such training opportunities were especially significant in developing countries with very little industrialization and few trained personnel.

III. CONCLUSIONS

The following conclusions of the Workshop were based on the discussion of the creation and transfer of metallurgical know-how.

The type of metallurgical know-how required by a developing country would be related to the nature of specific metallurgical industries and their end-products. It would, therefore, be necessary to examine each country's specific requirements concerning the nature and quantity of metallurgical know-how. This analysis should be undertaken by the developing country with appropriate technical assistance through UNIDO if needed.

There was an urgent need in developing countries for the establishment of centres for metallurgical technology for applied research and development work. Their programmes should range from the exploitation of indigenous raw materials to the quality control of end-products. UNIDO could assist the developing countries in setting up these metallurgical centres, which should include pilot plants with facilities for research on new processes and for their technical and economic evaluation. These centres could also undertake feasibility studies and provide technical consultancy services with emphasis on local geographical, social and economic conditions.

A critical problem in many developing countries was the paucity of technical personnel and trained manpower; these were essential not only for preparing feasibility studies and project reports but also for the efficient operation of metallurgical plants.

It was necessary therefore, to plan the training of a sufficient number of metallurgical engineers in reputable technical consultancy and design organizations in industrialized countries.

Those developing countries which had attained a good technological basis should be encouraged and assisted in establishing their own technical consultancy and design organizations. Those indigenous design organizations must then assume the responsibility for selecting the appropriate metallurgical know-how from other countries.

In the creation, transfer and growth of indigenous metallurgical know-how, it was important that there would be feedback between the research organizations that would create the indigenous metallurgical know-how and the metallurgical plants that would use it. Therefore, even when metallurgical technology was being imported, it should be possible for the local research and development and technical design agencies to become self-reliant and avoid the repetitive import of metallurgical technology by local metallurgical industries in the public and private sectors. A directory could be prepared that clearly indicated the nature, scope and sources of the imported metallurgical technology. The directory would be valuable for the feedback of requisite expertise to recently established metallurgical industries in a developing country.

Prior to the transfer of technical know-how for basic metallurgical industries such as the iron and steel industry and the non-ferrous metals industry, consideration should be given to the ancillary industries based on the by-products of the basic industries. Careful planning would ensure the optimum operational linkages between the basic and ancillary metallurgical industries. As the basic industries would be highly capital-intensive, it was necessary that the Governments of developing countries offered appropriate protection, subsidy and other forms of support to those metallurgical enterprises.

There would always be a time lag between the setting up of design engineering and technical consultancy facilities in a country and the effective adaptation in those facilities of imported technical know-how. Gradually the technical and operational expertise would be developed for local application and possibly for transfer to other developing countries. There were no short cuts in the growth of metallurgical technology.

IV. RECOMMENDATIONS

The Workshop approved recommendations for action by the Governments of developing countries, by industry in both developing and industrialized countries, and by UNIDO.

A. Recommendations to Governments of developing countries

It is recommended that the Governments of developing countries take the following action:

(a) Adopt policies that favour a scientific climate be conductive to the transfer of metallurgical know-how;

(b) Establish national centres for metallurgical research and development;

(c) Implement a policy of progressive expansion of manufacturing activity and capacity;

(d) Encourage the import of technical know-how;

(e) Establish educational institutions and training centres;

(f) Maintain a roster of local and foreign metallurgical experts and design consultancy services;

(g) Seek appropriate assistance through UNIDO;

(h) Provide incentives for the development of indigenous metallurgical expertise.

Creation of a scientific climate

The following government actions would further the achievement of a proper scientific climate for the creation and transfer of metallurgical know-how:

(a) The initiation of long-range economic and industrial development programmes with careful consideration of the available indigenous resources;

(b) The planning of national science and technology policies;

(c) The formulation of policies to encourage progressively increasing responsibilities for local metallurgical experts in preference to the perennial and costly hiring of foreign experts.

Establishment of centres for metallurgical research and development

Active centres of metallurgical research and development should be independent organizations with a broad spectrum of functions and services.

Their programmes could include some or all of the following tasks:

(a) Surveying and testing local raw materials;

(b) Planning, executing and evaluating techno-economic studies for metallurgical industries;

(c) Evaluating industrial projects and providing consultancy services for the metallurgical industry;

(d) Developing local metallurgical research and industrial talents through the training of scientists and technicians;

(e) Investigating new metallurgical processes and production techniques;

(f) Solving local metallurgical problems;

(g) Collecting, classifying and desseminating technical data;

(h) Setting up quality-control standards and testing procedures for different metallurgical industries.

The staff of these centres should include market research analysts and economists as well as technical design engineers and metallurgists.

At appropriate stages of development, the centres in developing countries could be supplemented by highly specialized centres for different branches of ferrous and non-ferrous metallurgy, mineral beneficiation and agglomeration, metal transformation, metallurgical refractories, physical metallurgy, heat transfer and combustion technology, as well as operational research units. The patterns of development would not necessarily parallel those in industrialized countries because the objectives would be the adaptation of technology to local conditions and requirements.

Technical design facility

The technical design services in a developing country should point out the operational deficiencies and the techno-economic shortcomings in the metallurgical expertise developed at the research centres and assist the centres in rectifying them. Such feedback and co-operation between the two specialized services would lead to self-sufficiency in the technical fields instead of the permanent borrowing of costly technology.

Progressive expansion of manufacturing activity and capacity

Appropriate incentives should be given for the manufacture of metallurgical equipment, machinery and plants in developing countries.

Otherwise local manufacturers may not be willing or able to undertake the rigorous design specifications and complex engineering methods that would be required for the manufacture of costly and highly specialized equipment. Moreover, local manufacturers should be assisted in the acquisition of technical know-how in new areas of design and the manufacture of equipment such as for continuous casting of steel slabs and continuous steel rolling mills.

Import of technical know-how

Specific metallurgical know-how should be imported only once to a developing country. The imported technical know-how for a particular process should be made available to all metallurgical plants in both the public and the private sector. The imported technology should be as modern as possible. It should serve as a catalyst and not as an inhibitor in the growth and development of indigenous technology and metallurgical know-how. The imported technology should be adaptable to local conditions, infrastructure and the technical skills of the available manpower. In some developing countries, the creation of a central agency for channelling the technology transfer could be advantageous.

In the selection of an overseas supplier of technical know-how, it would be preferable in some cases to select one who could offer the requisite process information and production know-how and could also provide project engineering services and assistance. The proper selection could ensure the correct and quick implementation of a project and the assistance for overcoming possible initial production troubles.

Establishment of educational institutions and training centres

The training programmes for local personnel should cater to the multiple needs of the research and design organisations and to the operational needs of the growing metallurgical industries. Moreover, trained personnel should also be available for trouble-shooting tasks in production units.

Maintenance of a roster

A complete roster of local and foreign metallurgical experts, technical personnel and design consultancy services would be a convenient, up-to-date listing for the metallurgical industry. Furthermore, it would provide an opportunity for the optimum use of both local and foreign personnel in the setting up of a metallurgical project.

Approach to UNIDO

The Governments should approach UNIDO for assistance in technical training programmes through UNIDO fellowships, study tours by senior personnel and in-plant training programmes. Specialized training in metallurgical research laboratories and engineering design organizations for designers and research personnel from developing countries should be arranged through the technical assistance programme of UNIDO.

Incentives

A number of incentives could be offered to local organizations for the creation and development of indigenous technical know-how and metallurgical expertise. Those incentives could be in the form of tax holidays, preferential financing and subsidies, the relaxation of tariff and quota restrictions for the import of equipment and raw materials that were not available locally, and preferential treatment in the allocation of ancillary service facilities.

Follow-up action

A questionnaire should be prepared to gather pertinent information concerning the status of consultancy services for metallurgical industries in a country. UNIDO's assistance could be sought in preparing the questionnaire.

At that time, the Governments should indicate the plans for developing the indigenous technical consultancy services in collaboration with overseas interests. Moreover, the Governments should indicate the present status of their metallurgical industries, their future plans and outline the technical assistance needed from UNIDO in the preparation of practical plans for the establishment of indigenous technical consultancy services. Proposals for the establishment or future expansion of technical consultancy services should be linked with specific metallurgical projects in the iron and steel industry and the non-ferrous metallurgical industry in a developing country.

B. Recommendations to industry

It is recommended that industry in developing and industrialized countries take the following action:

(a) Encourage the establishment of centres of metallurgical technology;

(b) Prepare pre-investment and feasibility studies;

(c) Expend special efforts to further the development of local talent and expertise;

(d) Select appropriate research and development projects;

(e) Consider local conditions before importing specific know-how;

(f) Observe the terms of the arrangement for the transfer of know-how;

(g) Issue handbooks on the methods of project engineering.

Centres of metallurgical technology

Centres should be established in local plants even while they were importing specialized technology and metallurgical know-how from industrialized countries. The developing countries could not afford to ignore the importance of research and development activities for the achievement of technological self-sufficiency in metallurgy. The local industry should assist the research and development programmes of the research centres by contributing both personnel and finance. Concurrently, their counterparts in industrialized countries could offer technical assistance to the research and development programmes.

Industry in developing countries should direct its research and development efforts towards specific project needs. The programmes of the centres should be formulated through a close co-operation with the industry to ensure favourable sales of the end-products.

Pre-investment and feasibility studies

Local firms and consultancy organizations should be awarded pre-investment studies and feasibility studies as well as foreign organizations. Thus developing countries could progressively acquire local expertise while employing foreign experts.

Local talent and expertise

Individual initiative should be encouraged by the management of metallurgical plants in developing countries. A system of incentives including an innovation bonus to personnel was a positive step in the development of local expertise. Research organizations in industrialized countries should support these efforts as much as possible by supplying expertise and research equipment.

Research and development projects

Selection of the proper research and development projects required the assistance and co-operation of industry in industrialized countries. A desirable guidelire was the achievement of the maximum practical results with the minimum acquisition of imported know-how; the principal aim should be progressively increasing self-reliance and self-sufficiency. The projects should be critically formulated and carefully evaluated in terms of the domestic and potential export market requirements with consideration of the available technical personnel and financial resources.

Local conditions and imported know-how

The policies and practices for the import of capital and technology must be integrated with those for national research and development programmes. However, the extent and nature of the two components for the acquisition of technology must be determined by each developing country on the basis of its technical, managerial and commercial status.

Industry in developing countries must consider the local social and economic patterns when introducing modern technology. Local demands and the ability to exploit the most modern and up-to-date technique should also be taken into consideration; the technical know-how introduced should be suitable to the social and economic conditions of the developing countries and should make the best use of the available human resources.

The suppliers of technical know-how and expertise from industrialized countries should have adequate knowledge of the infrastructure in developing countries. Such knowledge would likely be available from local firms who have been engaged in development work in their own fields.

The technology used in industrialized countries was not necessarily the best solution for a developing country. Since labour was very costly and was often in short supply in industrialized countries, an automated technology was preferable. However, a labour-intensive technology could be desirable in developing countries to promote the employment potential. Each case of transfer of technology should be judged on its own merits for a particular country. The extent of the metallurgical know-how that would be transferred should be formulated by industry in developing countries after a careful assessment of the complete situation.

The transfer of technology and its adaptation to the needs of the developing countries required a balanced approach. Caution was required about the conditions of transfer with warnings about high rates of foreign exchange, exorbitant fees for patents and licenses, restrictive industrial practices and the possibilities of the foreign investors building up assets from obsolete machinery and second-hand plants.

Local consultancy organizations in developing countries should derive the design data and extrapolate the operational and production costs on the basis of pilot experiments in their own research laboratories. Thus the know-how generated in these laboratories could be implemented on a commercial basis. The metallurgical plants and equipment should be manufactured in the developing countries to the maximum extent possible.

Transfer of know-how

The joint participation of industrialized and developing countries was essential for detailed project engineering in the developing countries. The joint arrangement could be on a continuing basis. The terms of the transfer should be observed by both parties. The interests of the recipient country could be safeguarded by a responsible and knowledgeable third party. International exchange of technology was effective when the technical co-operation strengthens the economy of both countries.

Industry in developing countries should survey the available raw materials and facilities before entering into arrangements for the transfer of know-how. The proposed terms must be carefully studied. Local personnel should be associated with every stage of the project study.

Handbooks

Project engineering firms in both industrialized and developing countries should be encouraged to issue handbooks about their methods. Furthermore, international business organizations should co-operate with UNIDO in the compilation of technical information, data and case studies. A continuous dialogue should be maintained to shorten the lengthy period needed for technical development.

Follow-up action

Technical consultancy services of industrialized countries should be canvassed to determine their potential assistance to developing countries in the following areas:

Setting up subsidiary technical consultancy services in developing countries

Setting up technical consultancy services in developing countries as joint ventures with the Government or private industry

Practical measures for the planning of specific metallurgical projects

C. Recommendations to UNIDO

It is recommended that the United Nations Industrial Development Organization take the following action:

(a) Assist in the establishment of metallurgical research laboratories and centres of metallurgical technology in the developing countries;

(b) Promote the establishment of international technological societies and technological consultancy organizations in developing countries;

(c) Sponsor the preparation of pertinent documentation;

(d) Provide technical assistance in the evaluation of metallurgical projects and feasibility reports as well as of specific technology;

(e) Co-operate in the formulation of training programmes for technical manpower in developing countries;

(f) Organize workshops and seminars to assess the growing needs of specialized metallurgical industries.

Research laboratories and centres of metallurgical technology

UNIDO should contribute to the establishment of research laboratories and centres of metallurgical technology by providing technical experts, training fellowships and the supply of research equipment and metallurgical pilot plants. It could act as a clearing-house for the exchange of information concerning the experience of developing countries.

International societies and organizations

International technological societies and technological consultancy organizations could promote a better understanding of the problems and needs of the developing countries. Both industrialized and developing countries should be included in the membership. One proposal for study by such international professional bodies was the purchase of proprietary technology which would be available to developing countries at reasonable prices, terms and conditions.

Documentation

The following documentation would be helpful in the transfer of metallurgical know-how to developing countries:

Manuals and monographs that indicated guidelines and appropriate steps for the development of technical consultancy organizations and project engineering facilities in developing countries

Case studies of organizations engaged in planning and design work in a developing country

A series of case studies of developing countries that successfully solved their specific problems in the creation and transfer of metallurgical know-how from industrialized countries

Technical standards for the transfer and management of know-how that would maximize the efficiency of the transfer process

Reference documents for the planning and management of creative facilities in developing countries

A monograph on the metallurgical investment potentials in developing countries

A list of competent consulting metallurgical engineers with adequate experience in designing and preparation of feasibility reports whose services were available either directly or through UNIDO's technical assistance programmes

Guidelines for the design and manufacture of metallurgical plants and equipment.

Technical assistance

If a particular technology was available through two or more alternative sources, UNIDO could provide assistance in assessing their relative merits with respect to the selection and adaptation of appropriate technology, training of personnel, research and development, "forward" and "backward" linkages with the domestic economy, home markets and export potential. Furthermore, UNIDO could assist in determining the extent to which the suppliers of technical know-how and specialized expertise would agree to some degree of oligopoly through restrictive business operations and in particular access to the world markets for the export of metallurgical products from developing countries.

The advice of reputable project engineers could be sent through UNIDO to newly established project engineering organizations in developing countries. The dissemination of technical data to those organizations by UNIDO could counteract the effect of changes in the technical personnel in developing countries.

Training programmes

The technical experts provided by UNIDO should be part of a team with counterpart local engineers. They should participate in an orientation and familiarization programme that would increase the effectiveness of UNIDO assistance. At the same time, UNIDO should assist developing countries in expanding their local training programmes for technical manpower.

Workshops and seminars

The application of indigenous technology for import substitution should be fully examined in workshops and seminars that would be held in the developing countries. The potential benefits that would be derived from an exchange of technical know-how between developing countries should be examined. Attention should be focused on the different types of technical collaboration arrangements and agreements including those based on turn-key package deals. The insertion of clauses covering the training of personnel by the technology supplying enterprises would also merit discussion.

Follow-up action

UNIDO should take the initiative in co-ordinating the recommendations above. It should act as a laison unit between the industrialized and developing countries in that respect.

Part two

SUMMARIES OF PAPERS PREPARED FOR THE WORKSHOP

EXPLANATORY NOTES

The term "billion" signifies a thousand million.

Reference "tons" indicates metric tons.

Reference to "dollars" ($) indicates United States dollars.

V. CURRENT CONDITIONS FOR THE CREATION AND TRANSFER OF METALLURGICAL KNOW-HOW

Creation and transfer of metallurgical know-how

Secretariat of the United Nations Industrial Development Organization

Know-how can include process and production technology, flow sheets, detailed design and engineering, products and detailed specifications, performance charts and quality criteria, operation manuals, technical skills and specialized expertise, training of local personnel, maintenance and repairs and trouble shooting. Know-how may be considered as intellectual property that is quite distinct from patents that legally protect process details.

It has been reported that during 1964, payments for the transfer of technology from the industrialized countries to developing countries totalled about $1 billion. The estimates are of a general nature and cannot be calculated by any specific formula and methodology.

It is estimated that during the next decade, developing countries will have to invest $20 billion for the development of their metallurgical industries. One fourth of these investments may be allocated for the acquisition of direct and indirect know-how.

Many developing countries, including Argentina, Brazil, India and Mexico, feel that they cannot continue to depend on imported equipment and technical know-how. Such countries plan to establish local sources and technical systems for the creation and transfer of know-how.

The need for such autochthonous know-how may also arise from special considerations where the national economy depends markedly on specific metallurgical products. In other countries, the need to maintain or accelerate the process of industrialization requires a ready availability of local expertise for planning, design and operation of a metallurgical plant.

Technology can be transferred in one of the following ways:

(a) From a foreign enterprise to its branch or subsidiary in a developing country. There is direct foreign investment, possibly without the financial participation of the developing country;

(b) Licensing the use of a process by an indigenous manufacturer in a developing country. There are not always adequate safeguards against the use of these specialized processes by other parties in the same or another developing country. Moreover, the licensee is obligated to continue to pay the royalties;

(c) Turn-key package agreements in which a technical process or equipment is transferred. The supplier gives performance guarantees over a certain period. This type of transfer is not fully satisfactory since it involves repetitive import of similar technology and continuous dependence on foreign technology and expertise.

Before a metallurgical project can become fully operational, it must pass through the following four stages:

(a) Identification and formulation of general concepts for setting up a particular industrial project;

(b) Study of technical feasibility and economic viability;

(c) Erection, installation and the assembly of industrial plants. This stage can be implemented only if the conclusions arrive at under (a) and (b) above are positive;

(d) The actual commissioning of the plant.

UNIDO can help in promoting the creation and transfer of metallurgical know-how in developing countries by providing technical assistance for the assessment of the feasibility of a particular project, by assisting the developing countries in the evaluation of their raw materials, by selecting suitable technological processes and equipment appropriate to the needs of the developing country and by providing suitable facilities for testing, development and research. UNIDO is assisting a number of developing countries in a more advanced stage of industrialization in the establishment of advanced centres for metallurgical technology.

Types and conditions of technical co-operation

T. Tabata

The economic and technical co-operation for the transfer of know-how and the finalisation of technical co-operation agreements are discussed. It is stated that the developing countries should accelerate their own research. The transfer of techniques can take root and develop in the area of adoption if further research is carried out to adapt the metallurgical techniques to local needs. As long as technical co-operation strengthens the economic basis of the country and when the technique itself has an unlimited possibility for development, the international exchange of techniques must be expedited by overcoming difficulties on the basis of mutual understanding.

Challenges to the creation and transfer of know-how

H.I. Martin

Technological expansion based on the available natural resources should be the prime objective of the developing countries. When technology is transferred to a developing country, it is most important that there should be mutual confidence between the technical consultant and the client. The size of the project should be clearly worked out on the basis of techno-economic feasibility studies, the availability of raw materials and the needs of the country. Labour-intensive and capital-saving techniques are generally adopted in developing countries. Training facilities should be provided for the staff of the plant to be set up. The industrialized countries have a pool of technical knowledge which they are willing to transfer to the developing countries. Organizations such as UNIDO are the proper intermediaries for the transfer of appropriate technical knowledge and know-how from the industrialized countries to the developing countries.

The role of research and development work and pilot plants in the creation and transfer of metallurgical know-how in developing countries and regions

V.A. Altekar

Theories regarding the creation and transfer of metallurgical know-how through research and development and pilot-plant investigations are discussed. Examples are given from industrialized and developing countries. The experiences of the National Metallurgical Laboratory, Jamshedpur, India, and the parts played by the United Nations Development Programme (UNDP) and UNIDO are given in detail. The major prerequisites for the implementation and application of science and technology are the allocation of adequate finances and human resources and the recruitment and training of a sufficient number of scientists and technicians.

The following measures are recommended as means of furthering research and development in developing countries:

(a) To optimize the limited resources, a national science and technology policy should be evolved to ensure that research and development programmes shall lead to economic and social gains. Co-ordinated development of institutional resources for science and technology is essential since the activities of the universities, technological institutes and national laboratories are interrelated.

(b) Conditions favourable to the growth of the different types of research (basic, applied, developmental and adaptive) should be encouraged for a continuous exchange of ideas and techniques between neighbouring disciplines.

(c) Since the achievement of self-reliance and the sustained growth of technology are the fruit of technological competence, indigenous research and development programmes should be initiated.

(d) Indigenous scientists, engineers, technicians and management experts should be engaged in the adaptation and use of imported know-how from the beginning of each project.

(e) Research and promotion centres for the broad application of science and technology to the national development should be established.

(f) These centres should employ research scientists, engineers, technicians, economists and sociologists who could exert a joint effort. Their structural organization should include units for information and documentation, design, experimental laboratories, economic analysis, computer programming and training.

(g) The research results and the experience of the centres should help the Government in determining the technology policy which can form a vital link between the national science and industrial policies. It is essential that there should be feedback arrangements between the national science and planning organ and the research centres.

(h) While large plants may be encouraged to undertake innovative research, medium-sized plants should receive some protective incentives for developing local expertise and indigenous technology. The developmental expenditure for a new project or process could be borne by the Government.

(i) The Governments of developing countries which are still in the early stages of industrial development and which desire rapid economic growth through industrialization should permit a free flow of imported technology as far as possible. The expenditure for the imported know-how may be equal to, or much greater than, the allocation for local research and development. However, efforts should be made to build up indigenous research and development for the adaptation of imported technology.

(j) Developing countries with an adequate industrial basis should allocate more funds for indigenous research and development than for the steady import of technology.

(k) The research centres in developing countries should participate in the international, bilateral and institutional exchange between scientific institutions.

(l) Research and development boards should be established for major mineral and metal-based industries.

Managing the transfer of know-how

M.J.H. Giedroyc

The transfer of know-how is defined as the transfer of a total and complete package of knowledge, procedures and methods. Complementary to the technical know-how are the techniques for its successful application. They can be universal, systematized and easy to describe or they can be dependent on local conditions and traditions.

Although the word "transfer" implies a process in one direction from a giver to a receiver, a partnership between them is necessary for an effective transfer. Since the relationship is very important, the proper management of the transfer of technical know-how would require the services of a manager.

The main functions of the manager would be the control of the transfer itself for maximum effectiveness and efficiency. The flow and control of transfer will ensure the proper guidance through the system of feedback and continuous correction during the execution of a project.

VI. DESIGN AND ENGINEERING SERVICES AND FEASIBILITY REPORTS

Preparing feasibility studies for metallurgical projects

R.D. Lalkaka

The feasibility report should essentially outline the present production, exports, imports, current and future market patterns and international trade possibilities. The estimated and proved reserves of raw materials, schemes for mining, transport and beneficiation should be dealt with in detail. The choice of location for the plant must take into consideration such factors as the raw materials supply, transport costs, utilities and services, labour supply, topography and climate. The plant size and product mix must be determined on the basis of the market study, both for home and export possibilities and the latter's share in the total demand of the product.

In selecting the production processes and suitable equipment, various process alternatives must be evaluated within the framework of the given raw materials and the product mix. In the choice of the available technology or new processes, the auxiliary facilities and utility systems must be studied. The planning and layout of the integrated plant should include provisions for expansion, residential areas, ancillary industries, railway marshalling yards and a slag dump. Capital cost estimates should be based on firm prices quoted by equipment suppliers and on the preliminary designs for structural and utility systems. Provisions must be made for spare parts, freight, training, commissioning, administration and contingencies during construction. The managerial, supervisory, skilled and unskilled labour requirements for the plant must be determined. The production costs per ton must be estimated on the basis of the input. The final step in a feasibility study should be the analysis of the financial viability. The details of the required integrated action should appear in the feasibility study. In metallurgical projects, special consideration should be given to the total capital costs of the plant and the economies of scale involved, the supply of raw materials and the labour requirements of highly skilled workers, technicians and managers.

A strong organization is needed for project planning, evaluation, engineering, the preparation of specifications and construction. Independence and objectivity are important requisites for project planning. Specialized institutes for feasibility studies and engineering know-how should be created in the developing countries. They should be manned by dedicated, dynamic and confident technocrats. Assistance may be received in the early stages from foreign design organizations. The transfer of technology from the donor to the recipient institute may be accomplished by careful planning at different stages.

The time required for completing a feasibility study may extend from 4 to 12 months. The costs of such a study would be less than 0.25 per cent of the total costs of a large metallurgical project. A project manager should co-ordinate the work of different engineering experts. He must use the PERT system to plan the flow sheets and the work programme and to determine the local organizations that will be connected with the project. The work can be divided into the following stages: (a) Initial preparations, which may last about 4 weeks, (b) field work, which may last 6 to 8 weeks, and (c) drafting, which may require about 22 weeks. Although the local organizations must be consulted in the preparation of the draft report, the final responsibility for the objectivity of the technical recommendations must rest with the project manager, who must also clearly lay down the flow sheet, work programme and agencies to be involved in the project, following the PERT system of implementation.

Design and engineering services in metallurgical projects

M.N. Dastur

The requirements of the design and engineering services in the transfer of know-how are discussed. While foreign assistance is both necessary and helpful in the establishment of new plants, many developing countries feel that they cannot continue to depend primarily and permanently on imported know-how for the development of their metallurgical industries. The creation of indigenous design and engineering capacity in developing countries, therefore, assumes great importance. In countries where these facilities exist, local expertise and technical skills should always be used.

Independent professional consulting firms can assist in the choice of the most appropriate technology, process machinery and equipment. Such firms can also help in speedy and practical application of the indigenous research results. Some developing countries, for example India, have established consulting firms and are able to share their experiences with other developing countries.

Complete design and engineering services are necessary for the preparation of a detailed project report that gives the over-all design of the project. It includes details about raw materials, product mix, production processes, capital and manufacturing costs. Moreover, detailed specifications are prepared, tenders are invited and awarded for equipment and services. Further tasks are the inspection of equipment, the supervision of the civil engineering work, the erection and assembly of the plant, equipment and ancillary services, the start up and trial commissioning of the plant, assistance in trouble shooting and effective training of the personnel. The general planning of the plant must aim at uninterrupted production by providing for continuous receipt and stocking of bulk materials, the rapid movement of materials in process and the smooth flow of finished products and by-products. The plant layout should include adequate provisions for future expansion.

The consultants assess the data given in the feasibility study on raw materials and other requirements of the project. After reviewing the available technology, they select the most suitable technology for local conditions and requirements. In view of the large investments involved, well established commercially proved processes are selected. Once the technology is selected, the optimum size of the production unit to derive maximum economies must be determined. Detailed layout, engineering and working drawings for each unit of the plant are prepared.

Where a technology has to be transferred from a foreign country, the services of consultants are necessary in negotiating foreign aid and requisite agreements to avoid mistakes and pitfalls in the selection of technology or design and engineering which might impair the economic viability of a project. Aid-giving countries generally insist that feasibility studies and project reports should be carried out by agencies in their own countries even when the requisite expertise is available in the recipient country. In such cases, the technology of the aid-giving country may be transferred *in toto*, and even the control of the project during construction and early operation is assumed by the foreign collaborators. Inappropriate choices of the plant and service layout, technology and design deficiencies in the absence of proper scrutiny may cost the recipient country much more than a comparable plant set up in an industrialized country. It is, therefore, essential that independent consulting metallurgical engineers should conduct negotiations for foreign aid and collaboration arrangements to ensure the transfer of appropriate technology. The services of the consulting engineers also are necessary for the preparation of detailed technical specifications and tender documents, the evaluation of tenders, supervision and project construction, equipment manufacture and procurement. Moreover, they can help in the supervision of the start up and trial commissioning of the integrated plant and in the training of plant management staff at plants of the equipment manufacturer locally or abroad.

The wide range of consultancy services required for the installation of modern metallurgical plants demands the combined talents of experienced engineers, designers and economists. The size and type of consultancy organization depend upon the range of consultancy services provided and the projected volume of work to sustain it. It must be borne in mind, however, that a consultancy organization cannot be set up like a factory merely with foreign aid; it must be built up from a nucleus and must have adequate scope and opportunities for development under competent leadership. The following conditions are imperative for the attainment of this objective:

(a) There should be an awareness of the need for independent consultancy services on industrial projects;

(b) Both the Government and industry should have confidence in the ability of local personnel, engineers and consultants;

(c) Opportunities should be given to local engineers to assume responsibilities on industrial projects;

(d) Local personnel should fully participate in projects built with imported know-how;

(e) A developing country should assess the know-how and skills already available in the country and identify the needs for imported know-how.

The independent status of the consulting organization is important for the speedy indigenous development of technology, since there would be no financial or business commitments with manufacturers and suppliers of equipment. The independent status should be scrupulously maintained. The creation and development of design and engineering organizations in developing countries will reduce their dependence on outside sources of technical know-how. The local and foreign consultancy organizations can supplement each other's efforts, especially in developing countries which do not have well developed consultancy organizations. It would, however, be in the interests of the developing countries to use the local consultancy services to the maximum extent possible and to encourage their development as a matter of national policy. Foreign know-how and consultancy services would then be imported only when absolutely necessary.

CONTENTS

VII. EXTRACTIVE METALLURGY

The transfer of extractive metallurgical technology to developing countries

R.M. Nadkarni, C.L. Kusik and C. Bliss

The development of the extractive metallurgical industry in developing countries would be helpful in stimulating economic growth by providing jobs and reducing labour costs on exportable materials. However, a blind copying of western technology may be inappropriate in developing countries with conditions of scarce capital and foreign exchange resources, an abundance of labour and small-sized internal markets. It is necessary to transfer only appropriate technology which optimizes the available resources of capital, labour and raw materials in a particular economic climate.

Inappropriate technology is sometimes transferred solely because it is tied to the financing sources. Moreover, the system of international bidding on contracts tends to introduce capital-intensive technology which may be inappropriate in a developing country.

The careful selection of the technology to be transferred to a developing country is stressed. In some cases, it may be desirable to transfer intermediate technology, i.e., technology at a lower stage of development than modern, capital-intensive technology. Developing countries could also provide incentives for the pursuit of a more appropriate technology by providing price and taxation structures favouring labour-intensive projects.

With the exception of aluminium, the major industrial metals are extracted by pyrometallurgical techniques that require a significant expenditure of energy. Economies in energy consumption are, therefore, important and require relatively large-scale operations. An area in which economy could be affected is the upgrading (or concentration) of low-grade ore prior to pyrometallurgical or electrometallurgical processing.

It may be possible for the extractive metallurgical industry in developing countries to use skilled labour that is less costly than sophisticated control equipment. The costs of raw materials, the energy required for metal production and transportation from the mine to the factory and then to the market mainly determine the profitability of any extractive metallurgical process. Recycling of secondary metals also affects the economies of metal production. Secondary metal (scrap) may not be available in a developing country in comparison to its abundance in an industrialized country.

Available technology is classified in three groups:

(a) Technology in which labour can be substituted for capital, e.g. ore concentration, hearth smelting of lead ores and fire or electrorefining of copper;

(b) Recently developed, advanced technology, which makes it economical to produce a primary metal on a small scale in keeping with the local demand, such as the production of steel in mini steel plants, pig iron in low shaft furnaces, the direct smelting of sulphides of copper or lead in a converter (ADL process) and the production of copper, lead or nickel by hydrometallurgy.

(c) Advanced large-scale, capital-intensive technology, which may be appropriate for some developing countries in special circumstances, perhaps through regional or multinational arrangements or through the use of local, low-cost energy resources. The latter concept is adopted in refining blister copper produced in smelters near mines "in transit" thus reducing transportation costs.

Case studies of technology transfer are discussed on the basis of the authors' experiences. They include a lead smelter in Nigeria, the factors favouring establishment of mini steel plants and the establishment of regional manufacturing plants such as the West African Iron and Steel Plant at Monrovia, Liberia.

VIII. THE IRON AND STEEL INDUSTRY

The transfer of technical know-how in the steel industry in Brazil

Bruno Leuschner

The growth of the Brazilian steel industry between 1960-1969 changed the status of the country from a net importer to a net exporter of steel, even though there was still an annual import of as much as 404,000 tons of finished steel* products that were not produced in Brazil. During this period, there was a large increase in the capacity of the steel industry. Some changes were introduced into the prevailing technology, e.g. using coke as a reducing agent and fuel instead of charcoal, the adoption of the LD process with oxygen converter, the sizing of iron ore, and the use of sinter. Higher productivity and lower coke rates have been obtained by using the latest technical innovations such as fuel injection through the blast furnace tuyères, oxygen enrichment of the air blast and higher blast temperatures.

Most steel plants use the LD concerter process; the open-hearth furnaces have for the most part been converted to basic lining. Continuous casting and vacuum casting techniques have been adopted only for special products. Quality control is being introduced at all levels. Research and development work for improving the quality of the end-products and for diversifying production is carried out by special groups formed within a plant or by groups of plants. Some plants prefer to enlist the services of the Institute de Pesquisas Technologicas at São Paulo.

The planning and construction of a new steel plant are time-consuming and require large capital investments. The planning for a particular steel plant must be a part of the over-all development planning for the steel industry. In order to achieve a high degree of technological efficiency, it is advisable to receive both technical and financial assistance from abroad.

In Brazil, reliable foreign technical consulting firms are usually employed for the planning, the feasibility study, and the construction and start-up of a new steel plant, although a local technical group is associated with the foreign consultants from the very beginning and thus gain technical knowledge and practical experience in plant operation. The demands for raw materials, location, process and techno-economic feasibility must be projected for the next decade. Moreover, the planning must include sufficient provisions for the training of personnel.

In Latin America, the plants are generally built in gradual steps. The plans for successive expansions are made at the beginning of the construction. However, these plans are evaluated at the time of each expansion for the possible incorporation of new technological developments. Since these developments could require additional capital investments, their evaluation is generally delegated to a technical consultancy firm. When new products are sought, it is best to seek collaboration or technical assistance from overseas manufacturers.

Two typical new plants set up with foreign assistance are discussed. The planning for them was quite similar except for the selection of the site. Although Brasilian participation in the selection of plant equipment had been quite marked, the responsibility for commissioning the plant rested with the manufacturer's technicians, who must control the achievement of the achieving rated performance specifications that are guaranteed. An important role had been played by a local consultancy firm formed by the existing steel plants. A firm could now plan and build new conventional steel plants in Brazil except for the techno-economic evaluation of the site and the selection of equipment and machinery.

While the Brazilian steel industry can develop flow sheets for coking, agglomeration and reduction processes, the industry is dependent on the manufacturers of equipment for the supply of plants, their erection, performance testing and running in. Consultants are necessary for designing, selection and running in of the equipment in the steel shop and the steel rolling-mills.

The management and technical staff are both inclined to introduced any technical innovation which has proved valuable in other countries as soon as possible. Research for further improvement is being conducted in fields in which the technology is fairly advanced in Brasil, e.g. coking and agglomeration, and reduction. The dependency on foreign know-how is limited to the method of using oxygen in LD steel converters, the design of electric steel furnaces of sizes larger than those operating in the country, continuous and vacuum casting and automation in the rolling mills. Local staff that have been trained abroad are generally responsible for quality control, a foreign technical consultancy organization is engaged for improving the administrative organization and productivity.

Each plant should be able to provide technological solutions for the daily routine problems. Major problems should be referred to a research institute.

The best results can be obtained generally by sending technical staff abroad for training rather than hiring an expert for a limited period who leaves a recipe. However, it is sometimes considered less costly to import technology from experienced overseas producers than to begin the very costly training of staff.

There are no legal restrictions to the purchase of foreign technology by the steel industry in Brazil. The technological knowledge existing in the country is disseminated in many plants. For several reasons, the existing technological institutes have contributed little during the last few years to the progress of the industry. A considerable strengthening of their human resources would be necessary in order to change this situation.

The technical staff of the Brazilian steel industry is generally quite conversant with the technological advances in the world steel industry. The staff of plants that have been built with foreign investments are particularly alert; innovations are adopted as soon as feasible. However, in some cases, there are managers and technicians, who are afraid to make mistakes and, therefore, are reticent in applying new innovations. In such cases, the management should engage an overseas expert.

Acquisition of steel technology know-how in Brazil

Mascos de A. Contrucci

In Brazilian industries there is a strong tendency to acquire foreign know-how in the fabrication of products or other applications of new processes instead of relying on local development. The methods for acquiring the foreign technology are the purchase of patents and drawings, the payment of "royalties", and technical assistance for the manufacture of products or use of processes. However, some important industries have recently started research and development centres for solving local problems. It has been recognized that for the country's development, dependence on foreign imported know-how is no longer desirable. However, programmes for changing the nature of know-how from a pattern of imported know-how to one in which local developments are dominant require a long time for becoming fully effective.

In the steel and related metallurgical industries, the following categories of know-how are needed:

(a) The fabrication of metallurgical products and the plant operation;

(b) The conception, planning and design of metallurgical plants adapted to local circumstances;

(c) The manufacture of metallurgical plants and equipment.

In Brazil, foreign developed technical know-how has been acquired for special steels, deep drawing and corrosion-resistant carbon steels, different rolls for the rolling mills, malleable and nodular cast iron, seamless and centrifugally cast iron pipes, and for the oxygen, electric steel and blast furnace processes. Several procedures have been adopted for the acquisition and local creation of the technical know-how. Two typical cases are discussed. In one example, the emphasis has been on the development of indigenous know-how, by employing some foreign technical experts to guide the local team if necessary, or by purchasing locally developed technical know-how In the other example, parallel activities included the import of know-how that required the presence of foreign specialists in the plant, the training of local personnel abroad and an intensive development programme for indigenous know-how. The manner of know-how acquisition depends primarily on the management's belief in the actual benefits which can be derived from it.

Local expertise is available in Brazil for the preparation of feasibility, market and related studies and for the basic designs. Detailed engineering services are available, however, only in certain selected fields. For other fields, while technological capability is currently being developed within Brazil, technical know-how and specialized expertise are also acquired through local subsidiaries of foreign firms.

The design and development of equipment for steel and other metallurgical industries generally require large capital investments, which must be shared by a large number of local plants. Research and development must be the last step in any integrated effort to effectively develop local know-how in a developing country. In Brazil, facilities for heavy equipment manufacture based on imported know-how already exist, but local development of technical know-how and specialized expertise is also taking place.

It is concluded that in Brazil there is scope for both the acquisition of foreign know-how and the development of local expertise. Even where manufacturing capabilities exist within the country, it is desirable for a company or individual experts from more developed countries to help in the planning and design work.

Converter steelmaking in the Union of Soviet Socialist Republics

V.S. Butes and I.N. Kolybalov

The development of the oxygen converter process in the Union of Soviet Socialist Republics is described. The process was used for 17.2 per cent of the total steel production in 1970. By 1975, it is expected to be used in 30 per cent of the total production. The paper describes in detail the various stages through which the process has passed during the last three or four decades and the refinements made in the process to manufacture different types of steel from varied raw materials. The effects of variations in silicon, manganese, sulphur content, melt temperatures and slag compositions have been brought under control within acceptable limits. The important factors influencing the process of slag formation during converter blow and optimum regulation of these aspects should be ensured for an efficient slagging operation. Specially prepared limestone ore briquettes have been used in the Union of Soviet Socialist Republics to achieve good results and a marked increase in the basicity of the initial and final slags in comparison to the usual compositions.

Research and plant experience revealed that the position of the lances that usually have three and four holes with the hole angle varying between 8^{o} and 20^{o}C during the blow should be variable rather than fixed to effect considerable dephosphorization and thereby reduce the period of the blow and increase the slag basicity. The output can be increased by raising the pressure to 5 m^3 per ton per minute and by reducing the blow period from 24 to between 12-15 minutes up to 200 ton steelmaking converter capacity.

The increase of pressure does not materially become effective if the time spent on auxiliary operations remains the same (22 minutes or more). Higher pressures of up to 10 m^3 per ton per minute with converter capacity of 300 to 400 tons require careful design and involve economic considerations because a completely new type of converter shop is required.

The converter process can be intensified by standardizing the basic materials and by using high-speed computers. Reducing the blowing period will increase the converter shop productivity and lengthen the lifetime of the converter lining. Thus, it is possible to increase the quantity of steel scrap in the charge, increase the output of usable steel, and improve the basic indicators of the converter process as a whole.

The oxygen converter process is now being developed for the production of alloy steel. Though the output was limited to standard types of steel at the initial stages, it now covers almost all types of steel produced by the open-hearth steelmaking process. The lifetime of the converter lining was one of the main problems during the early years. It was raised to 200 melts in the 1966-1968 period; it has been further increased to 500-700 melts by using tar-dolomite refractory materials of better quality and by improving the steelmaking operation itself.

Three methods for removing gases are practiced in the Soviet steel industry. The most economical method is the removal of gases without combustion in the high-capacity converter. It is used in an increasing number of shops.

The oxygen converter process and steel smelting as a whole depend to a considerable extent on the casting system used. The world's first large-scale oxygen converter shop complex with continuous casting of steel was commissioned in the USSR. Oxygen conversion will now be the main process in all new steel converter shops in the USSR.

Automation has played a substantial role in improving the quality of the steel output and the productivity of the steelmaking converter. Computer control of static smelting has been operative in converter shops in the USSR to automate the charge mix, oxygen supply and heat balance. A dynamic control system is the object of much research and development work.

In the initial stage of developing large converters with 300-400 ton capacity, smaller shops with 100-130 ton capacity were built and operated.

There was a shorter run-in period. Increasing the capacity of the converters did not create any technological difficulties in the steelmaking process. A considerable part of the unused capacity of the smaller converter could be utilized by increasing the oxygen blowing pressure, reducing the length of the cycle (particularly the charging period), increasing the output of usable steel and the lifetime of the refractory lining and by carrying out further automation.

Main trends in the development of continuous steel casting in the Union of Soviet Socialist Republics

V.S. Rutes and I.N. Kolybalov

The rapid development of continuous steel casting in the metallurgical industry of the Union of Soviet Socialist Republics is related to the economic efficiency of the process and the increasing quality requirements of the consumers. It is imperative that the weight of cast ingots should be increased to meet the demands for rolled steel products. But ingot size cannot be unduly increased since an increase in ingot cross-section results in the deterioration of steel quality and the lack of uniformity in the structural and chemical composition of the steel. These drawbacks can be eliminated to a large extent by the continuous casting of steel, for which a process has been successfully developed and improved in the USSR. This process can help to increase the production and raise the quality of the output. Large industrial units are planned in the USSR based on continuous casting of steel.

Universal designs have been created in the USSR for continuous casting of steel slabs of any dimension from 300 to 2,000 mm wide and from 70 to 315 mm thick. The thermal stresses in the copper walls of the mould (which exceeds the yield strength) cause deformation of the walls by warping, shear and drag with resulting cracks on the ingot surface. Theoretical calculations and practical development work have permitted a redesigning of the moulds. The new moulds give a uniform distribution around the perimeter of the ingot, thereby permitting higher rates of steel casting. Various secondary cooling systems have also been developed.

For the casting of different sizes of ingots, a tundish with chargeable heads corresponding to the cross-section of the ingot being cast is used.

These units are generally suitably automated and are characterized by the regularity of operation, the ease of maintenance and the high rates of productivity.

Normal combined operations of the converters and continuous casting machines have been made possible by using highly refractory materials for intermediate ladles, improving the design of the casting units and raising the speed of casting, devising new methods of feeding molten metal into moulds and by protecting molten metal from secondary oxidation, thereby ensuring a standard quality of steel in successive melts. The productivity has been raised as much as 20 per cent after the introduction of these innovations.

The introduction of the "melt on melt" continuou casting method in large steel works made it possible to obtain a sharp increase in the yields and productivity and a reduction in the steel rejections and wastage. The continuously cast steel is subsequently rolled in rolling mills. Continuous casting units produce round, square, rectangular and irregular shaped ingots. Hollow ingots have been obtained by a combination of continuous casting and rolling, where throughput of liquid metal is reduced by as much as 275 kg/ton of finished product compared to the traditional methods.

Improvements and innovations are still being made on the melt on melt method of continuous casting. It is expected that it will come into wider use and, there may be the possibility to organise continuous casting on an around-the-clock basis. This will also involve avoidance of the oxidation of the molten metal, placing metal in vacuum in the ladle and the use of synthetic slags, magnetic fields and ultrasonics for the continuous casting process.

Planning of LD steelworks
VOEST of Austria

The main factors which must be considered in installing any new LD converters are discussed. Since $20-$40 million are invested in new LD steelwork according to its size, proper planning becomes essential for the capital investment to be economically sound. Since the customer usually asks for the erection of a steel plant with a specific guaranteed annual output, it is possible to calculate the theoretical vessel size and take

into consideration the climatic conditions and the experiences of the operational and the maintenance staff. It is well known that productivity increases with vessel size. But if only one vessel is installed there may be a considerable loss of production due to idle time required for the maintenance work.

In designing the LD steel plant, it is necessary to consider the area available for the LD units and all the installations grouped around the vessel, such as the steel delivery cars, slag cars and lance installations, as well as their capacities, and the final size and number of vessels to be installed. The flow of materials in the plant must also be known. In the LD steel works, construction may be carried out in three parts: (a) the charging bay that houses the hot metal and scrap departments, (b) the converter bay that houses the LD vessel and all addition sections (the electric substation and water supply station should be installed to the right and left of the LD converter), and (c) the casting bay that houses the ladles section and degassing units. This bay is designed according to either conventional practice, continuous casting or a combination of the two. Proper design must take into full consideration of the locations of the charging scrap bays, the LD vessel installation, the effective exhaustion of gases, the provision of gas cooling and cleaning facilities, temperature censors, automatic weighing and feed devices, and the use of proper sized hoppers, arrangements to prevent the escape of dust, for additions in the ladles and proper oxygen lancing. If the lack of space does not permit the installation of more LD vessels, it may be possible to design replaceable vessels. Slag should generally be removed from an LD steel works on the same side from which scrap is being charged, since a thin coating of slag formed on the converter lining during tapping gives a good protection to the refractory lining thus ensuring better lining life. Since casting is often the main bottleneck in the production, generous provision should be made for casting pits, moulds and other subsidiary installations.

A central control room that monitors all operations other than the tilting device and the steel and slag transfer cars is now provided in the LD steelworks as a standard practice. As far as possible, a computer is provided near the central control room at a place free from vibrations and air pollution. This helps in automatic control of the operations including the feed of raw materials.

VOEST has worked on LD plants up to 500 ton converter capacity and has supplied over 80 LD vessel installations to 21 countries throughout the world. The firm is willing to assist any party or country with the transfer of technical know-how developed by them.

IX. THE NON-FERROUS METALS INDUSTRY

Technical consultancy services and development of metallurgical know-how for the design and operation of non-ferrous metallurgical plants in developing countries and regions

W.H. Schwartz and M. Peucker

Until recently, the trends in developing countries have been to export raw non-ferrous ores to industrially advanced countries for processing and extraction of the metals. Now there are growing trends in these developing countries to set up their own smelters, thus saving foreign exchange for the import of non-ferrous metals.

As the industrially advanced countries have greater markets for non-ferrous metals because of their higher *per capita* consumption, it is proposed that developing countries should preferably set up smelters in the industrially advanced countries in close co-operation with the consumers, since the technical know-how must be imported from these countries in any case. Important factors in the setting up of a smelter are a low production cost, good metal recovery, the application of suitable processes and the quality of the end-products. If sound know-how is applied at the right time, many problems arising during the planning, construction and operation of the smelter can be solved. For sound technical and operational know-how, the techno-economic evaluation of the extraction process most appropriate for the local raw materials and conditions is vital.

Detailed laboratory scale studies and subsequent pilot-plant investigations are essential to develop the process parameters, define the number and dimensions of equipment and reduce the costly test work and production losses. Though pilot plants require considerable capital investment and also entail the loss of time, the alternative is to erect a plant that could run into tremendous serious difficulties at later stages because of the absence of pilot-plant trials. This contention is fully supported by two examples where the setting up of a pilot plant prior to the industrial plant proved highly beneficial in the long run.

Feasibility studies and pilot plant trials are followed by:

(a) Agreements on the scope of work, conceptual engineering limitations and the handling of the project;

(b) Basic engineering and cost estimates including formulating the flow sheets, materials and heat balances, the main equipment and general arrangements;

(c) Detailed engineering including final design and arrangement of equipment at the site;

(d) Procurement including tenders, orders, expediting and control;

(e) Site management including civil engineering, erection, installation, assembly and test runs;

(f) Commissioning including staging trials, operation and guarantee operational runs;

(g) Management including plant organization, sales and marketing.

In every step of the preparation, a certain amount of know-how is applied and transferred. Technical know-how is divided into: (a) process know-how, (b) project know-how, and (c) operating know-how.

Process know-how is concerned with all metallurgical, economic and technical aspects of the processes, such as the best methods for the treatment of ore, exploring the best sites for ore dressing, smelting and refining, developing new and cheap methods for processing unconventional raw materials, considering the economical, political and sociological conditions including market studies, confirming the feasibility of the selected process, selecting equipment and supplying process descriptions.

Project know-how includes the ability to manage a large project. The scope of work includes the organization of planning, the preparation of tenders and placing orders, formulating responsibilities for the different activities, discussing conditions of finance and guarantee, and the co-ordination and control of all stages of a project, time scheduling and quality control.

Operating know-how covers the supply of skills needed to operate the tools and machines, to maintain and effectively repair them, to operate, improve and co-ordinate the successive process stages, to apply labour for continuous quality production, trouble shooting, creation and maintenance of a good psychological climate in the plant, and research and development work and improved methods of purchase and sale.

Instead of spending time and money on developing know-how which might already exist, it is better to transfer it from the source country to the recipient country irrespective of one being more advanced than the other, because the know-how has been developed as a result of long experience, tradition and learning extending through generations.

For a purposeful transfer of know-how from the donor to the recipient country, mutual co-operation based on full confidence and appreciation is essential. The staff to man the new plant should be trained in the country, if facilities exist; otherwise it can be done in the donor country. This training must be planned well in advance. It is better to import personnel from abroad to run a plant and to train the staff rather than sending local personnel for training abroad, since the latter method involves the risk of losing the trainees, who may remain abroad for better remuneration. If the local staff must be trained abroad at all, it should be at the level of technicians and craftsmen and not graduate engineers.

When a country decides to seek overseas assistance with a project, it must decide upon the source of know-how. Experienced engineering and construction companies can supply the know-how for every step of the project, carry it through and commission the plan to full operations. Since the client must operate the plants, the operating organisation of the client should be in touch with the donors from the beginning to the commissioning of the plant.

Technical consultancy services and creation of technical know-how for the aluminium industry in the developing countries: Past experience and future recommendations for practical implementation on a self-sustained basis

G. Dobos

The aluminium industry in Hungary was developed on the basis of self-sustained research and development. Over the past four decades, the position of the country has changed from a pure recipient of know-how to a net exporter that assisted in the establishment of industrial plants in other countries.

Even though bauxite mining started in 1915, and the first alumina factory and aluminium smelter went on steam in 1934 and 1935 respectively, before the Second World War, most of the better grade bauxite was exported. However, after the Second World War indigenous know-how was developed while the aluminium industry was being expanded and consolidated. Regional co-operation in which the alumina produced in Hungary was smelted in

Czechoslovakia, Poland and the Union of Soviet Socialist Republics counteracted the effects of the costly Hungarian electric power. A comprehensive linkage of technology with the industry permits improvements in mine and plant designs and operations. The design and engineering activities of the Non-Ferrous Metals Research Institute, ALUTERV, have contributed to this development. Moreover, a centre for the applications of aluminium and its alloys has been investigated by ALTAK (now MATAK).

The generation of know-how requires the accummulation of a critical mass of certain ingredients in appropriate concentration. These are (a) a body of specialized metallurgical, technological and engineering knowledge, (b) suitably educated, trained and skilled men in sufficient numbers and (c) an industrial base of engineering and construction organizations so that the bulk of plant, equipment and facilities can be made locally. The industry to be set up should be a part of the over-all development plans of the country. Once this industry has started earning profits, research and development institutions should be established to tackle the problems of the industry.

Quite a few developing countries could generate technical know-how for a particular industry given the time. But the developing countries cannot spare the time, since they must develop key industries from scratch without any loss of time. The only alternative available is to acquire know-how from a developed country. It is imperative that a judicious selection is made of a suitable technology from the various technologies available. Local manpower should be involved in designing the plant, training local staff for running the plant, assistance in the formulation of tenders and the supervision of construction. The conditions of transfer of such know-how vary from one country to another.

In most developing countries there is a mild to acute shortage of suitably trained manpower to staff newly started industrial projects. It would take quite an effort to train such personnel. The skilled personnel will also have to be imported with the transfer of technology, which makes the industry unduly expensive. It is, therefore, imperative that industry should train local personnel, using the foreign experts as guides. It may not be possible to provide graduate level education in this way.

Though it may be advantageous to import the plants on a "turn-key" basis for a particular industry, it is possible only if sufficient funds or credit are available, and if little of the equipment can be produced locally. In these cases, heavy reliance has to be placed on imported spare parts, the volume of know-how imported is large and its servicing is arranged for a long period. It also entails the disadvantage of training fewer local personnel for higher skilled jobs. On the contrary, if some industrial base already exists in the country, it may be possible to obtain locally produced crushers, ball mills, pressure digesters, thickeners, vacuum drum filters, disc filters, calcination plant, evaporators, drives, reductors, centrifugal pumps, electric motors, mild steel sheet, piping and steel sections, for the alumina plant, and electric and bus bar system, heavy steel structures for the aluminium smelters. These will, however, depend on the industrial capability that is readily available in a country.

The development of engineering capability required for the above industrial requirements would be helpful if the industrial capability is multiplied at a quick rate. It would be desirable to avoid repetitive import of similar technology. Differences in raw materials, climate, comparative costs of labour, power and transportation may require changes in the technology to be applied in an existing plant and a new one. The local engineering organizations can contribute greatly to the required changes in design.

In the long run it is more useful to rely on locally made equipment, even if its manufacture involves more critical supervision and training of the engineering personnel. The technical assistance given to an engineering organisation should enable it to gradually reduce its dependence on further external assistance.

When a new plant is being set up with external know-how, it is important to identify problems of plant operation and maintenance. These problems will form the nucleus around which a research and development organisation can be built up. A plant laboratory properly equipped for research work over and above its usual control functions and an engineering team can fill this requirement; these two units should fully co-operate with each other and should be complemented by a documentation centre with technical publications, journals, patent specifications and equipment manuals

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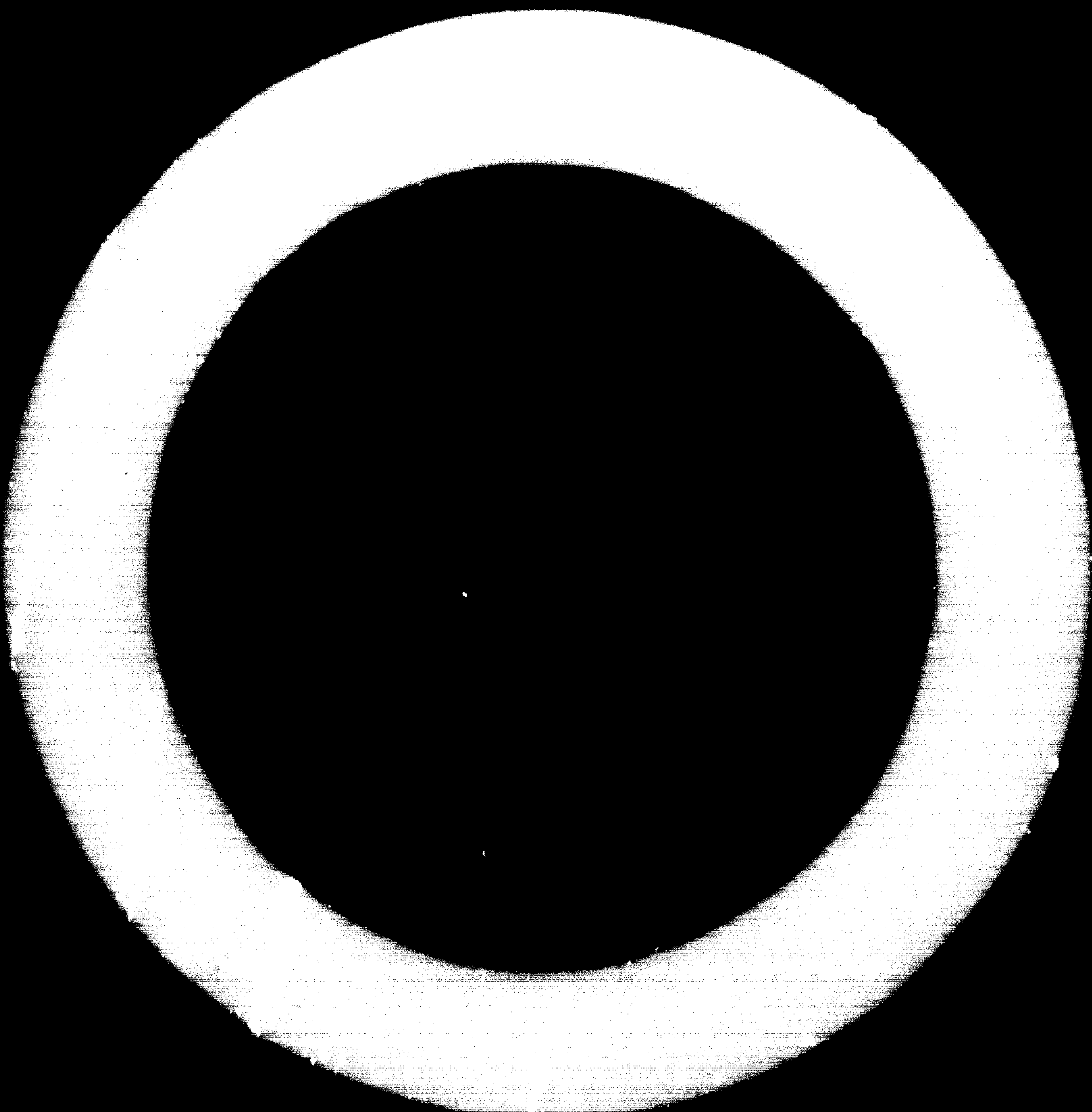
INTRODUCTION

The Workshop on the Creation and Transfer of Metallurgical Know-How was held at Jamshedpur, India, from 7 to 11 December 1971. It was organized by the United Nations Industrial Development Organization (UNIDO) to focus attention on a subject which little attention had been given in direct or bilateral programmes of industrial collaboration and technical assistance.

The purpose of the Workshop was to assess the problems and needs of developing countries with regard to metallurgical know-how, to analyse mechanisms and practical ways for furthering the establishment of capacities needed in the developing countries and to make action-oriented recommendations for consideration by Governments, by industry and by UNIDO. The Workshop was also requested to arrange direct contacts for the transfer of metallurgical know-how for plant and equipment design or operation.



Part one

REPORT OF THE WORKSHOP

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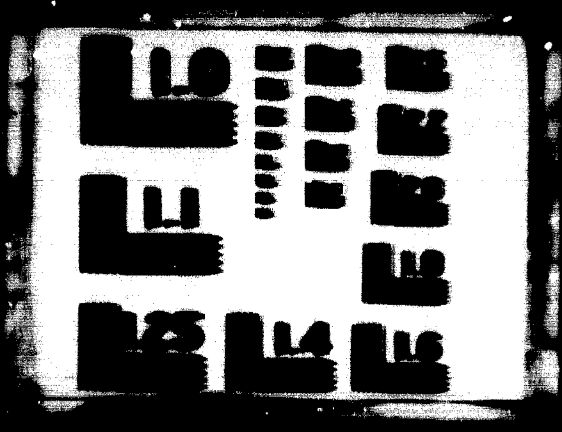

for the dissemination of required technical data and information among the personnel. Market research and studies for the creation of demand for the products of the industry and education of the public in their use are also important requirements for the growth of any new industry on a self-sustained basis.

Such an organization should maintain close contact with sources of know-how transfer and should be able to decide their future tasks, if any. It should also co-operate with important local and foreign centres of research and development, universities and private laboratories in the solution of the industry's problems. The staff may, if necessary, include foreign technical experts assigned by such international organizations as UNIDO. Research and development plans that are jointly drawn up by the laboratory, engineering units and plant management should establish priorities for the investigations of problems. Adequate provisions are desirable for study trips, plant visits and participation in national and international conferences by research and development personnel. In this way, indigenous know-how can be generated on a continuous and self-sustaining basis.

When a certain industry, its research and development programme and engineering capabilities have reached a certain level of development, it becomes necessary to consolidate their work. This can be best achieved by merging the smaller local research and development units into a central laboratory and engineering centre, which might act as a clearing-house for technological know-how developed at the centre. Furthermore, the establishment of a national centre would reduce the research and development costs. Healthy competition among workers and different plants manufacturing similar products can exist, while an effective exchange of ideas does not infringe the proprietary rights.

The further expansion of technological capabilities in research and development activities is a natural consequence of the growth of an industry. It should keep pace with all developments in related fields. It may be possible for such a unit to begin exporting know-how after a certain stage of indigenous development and competence.

Annex I

LIST OF PAPERS PREPARED FOR THE WORKSHOP[a]

ID/WG.110/2 The transfer of extractive metallurgical technology to developing countries
R.M. Nadkarni, C.L. Kusik and C. Bliss

ID/WG.110/3 Technical consultancy services and development of metallurgical know-how for the design and operation of non-ferrous metallurgical plants in developing countries
W.H. Schwartz and H. Peucker

ID/WG.110/4 Managing the transfer of know-how
J.H. Giedroyc

ID/WG.110/5 Challenges to the creation and transfer of know-how
R.L. Martin

ID/WG.110/6 Technical consultancy services and creation of technical know-how for the aluminium industry in developing countries; Past experience and recommendations for future practical implementation on a self-sustained basis
G. Bobos

ID/WG.110/7 Design and engineering services on metallurgical projects
R.R. Bartur

ID/WG.110/8 Preparing feasibility studies for metallurgical projects
R.B. Lalkaka

ID/WG.110/9 Planning of LD Steelworks
VOEST Austria

ID/WG.110/10 The role of research and development work and pilot plants in the creation and transfer of metallurgical know-how in developing countries and regions
V.A. Altekar

ID/WG.110/11 Types and condition of technical co-operation
Y. Takata

ID/WG.110/12 The development and acquisition of steel technology know-how in Brazil
Marcos de A. Cantrucci

ID/WG.110/13 Main trends in the development of continuous steel casting in the Union of Soviet Socialist Republics
V.S. Rutes and I.N. Kolybalov

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a/ A limited number of copies are available from UNIDO upon request.

ID/WG.110/14	Converter steelmaking in the Union of Soviet Socialist Republics V.S. Rutes and I.N. Kolybalov
ID/WG.110/16	Creation and transfer of metallurgical know-how Secretariat of the UNIDO
E/CN.12/922 (Summary)	The transfer of technical know-how in the steel industry in Brazil Bruno Leuschner

Annex II

DESCRIPTION OF LABORATORY AND PLANT VISITS

National Metallurgical Laboratory, Jamshedpur, India

The National Metallurgical Laboratory (NML) is a link in the chain of more than 30 national research laboratories and institutes in India, that was set up by the Council of Scientific and Industrial Research since 1947. It was formally inaugurated in November 1950.

The National Metallurgical Laboratory has modern equipment for research work on applied projects and on fundamental aspects of metallurgy. The NML serves as a central station for carrying out research and development work and pilot-plant scale trials on indigenous ores, minerals, refractories, ferrous and non-ferrous metals and alloys. The NML acts as technical consultants in metallurgical research and development fields to Indian metallurgical industrial complexes in the public and private sectors. Several research divisions have been set up at the NML including design engineering. In integrated pilot plants for prototype production trials the technical feasibility and techno-economic aspects of the NML developed processes and technology are assessed, and the applications of known metallurgical technology to Indian raw materials and operational conditions are investigated. Many of the pilot plants have been wholly designed and fabricated at the National Metallurgical Laboratory itself while others have a high proportion of indigenously designed and fabricated equipment.

The following activities are carried out in NML pilot plants that often operate in three shifts.

(a) Low shaft blast furnace (with a daily rated capacity of about 15 ton of pig iron) for pig iron smelting with substandard raw materials such as semi-coking Indian coal. The integrated plant is well equipped with briquetting facilities and constituent units for oxygen enrichment of the air blast and injection of oil and naphtha through the tuyeres of the low shaft blast furnace.

(b) Integrated mineral beneficiation and agglomeration of iron and non-ferrous ores. The pilot plant has practically all the known mineral beneficiation equipment and facilities including a 20-25 ton per hour heavy media separation pilot plant, continuous sintering pilot plant, rotary kiln for pre-reduction of iron ores and pellets and for magnetic reduction roast treatments and gas producer plant for synthetic gas for reduction trials.

(c) Submerged arc smelting furnace for electric smelting of pig iron and ferro-alloys.

(d) The production of magnesium from dolomite (250 ton annually and which can conveniently be upgraded to 400 ton of magnesium output annually).

(e) Hot-dip aluminising of steel wire and strip.

(f) The production of electrolytic manganese metal (100-200 lbs per day capacity).

(g) The production of electrolytic manganese dioxide.*

(h) The termal beneficiation of low grade manganese and chrome ores.

(i) The recovery of vanadium pentoxide from vanadiferrous magnetite ores.

(j) The production of metallurgical refractories including a continuous tunnel kiln set up.

(k) Production of steel in basic side blown converter and LD oxygen converter.

(l) The production of cryolite.

There are other semi-pilot plants for the production of permanent magnets and soft ferrites, alumino-thermic production of ferro-alloys, submerged arc welding fluxes, production of carbon and clay bonded graphite crucibles. Painstaking research followed by prototype production trials in the NML pilot plants are conducted on potentially practical and applied themes culminating in detailed project reports for industrial implementation.

Heavy Engineering Corporation Ltd., Ranchi

The Heavy Engineering Corporation is a public sector enterprise. It is comprised of the following main plants:

Heavy machine building plant

This plant was developed with the technical collaboration and credit assistance of the Government of the Union of Soviet Socialist Republics. It is mainly designed to produce 80,000 ton annually of equipment required for the iron and steel industries and to meet the requirements of other heavy industries such as heavy oil drilling rigs, cranes and excavators. It has a structural shop with an annual production capacity of 25,000 ton of fabricated units per year.

The total investment for the project is estimated to about 467.3 million rupees including 219.2 million rupees in foreign exchange. The total annual value of the products when full capacity is attained by 1975 will be 850 million rupees.

<u>Heavy machine tools plant</u>

This plant has been developed with technical collaboration and credit assistance from Czechoslovakia to produce annually 10,000 ton of heavy machine tools with a provision for expanding the capacity up to 20,000 ton. The total investment for this plant is estimated to be 222.7 million rupees including 118.8 million rupees in foreign exchange.

<u>Foundry forge</u>

This plant has been established with technical collaboration and credit assistance from Czechoslovakia. It is intended mainly to supply forgings and castings to the other two plants. This plant is designed to produce 147,000 ton of castings and about 70,000 ton of forgings annually. The total estimated investment for this plant is about 1.08 billion rupees including 493.9 million rupees in foreign exchange.

Several steps are currently being taken to diversify the production pattern of the various plants of the Heavy Engineering Corporation at Ranchi; the latter is engaged in supplying a substantial part of the equipment for the Bokaro Steel Plant, another public steel complex in India which will ultimately have an annual capacity exceeding 5 million ton of crude steel.

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Printed in Austria
Id. 72-[illegible]—February 1973—[illegible]

[illegible]
ID/WG. [illegible]
2 October 1972

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