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STEEL PLANT DESIGN AND ENGINEERING ORGANIZATIONS - THE INDIAN EXPERIENCE[1/]

by

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India

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SUMMARY

This paper deals with the growth and experience of M.N. Dastur and Company Private Limited (Dasturco) - India's first steel plant design and engineering organization - and examines the applicability of the Indian experience to other developing countries/regions. Iron and steel industry occupies high priority in the development plans of many developing countries. However, as the massive investments required are beyond the financial and technical resources of many developing countries, their steel development programmes depend in many cases on foreign aid.

Experience has shown that the construction of steel plants with foreign aid has not automatically generated local design capability. While it would therefore be advantageous to create a nucleus of local design capacity, not all developing countries may have the conditions necessary to set up large steel industries required to sustain full-fledged design organizations. This would emphasize the need for greater regional efforts for both steel development and design services.

India today has attained near self-sufficiency in the steel plant design and engineering. The paper traces the development of Dasturco and reviews its contribution to long-term planning of steel development and its work as retainer consultants to the Government of India on the development of steel industry. The pattern of development of the organization from a staff of two to about 800 is outlined in the context of the wide range of services offered and the various projects handled. Its role in spearheading the introduction into the country of new technologies and modern techniques of project management and control, and in the transfer of technology from local research institutions to industry is discussed. The work of the organization and its overseas subsidiary, Dastur Engineering International GmbH, Düsseldorf, in steel planning in other developing countries in Asia, Middle East, Africa, etc. is reviewed.

A design organization cannot be set up or transplanted like a factory, with foreign aid. The nucleus of the design force must be created within the country and then given adequate opportunities to develop under competent leadership. While it

is considered difficult to specify the 'lower techno-economic limit' for establishing an indigenous steel plant design organization, some of the basic minimum requirements have been indicated.

The size and type of design organization would depend primarily on the range of services and the volume of work. In countries where only one or two plants are envisaged, a full-fledged design organization may not be justified. However, design organizations in developing countries have often to provide certain additional services beyond the line of normal design and engineering services on a project, such as infra-structure development, raw-material investigations, assistance in equipment design etc. This would necessarily require a larger organization and carrying always a certain number of 'surplus' personnel on the staff, as 'hiring and firing' on a job-to-job basis cannot be resorted to as in advanced countries. A full-fledged steel plant design organisation would need a minimum staff of about 300 to 400, whereas smaller ones with only the core group less than 100.

In view of the fact that a design organization is essentially result-oriented and multi-disciplinary, the horizontal organization structure may be more suitable because it permits greater flexibility of operations, injection of new blood into the organization at all levels, greater opportunities for growth of personnel, compared to hierarchical relationships. A typical functional organization structure for a medium/large size design organization has been developed. The need for selective recruitment of personnel and for striking a balance between technical capability and experience at all levels is emphasized.

The pros and cons of single-industry and multi-industry design organizations are discussed. While functional specialisation may be desirable at a certain stage of development, some diversification of activities would be advantageous in developing countries to ensure fuller utilisation of scarce technical skills and steady flow of work to the design organisation. The possibilities of setting up design organizations on a regional basis are examined, particularly for those countries where the small domestic market, inadequacy of indigenous raw materials, and lack of financial resources, technical and managerial skills, and infra-structure facilities do not justify a large steel industry or design organization at the national level.

The development of local design and engineering organizations will facilitate the adaptation and absorption of foreign technology and reduce the cost of technology transfer. There need be, however, no conflict between local design services and the international flow of technological know-how. There are many situations where local and large international design organizations can supplement each other's efforts and cooperate on assignments in a particular country or group of countries.

PREFACE

The paper is presented in two parts. Part A is a case study. It deals specifically with the growth and experience of M.N. Dastur and Company Private Limited (Dasturco) - India's first steel plant design and engineering organization.

Part B examines the applicability of this experience to other developing countries or regions. It needs to be appreciated, however, that this experience in typically Indian setting may not be fully applicable to all developing countries, due to the widely varying conditions obtaining in them. Moreover, not all developing countries will have large steel industries capable of sustaining design and engineering organisations. In such circumstances, it may have greater relevance to regional economic groupings that may embark on steel development on a regional basis.

I. INTRODUCTION

1. Metallurgical industries, particularly iron and steel, occupy high priority in the development plans of many developing countries. They are regarded as essential for sustained economic growth and for the transformation of backward agrarian economies into modern developed economies. However, in the implementation of the programme of steel development, there are many initial impediments to be reckoned with, even when natural endowments and raw materials resources may be available within the country. The most difficult of these are in the fields of finance, plant and equipment manufacture as well as design and engineering services.

2. The massive investments required for the installation of large steel plants are beyond the financial resources of many developing countries and, therefore, their steel development programmes depend in many cases on foreign aid. Also, in most developing countries local design and engineering services are not available. An adequate base for the manufacture of plant and equipment does not exist and reliance has to be placed on imports to meet the requirements of the projects. More often than not, foreign suppliers of equipment also offer design and engineering services to set up new plants. In such cases, the tendency on the part of the administrative set-up in the developing countries is to enter into so-called turn-key arrangements, specially when they are backed by foreign credits tied to such projects.

3. In the course of the next decade, developing countries may have to invest an estimated $ 20 billion (including investment on infra-structure development) on metallurgical industries.(1) Apart from the overall investment requirements, the question to be faced is, how much of this investment will be in local currency and what will be its foreign exchange component. The foreign exchange component needs to be reduced to the minimum, particularly because foreign aid flows are drying up and becoming more and more costly, and the balance of payment position difficult.

Need for local design and engineering services

4. Experience in some developing countries has shown that the construction of steel plants by outside agencies has not automatically generated local ability to design and build new plants, particularly because the interest of these agencies is essentially project-based and lacks national perspective. There is less effective transfer of know-how and opportunity for the development of local skills. At the end of the construction and commissioning of each plant, the

country remains essentially at the same point where it started - so much so that problems arise even in running and maintenance of the plant and optimum utilization of established capacity. For, such plants are in the nature of foreign transplants and do not take organic roots in the soil where they are located.

5. On the other hand, with the establishment of local design and engineering organizations, technical know-how and experience can be continually built up. They can take full advantage of the technological advances elsewhere, choose the most appropriate processes, and adapt them to suit the specific requirements of projects and the national conditions, raw materials, and locational factors in the country. They can help in bringing about speedy and maximum utilization of indigenous research and development efforts and supplement them. They can also assist in the evolution and development of national standards, specifications, and codes of practice.

6. As and when a country or region embarks on a large steel programme, it would be advantageous to create a nucleus of design and engineering capacity, which should be closely associated with the foreign agency that might be engaged on the project. The know-how, skills, and experience thus gained would be useful not only for the successful operation of the plant, but also for its future expansion. In the case of larger countries/regions, where conditions permit the installation of a number of new steel plants (integrated, semi-integrated or mini), the existing nucleus may be strengthened so that it may assume greater responsibilities for their design and engineering. It should be noted, however, that the time-lag between the construction of the plants may be long. In such cases, the design organization may be faced with the problem of finding adequate work to sustain it, which may necessitate diversification of its services to cater to other allied industries.

7. However, it may not be feasible to set up such a design organization under all situations, as many countries may not have the conditions necessary to set up large steel industries. It needs to be stressed that of the 100 countries of the developing world, less than one-fourth today have the population, resources, and infra-structure for setting up large steel industries. Of these, perhaps only a dozen could sustain a full-fledged design organization. This would imply that many of the smaller countries could benefit more from steel development programmes and design organizations planned on a regional basis.

Indian experience

8. In India, for historical reasons, the development of design organisations is essentially a post-independence phenomenon. Before independence, Indian engineering had little scope, as the country's engineering work was handled by foreign firms. Since independence, under the impetus of the Five Year Plans, Indian consultancy firms came to be established and found opportunities to grow.

9. In the early years after independence, however, the growth of the design and engineering services was inhibited by two major factors. First, there was some prejudice against and lack of confidence in Indian engineering expertise, while foreign engineering was encouraged and eagerly welcomed. Second, the encouragement given was uneven, though various Government committees(2) had called for definite policies to promote Indian consultancy services and the Government itself was committed to a policy of 'self-reliance' In the early stages, both government and industry preferred to rely on the easy availability of foreign engineering services linked to foreign aid, even where Indian design and engineering services were available. This state of affairs led a visiting UN official to remark in the mid-fifties: "In India,

the inevitable adjective for expert is foreign; so it is not surprising that the ordinary citizen has the impression that the Indian expert is a rare bird indeed".

Near self-sufficiency in steel plant consultancy services

10. Today, India has attained near self-sufficiency in the field of design and engineering of iron and steel plants. There are two indigenous organisations offering comprehensive services and with wide experience in the field, namely M.N. Dastur and Company (Dasturco) established in 1955 and the Central Engineering and Design Bureau (CEDB) of Hindustan Steel Limited established in 1959. Indian branches and subsidiaries of foreign firms and also equipment suppliers offer consultancy services in respect of their equipment.(3) India thus provides a good example of a developing country which has not only established the nuclei of metallurgical know-how, but also well-developed design and engineering services, research institutions etc.

11. Dasturco's case amply demonstrates how an indigenous organisation can help catalyse development to the stage of self-sufficiency, when it receives the encouragement of enlightened national leadership. Though India had over 40 years' experience of steelmaking, there was not a single indigenous design organisation offering comprehensive engineering services until Dasturco was established in 1955. This also provided the impetus to the formation in the country of a number of other design organisations in different fields. This in turn was responsible for the creation of the indigenous technological base for the development of various industries besides iron and steel, such as ferro-alloys, cement, power, petrochemicals, fertilizers and chemicals, atomic fuels etc.

PART A : CASE STUDY

II. FOUNDING OF DASTURCO

Need and scope

12. The planned development pursued by India since the early fifties and the pivotal role assigned to the steel industry afforded an unique opportunity for the development of indigenous expertise in steel plant design and engineering. The challenge came when work was started on the three new integrated steel plants in the public sector, which were being set up (1955-1960) with foreign assistance.(4) With the experience of the 'tied aid' on those projects, the Government of India realised that, given the large and long-term plans for the development of the steel industry and the need for conserving foreign exchange resources, it was necessary to develop indigenous expertise to the maximum possible extent.

Opportunity and encouragement

13. At this time, Dr M.N. Dastur - who had his initial engineering education in India and steel plant experience with Tata Iron & Steel Company (1938-1945) - was working with Ramseyer & Miller, a U.S. firm of consulting engineers, after completing (in 1949) post-graduate studies at M.I.T. In 1954 he visited India on behalf of his firm, on an assignment from the U.S. Technical Cooperation Mission, to advise Mysore Iron and Steel Works on its expansion programme. He had occasion to meet at Delhi officials of the Government of India who interested him in India's need for an indigenous consultancy organisation which could assist in the country's rapid steel development programme. Accordingly, at the instance of the Government, he returned

home in early 1954 to set up a steel plant design organisation. Some steel plant experience was already available in the country which needed to be properly channelised and the available engineering talent welded into a team. Thus the first Indian steel plant design and engineering organisation, M.N. Dastur & Company Private Limited, came to be established in 1955.

14. The first three new integrated steel plants in the public sector at Rourkela, Bhilai, and Durgapur were constructed more or less on a turn-key basis with German, Soviet, and British aid respectively. However, under the inspiring leadership of Prime Minister Nehru who had great faith in Indian engineers, there was general disillusionment about the tied aid and a new awareness in the country about self-reliance in design and engineering. The Estimates Committee (1958) of the Indian Parliament(5) which examined the problems of the three new steel plants also came out strongly in favour of the utilisation of indigenous engineering talent for the design of India's steel plants.

15. It was under these circumstances that Dasturco built up its organization to gear itself to the needs of the steel industry for design and engineering services. The organisation started with only two persons, but expanded to a well-knit team of about 800 personnel within a period of nine years.

Incorporation and capital

16. Dasturco was incorporated as a Private Limited Company under the Indian Companies Act in the year 1955. Capital as such is not a very important factor for the setting up and growth of a consultancy organisation. The initial paid-up share capital of the company was only about Rs 2 lakhs (approximately US $ 27,000) and it was subsequently increased in stages to Rs 6.77 lakhs (approximately US $ 90,000) by 1960. There has been no increase in the paid-up capital since then. The subscribers to the capital include employees of the company as well as friends and well-wishers.

17. The share capital of Dasturco is only of nominal significance in the financing of its operations. Besides share capital, the company has no other loans or borrowings. The present annual turnover of the company is over Rs 1.50 crores (US $ 2 million) which is about 22 times the paid-up share capital. The entire financing of the company's development programme has taken place from the income earned by the company through technical consultancy services.

Professional policy

18. Dasturco, ever since its inception, has been a wholly independent organization with no financial ties with manufacturers/suppliers of equipment in India or abroad; nor is it a 'captive' organization owned by Government or private industrial groups. This independent status is strictly maintained, because the company believes that a design and consultancy organisation should have objectivity and proper perspective to give impartial advice to the clients without being influenced by pressures or conflicting loyalties and interests. Though statutorily constituted as a private limited company, its operations are more akin to those of an industrial cooperative of engineers and technicians.

III. DEVELOPMENT AND GROWTH

19. Dasturco commenced its operations with its headquarters in Calcutta, the capital of West Bengal. West Bengal, which is known as the 'Ruhr of India' for its well-established steel and engineering industries, rich mineral resources, and well-developed infra-structure facilities, provided the natural environment for the growth of consultancy services. The choice of Calcutta for locating the head

office was, therefore, no mere accident, as it is the hub of this huge industrial belt, besides being the largest city of India.

20. As mentioned earlier, Dastur started with only two persons, but gradually expanded its strength in order to prepare itself for the challenging tasks of steel plant design and engineering. It was no doubt an uphill task at the start, full of trials and frustrations - before awareness could be created both in industry and government about the advantages of indigenous engineering. The pattern of development consisted in the selection initially of a core group of experienced senior technical personnel drawn from the industry, then the recruitment of junior engineering personnel for the middle tier and training them on the job and the provision of supporting staff of draftsmen and other service personnel. Initially, to attract suitable staff the strategy of assurance of minimum two years employment was adopted. It was necessary for a private-sector organization to assure job security for its new entrants, specially as the new venture was of the nature of pioneering effort. In anticipation of India's requirements of steel plant engineering services - and its own role in it - the company commenced building up early its cadres and widening the range of services, beyond the actual needs of the jobs on hand.

21. Thus, as and when new jobs did materialise, the organisation was already in position with requisite personnel and capacity to accept the engineering responsibilities, without having to resort to ad hoc recruitment. Qualified engineers with requisite training in India and abroad (UK, USA, West Germany, USSR etc.) and steel plant and industrial experience ranging from 5 years to 20 years in responsible positions were recruited. Fresh engineering graduates and draftsmen were recruited and trained under the various specialist

groups. The organisation also developed a field cadre for supervising construction and commissioning as well as a team for inspection of various items of machinery and equipment. This build-up of the organization was carried out progressively, but always a step ahead of the current requirements, keeping in view the ultimate objective of providing comprehensive services to the steel and allied industries in the country.

22. The breakthrough in Dasturco's consultancy work came with the award of design and engineering contract for the ferro-manganese plant of the Tata Iron and Steel Company at Joda, Orissa - which was won in international competition with bidders from USA, UK, Germany, and Japan. Dasturco was able to deliver a successful plant within a period of 24 months, eight months ahead of the contract schedule. This consultancy job helped the organisation to make a start, and the core of the organisation was thus set up with experienced engineering personnel in the various disciplines - metallurgical, electrical, civil, structural, and constructional - drawn from the steel industry.

23. For a while after this, during the early years of its operation, the organisation had to be content with smaller assignments. The engineering work on the three new public-sector steel plants as well as the expansion of the two private-sector plants - TISCO and IISCO - had already been entrusted to the foreign collaborators, and for the time being there was no work on a large integrated steel plant which the organisation could take up. However, the successful completion of the Joda ferro-manganese plant had established Dasturco's technical competence and capability. This attracted to the organisation work on other projects in the country, such as mini-steel plants, electric pig iron, foundries, rerolling mills etc, besides a number of ferro-alloy plants.[2] To meet

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2/ The organisation has designed and engineered the bulk of the ferro-alloy capacity - ferro-manganese, ferro-silicon, ferro-chrome (low and high carbon), ferro-vanadium etc. - in the country.

the design and engineering requirements, the project group of the organisation was further strengthened with the addition of engineering personnel and supporting staff experienced in the design, fabrication, and construction of various engineering plants. For some specific items such as evaluation of ore bodies, soil engineering, transport and economic studies, however, Dasturco continued to retain outside consultants, at that stage in its development.

24. It was about this time that the idea of a fourth steel plant in the public sector at Bokaro was mooted and negotiations were under way to bring in foreign consultants. However, due primarily to the late Prime Minister Nehru's vision and the policy of self-reliance in engineering formulated at that time, Dasturco was entrusted in 1959 with the task of preparing the preliminary project report for the 4 million-ton integrated steel plant at Bokaro. This was the first assignment on a project of this magnitude to an Indian organization, and, incidentally, also the first for Dasturco in the public sector.

25. This was owed in 1960 by the assignment to Dasturco of the detailed project report and engineering of the Durgapur Alloy Steels Plant of Hindustan Steel Limited - the Government-owned steel company. Thus, for the first time, an Indian engineering organization assumed full responsibility for the complete design and engineering of a large metallurgical complex. The plant provided an example of international cooperation in steel development, with India providing the engineering services, Japan the required equipment under yen credit, and Canada the production know-how.

26. Towards the end of 1961, the Planning Commission, Government of India, prepared a blue print for the long-term development of the Indian steel industry. Dasturco was assigned a major role in this development programme and as a first step, the organisation was entrusted by the Government of India

with the task of preparing the detailed project report for the Bokaro Steel Project. This was followed in 1964, with the Government's decision to award the detailed engineering of the Bokaro steel plant to Dastur&co. The organisation had geared itself for this major assignment and had in the meantime built up its strength to about 800 personnel, covering the complete range of disciplines - metallurgical, chemical, mechanical, electrical, civil, architectural, structural, industrial, geological, and mining - as well as experts in economic evaluation, industrial and personnel management, inspection, project control, plant management and operation. However, with the Soviets assuming major design and engineering responsibilities on the Bokaro steel plant as a part of their aid, the organisation's work on the project was curtailed and limited to specific plant areas. This came as a temporary set-back to the organisation.

Diversification

27. Dastur&co's policy of augmenting its strength to include newer disciplines as the scope of its service expanded facilitated the diversification of its activities during the lean years. Though the main field of activity continued to be steel and allied industries, it was possible to diversify to some extent, to provide design and engineering services in other fields such as nuclear fuels technology, chemicals, electrolytic and electro-thermal processes, management services, financial studies etc. Dastur&co's pioneering work in these fields paved the way for the development of other consultancy organisations in the country.

Regional offices

28. The close association of Dastur&co with the Planning Commission in its work on long-term planning for steel and its appointment as the retainer consultants to the Steel Ministry, Government of India, to advise on all matters

pertaining to the development of the Indian iron and steel industry, necessitated the establishment of a branch office at New Delhi in 1959. With the setting up of this office, the organisation was able to maintain close liaison with various Government departments and agencies concerned with steel, not only on matters connected with the retainer consultancy but also on the public sector steel plant assignments entrusted to the organization. The availability of Dasturco personnel on the spot also helped more effective cooperation with the Government.

29. The gradual widening of the geographical area of operations and the location of projects in distant parts of the country led to the establishment of other regional offices. In the western region, the states of Maharashtra, Gujarat etc. were fast developing industrially and new metallurgical industries (mini-steel plants, rolling mills etc) and engineering industries were being set up. The Bombay office, started in 1961 and designed to serve the needs of the western region, has a full complement of engineers in the various disciplines and a large well-equipped drawing office.

30. It was also found necessary to open an office in the southern region, particularly in view of the new steel plants and other industrial projects coming up in the region. Thus the third regional office in India was set up in Madras in 1969. This branch office is now being expanded to meet the requirements of the alloy and special steels plant at Salem, the large integrated steel plant at Visakhapatnam, and the mini-steel, sponge-iron, and other projects in the southern states.

31. Dasturco has found the regional offices very useful in its operations. It has been possible to achieve a certain amount of decentralisation of work and to effect better liaison with the local authorities and clients. The regional offices have also provided the company a wider choice in its recruitment

programme and training of local cadre for the projects; also, in this process, brought the regional universities and technical institutions into closer contact with the company. The need for frequent deployment of personnel and the shifting of their families from the Calcutta headquarters to various job sites in the different parts of the country have been obviated to some extent. The regional offices have, moreover, served to fill the gaps in consultancy services in the various regions. They have been specially useful for inspection work - which is very important in India where many items of equipment are being manufactured, some for the first time, in pursuance of the country's import substitution efforts. As equipment manufacturing units are spread all over the country, this would have otherwise entailed frequent long-distance travelling to and fro from the head office, with much waste of time and effort.

Overseas subsidiary

38. With the confidence and accumulated experience gained in the design and engineering of a large number of projects in India, coupled with the special knowledge of the problems of developing countries, the organisation has also sought to share its experience with other developing countries. For this purpose, it has set up in 1969 an overseas subsidiary - Dastur Engineering International GmbH (DEI) - with its office at Düsseldorf, F.R. Germany, which handles its overseas activities.

39. One of the significant activities of the subsidiary company is to participate in international sub-contracting on projects in third countries. Major equipment consortia who have contracted for supply of turn-key projects in third countries have utilised DEI's services for preparation of designs and detailed drawings. DEI has done the overall coordination and liaison in its Düsseldorf office and sub-contracted the detailed drawing work to its Indian parent company. In this manner, the principal contractor is relieved of the problem of employing additional staff to take care of peak loads and the work completed at competitive rates and to tight schedule.

IV. ROLE IN IRON AND STEEL INDUSTRY

A - IN INDIA

Long-term planning for steel development

34. Over the years Dasturco has been involved in the study of techno-economic possibilities of steel development in India.(6) In the early 60's, it prepared for the Government of India the framework for a long-term plan for the steel industry, indicating the broad approach and various inter-relationships involved. The note also outlined the detailed studies to be carried out at the technical level and the various steps to be initiated simultaneously to bring about integrated progress over a wide front to achieve the planned steel targets.(7)

35. Such long-term studies are designed to identify the complex inter-relationships involved in the entire steel development programme, assess the requirement of resource input and plan for their development; evaluate modern technological alternatives for iron and steelmaking; and prepare the basic techno-economic data for the Planning Commission and Government to assist them in formulating a long-term steel development plan.(8) This long-term approach is reflected in the various steel plant assignments handled by Dasturco for the Government of India.

Location studies

36. The all-India study of locations for future pig iron/steel plants carried out by Dasturco for the Government of India may be regarded as a part of the long-term approach to steel development in India. In this study, techno-economic factors for twenty-eight widely distributed locations were evaluated and locations which have potential for development into integrated steel plants were indicated. Similarly, the preliminary work done by the organisation on the location of steel plants in the Neyveli/Salem and the Goa/Hospet regions provided the bases for the two new steel plants now proposed

to be installed at Salem and Vijayanagar (Hospet region) respectively. Another locational/feasibility study carried out by the organization is for an integrated steel plant in the Bonai-Keyagarh area and the Paradip port in Orissa. These locations may be considered for locating future steel plants.

Steel plant planning and engineering

57. It would be relevant to mention that during the last decade, Bokaro and the Durgapur alloy steels plant were the only two large new steel plants to be constructed in India. Dastur&co was closely associated with both these plants, since their very inception. This involvement in India's steel development programme still continues and the organization has been named as consultant on two of the three new steel plants now proposed to be installed in the South, namely the alloy and special steels plant at Salem and the integrated steel plant at Visakhapatnam - the first coast-based steel plant in the country. The organization has also designed and engineered a number of modern mini-steel plants based on arc furnace steelmaking and continuous casting, in different parts of the country.

Retainer services

58. Apart from specific project assignments, the organisation was engaged by the Ministry of Steel for continuous consultation on a retainer basis. The consultancy organisation was required to advise Government on such matters and problems connected with the iron and steel plants (including ferro-alloy industry, ores, mines and quarries) that have been or are being established in the public and private sectors and their expansion; also in the coordination of the development of the iron and steel industry. Queries from the Ministry under the retainer consultancy agreement were wide ranging, mostly new processes and new steels, manufacture of various steel products, scrap and slag utilisation, [illegible] and [illegible]

creation of new electric arc furnace/continuous casting capacity, steel prices, pre-reduced blast-furnace burden, electro-slag refining, tin-free steel etc.

Infra-structure and raw materials development

39. The organization has often been called upon to investigate the development requirements of infra-structure such as new rail links required, the opening of new areas, potential traffic pattern in the region, harbour facilities required for coastal locations, power requirements and development, water resources and supply, training programmes etc.

40. The organisation has also contributed a good deal to the development of raw materials - including mining, beneficiation, and agglomeration. Assignments handled range from assessment of raw-materials requirements to exploration and evaluation of iron-ore deposits, mining development schemes, test programmes for iron ore and fines, development of iron ore deposits, beneficiation and pelletisation facilities etc.

Introduction of new technologies

41. The design organisation has also spearheaded the introduction of new technologies into the country, particularly in the field of pelletisation of iron-ore fines and sponge iron. Among the pelletising schemes prepared by the organisation, mention may be made of two pelletising plants at Goa (for two private sector entrepreneurs) and schemes for the establishment of pelletising facilities at Jonimalai and Bailadila iron-ore deposits (for the National Mineral Development Corporation, Government of India). In the sponge-iron field, Dastur&co has prepared feasibility studies on sponge-iron plants at Arkonam (for the Tamil Nadu Industrial Development Corporation), and at Ballarpur (for the State Industrial and Investment Corporation of Maharashtra), and is consultant to the Andhra Pradesh Industrial Development Corporation on the [illegible] sponge-iron unit to be set up with UNIDO assistance.

Continuous casting, electroslag melting, supe alloys, vacuum decarburising etc

42. In the field of continuous casting, Dastur co can claim to have introduced advanced continuous casting technology into the country. At Mukand Steel - the first modern mini-steel plant to be installed in India - the S-type curved mould continuous casting unit was adopted, at a time when continuous casting technology itself was new and the S-type machine was just then developed. Since then, the organization has designed a number of modern mini-steel plants in different parts of the country. Currently, the company is engineering an electro-slag melting facility and working on a special metals and superalloys project. For the Salem steel plant, the latest technology of vacuum decarburisation for stainless steelmaking will be adopted. These techniques are being introduced for the first time in the country.

Network analysis (CPM) and computer techniques

43. To achieve optimum plant design and rapid completion, Dastur co employs advanced techniques such as computer-oriented critical path analysis, scale models and computerised design for optimum solutions. CPM/PERT control systems are adopted on all projects - large and small. The largest project where such networks have been successfully employed is the Bokaro steel project, on which three categories of networks have been prepared to control approximately 65,000 activities represented by about 800 sub-nets, and processed on an IBM computer.

Promotion of research and development

44. Consultancy organisations form the vital link between the research institutions and the potential industrial entrepreneurs for the effective transfer of know-how developed at the laboratories. They accelerate the process of [illegible]

i) identifying the immediate and long-range problems facing the industry, which require to be investigated by the R and D institutions;

ii) indicating areas for development of new processes and products suited to the available raw materials and operating conditions;

iii) evaluating the techno-economic potential of the processes developed in the R and D establishments to ascertain their commercial viability; and

iv) providing design and engineering services for translating the results of research during pilot plant trials and commercial scale production.

45. One of the major impediments to the speedy utilisation of indigenous research in India has been the inadequacy of appropriate institutional arrangements to develop the processes beyond the laboratory/pilot plant stage. The Indian R and D institutions have recognised that it is essential to draw upon the services of design and engineering organizations for this purpose. This fruitful cooperation is particularly evident in the fields of metallurgy and nuclear engineering, where good understanding has developed between the research institutions and Dasturco, with the research laboratories assuming the responsibilities for the process and the consultancy organisation for the design and engineering for a commercial scale plant.

46. The consultancy organization maintains 'live contacts' with various research organisations. In the field of nuclear engineering, Dasturco has assisted in the development of nuclear fuels based on the research work done by the Bhabha Atomic Research Centre (Department of Atomic Energy, Government of India). The main credit for pioneering this sophisticated field of technology with totally Indian efforts goes to the late Dr Homi Bhabha, who starting from scratch was able to build a dynamic team of scientists and engineers and develop expertise in the country within a short time. On the uranium milling plant at Jadugoda, Bihar, the first uranium mill in India to produce concentrates, the complete process was developed by the BARC and the detailed engineering was provided by Dasturco.

Similarly, on the Nuclear Fuels Complex at Hyderabad, which provides zirconium-clad natural uranium oxide fuel for India's nuclear power reactors, the process know-how and flow diagrams were developed by the Bhabha Atomic Research Centre, while the design and engineering services were provided by the firm.

47. In the field of metallurgy, Dastur has worked in close collaboration with the National Metallurgical Laboratory (NML), Jamshedpur. On NML's 250 tons/year magnesium metal project, the firm was responsible for the design, engineering, and supervision of construction. The plant is the first of its kind in India and, except the imported vacuum system, the entire plant was built with indigenous equipment. The consultancy organisation is also associated with the development work currently in progress at NML on sponge iron.

48. Based on the pilot plant work at the Regional Research Laboratory, Hyderabad, the organisation prepared a complete project for their 600 tons/year silicon carbide plant of abrasive grades.

49. The consultancy organisation also develops appropriate testing programmes for raw materials to be carried out under its supervision at the national laboratories. For instance, in connection with the Salem steel plant, an extensive test programme was devised for the magnetite ores from Kanjamalai (South India) at NML, Jamshedpur. For Bokaro steel plant, in connection with the detailed project report prepared by Dastur, NML carried out extensive pilot-plant studies on Kiriburu north ores.

Contribution to professional development and education

50. The company's contribution to professional development is in the fields of technical committee work, professional organisations, education, and training. The organisation does a considerable amount of professional work on honorary basis in order to advance the cause of technology and self-reliance

in the country [illegible] in India, its engineers are actively participating in Government committees, in steel delegations abroad, in the work of the Indian Standards Institution, National Productivity Council etc. In their professional field, its personnel take leading part in professional technical organisations such as the Indian Institute of Metals, the Institution of Engineers (India), the Indian Institute of Welding etc. and actively support them.

51. In the field of education, Dasturco personnel are examiners and visiting lecturers in a number of engineering colleges and technical institutes all over the country. At the request of Government and various universities and technical institutions, the firm periodically takes engineering students for training in design work, including students from the neighbouring countries of Africa and Asia.

3 - OTHER DEVELOPING COUNTRIES

Steel planning and development

52. In the international field, Dasturco and its overseas subsidiary, Dastur Engineering International (DEI) have been intimately associated with steel planning in developing countries. In 1965, the organisation completed a study on economics of scale in steel plants of sizes varying from 25,000 to 300,000 tons per year for Latin American locations for the United Nations Economic Commission for Latin America. The organisation has already completed or is currently carrying out several steel plant assignments in various developing countries such as Iran, Syrian Arab Republic, Libyan Arab Republic, Arab Republic of Egypt, Mauritius, Morocco, Sri Lanka, Thailand, Lower Mekong basin countries etc.

53. Dasturco/DEI have recognised the need for building up local expertise in the developing countries and have endeavoured to work in close cooperation with local engineers on a number of projects. The organisation is also associated in the work of UNIDO in the development of steel industry in developing countries.

PART I - GUIDELINES

54. An attempt is made in the following paragraphs to draw some general guidelines which may be helpful to other developing countries in setting up their design organizations, based on Dastur&co's experience in India. It has to be remembered that there are wide variations in size, social and economic structure, scientific and technological development, and national objectives between one developing country and another. It is impossible, therefore, to offer any one set of guidelines which could be applied to all. However, some of the major pre-requisites and problems of setting up a steel plant design and engineering organisation in a developing country or region are outlined.

V. PRE-REQUISITES FOR ESTABLISHING DESIGN ORGANIZATION

55. A design organisation cannot be set up like a factory, with foreign aid. In order to meet the specific needs and conditions, the nucleus of the design force must be created within the country and then given adequate scope and opportunities to develop under competent leadership. While the process of economic development itself is a factor in the growth of strong and competent design organisations in the developing countries, the proper climate for their progress has to be created by the Government as well as industry in those countries.

56. As design organisations are primarily concerned with the application of science and technology to development, their establishment is closely linked to the development of science and technology in the country. Certain basic pre-requisites must be satisfied, therefore, before the right combination of knowledge and understanding of the scientific, technical, social, and economic aspects could be built up which will carry the country forward to the 'take-off' stage.[9] The major pre-

requisites are (i) the creation of a social climate favourable to the application of science and technology, (ii) development of high standards of science education and technological training, (iii) promotion of research, (iv) development of auxiliary services such as science documentation, standardisation and instrumentation, (v) publication of technical books and manuals and making them available at nominal prices, and (vi) the evolution of a national science and technology policy in the context of development planning.

87. It is however, difficult to state precisely what constitutes the 'lower techno-economic limit' that would determine the feasibility of establishing an indigenous design and engineering organisation. In most developing countries, the main obstacles to progress are economic and social, including lack of education, communications, acceptability of new ideas, administrative effectiveness and business enterprises. Some of the basic minimum requirements governing the establishment of a steel plant design and engineering organisation would be:

i) the existence or potential for the establishment of a steel industry which would require the services of design and engineering organisation and sustain it on a long-term basis;

ii) the availability of the major raw materials and natural resources for the development of steel industries;

iii) the size of the domestic market and export possibilities;

iv) the 'absorptive capacity' of the country for utilising technology;

v) the level of industrial activities and the overall structure of industry and its management; and the potential for rapid industrialisation;

vi) local manpower with a general level of skills as well as technological and managerial personnel to effectively absorb imported technology;

vii) educational infrastructure facilities for scientific, technological, and vocational training;

viii) research and development facilities to adapt imported technology to local conditions and requirements.

Indian experience has shown that governments of developing countries have a crucial role to play in the growth of their design organizations, particularly as they will have to assume the responsibility for the massive investments in iron and steel industry as well as for the development of science and technology.

VI. SIZE AND TYPE OF DESIGN ORGANISATION

58. The size and type of design organisation would depend primarily on the range of services provided and assured volume of work to sustain the organisation. A long-term steel and metallurgical development programme involving a number of new steel and metallurgical plants over the years can generate adequate amounts of design and engineering work which could sustain a medium to large-sized consultancy organisation. In developing countries where there is no long-term steel development programme, and the installation of only one or two plants is envisaged, the setting up of a full-fledged design organisation may not be justified.

59. A design organisation in developing countries is very often required to provide additional services beyond the normal scope of design and engineering work performed by its counterparts on similar jobs in industrialised countries. It is also not generally realised that in developing countries the consultants have to work under certain limitations. They have to base their work on scanty data and carry out multiple studies on various aspects of the project outside the actual terms of references. Dastur's experience has shown that, besides the plant engineer-

ing proper, considerable additional work has to be done, often starting from scratch, in other areas such as development of infrastructure facilities (water, power, transport etc), investigations on raw materials, planning of manpower, recruitment and training programmes, development of feeder industries etc.- all as part of a single project.

60. In the field of raw materials, the scope of service gets extended to detailing the type and nature of prospecting work, mining methods and development - all for the purpose of evaluating the potential raw material resources to sustain the plant operations over a period of time. During such investigations, not infrequently, alternative source of raw materials have to be studied, which in the case of countries depending on imported raw materials may be on a global basis. The data available on raw materials is often so scanty that the consultants have to arrange for elaborate testing and beneficiation programmes to ascertain the quality of the ore and its suitability for an appropriate process.

61. Though the consultancy organisation as an independent agency is not involved in the design and manufacture of equipment, it is often called upon to assist local equipment manufacturers in developing countries. Most of the equipment manufacturing units in the developing countries have been set up with foreign know-how. They do not have the design expertise and personnel to prepare design drawings for the manufacture. Even where the design documentation has been obtained from foreign sources, certain modifications and detailing need to be carried out to adapt it to local conditions. Until such time as the equipment manufacturers develop their own design department, the consultants have to assist them by providing the basic equipment parameters for detailed design. The rendering of these services beyond the line of normal design and engineering services on a project necessarily requires a larger organisation.

62. A full-fledged design and engineering organization providing comprehensive services for a large integrated steel plant would need a minimum staff of about 300 to 400; whereas a smaller one with only the core group may have a strength of even less than a hundred. It is not unusual for design organisations - even large ones - to have regular arrangement with other specialist organisations or individual experts whose services could be drawn upon as and when required. For instance, market research, geological investigations, mining development, soil investigations, plant transport requirements etc. may be entrusted to outside agencies. However, the scope for farming out may be limited in many developing countries owing to the lack of appropriate agencies and it may also pose problems of coordination.

VII. ORGANIZATION STRUCTURE

63. A design organisation is essentially a result-oriented multi-disciplinary team and therefore, its organisation structure should reflect its functional character, rather than line relationships. Though both the vertical and horizontal types of structures have their advantages and disadvantages in particular situations, the horizontal form of organisation is endowed with the flexibility needed by a design organisation to inject new blood at any level as required, without being tied down by line relationships. This also exposes the individual member of the organisation to challenging work and increases his growth potential and recognition on the job, without the restrictions associated with hierarchical relationships.

64. Easturco has found the horizontal structure well suited to the functional requirements of its consultancy services, as it also permits greater flexibility of operations for the parallel and efficient functioning of a number of teams on different assignments without affecting the organisation structure. This has also enabled the effective use of the task-force concept for

project management, that is the regrouping of personnel depending on the nature of the task, under a project manager on different assignments. The line relationships do exist, but only to the extent required for purposes of administration and management.

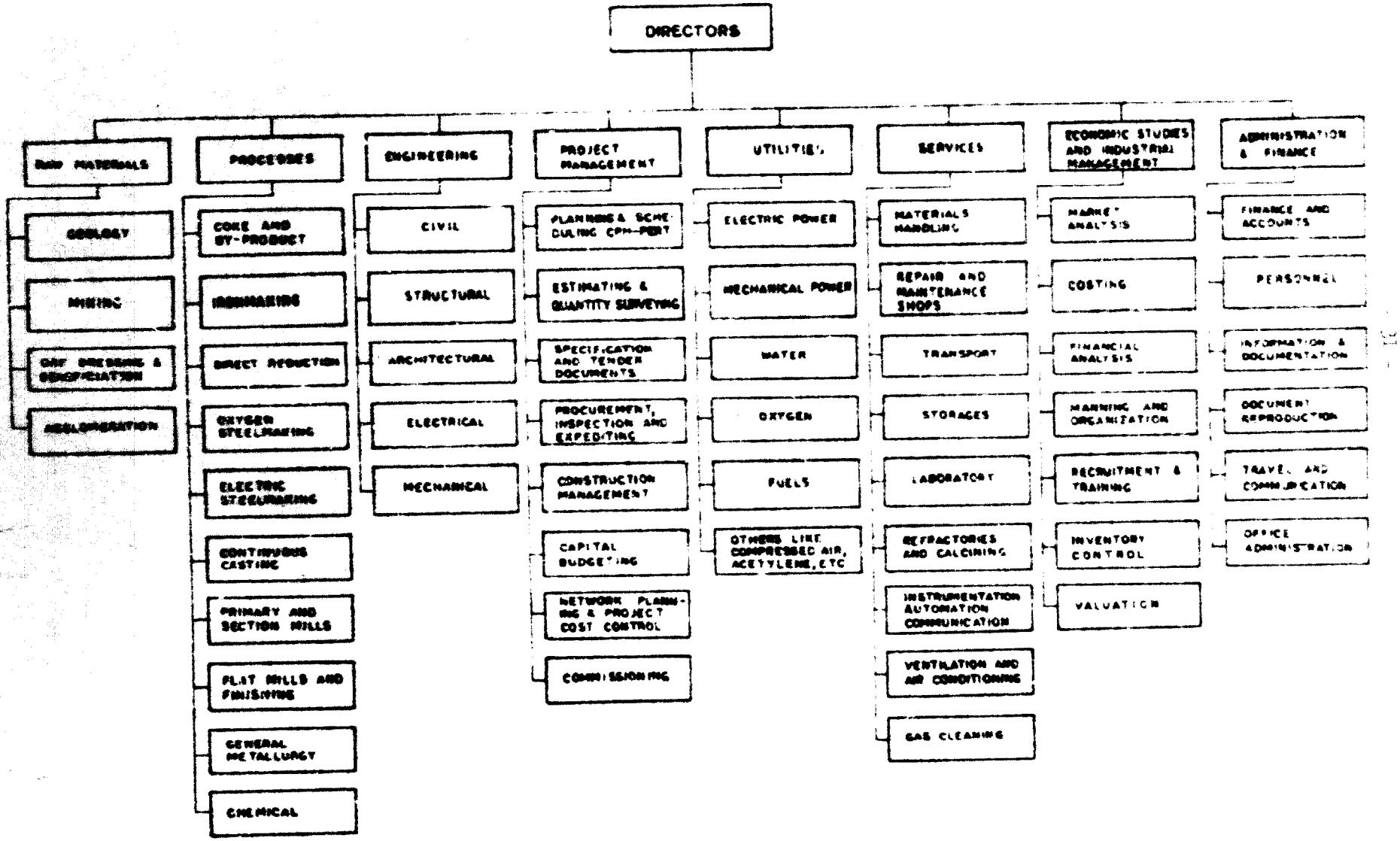
Functional organizations

65. A typical functional organization structure for a medium/large size design and engineering organization geared to provide integrated services for steel and metallurgical projects is shown in Figure 2. However, in a creative professional activity like design and engineering, it is the technical leadership and the calibre and competence of the personnel (their training, experience, capabilities, and specific qualifications), more than the mere size of the organization, which ensures that a project will be carried out successfully and economically. In fact, these are the very factors that weigh with the users of design and engineering services.

VIII. RECRUITMENT AND TRAINING

66. Selective recruitment of personnel, particularly for senior positions of responsibility, is important in any organization, but it is doubly so in a design and engineering organization, whose only stock in trade is the expertise and specialized engineering services it offers. In the early stages of development, it is often difficult to attract talented personnel to the new organization. At this stage, it is largely the vision of the men heading the organization, the leadership they provide to the technical community, and their ability to convince like-minded people in the engineering profession about the soundness of the new venture that will attract the right type of people, rather than the best of recruitment procedures and financial inducements.

FIG. 1 A TYPICAL FUNCTIONAL ORGANIZATION STRUCTURE FOR A METALLURGICAL CONSULTANCY ORGANIZATION



67. Once a start is made with a small core of competent personnel, recruitment has to proceed at all levels - junior personnel for further training on the job, senior personnel for direction, and middle-level employees for carrying out the bulk of the work. In most developing countries, due to the shortage of technical manpower, great difficulty is experienced in the recruitment of personnel to fill the middle level. As this tier constitutes a vital sector of the design and engineering organisation, it would be advisable to recruit and train promising young men who could assume responsibilities at this level as early as possible. As regards the mix or composition of personnel, it would be necessary to strike a balance between technical capability and experience at various levels, namely i) operating personnel with long steel-plant experience at the shop level or in the engineering department; ii) design staff with experience in industry or project work; iii) construction engineers with experience of plant installation; iv) graduate engineers - fresh from college or with short experience of industry; v) industrial economists and financial analysts with industrial and project experience; and vi) supporting staff of draughtsmen, technicians, and other service personnel.

68. It is interesting to note that, right from its inception, Dasturco has been completely manned by Indian personnel without any assistance from foreign agencies and experts for organising and developing it. It is not that Dasturco is opposed to any foreign collaboration as such; nor is it intended to minimise the important role of foreign organisations in the transfer of technology to developing countries and in building steel plants. In Dasturco's case, foreign collaboration was not necessary, because it had the advantage of having amongst its personnel Indian experts with training and experience of steel plant design, engineering, and operation in USA, UK, Germany, USSR etc, who are familiar with the technologies of all these countries. The existence of this internal expertise was of immense use in the adaptation of technology to Indian conditions on foreign aided projects. The firm was also able to generate new expertise

within its own organisation and build up a valuable reservoir of skills and experience. Thus the pace of technology transfer was accelerated and technology readily absorbed without recourse to any foreign collaboration.

69. Though professional development is largely individual responsibility, there are many ways in which a design organization can promote it among its employees. Engineers need to be encouraged to join professional engineering organizations, to prepare technical papers in their specialised fields, and to participate in technical meetings and seminars in India as well as in other countries. Where feasible, they should also attend short refresher courses on specific topics which would bring them up-to-date with the developments. Periodically they may visit advanced countries for plant visits and discussions in order to obtain first-hand knowledge of modern developments.

70. A design organisation should be well-informed and alive to the technological developments taking place elsewhere. This serves to reinforce the need for a well-organised technical information service or data bank on a national or industry basis. In most developing countries, technical/industrial services are at present either non-existent or at an incipient stage. In India, where a beginning has been made, most of the information is not readily accessible, and is available only at the institutional level. By virtue of Dasturco's close contacts with other professional organisations and technical personnel working in the metallurgical field both in India and abroad, its engineers have ready access to the latest information and keep themselves abreast of technological advances. This information is supplemented by the company's own library and documentation division and other sources of information.

IX. SINGLE-INDUSTRY BASED OR MULTI-INDUSTRY BASED?

71. A question that naturally arises is whether the design organizations in a developing country should be single-industry based or multi-industry based. The single-industry organization is geared to provide the entire range of specialised services required by one industry only - such as iron and steel or steel products, or a group of related industries such as alloy and special steels, ferro-alloys, mineral development and ore beneficiation, pelletisation and direct reduction etc. While this functional specialisation is desirable at a certain stage of industrial and technological development, in the conditions obtaining in most developing countries too narrow a specialisation may lead to under-utilisation of scarce technical skills and may result in uneconomic working.(10)

72. Initially, in developing countries, the design organisation starts as a single-industry organization or simply as a service such as civil engineering or architectural work, in which it builds up its expertise. However, as industrialization progresses, a country does not merely duplicate its existing industries, but moves into a wider range of industries. Many of these new industries are design-intensive, but as other specialised consultancy services are not available, greater demands are made on the existing consultancy organisation - once it has reached a certain size and established its reputation. It should be possible to provide these services as in many industries the work can be handled by the existing multi-disciplinary staff of the design organisation, supplemented by a few specialists to tackle the specific requirements of each industry. Such diversification would also lead to greater utilisation of the personnel and assist the organisation to tide over lean periods. After a while, however, with the setting up of consultancy organizations for other industries, some of the demand for services would taper off, and the organisation may revert to its main field of activity.

73. Moreover, an additional difficulty faced by consultancy organisations in developing countries is their inability to resort to 'hiring and firing' of personnel, depending on the work load, either due to the local laws or because the specialised skills developed through training would then be lost to the organisation. As a result, at all times, the consultancy organisations will have to carry on their rolls a certain number of 'surplus' personnel. This reinforces the need for sustained flow of work to the design organisation. As steel plant design and engineering jobs come once in a while in most developing countries, it would be prudent also to remain diversified to a certain extent. This is the case even in developed countries where the consultancy organisations can no longer afford to continue to specialise in one industry only.

L. NATIONAL OR REGIONAL ORGANIZATION?

74. The question of work load and size is also linked to the possibilities of establishing regional design and engineering organisations in certain geographical areas. From the point of view of effective management, it would be perhaps advantageous if such an organisation is single-industry based, but where conditions demand, it may also serve other allied industries. In regions where the countries are faced with common problems of steel development and the individual country's resources are not adequate to support a national design and engineering organisation, collective effort in the form of a regional organisation may be the best answer. Such organisations have greater chances of success in homogeneous geographical regions like Latin America, the Arab countries, and the African countries, where a certain amount of regional economic coordination has already been established.(11)

75. In the Latin American region, thanks to the efforts of the Economic Commission for Latin America (ECLA), the Latin American Free Trade Association, IDAFA, and other institutions,

the countries of the region have made considerable progress towards sectoral industrial cooperation. In the Arab countries, agencies like the Industrial Development Centre for Arab States, the Maghreb Centre for Industrial Studies sponsored by UNIDO, and other agencies have done useful work in bringing about regional industrial integration. In Africa, the East African Community (Kenya, Uganda and the United Republic of Tanzania), the common Afro-Malagasy Organization (OCAM), and other bodies are working towards joint development of industrial units and markets in the region with UN assistance. In West Asia, a sub-regional group exists, namely the Regional Cooperation Development (RCD), comprising Iran, Pakistan and Turkey. In South East Asia, too, regional/sub-regional design and engineering organizations may be feasible, if ECAFE and the Asian Industrial Development Council (AIDC) take initiative in this direction.

76. In this connection, it is interesting to note the various techno-economic problems which make it difficult to establish viable large-scale steel industries in many of the developing countries of the region, mentioned by the Second Asian Conference of Industrialization (sponsored by ECAFE and UNIDO and held in Tokyo in January 1970):

i) the smallness of the domestic markets and of the increment of growth in steel demand in individual developing countries;

ii) the insufficiency of indigenous raw materials for crude steel production;

iii) the lack of adequate financial resources for capital investment in machinery and equipment, particularly as regards the foreign exchange component;

iv) a shortage of technical know-how and managerial skill;

v) the lack of essential infrastructure - power, transport etc.(12)

These observations have also relevance to other developing countries of Africa and West Asia, which are also facing similar problems. At the same time, there is a growing demand for steel

in smaller countries of the developing regions, which cannot be ignored. A possible solution, which the conference has strongly endorsed, is the establishment of steel plants (integrated, semi-integrated and mini) on a regional/sub-regional basis.

77. The problems likely to be encountered in such regional steel development programmes, arising out of the diversity of national policies on investment, the nature and scope of agreements, customs and tariff regulations etc. need to be tackled and the governments concerned should vigorously pursue the concept of regional cooperation for the sound development of the steel industry. The primary reason for the regional cooperation is the mutual benefits obtainable through larger markets, economies of scale, and specialisation in product-mix to achieve maximum efficiency and productivity. As a corollary, it would also be advantageous for the successful implementation of these regional steel projects to develop design and engineering organisations on a regional or sub-regional basis, where conditions permit.

78. The similarity of conditions in developing countries and the common orientation of problems also indicate the possibilities of the sharing and/or transplantation of the experiences of one developing country to another. It would lead to a better utilisation of technical manpower resources and infrastructure facilities such as research and development, technical and vocational training etc. if the design and engineering services were pooled and developed to serve the requirements of the region. It should be borne in mind, however, that the technological needs of developing countries within the region may differ depending on their specific resource endowments and socio-economic conditions. This broad limitation apart, there are vast areas where the problems of technology and its application/modification are similar.

79. The steps taken by the Andean Group (Bolivia, Columbia, Chile, Equador, and Peru) to integrate the technological effort in the sub-region under the terms of the Cartagena Agreement

(May 1969) may be cited as an example of regional cooperation which has great potential for further integration. The programme envisages, as part of the overall industrial development strategy of the sub-region, the encouragement of local consultancy firm, preference to the technology of the sub-region, the elimination of restrictive clauses in licences for transfer of technology, and the establishment of centres of investigation and development for advising medium and small industries. These measures may in course of time provide the basis for the establishment of a regional design organization.

XI. CONCLUDING REMARKS

80. The creation and development of local design and engineering organizations will facilitate the adaptation and absorption of foreign technology and minimise the dependence of the developing countries on foreign sources for know-how as well as reduce the cost of technology transfer through imported technology and services. There need be, however, no conflict between the growth of local design organizations and the international flow of technological know-how. There are many situations in developing countries where local design organizations and large international organizations can supplement each other's efforts and cooperate on assignments in a particular country or group of countries. This is particularly true of those developing countries which do not have well-developed design organizations.

81. On the long-term basis, however, it would be to the advantage of the developing countries to set up local/regional design and engineering organizations and utilise them to the maximum on their metallurgical and other developmental projects. They should actively encourage the growth of the indigenous design and engineering organizations as a matter of national policy and import know-how and related engineering services only where absolutely necessary for the development of the technological and industrial structure of the country.

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