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FIRST ECA/UNIDO WORKSHOP ON MANPOWER AND TECHNOLOGICAL DEVELOPMENT FOR BASIC INDUSTRIES: METALS AND ENGINEERING INDUSTRIES FOR THE EASTERN AND SOUTHERN AFRICAN SUBREGION

Lusaka, Zambia, 17 November to 7 December 1980

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CHAPTER I

INTRODUCTION

Background

1. The First ECA/UNIDO Workshop on Manpower and Technological Development for the Basic Industries: Metals and Engineering Industries for the Eastern and Southern Africa Subregion, was a follow-up to the First ECA/UNIDO Meeting of Experts on Basic Metals and Engineering in Addis Ababa from 3-? December 1979 and a response to the expressed need for technical manpower training and development in the region.The workshop was part of the ECA/UNIDO's continuing support for the African countries in their endeavour to develop their resources in trained manpower and geared to develop and update the capabilities of metallurgical, mechanical, industrial and production engineers as well as industrial economists directly involved in the planning of projects or engaged in the operation and management of production facilities in the metal and engineering subsectors and those likely to be involved in the development of multinational or parastatal projects relating to iron and steel production and engineering establishments.

Workshop objectives

2. The workshop was to prepare the ground work for the establishment and operation of the proposed multinational iron and steel and engineering industries projects for the Lusaka MULPOC countries through collaborative consultations and training of the staff that will be closely concerned with the planning, design, development and operation of the projects. In specific terms the workshop was to enhance the participants' ability to:

(a) establish relationship between metals (iron and steel) and engineering industries, thereby facilitating the formulation of integrated programmes in the two subsectors with respect to partial, temporal and inter-process,inter-dependence;

(b) formulate and apply approaches to integrated planning of metals-engineering industries;

(c) determine the criteria for formulating and specifying investment programmes in the metals and engineering industries and apply such criteria in the development of projects in the subsectors;

(d) formulate guidelines and approaches for the promotion of integrated metals and engineering industries;

(e) determing the manpower implications of the metal and engineering industries, develop related skill matrices and profiles and subsequently programme for the development and obligation of the manpower required for such industries and ;

(f) through experimental exposure and opportunity observe current industrial practices, processes and advances in related industrial plants.1/

Participants

3. There were 31 participants from Eastern and Southern Africa subregional states of Ethiopia, Kenya, Malawi, Somalia, Tanzania, Zambia and Zimbabwe and observers from Algeria, Nigeria and UNIDO(Vienna). The participants were metallurgical, mechanical, industrial and production engineers and economists involved in planning projects relating to metals and engineering industries and their subsectors.

Official opening of the workshop

4. The First ECA/UNIDO workshop on Manpower and Technological Development for the basic industries for the Eastern and Southern Africa Region was held in Lusaka on 17 November 19?0 at Mulungashi Hall. The workshop began with the introduction of personalities by Mr. S.S. Sangweni, the Acting Director and Team leader of the ECA Lusaka MULPOC. The workshop was then formally opened by the Hon. Remmy Chisupa the Zambian Minister of Commerce and Industry.

5. In his opening speech the Hon. Minister emphasized the importance of integrated manpower development as a component of investment programmes within the context of regional cooperation. He pointed out that the development of technology is inseparable from that of manpower. In concluding his opening speech, the Hon. Minister requested the workshop participants to examine possible ways of co-operation between individual countries in the promotion of industries, such as inter-change of raw materials. He then declared the workshop open.

6. In response to the Minister's opening speech Mr. Sangweni made an opening address on behalf of Professor Adebayo Adedeji, the Executive Secretary of the Economic Commission for Africa in which he emphasized the importance of basic metals and engineering industries to the economy of any country. He went on to point out that meaningful creation and operation of metals and engineering industries implied the production of raw materials and capital goods.

Programme and the organization of the workshop

7. The workshop then went into plenary session in order to approve the programme of work and the organization of the workshop. The workshop was organized into two committees namely: committee I (iron and steel) and committee II (engineering) and the plenary sessions for joint discussions at intervals to be determined in

1/ This was partly achieved through planned visit to the Zimbabwe Iron and Steel plant and Engineering Workshops accordance with workshops needs. In order to monitor daily developments and plan for subsequent committee work, a steering committee was also constituted. The arrangements adopted were as follows:

(a) General administration and coordination of workshop

Mr. J.W. Murisi (Zimbabwe)
Manpower Economist & Project Officer
Public Administration Management &
Manpower Division
Economic Commission for Africa
Addis Ababa

(b) Plenary session

Chairman - Dr. A. Banjo (Nigeria)
Consultant to Workshop

Rapporteur - Mr. M.K. Mwango (Zambia)
Economic Affairs Officer
Joint ECA/UNIDO Industry Division
Addis Ababa

(c) Committee sessions

(i) Committee I

Chairman - Eng. F. Abouzaghla (Egypt)
Consultant to Workshop

Rapporteur - Eng. N. Ojobor (Nigeria)
Participant to Workshop

(ii). Committee II

Chairman - Mr. S.K. Tamele (Zambia)

Rapporteur - Mr. Amahayes Dimiru (Ethiopia)

(d) Steering committee

The steering committee was composed of officers of the plenary and committee sessions:

Chairman - Dr. A. Banjo

Secretary - Mr. M.K. Mwango

Mr. J.W. Murisi
Project Officer & Co-ordinator
of Workshop Activities

(e) <u>Discussion of alternative technologies for iron and steel production papers presented in Committee I</u>

(i) Iron making by Mr. V.A Ivanchenko and Dr. A. Banjo

(ii) Steel making by Dr. F. Abouzaghla and Mr. H. Hadjiat

(iii) Ore preparation - Direct reduction by Dr. N. Mahinda and Mr. S.M. Ojobor
- Ore preparation by Mr. V.A. Ivanchenko

(iv) Coke preparation by Mr. V.A. Ivanchenko

(v) Gas preparation by Mr. H. Hadjiat and Mr. S.M. Ojobor

(vi) Pollution by Mr. S.M. Ojobor, Mr. V.A. Ivanchenko and Mr. H. Hadjiat

(vii) Ingot casting:

(a) Mould casting by Mr. S.M. Ojobor

(b) Continious casting by Mr. H. Hadjiat

(c) Blooming by Dr. F. Abouzaghla

(d) Finishing - flat by Mr. S.M. Ojobor
- long by Mr. M.X. Mwango

(viii) Special steels by Mr. H. Hadjiat

(ix) Power and water by Dr. F. Abouzaghla

(x) Air and oxygen supply by Mr. S.M. Ojobor and Mr. H. Hadjiat

(xi) Refractories by Mr. V.A. Ivanchenko

(xii) Materials handling by Mr. S.M. Ojobor, Dr. F. Abouzaghla and Mr. V.A. Ivanchenko

(xiii) Maintenance facilities and spare parts by Mr. A.K. Mitra

(xiv) Metallurgical laboratories by Mr. H. Hadjiat and Dr. F. Abouzaghla

(xv) By products by Mr. V.A. Ivanchenko and Dr. F. Abouzaghla

(xvi) Planning for an iron and steel works by Dr. A. Banjo, Mr. Hocine and Mr. V.A. Ivanchenko

(xvii) Selection of technology by Dr. F. abouzaghla

(xviii) Construction and project implementation by Mr. S.M. Ojobor

(xix) Manpower planning, training etc. by Dr. M.X. Khanijo

(f) Discussion of alternative technologies for an engineering plant papers presented in Committee II

(i) Casting by Mr. A.K. Mitra

(ii) Hot forming by Mr. A.K. Mitra

(iii) Cold forming by Dr. A. Banjo

(iv) Metal cutting:

(a) Linear cutting processes by Dr. A. Banjo

(b) Unconventional metal removal techniques by Mr. A.K. Mitra

(c) Rotating cutting processes by Dr. A. Banjo

(v) Fabrication by Mr. S.K. Tamele

(vi) Tool making and heat treatment by Mr. A.K. Mitra

(vii) Metrology by Dr. A. Banjo

(viii) Metal coating by Mr. H. Hadjiat and Mr. A.K. Mitra

(ix) Manpower planning, training etc. by Dr. M.K. Khanijo

(g) Papers presented in plenery session for planning, implementation and manpower development for industrial project

(i) General considerations:

(a) Iron and steel works by Dr. F. Abouzaghla

(b) Engineering manufacturing works by Dr. A. Banjo

(ii) Planning for an iron and steel plant by Dr. A. Banjo

(iii) Planning for an engineering plant by Mr. A.K. Mitra

(iv) Economics and finance by Dr. A. Banjo

(v) Determination of manpower requirement and training by Dr. M.K. Khanijo

(vi) Descriptions of plant visits:

(a) Metals by Mr. V.A. Ivanchenko

(b) Engineering by Mr. A.K. Mitra

CHAPTER II

DISCUSSION ON IRON AND STEEL PRODUCTION TECHNOLOGIES

A. Report of the proceedings of the Session

8. Session I opened at 09.00 with a brief introduction by Eng. Abouzaghla. He described the development of the Egyptian steel industry which started in 1955 and its technical and personnel problems. The loss of skilled manpower through emigration has had a marked effect on the steel industry in Egypt.

9. Dr. Banjo then explained that the purpose of the discussions in Session I was to review the technologies available for iron and steel making and the parameters and circumstances that should be taken into consideration in selecting a combination of technologies for the iron and steel industry by African countries. In particular, he pointed out that metallurgical processing research was expensive and time-consuming and advised that African countries should not allow their projects to be used as opportunities for research by the foreign consultants often hired to advise at project planning stages. Consequently, he recommended that for countries just entering into the field of iron and steel production, it was advisable to select well-tested and proven technologies for all aspects of their operations and to avoid those processes, however promising, which were still in the course of development. From this point of view, the range of choice for iron making offered two possibilities the Blast Furnace Process and the Direct Reduction Process. For steel making, the choices available include the air-blown converter processes (Bessemer Process or Thomas Process), the oxygen-blown converter processes, the open hearth furnace and electric furnace processes. Although it is now the trend to consider the open hearth furnace as out of fashion, it offers some special features of flexibility and versatility which might be advantageous for a country just entering into iron and steel making.

10. Mr. Ivanchenko spoke on iron making processes. He elaborated on the two well-proven processes in application at the present time.

(a) The blast furnace process

11. This process has been in existence for over 90 years and has been well-researched and proven in practice. The process can accommodate any type of ore except ore that contains chlorides and other salts or titanic oxides. The main advantage of this process is its reliability; the disadvantages are higher investment cost for lower capacities and the need for coke which is usually quite expensive because of the scarcity of coking coal. This process normally requires a carefully prepared input of raw materials (the burden) and is usually requires the establishment of a sintering plant or pelletizing plant and coke-ovens.

(b) The direct reduction process

12. The direct reduction process uses gaseous and solid fuel and depends on availability of high grade ore. The main advantage of this process is its lower investment cost per tonne of steel especially for lower capacities as compared to blast furnace process. In countries where natural gas and electric power are scarce, this process becomes uncompetitive since it is energy intensive. The end result of the direct reduction process is a porous iron product called sponge iron.

B. Discussions on technologies for iron making

13. Lively discussions took place on the advantages and disadvantages of blast furnace iron making in comparison to direct reduction iron making.

The following issues were the focus of the discussions:

(i) the problems of access to and acquisition of conventional blast furnace and direct reduction iron making technologies;

(ii) the criteria for assessing these two technological options;

(iii) the need for comprehensive survey and assessment of iron ores, the testing and evaluation of ores to provide the data for deciding upon an iron making route;

(iv) planning for manpower for the iron making plant and training this manpower well ahead of the plant start-up.

14. Discussions regarding the blast furnace process centred around the critical role of coke and the importance of using a closely controlled burden for the purpose of regulation of the blast furnace regime. In this respect, it was concluded that the availability of an assured supply of coking coal is a mandatory condition in adopting a blast furnace option.

15. In Brazil which possesses large tropical forests but lacks coal, the use of charcoal as a furnace fuel has been tried experimentally in low shaft blast furnaces. However, the main difficulty with following this example is obtaining supplies of charcoal adequate to sustain economically feasible levels of production.

16. Discussions concerning the direct reduction process reflected the following points of emphasis:

(i) issues related to the processing economy;

(ii) the degree and extent to which a particular process has been proved in terms of commercial success.

17. In this connection, a few processes were mentioned that have been successfully tested and proved on a commercial scale notably Midrex and Hyl processes. The most important of these are:

(i) SL/RN (solid fuel);

(ii) Shaft - (Midrex process (gaseous fuel);
- (Purofer process

(iii) Hyl process (gaseous fuel).

18. The most important consideration emphasized was the availability of natural gas as the prime source of the reducing gases necessary for using the gaseous reduction processes.

C. Discussions on steel making technology

19. Eng. Abouzaghla made a presentation on steel making technology. Discussions after the presentation centred around the choice and selection of processes from one of the following optinns:

(i) Open hearth furnace process;

(ii) Pneumatic converter processes (air/oxygen blown);

(iii) Electric furnace processes.

20. The advantages and disadvantages of each of these processes were discussed in relation to the iron making technology employed. In the case of the pneumatic processes, it was pointed out that the LD type process is suitable only when liquid pig iron is used, therefore, this process is usually used in conjunction with a blast furnace. The Bessemer type process is an old type pneumatic process which uses air but in some cases oxygen may be injected. In most recent steel shops this process is however being phased out.

21. In the case of the electric arc furnace processes, a solid cold charge (scrap and sponge iron) can be used as input material. Therefore this process is ideal for sponge iron and scrap based steel making. In the discussions, the following conclusions were made:

(i) for many uses, the cost of basic Bessemer (Thomas) steel is higher than the cost of steels produced by other modern methods. The open hearth furnace requires a high capital investment in plant, high cost of refractories and a large input of labour for its operation. However its flexibility in the use of charge materials and adjustment of the melt is a great advantage;

(ii) the LD converters can be used in conjunction with blast furnace iron making;

(iii) electric-arc furnace process must be used in conjunction with the direct reduction processes and in cases where only scrap melting is envisaged;

(iv) in developing countries the Direct Reduction/Electric Furnace iron and steel making plant can be erected as an integrated installation or through the process of backward integration commencing with a re-rolling mill and scrap melting in an electric furnace. The capacity of such integrated mills may rise to 0.7 million tons giving bar, rod and section rolling facilities.

D. Discussion on pollution

22. This followed immediately after steel making discussions. It was pointed out that it is very difficult to solve pollution problems after the installation of the iron and steel plant. Therefore this problem must be adequately dealt with at the design stage. It was mentioned that the most important consideration in dealing with pollution problems was the choice of the right type of anti-pollution equipment. It is necessary to establish acceptable pollution standards at national levels in individual countries.

23. Some sources of pollution were mentioned among which were:

- the coke plant
- the sinter plant
- the steel plant
- the thermal power plant
- fluid effluents

24. To control pollution, baghouse filters, cyclone separators, electrostatic precipitators and both solid and liquid scrubbers are used. Water contaminants are removed through neutralization, sedimentation, flotation and concentration. However, care must be exercised in setting national pollution standards so that new plants are not immediately saddled with heavy investments to meet stringent pollution standards that may not be justified by local circumstances.

E. Preparation of iron ores and fuels

(a) Report of the proceedings of the session

25. Mr. Hadjiat in his presentation explained the resons for, and the technology of coke preparation. Mr. Ojobor made a presentation regarding gas preparation for the direct reduction process.

(b) Discussions

26. Discussions reflected the requirement to use a prepared burden as an input to the iron making process (whether blast furnace or direct reduction process). It was also pointed out that the main objectives for burden preparation are:

(i) improvement of physical characteristics such as: crushing strength, reducibility, permeability, etc.

(ii) improvement of chemical characteristics: especially basicity.

27. It was also pointed out that utilization of fine ore requires the sintering or pelletizing of the fine ore.

28. It was emphasized that many tests are required in order to establish the chemical and physical qualities of the ore and fuels so as to be ascertain the type of preparation required.

F. Ingot casting and rolling

(a) Report of the session

29. Eng. Ojobor delivered a paper on the ingot mould casting and continuous billet casting methods. This was followed by a discussion during which the Algerian and Egyptian experiences were examined.

30. The speaker went on to point out some new developments in the industry. There has been a marked improvement in casting speed in continuous casting machines which has had a tremendous effect on production. Improved cooling conditions have been introduced, resulting in greater reliability of the operations. The continuous casting machines have become fairly intricate in operation, a factor which necessitates would-be iron and steel producers to invest in thorough personnel training.

(b) Blooming mills

31. A presentation on role of blooming mills and their operation was made by Mr. Abouzaghla who gave an account of the Egyptian experience regarding their two steel plants in connection with the existing blooming mill.

(c) Finishing mills

32. Mr. Hadjiat delivered a paper on the rolling of flat products. From the Algerian experience it has also been brought to their experience that the complexity and high quality of equipment and instruments necessitates the setting up of a training centre for personnel in advance of commissioning a steel plant. The question of market growth trends was also raised. Careful analysis is, therefore, required before deciding on the product-mix though it is also known that long products would be cheaper and easier to produce since they can be made from ingots or billets from the continuous casting process.

(d) Long products

33. A paper was delivered by Mr. Mwango on the rolling of long products. From the Egyptian experience, it became clear that bars should be produced first because of the big demand for construction bars. This has got the advantage that we could make these in smaller plants, which could help the countries to acquire experience in the rolling of steel.

(e) Special alloy steels

34. A paper was delivered by Mr. Hadjiat on the production of special alloy steels. Following the discussions on the subject, it became clear that in Africa, the demand for these types of steel does not justify the investment. But if for some reason of strategic importance a country wants to produce special alloy steel, then a lot of research and highly skilled personnel would be needed. It was pointed out that in relation to this subject, a more profitable activity for African countries would be the setting up of industries to produce ferro-alloys for export from the abundant resources of the continent rather than exporting the raw materials to the developed countries.

G. Anxiliary facilities

35. A paper was submitted by Eng. Abouzaghla. The paper emphasized the critical role of power supply in assuring the reliability of production in a steel plant.

(a) Discussion

36. A necessary input of steel making is electric power. Power should be available, reliable and at reasonably low cost. For any steel making plant, a stand-by power supply would be an advantage and is in many cases a necessity.

(b) Water supply

37. A paper was submitted by Eng. Abouzaghla. Steel plants require a lot of water and therefore should have access to a good source of water. In some cases, a water treatment plant would be necessary to bring the raw water to the required quality. In such cases, a closed-system of water circulation in the plant would reduce water demand to just make-up water and thus reduce operating costs.

(c) Air supply and oxygen supply

38. A paper was delivered by Mr. Ojobor. During the discussion, it was seen that because of the large quantities and the multiplicity of users of compressed air in the steel works, careful optimization of the composition and disposition of compressed air equipment must be decided at the design stage. It was also agreed that in cases where oxygen could be readily available from outside sources, the steel complex may choose not to invest on an oxygen plant.

(d) Refractories

39. A paper was delivered by Mr. Ivanchenko. Types of refractories consumed by various units of the iron and steel plant were described.

Discussion

40. In planning a steel industry, we should also plan for a refractory production plant, if the raw materials are available. For the construction of an integrated steel plant the component cost of refractory products and their transportation is very high. The establishment of a large refractory plant in one country of the African subregion supplying the iron and steel and other industries in the subregion is a recommendable approach. Research on refractory materials is extensive and can be expensive, and so African countries may think of organizing research on a central basis. In this connexion, UNIDO can be of great assistance in establishing such regional/subregional centres.

H. Materials handling and transportation

41. A presentation was made by Eng. Ojobor on the transporation and handling of the following items:

(a) Iron ore;

(b) Fuels including coal;

(c) Limestone, dolomite, refractory clay and ferro-alloys.

42. It was indicated that the cost of transporting materials generally has a significant influence on the operating cost of an iron and steel work. Thus it is usual to find steel works sited in an optimum position in relation to its sources of major raw materials. However, it was pointed out that improved transportation methods are reducing the impact of transportation costs, thus allowing steel plants importing even a substantial protion of the raw materials to remain competitive.

(a) Transportation of iron ore from sources to plant site

43. The transportation of iron ore from the mines to the iron and steel works by railway was reviewed. Iron ore is carried to the plant in tipler-type rail wagons, or in self-discharging wagons. Self-discharging type wagons have proved more economical in operation than tipler-type wagons because of the saving in operation time and reduction in cost of maintenance. The tipler equipment requires frequent maintenance and can lead to "bunching up" at the discharging station.

44. Ocean liners and/or barges are also used to supply iron ore to steel works located at or close to sea ports or river ports. In cases where the plant site is not so close, the port has to be linked up by rail connexion. The problem here however is the cost of the intermediate storage between source and plant and the multiple handling involved.

45. Ocean liners for iron ore use bulk metal carriers and are economical. At port they are off-loaded by bulk ship unloaders using grab-buckets and despatched through conveyor systems to the storage. Barges can be used on river routes, which economically use metal containers as ore carriers.

(b) Transportation of coal, limestone, refractory clay etc.

46. The transportation of coal from mines to the works was also reviewed. Rail transportation and sea/river transport situations are similar to the iron ore. For transporting other materials such as refractory clay, dolomite, limestone etc. it was indicated that rail and water transportation invariably are cheaper means. However, it is not always that the sources of these materials make such modes feasible, especially in developing countries. In any case, because of the relatively smaller quantities of these materials, road transport by trucks can also be economical.

(c) Materials handling of ore, fuel and fluxes within the works

47. Conveyor belt transfer of ore, coal, and fluxes from the discharge station of the railway or the port of discharge by ship/barges was examined. Also reviewed were the stacking and reclaiming activities at the storage yard. The merits of combined stacker/reclaimer were reviewed. It was indicated that equipment design for the stacking, re-claiming and blending jobs take into consideration the following factors:

- quantity of materials to be handled;
- number and dimensions of storage piles required;
- number of machines and the engagement time, etc.

48. The handling of refractory clay, limestone, dolomite was also considered. The methods will depend on the quantities involved and the locations of the user shops. It is quite usual to carry many of these items in dumper trucks to the user shops. Conveyors are also in use, although lumpy materials like uncrushed limestone or very humid refractory clay are not quite suited to conveyors.

49. Pneumatic transfer of materials was also applicable in many instances, as for example ground ore fines, ground lime and coke breeze. Truck mounted silos are also used to transfer ground lime to the steel making shop or pellet sinter plants where it is transferred to the storage bins of the shop pneumatically.

(d) Discussions

50. The experience of the Helwan Steel Plant in Egypt was related. Their iron ore is coming by rail from a mine about 300 kms. away. One problem they normally have is the blocking of the rail route by sand deposits after sand-storms. This disrupts the iron ore supply.

51. Also at Helwan it was found in practice that one tipler equipment was just not enough, even though from the quantity of material to be handled calculations showed that it should be. Helwan is now investing in a second unit.

52. The supply of fuels like natural gas and liquid petroleum fuel was also reviewed, especially for many African countries without indigenous sources. Pipeline supply of natural gas has proved economical although liquid natural gas can also be supplied in tanks. The economics of available alternatives should be examined in each case. Another mode of natural gas transport discussed involved the reforming of the natural gas to carbon monoxide and hydrogen at the source-end, piping them separately and recombining at the receiving end to obtain methane. This was said to be aimed at obviating the risk of hydrate formation along gas pipelines. It was obvious, however, that this situation is not applicable in most circumstances.

I. Materials handling

(a) Scrap and slag

53. These could be transported by rail and truck. Inside the plant, transportation of scrap in special scrap boxes should be by truck cranes and rails. Scrap handling is problematic because of the abrasiveness of the material. Careful planning of supply should be made from the beginning.

54. There was a strong feeling that the supply of scrap should be left to specialized scrap companies because scrap handling and processing required good know-how and special equipment.

(b) Finished products

55. There is a need for adequately sized storage yards from which products could be despatched by road, rail or water to the consumers. The size should take into consideration the fact that despatch of finished products may not take place according to the best desirable rate.

56. In planning the storage yard, one should take into account the short-falls of transportation, as this will surely effect the size of the storage yard. A provision should be made in the storage yard for providing cover for some of the steel products. Some of the special steel products cannot be transported in the ordinary railway wagons; this may necessitate a redesign of these wagons, an exercise which can prove very expensive.

57. Rail and water transportation of finished products are economical. Truck transport usually is more expensive and requires heavy maintenance. In any event, adequate transportation studies should be carried out at the planning stage to determine the best combination of despatch methods of finished products.

J. Maintenance facilities

58. A presentation was made by Mr. Mitra who reviewed the machine tools and equipment required in each of these shops which will enable them carry out, as much as possible, the expected maintenance demands on them in casting, machining, gear-cutting, fabrication etc. In many instances, universal machines were preferable in view of the very few specialized jobs that are required in steel plant maintenance works.

59. It was agreed in principle that the subcontracting of major jobs of a specialized nature to specialised companies should be encouraged in order to facilitate the growth of service industries. However, where such specialist groups do not exist, as is the case in many African countries, steel plants must invest in the establishment of the above shops in order to ensure repairs and the manufacture of necessary spare parts for the smooth running of the plant.

(a) Operating maintenance and periodic overhaul

60. A presentation on maintenance schemes covering the above was made by Mr. Abouzaghla. He indicated plant units requiring overhaul at long intervals such as the blast furnace and the coke-oven batteries.

61. Discussions that followed pointed out that in steel plants maintenance personnel accounted for about 50 per cent of the labour force. Emphasis was laid on the need for advance and adequate training of the personnel for maintenance since efficient maintenance was critical to the efficient operation of the plant. A sound maintenance philosophy and practicable schemes must be installed early in the life of the plant.

K. Quality control

62. Any steel plant should deliver its products according to the specifications of the customers and products of bad quality are rejected. Consequently, all steel plants set up a quality control department to check that the delivered products are according to the specification of the customers.

63. Every ton rejected by the quality control department corresponds to a financial loss, particularly when the reject is a finished product. In order to minimize rejects, the quality control should have its control at the different levels of production to ensure that any poor quality is not carried forward to subsequent stages. The control starts at the reception of the ore, coke, ferro-alloys, etc. and ends with the finished products.

64. However, the effect of quality control will be very limited if no effort is made to study the causes of defects.

65. Two functions are associated with quality:

- quality control;
- metallurgical research.

66. Generally the quality control department checks the following:

- dimensions;
- defects (internal and external);
- chemical analysis;
- mechanical properties;
- metallographic structure.

Different techniques are used to effect the control:

- visual checks of defects;
- automatic checks with techniques like X-ray, gamma rays;
- defect checks by ultrasonic method;
- defect checks with dye penetrators.

L. By-products of steel plants

(a) Coke-oven by-product

67. A presentation was made by Mr. Ivanchenko who outlined the various substances that can be profitably recovered as by-products from the coking process of coal. These include crude tar, crude benzole, ammonia, coke-oven, gas, etc. Tar can be processed and used as fuel within the steel plant, for example in the thermal power plant. It can also be injected into the blast furnace to reduce coke consumption. Crude benzole can also be rectified to produce pure benzol and toluene which are used, among others, as a petrol additive and as a chemical solvent respectively.

68. Coke-oven gas is a premium fuel, with a calorific value of 4000 KCal/NM^3 and is used extensively for heating purposes inside the plant. Coke oven gas can also be used as domestic gas.

69. Ammonia gas, obtainable from the coking process is used for the production of ammonium sulphate fertilizer.

70. High quality steam can also be raised from the quenching of hot coke from the coke-ovens, using the technique of dry-quenching. This process will lead to greater total energy recovery and less air pollution.

(b) Discussions

71. Local circumstances which would make an extensive by-product recovery plant desirable were reviewed. It was generally agreed that where alternative cheap sources of some of the products are available in the country, especially through

the petrochemical industries there may be no justification for heavy investment to recover small quantities of some of the products. It was also the feeling that the use of dry-quenching process as against wet-quenching should be justified from investment studies. Dry-quenching facilities are expensive compared to wet-quenching. In many cases, within a steel plant, the available fuel sources of blast furnace gas, coke-oven gas, natural gas and liquid fuel may prove a more economical way of raising steam than through the dry quenching process.

(c) By-product of the tonage oxygen plant

72. The main by-product of the tonage oxygen plant is nitrogen which finds extensive use in steel plants especially where an inert atmosphere is desired. Nitrogen is thus used as seal-gas; as cooling medium where re-oxidation is to be avoided; as the inert atomosphere in annealing furnaces for cold-rolled coils, etc.

(d) Slag

73. Slag is produced from two resources:

(i) slag from the blast furnace;

(ii) slag from the steel making plant.

(e) Blast furnace slag

74. The slag from the blast furnace is usually poured into slag ladles and carried by railway to the granulating plant where the granulation process takes place. It is then stored and transported to the customers (mostly cement plants). In other cases slag can flow directly for the blast furnace to a granulation plant. The slag also is used to produce pumice which can be used for manufacturing bricks or slag wool.

(f) Converter slag

75. (i) slag from the Thomas steel plant which can be used, after crushing, as fertilizer;

(ii) slag can be sorted in different classes and used as a cooling additive.

CHAPTER III

DISCUSSIONS ON METALWORKING TECHNOLOGIES FOR ENGINEERING INDUSTRIES

Casting

76. Mr. A.K. Mitra made a presentation on this topic in which he described the processes involved in the casting of engineering components and the different operations involved in operating a foundry.

77. The process of casting involves melting and pouring of metal into prepared moulds in which the metal is left to cool and solidify. To obtain good castings, it is important to ensure that the liquid metal solidifies under carefully controlled conditions in order to obtain compnents free of defects.

78. The operation of a foundry involves several activities which include:

(i) preparation of design/drawings of components to be casted;

(ii) pattern making;

(iii) preparation of moulds and cores;

(iv) melting and pouring the metal;

(v) knockout and fettling of the casting;

(vi) inspection.

(a) Drawings

79. It is important to ensure that correct drawings are available before commencement of pattern making. These may be prepared by the design personnel or supplied by customers. Samples of items to be manufactured can act as a guide if available and sometimes are used as patterns if not worn in dimensions.

(b) Pattern making

80. This is the backbone of any foundry operation. The shop has to be equipped with the right tools and materials and experienced personnel. Patterns are usually prepared in good quality seasoned wood, but sometimes plastic or even metal may be used. After use, patterns are stored away in case they are required for future use.

(c) Mould and core preparation

81. Good quality sand has to be used for this purpose and reclaiming for future use is necessary to minimise costs. After preparation, drying and backing of the mould follow prior to pouring.

(d) Melting

82. The melting of the metal takes place in a furnace. The furnaces generally used in foundries may be of different types and include:

(i) cupolas fired by coke;

(ii) oil-fired furnaces;

(iii) electric induction furnaces;

(iv) electric arc furnaces.

83. Among these furnaces, the cupola fired with coke is the most commonly used.

(e) Knockout and fettling

84. When metal has solidified in the mould, the latter is broken up and the metal casting is extracted. The rough casting is then cleaned up by various processes which involve cutting off the risers, grinding and sand-or shot-blasting etc.

85. Good training programmes should be instituted to provide the highly skilled personnel required to run foundry operations, particularly in pattern-making and moulding. The requirements of various foundry personnel were elaborated upon by the author.

Discussion

86. Dr. A. Banjo drew attention to other moulding systems which are available using silicate and resin-binders for the sand which does not requires firing or baking of the moulds. Large castings are usually left for some weeks or even months to mature before machining. This is done to allow time for the internal stress to even out. In other cases, the castings may be subjected to stress-relieving in an annealing furnace.

87. A delegate enquired on how the skilled manpower required for the development of casting industries in the subregion could be trained. It was explained that training could be carried out in craft training schools. However, the more satisfactory method would be through apprenticeship schemes within existing foundries within and outside the African region.

88. A delegate also raised the question whether other materials can be used for patternmaking. It was explained that wood is normally used for the making of patterns because of easy creation of shapes. However patterns made of metal are sometimes used when the quantity of pieces to be produced is very high. The kinds of wood generally used are mahogany, teak, pine etc.

Hot forming

89. The paper was presented by Mr. A.K. Mitra. The purpose of hot forming is to shape the metal into a desired form and size in the hot condition by application of external force. In order to achieve this objective, the metal is preheated to a pre-determined temperature at which it is relatively soft and requires less force to deform the metal to the required shape.

90. There are two major hot forging techniques, namely,

(a) Free-form forging;

(b) Die forging.

91. Free-form forging is used at blacksmith level where the metal is not confined in a die but the form is generated by successive blows while the hot piece of metal is manipulated into different positions. Sometimes templates are used to guide the deformation of the metal whilst it is being struck.

92. In die-forging, special shaped moulds called dies are used to partially or completely confine the hot metal so that it flows into the shape provided within the die. The die may be an open die when the metal is only partially confined, or a closed die in which case the metal will be entirely enclosed by the die.

93. The force used to produce the deformation of the hot metal may be applied in different ways, e.g.

(i) as an impact force: in this case the force is provided by the kinetic energy of a hammer which is suddenly brought to a stop on the hot metal. The energy may be provided by a falling weight or a flywheel;

(ii) as a steady pressure produced by hydraulic or pneumatic means;

(iii) combination of impact force and steady pressure: this is usually obtained with mechanical toggle presses used in certain kinds of closed die forging.

Types of forging machines

94. The following are the machines generally used for forging operation:

(i) power striker: this is a small hammer similar to the blacksmith's hammer driven by a pedal or an electric motor which is used in free from forging on a blacksmith's anvil;

(ii) pneumatic or steam hammer;

(iii) drop forging presses;

(iv) mechanical forging press: types include friction flywheel presses, crank presses and toggle presses.

Die technology

95. The choice of material for the die is important to ensure sustaining of heat, pressure or force. Various tools and machines are used in die preparation including die sinking machines. Dies are usually in two parts. Sometimes various dies are used in stages to obtain the final form. In die design, the weight of the billet is important. The material to be die forged should be the right size and weight to reduce excess flash material which will ooze out between the dies.

Discussion

96. The development of forging facilities integrated with die-making and heat treatment is neglected in African countries and it is imperative that this important sector of engineering industry is given the important attention that it deserves.

97. As shortage of skilled manpower is a major obstacle, efforts must be directed towards ensuring that training programmes are organized in technical institutions and on-the-job after leaving educational institutions. It is important to offer the right level of remuneration and other incentives to ensure that trained and qualified personnel are retained.

Cold forming

98. Dr. A. Banjo gave a presentation on this subject.Cold-forming is one of the latest technologies in metal shaping by which ductile metals within a specified range of physical and chemical properties are formed into pre-determined shapes while in the cold condition.

99. Success in shaping metal by the cold-forming process is highly dependent on the size and composition of the products and the choice of raw materials. Cold forming requires the application of larger forces when compared with hot forming operations. Hence, its application is limited to the manufacture of:

- small components required in large quantities;
- for parts which need to be tough and resilient;
- for components in which high precision form is required.

100. The best known range of products that are manufactured by cold forming processes are fasteners; bolts, nuts, rivets and woodscrews. Steel balls for ball bearings and nails are some of the products that are also produced by cold forming processes today.

101. Since the introduction of this technology in engineering industries, a wide variety of cold forming operations are quite well developed today. Among the various types of cold forming operations the most commonly used are:

- upsetting (cold heading)
- extrusion

- metal spinning;
- thread rolling;
- wire and tube drawing.

102. Among the above types of cold forming operations upsetting is the most commonly used. Today, different types of nails, screws and bolts are manufactured using upsetting operations.

103. Extrusion is normally used in shaping non-ferrous metals like copper and aluminium into different forms such as tubes, bars, window and door frame sections.

104. Wire-drawing is employed in many engineering industries in the manufacture of different sizes of wire. Tube drawing is employed in the production of high quality seamless tube.

105. Mr. A.K. Mitra presented the metal spinning process which is frequently employed in shaping sheet metal and is found to possess the following main advantages over other types of cold forming operations. The major ones are:

- the possibilities of using less skilled workers;
- it is less capital intensive than other cold forming operations;
- it is easier to obtain uniform distribution of materials than with sheet metal pressing;
- it requires simple formers and eleminates high cost of dies.

106. The spinning process is being increasingly used in the manufacture of kitchen-wares especially cooking pots and containers. Due to the advantages of this operation, some of which are outlined above, and the large demand for kitchenware in many countries, it was recommended that metal spinning operation could easily be developed in many African countries.

107. The need to train the manpower required for cold forming operations should be seen as part of the general manpower development requirements for engineering industries in Africa.

Discussions

108. During the discussions, some of the cold forming operations presented were further elaborated by different delegates and consultants.

109. A delegate enquired about the difference between extrusion and drawing operations. It was explained that in extrusion, the metal was pushed through a die by suitable pressure. In wire or tube drawing, the metal was pulled through the die.

Fabrication

110. Mr. S.K. Tamele gave a presentation on this subject. Metal fabrication is the process by which sheet metal, plates, tubes, etc. are cut to required forms and joined together by welding, rivetting or other type of fastening method to produce larger and more complicated components or structures.

111. In all fabrication works, the sequence of operations could be summarized as follows:

- prepration of component drawings and designs;
- selection of appropriate materials;
- inspection and testing of the marked selected materials either by physical examination or by metallurgical tests;
- cutting of the pieces to be joined together;
- assembly and/or joining operations;
- stress relieving (if required and depending on the assembly and/or joining process, complexity of the fabrication work, etc.);
- inspection and testing of the assembled and/or joined parts;
- cleaning and heat treatment if required;
- machining to final shape and dimensions;
- painting (both for protection and appearance).

112. All the above operations have to be carried out with care and require experienced and skilled workers. Special attention has to be given to the preparation of component drawings and selection of materials and the assembly operations.

113. It is to be noted that the development of appropriate component drawings calls for the creation of good design offices and the employment of experienced and skilled draughtsmen.

114. Preparation of the materials is usually achieved by the use of standard and appropriate machines such as guillotine machines, bending machines, presses, saws, etc., while the joining of the cut pieces materials is carried out by welding, rivetting, brazing as well as by the use of bolts and nuts.

115. Today, many types of welding such as gas welding, arc welding, stud-welding, CO_2 welding, etc., are widely used in joining metals. The successful joining of metal parts and sectinns is mainly dependent on the selection and application of welding electronics. The proper selection and application of welding electronics is often neglected in welding operations carried out in workshops in African countries.

Discussion

116. It is important to develop the skills of the welding technician and the craftsman for metal fabrication in the African countries. Proper training and suitable remuneration schemes should be devised if fabrication works are to flourish in these countries.

117. The importance of maintaining adequate stocks of raw materials for the preparation of cut components was emphasized. Close control of the quality of such raw materials is necessary to ensure satisfactory output of fabricated pieces.

Metal-cutting

118. The papers were presented by Dr. A. Banjo and Mr. A.K. Mitra. Metal-cutting involves the shaping of metal by cutting off unwanted portions of the material to leave behind desired surfaces and shapes of the required dimensions. Metal-cutting can be carried out by the following methods:

- by linear cutting processes;
- by rotating cutting processes;
- by unconventional cutting processes.

119. In linear cutting of metals, different types of tools are used to generate required surfaces and shapes either by the linear movement of the work piece, keeping the tools stationary, or vice-versa. This principle is used in shaping and planning machines for the production of plane surfaces.

120. In rotating metal-cutting processes, metal-cutting is achieved by rotating either the workpiece while the cutting tools are kept stationary, or vice-versa, or both. Rotating metal-cutting processes constitute the bulk of the metal-cutting operations in industry.

121. The cutting of metals in linear and rotating cutting processes is achieved by the use of tools made out of hard metal alloys (e.g. high speed steels)or from hard non-metallic materials (e.g. tungsten carbide).

122. As the rotating cutting processes are widely used for cutting metals with varying physical and metallurgical characteristics and for different applications, there is a wide variety of machine tools developed for different purposes. Similarly, there is a wide variety in the cutting tools employed. Therefore, the selection of the appropriate machine tool and cutting tools for a particular application requires a thorough knowledge of metal-cutting and the capabilities of different machines. Machine tools for rotating cutting processes include lathes, drilling machines, milling machines, boring machines, grinding machines and so forth.

123. The manufacture of cutting tools required for metal-cutting can be associated with an existing engineering production works or set up as a separate entity. The successful production of cutting tools calls for the employment of skilled workers with extensive experience and training in precision machining as well as the special skills of toolmaking.

124. Unconventional metal removal technology is a recent development in engineering industries. The technology is used when the metal is too hard to machine or when intricate shapes are required which cannot wotherwise be conveniently generated by conventional tools. The most common technology used in unconventional metal removal is the spark erosion technique.

125. The success of metal cutting by the unconventional metal removal processes depends to a great degree on the skills of the craftsman using them. Generally, the manpower required for this operation has to be especially trained from amongst craftsmen already qualified as machinists.

Discussion

126. The advantages and disadvantages of two different appraoches of establishing metal-cutting workshops (units integrated with industries and units established as separate entities) were discussed. Furthermore, it was decided that every engineering industry must have a cutting tool maintenance facility in the form of a toolroom.

127. Multinational co-operation in the setting up of small tools manufacturing industries which require large capital and large markets was discussed.

128. The shortage of skilled manpower required in many metal-cutting establishments was raised. One of the reasons for this problem is said to be the poor remuneration policies of many engineering establishments in the subregion.

129. A delegate asked for the advice of the consultants on how to go about selecting machine tools for a production workshop and some guidelines for this purpose were provided by one of the consultants.

Toolmaking and heat treatment

130. The paper was presented by Mr. A.K. Mitra. Toolmaking is considered as one of the important services for the promotion of engineering production in any country. The development of toolmaking capabilities provides the base for the supply of the various types of tools required in all types of engineering industries, including casting, forging, fabricating and machining in industries and workshops.

131. Although some engineering industries are in existence in many countries of the subregion, the establishment of well-equipped toolrooms and toolmaking facilities are not yet given proper consideration. None of the subregional countries have toolrooms of adequate standard.

132. The presentation dealt with the following topics:

- functions of toolrooms;
- structure of toolrooms;
- types of heat treatment applied in toolmaking;
- equipment and machinery required for toolmaking;
- common services in toolmaking shops;
- design of toolrooms.

133. The presentation also eleaborated on:

- the suitability of induction hardening for small toolmaking shops;
- the need to develop the highly skilled manpower required for toolmaking. A detailed list of different grades of toolmakers was presented and discussed;

- the need for providing air conditioned rooms for special machines and equipment such as jig boring machines, cylindrical grinding machines and die sinking machines as well as for special purpose instruments;
- the need to separate toolrooms from general machine shops;
- the need for applying appropriate cleaning methods such as vacuum cleaning in toolroom;

134. The also dealt with the heat treatment processes. There are three important heat treatment application in general engineering activity e.g.

- annealing ;
- through hardening and tempering;
- case hardening;
- stress relieving.

135. Annealing involves heating the metal component up to a temperature which varies according to the metal or alloy, but which is sufficiently high to induce a softening in the metal as a result of changes in its crystal structure. For steels, this temperature is of the order of 750°C. The metal is then allowed to cool slowly.

136. Through-hardening is carried out on high carbon and alloy steels to obtain hardness in order to improve the strength of the metal. Through hardening can be effected with steels by heating the metal up to a temperature of 900° C to 1000° C and subsequent quenching in water or oil. Through-hardening is often followed by tempering the object to give definite hardeness. In tempering, the steel is raised to about 200° C and allowed to cool in air or in controlled atmosphere.

137. Stress relieving is an annealing treatment given to fabricated or cast components, especially large items, to remove internal stresses that may have been caused by uneven cooling of the metal. During stress relieving heat treatment, the component is usually left to cool down within the furnace.

138. Case-hardening is used to create a hard surface on steel in order to achieve greater wear resistance properties, while leaving the inside of the metal relatively ductile and tough. It is carried out by covering the metal object with charcoal and special compounds and soaking it for several hours in a sealed box within a furnace at 850 to 900°C. This allows the carbon to penetrate inside the surface upto a few hundreths of a millimeter. The component is then taken out from the box and quenched in water or oil. Case hardened surfaces can achieve hardness up to 64C Rockwell. The material used is low carbon steel. Case-hardening and through-hardening are used extensively in the manufacture of engineering components and tools.

Discussion

139. During the discussions, participants exchanged information on toolmaking and toolroom facilities in their different countries. A delegate proposed the idea of estalbishing a central toolroom within a country for the purpose of:

- supplying tools for other industries;
- procuring of critical tools and toolmaking material, and supplying them to smaller toolmaking shops;

140. ECA/UNIDO representatives were requested to develop prototype layouts of toolrooms, showing proper arrangement of different facilities and equipments and to distribute these to member States as soon as possible. Assistance was also requested on preparing estimates for the total investment of typical toolrooms, with breakdown of costs of machinery, equipment and buildings.

141. African countries are strongly advised to provide adequate maintenance facilities for the tools used in their various industries.

142. Heat treatment is the most neglected area in the machine shop activities in African countries. Greater emphasis should be given to improve the heat treatment facilities in engineering industries.

143. Toolroom skilled operatives require to be paid higher wages than the other craftsmen in machine shops.

Metrology

144. Dr. A. Banjo made a presentation on this subject. He drew attention to the need within the African region to develop metrology which is the science of measurements. Measuring instruments and devices are employed constantly in industry to determine the geometry, the sizes and the dimensional accuracy of production of engineering products.

145. The various measuring instruments and their application in measurement of products were illustrated. He gave examples of the levels of accuracy that can be obtained in different production operations, e.g. in iron casting made in sand moulds, components can be produced to an accuracy within 3 mm whereas a reinforced concrete structure can be cast only with an accuracy of about 10 mm. In producing machine parts the range of accuracy required could vary between 0.4 - 0.02 mm for ordinary work. He explained the need for well equipped central metrological laboratories where services could be provided to industries to set and reset their measuring instruments and gauges.

146. Within each manufacturing workshop, many different types of measuring instruments and devices are employed such as steel rules accurate to 0.5 mm, vernier calliper gauges and micrometer gauges accurate to 0.05 mm. Special checking gauges needed in mass production control of dimensions also are used with accuracies of the same order or higher. All these gauges require to be set and re-calibrated from time to time on regular maintenance programme. It was therefore necessary to provide in each large engineering workshop a metrology laboratory or a measurements room to provide this service.

147. Such a metrology laboratory would possess secondary reference standards (e.g. slip gauges) and comparators to enable them calibrate and adjust the measuring tools used in normal production operations. The need for the control of temperature and humidity in a metrology laboratory was explained. The presentation dealt with the following topics:

- concepts in taking measurements;
- the types of measuring instruments;
- ordinary hand measuring instruments;
- special measuring instruments;
- metrology laboratory operations and some major types of instruments;
- primary reference standards;
- secondary reference standards;
- the concepts of and some basic types of fits and allowable tolerances (limits).

Discussion

148. During the discussion, the accuracy levels that have to be maintained in the manufacture of different engineering products were further elaborated by Dr. Banjo, Mr. Mitra and other delegates.

149. An exchange of ideas on how measurements are taken and what levels of precision are required in the manufacture of engineering products in countries like Zimbabwe were also discussed.

150. The two major functions of metrology laboratories namely providing of a place for checking measuring instruments and the production of measuring instruments and gauges were further elaborated.

Metal coating

151. Presentations were made on this subject by Mr. H. Hadjiat and Mr. A.K. Mitra. The speakers highlighted the needs for metal coating as a means to protect the metal surface by covering with another metal namely zinc, tin, copper, aluminium, nickel, chrome, etc. in order to protect the surface against corrosion and sometimes to obtain a decorative effect.

152. The two widely used processes in metal coating are:

- hot dipping;
- electrolysis process;

153. Electrolysis enables the coating of metals uniformly to pre-determined thickness at a lower loss of materials.

154. The presentation outlined the different aspects of the following types of metal coating:

- galvanising;
- tin plating;
- nickel-chrome plating;
- copper plating;
- phosphating;
- annodizing;
- painting, and
- plastic dipping.

155. For all the above mentioned types of coatings, the purpose, procedures and applications were briefly outlined.

Discussion

156. Chrome plating was identified as a very widely required service and the need for establishing a central chrome-plating facility in each country was discussed.

157. The participants noted the limited activities and capabilities for metal coating in the subregion.

158. A delegate pointed out that in his country they were confronted with several standards on tin plating for food containers. There is an urgent need for standardization on this subject.

159. It was observed that nickel and chrome plating technology and their applications were not developed in the East/South African subregion. It was suggested by another delegate that electroplating industries should be treated as a common service facility to the industries.

CHAPTER IV

DISCUSSION ON MANPOWER DEVELOPMENT FOR METAL AND ENGINEERING INDUSTRIES

Summary of presentation

160. The paper was presented by Dr. M.K. Khanijo. The importance of manpower planning is being increasingly realized in developing countries as it is felt that the national effort in the area of economic development is being hampered by the non-availability of adequate skills. Essentially, manpower planning involves forecasting of future requirements, development of skills through education and training, and utilization of skills in an optimum manner.

161. Forecasting is done at national, industry and enterprise level. Forecasts may be long-term, medium-term and short-term, depending on the objectives of the forecast and the manner in which the results are to be used. Forecasts in developing countries are conditional forecasts based on assumptions regarding the rate of growth, changes in technology, etc. The oldest method of forecasting is the extrapolation of time series data. Other methods in used at the national and industry level are the direct enquiry survey and the use of labour co-efficients. At the enterprise level, work study provides the most accurate forecasts.

162. Development of skills in the formal system starts at the school level and ends at the level of industrial training centres, polytechnics/colleges of technology, and universities for the skilled worker, technician and engineer categories, respectively. The programmes can be discipline/trade oriented or industry/function oriented. It is possible to supplement the skill development efforts by the non-formal system. However, at the worker level, and important source of skills is the unorganized sector where skills are acquired without going through organized programmes. To develop the skills further as required for work in the industry, different kinds of industrial training programmes are developed. Training could be pre-employment, inducation level or re-training. Adequate institutational facilities as well as teachers/trainers need to be provided to meet the targets in terms of quality as well as quantity. Training could be organized within the company, in other companies, in specialized institutions, or overseas.

163. Enterprise level forecasts are made to plan the recruitment and training schedules. They also aim at job analysis, taking into account the changes in the work organization and the demands of the processes and equipment in terms of complexity, speed, performance and cost of machinery as well as materials. Job specifications are reviewed from time to time and better skill matching attempted using internal as well as external sources. Utilization also aims at appropriate personnel policies in terms of, inter alia, salaries and wages, performance appraisal and career planning, identification of training needs, and motivation and job satisfactinn of employees.

Determination of manpower requirements

164. Developing countries have adopted planning as an instrument of economic and social development. In their situation, forecasting on the basis of output, investment or value added could provide useful data for funds allocation for education and training facilities. More detailed forecasts for the purpose of planning education and training programmes require more detailed exercises involving collection of a large amount of data.

165. Direct enquiry method has the advantage of presenting the actual needs of organizations as assessed by them on the basis of their production programmes, technology, product mix, size and so forth. Data obtained is the latest and requires little processing. However, the method has two major disadvantages. First, response is often poor and therefore, requires blowing up of results. Secondly, enterprises prepare only short-term forecasts, if at all, except in the case of very large organizations which require a long period for setting up or expansion. Also, organisations not yet set up would be excluded from consideration.

166. Surveys of existing organizations for the evaluation of appropriate relationship between manpower and economic parameters in different sectors and industries could be more useful for long-term forecasts. Such surveys can be designed if the industry has already a large number of establishments and their preliminary data to enable drawing of representative samples is available.

167. It would, therefore, be seen that a country could adapt the direct enquiry method or the labour coefficient method or a combination of the two depending upon the situation. For iron and steel plants whose number in any developing country in Africa is small at best and where establishment or expansion is a discontinuous function, direct enquiry method will be more useful. This is also true of engineering industries in a country if the base is not sufficiently wide, or if the units being set up are very much larger than or differnt from the existing units. In countries where the engineering industries is fairly well developed, labour coefficient method can be used to advantage.

168. It may be noted that the greater the refinement aimed at in forecasting, the more eleaborate is the data required for the prupose. Ultimately, the accuracy of the forecast is dependent upon the comprehensiveness of the data and the speed and accuracy with which it is collected and processed.

159. Estimates of present stock and anticipated supply also are required. The former will provide attrition or replacement requirements for deaths and retirements on the basis of age profiles. The latter are evaluated from intake data of educational training institutions and wastage rates. In some countries, international migration also needs to be assessed. Refinements in the estimates could incorporate such factors as occupational and educational substitution. Greater accuracy can be achieved if forecasts are prepared at a considerable degree of disaggregation of industrial activities. However, this requires complex survey design, elaborate data collection and considerable inputs in terms of time, manpower resources and funds.

Strategies for training

170. Processes of skill acquisition are facilitated by the provision of appropriate preparatory education in terms of level of education as well as contents. Practices vary in African countries regarding the age of entry into trade training. However, keeping in view the conflicting requirements of as high a level of general education as possible and as early an entry into trade training as possible, it would be reasonable to commence trade training at the age of 14-16 years. Entry into polytechnics and universities has to be at a later stage at the end of senior secondary level. To provide a better orientation for the development of industrial skills, it would be useful to incorporate greater exposure to science and technology in the school curriculum by vocationalizing education at the secondary level. The objective would be to develop an appreciation of the application of scientific principles in simple industrial processes and products and to inculcate the dignity of labour. This would also enable the students to make a choice of a creer on the basis of inclination and aptitude at a later stage.

171. Technical courses, whether at the level of industrial training centres, polytechnics or universities, need to be geared to meet the needs of the industry in terms of the broad based knowledge of scientific principles and their application in problem solving. They need to be reviewed from time to time and improved upon through curriculum development. Narrow specializations are to be avoided and a certain degree of versatility and flexibility developed to meet the demands of jobs in the developing countries. An important aspect of technical education is improvement in the quality and remuneration of teachers. This can be achieved by providing adquate facilities for teacher training for industrial training centres, short-term quality improvement programmes for teachers of all levels of institutions, and encouragement of research activities for teachers in the universities. Another issue which needs serious consideration is the inclusion of industrial training in the formal programmes. In this context, it may be stated that it is not only necessary to provide industrial training to students enrolled at the institutions, it is also necessary to provide institutional facilities to workers employed in the industry.

172. Students coming out of educational institutions need training in industrial skills to enable them to perform at an acceptable level of proficiency in the industry. Large organizations would do well to organize their own institution level programmes, to cater to the needs of organizations which cannot support their own training programmes, facilities of larger organizations may be utilized for continuing education under government schemes funded by special arrangement.

173. No amount of training in the educational institutions or at the induction level can equip a person for the entire working career. At certain stages during the working life, need for re-training is felt for updating of skills, upgrading of skills and enlargement of skills. For higher level personnel, such training would include apart from advanced knowledge on materials, equipments and methods, development of managerial skills.

174. To make the training strategies meaningful and effective, active co-operation of the industries is essential. This co-operation could be in the form of:

- participation in curriculum development;
- provision of facilities for industrial training;
- grant of stipends for industrial training;
- institution of scholarships and awards for meritorious performance;
- making research grants for programmes of interest to the industry;
- encouraging consultancy work by the higher level institutions on specific problems faced by the industry, and
- exchange of teachers and experts between the institutions and industries.

Planning and programming of training

175. A necessary pre-requisite for planning of training is the preparation of forecasts. For the pruposes of training planning, forecasting may be done on the basis of macro data or productivity norms duly corrected according to local conditions of level of skills, degree of automation and support facilities. Such forecasts may be used for the allocation of funds and the planning of institutional facilities. In the second stage, short- and medium-term forecasts are prepared using more accurate techniques to decide the actual number of trainees required for each discipline or trade for all the levels of training. A major handicap in African countries has been the inability to develop adequate institutional facilities which, in turn, is due mainly to the non-availability of long-term perspective forecasts. A slight surplus(rather than a shortage) of technical manpower may be aimed at.

176. Planning of training facilities has to cover such aspects as:

- organizational arrangements, administrative as well as academic;
- funding arrangements;
- land, buildings and infrastructural facilities;
- nature, contents and capacity of training;
- laboratories, workshops, library and other technical facilities such as computers;
- staff-teaching, supportive technical and general services;
- hotels for trainees and housing for employees;
- other facilities e.g. recreational, medical, transport, etc.

177. Training institutions often have a low utilization of facilities in terms of time. This is more so in the case of highly specialized equipment which also happens to be expensive. Owing to the constraints of funds as well as inability to plan and develop facilities in time, it would be useful to consider improving the utilization of existing facilities. This can be done in the form of:

- parallel programmes with staggered timings running into the evenings;
- evening courses especially for those in employment, and
- short-term courses during vacation.

178. Likewise, the utilization of equipment in large workshops and factories may be improved by interleaving work programmes and training.

179. Planning and programming of training often suffers due to lack of an adequate mechanism for co-ordinating the work of various agencies involved in the training activities. It would be worthwhile to evolve a joint consultative and advisory forum comprising representatives from ministries of education, manpower, labour, industry and other ministries whose programmes utilize large amounts of industrial manpower, and other organizations such as:

- associations of different industries;
- professional societies;
- curriculum formulating and examining agencies;
- consulting, design, research and standards organizations;
- training institutions.

180. Such a body as suggested above could be charged with the responsibility of making recommendations regarding the quantum of training facilities required at different levels, curriculum development, equipment and other technical facilities in individual institutions, standards of training and evaluation, accredition of qualifications, measures for improving the quality of teachers and framework for liaison with industries especially for industrial training.

Utilization of manpower

181. Technical training is expensive in comparison with training in the liberal arts and sciences. It is, therefore, important that technically trained persons are utilized in an optimum manner. Greater attention needs to be paid to skill matching for this reason. This would mean, amongst other things:

- the organization of work in such a manner as to minimize under-utilization of skills at any level;
- the drawing up of job descriptions and job specifications;
- the selection of right kind of people and subsequent training as necessary;
- provision of opportunities for further development;
- mobilisation of existing industrial expertise available within the country.

182. A suitably designed appraisal system is necessary to monitor the performance in terms of achievement, indicate career development possibilities, and identify training needs.

183. A major problem discouraging employers from organizing or supporting training is the turnover of trained persons. The company not only loses the investment in training but also has its work programme upset. While it may not be possible to eliminate this problem, it can be minimized partly by imposing reasonable contractual obligations on the trainees and partly by providing adequate motivation, career prospects and job satisfaction - factors often neglected by employers in the design of management of human resources.

184. A common experience in African countries is the disguised under-employment of high level industrial manpower. This has resulted from the lack of availability of adequate middle-level manpower. In general, planning for training has lagged behind requirements. At lower levels, however, requirements are met to a large extent by persons trained to the informal sector. Training for high level manpower has not been too deficient because of social demand, but the supply of middle level manpower has been far too meagre because the needs cannot be met by people not formally trained and there has not been enough social pressure owing to limited growth prospects. Since work requirements have to be met anyway, some of the middle-level functions are being performed by high-level manpower. The situation could be gauged by the fact that the technician: engineer ratio in African countries is normally less than 2:1, often as low as 1:1. In developed countries, this ratio is of the order of 5:1. What is necessary is to increase the facilities for training of technicians at a faster rate and provide a better growth range for technicians. This will make the technician career more attractive and simultaneously improve the utilization of technicians as well as engineers.

185. An important aspect of the utilization of industrial manpower is the rationalization of salaries, wages and incentives. Salaries have to be based on considerations of:

- inputs of education, training and experience ;
- proficiency in the skill;
- hours of work, shifts and holidays;
- working environments and stresses due to noise, heat, weather and pressure of work;
- personal hazards, and
- risks in handling expensive materials, equipment and in decision-making.

186. On all the above counts, industrial manpower needs to be paid better than in most other occupations. Also, suitable incentive schemes need to be evolved based on productivity and equity.

CHAPTER V

PLANNING FOR AN IRON AND STEEL PLANT

A. General considerations

187. A presentation was made by Dr. Banjo who outlined some of the preliminary investigations of a general nature that should be carried out within the country during the conceptual phase. These include:

(a) Investigation and definition of the raw material and fuel base for the plant. The major raw materials and fuel are iron ore, limestone, dolomite, coal and natural gas;

(b) Investigation and definition of the state of required infrastructure including road and rail transport systems;

(c) Consideration of sources of water and power supply to the plant;

(d) Investigation and definition of internal manpower availability especially skilled technical manpower.

188. Some countries have approached the problem of these preliminary survey by setting up a task force of experts charged with tackling the various aspects. The information so collected should be assembled in a study report.

189. In order to enable decision to be taken whether or not to embark on a steel project the consumption and forecast of steel demand within the country must be determined. The steel demand should be broken up into the various steel categories so as to expose the most desirable product mix.

190. Other considerations of a preliminary nature should include the choice of location for the steel complex. It is often advantageous to locate plants close to the main raw materials bases. However, other locations could also be selected from point of view of other considerations like transporation links, harbour facilities etc.

191. Transportation methods should also be given thought at the early stage of planning. With rail transportation, demurrage should be ascertained in addition to the freight tariff as these could have big impact on cost of the project implementation.

B. Discussions on general considerations

192. Discussion on the preliminary considerations: for setting up industrial projects centred to criteria that would assist decision making on whether to embark at all on the projects. What volume of demand, of steel products for instance, would justify embarking on an integrated steel plant? Is the local availability of the

main raw materials like iron ore and coking coal a pre-requisite for African countries and if so in what minimum quantity?

193. The general view was that a level of demand below 300,000 tonnes per year should not be considered for an integrated steel complex: This figure also corresponds to the minimum capacities of the commercially proven iron and steel making processes. It was the view that such a low demand should be met by a semi-integrated re-rolling mill using imported billets or with scrap melting electric arc furnace.

194. On iron are reserves, it was the view that a minimum proven reserve of between 25-30 years should be available before setting up an integrated steel works. This however does not imply that a country with lower quantity of proven reserves, but which has other viable means of economically meeting the iron ore requirements of the steel works from embarking on such a project.

195. The need to maintain a general over-view of all the involvements the projects in order to avoid omissions or late-start of certain vital actions was stressed. So also is the necessity to get all the governmental organs that have inputs into the projects reperly co-ordinated by an authoritative co-ordinating body.

C. Discussions on economic objectives of an iron and steel project

196. In discussing economic objectives of an iron and steel project, Dr. Banjo mentioned that ideas about the decision criteria to be used in answering the questions of why steel plant should be built can differ from country to country and from time-time within a country. This compexity is compounded by the fact that in the early decision stages, it is not possible to quantify all cost parameters. Therefore one cannot base his decisions on pure numbers reflecting profit, DCF etc. However, it is possible to assemble a set of parameters that will constitute a scenario that will determine the decision elements such as:

(i) Value added of the project

(ii) Saving of foreign currency in the long-term

(iii) Creation of employment

(iv) Best use of national resources

(v) Assurance of steel supply to the economy

(vi) Multiplier effects on the tertiary sector (services, transportation etc.)

D. Assessment of feasibility

197. It was further emphasized in discussions that further studies are always mandatory. Feasibility, technological and engineering studies are conducted in order to establish the magnitude of the proposed investments and the cost of the production operations. These studies ascertain the following:

(i) Capital investments and financial efforts required. Extent and degree of external financing needed.

(ii) The time needed to construct, commission and then reach nominal capacities including measures required to ensure that operations at design capacity are reached quickly, and also measures needed to ensure optimal prlductivity.

(iii) Impact of the project.

E. Financing

198. One of the most important issues that came out of this discussion was that if we consider a theoretical case based on an estimated overal cost of say $1,500-2,500 per installed tonne of capacity in a new iron and steel plant; the investment needed for a small integrated plant could reach as much as 5% of the gross national product of a country. It is, therefore, imperative to consider in great detail what the effects that would be induced on the economy, in respect of financing and repayment.

199. It was further pointed out that sources of iron and steel investments are not many. The most common financing instruments being:

(i) International lending agencies

(ii) Bilateral financing

(iii) Commercial loans

(iv) Joint ventures

F. Site location

200. Several factors were discussed that are involved in determining the location of an iron and steel plant. Among the most important are the following:

(i) Raw materials

(ii) Energy

(iii) The market

(iv) Labour

(v) Socio-political considerations.

G. Raw materials

201. In his presentation on raw materials, Mr. Zerhouni Mustapha emphasized that it is important to thoroughly check raw materials parameters such as:

(i) consistency of the analysis

(ii) availability of local ores, coals limestone etc.

(iii) range of variations in the physical and chemical characteristics of raw materials.

202. This is conducted for locally available of imported raw materials because of the basic relationship between available raw materials and the process route to be used for Iron making. There are two available processes to be considered in this respect:

(i) Blast/Furnace and basic oxygen furnace

(ii) Direct reduction plant and electric arc furnace.

The blast furnace and basic oxygen furnace method is based on iron ore and coke. Specifications regarding the quality and characteristics of iron ores are considered to be flexible. Metallurgical coke however is considered to be a scarce raw material and the price changes are regarded with concern by all steel makers.

Direct reduction requires very rich ores (62% Fe) and natural gas. Sometimes the specifications and quality requirements for the iron ore and pellets required for sponge production can be difficult to satisfy.

203. Different technologies are available for changing the characteristics and properties of iron ores by benefication and/or ore prepration such as: concentration, removal of undesirable elements etc. By these methods it is possible to upgrade a low grade ore into rich ore.

204. It is important to conduct research and development during the planning stage in order to facilitate process selection for Iron making, coke and reducing gas preparation.

H. Production capacity

(i) Size effects

205. He further pointed out that according to the specific state of the technology, each plant has an optimal range of capacity. It is generally considered uneconomic to install small units. The upper size limit is generally fixed by technical consideration.

206. Generally the blast furnace route entails large sized plants. Direct reduction route entails a small sized plant. Installed plant capacities of the Blast furnace/oxygen basic plant type are in the range of 2 million per year.

Long products can be produced in a plant with an installed capacity of 100,000 tonnes per year.

(ii) Product mix

207. He continued by pointing out that the product mix and production programmes are determined by:

- statistical data about the overall economy
- data on steel consumption such as imports, exports and apparent steel consumption
- charastistics of the main steel consuming sectors in the economy.

I. Assembly of data on demand

208. The presentations was followed by a discussion regarding assembly of data on demand. It was said that many methods have been developed for forecasting steel demand. The most important generic types are:

(i) Global estimation methods

(ii) Analytical methods

Usually a 10-15 year time horizon is used for estimating steel demand. This time frame concides with the project cycle of an Iron and steel plant.

209. Global methods are based on correlation between the steel consumption and economic indicators such as:

- gross national product
- gross fixed capital formation
- population
- industrial output etc.
- steel intensities

210. Analytical methods for demand are based on the analysis of consumption of each of the main types of steel products of sector of the economy. The time frame used is the same 10-15 year horizon. Analytical methods require a lot of time and effort together the necessary detailed information. This methods have advantages over the global method because of the following reasons:

- a more refined picture of demand is obtained
- the structure of consumption is more definatively defined thus enabling a clearer defination of product-mix
- facilitates the compilation of a check-lict of the main steel products clients by product-mix.

J. Selection of technology

211. Eng. F. Abouzaghla went on to say that as a point of reference for the evaluation of total capital requirements, it has been assumed that a typical BF/BOF facility would have an annual capacity of 3 million tons of raw steel. As for DR/EF route, it has been assumed that most prospective users in the developing countries will be concerned with steel-making facilities in the range of 200-300 tons per day (i.e. up to 100,000 tons per year). This scale of production can be achieved by a newly erected DR/EF integrated installation or through the beackward integration of a re-rolling or scrap-melting EF operation. The capacity of such integrated mills (DR/EF route may rise to 0.4. - 0.5 million tons, given the appropriate bar, rod and section rolling facilities.

212. He further mentioned that a comparison of capital costs for flat and non-flat product mixes should encourage the developing countries to give priority to non-flat products, if such a policy is consistent with market requirements. In estimating average capital costs, it is assumed that the rolling and finishing sections of the steel plant will be oriented towards non-flat products, though not exclusively so.

K. Desingn of installations and selection of plant and equipment

213. Regarding the design of installations and selection of plant and equipment, Eng. Abouzaghla mentioned that usually the design of installations and the plant equipment is done by foreign companies according to the selected technology and the capacity of the plant whether it will be implemented as one stage or different stages. In some countries the main drawing of the installation is submitted by the foreign company and the detailed drawing is done by local companies whether in the civil engineering or mechanical engineering. Also in connection with the implementation most of the civil work, the steel structure fabrication, erection and some equipment can be done by local companies. In general the weight of equipment is equivalent to one thenth of the installed production capacity; excluding the weight of structural needed. The following table shows some estimates:

	Million tons of capacity			
	0.5	1.0	2.0	5.0
Gas route plants				
Equipment	45,500	65,500	150,000	
Structurals	20,000	35,000	60,000	
Blast furnance route				
Equipment			220,000	400,000
Structurals			175,000	320,000

The traditional steel making countries and to an increasing degree Brazil, China, India and Mexico carryout their own engineering and manufacturing work as well as that of other elements.

L. Indigeneous supply of spare-parts

214. In connexion with indigenous supply of spare-parts Eng. Abouzhagla pointed out that the development of engineering capabilities might well begin with the production of spare-parts to meet local demand, which can be assumed to be of the order of 2,400-3,200 tons per million ton capacity, depending on the age of the equipment and the maintenance standards. In order to be able to identify national technological constraints on manufacturing facilities, careful assessment should be made of the distribution of spare-parts in terms of their component raw materials (iron, steel and non-ferrous castings forgings, and structural steel) and their weight requirements. Particular attention should be paid to facilities for the manufacture of medium and heavy spares. In Mexico, for example, medium and heavy spares account for as much as 70% of total expenditure on spares, even though in quantitative terms they are relatively small.

M. Developing local engineering and production capabilities

215. He further mentioned that in developing local engineering and production capabilities, priority should be given to light and medium-weight equipment for rolling mills and finishing lines. The incorporation of heavy capital rolling equipment, such as mills for blooms, slabs, and wide hot and cold strip, in stages of development is not recommended, owing to the need for additional heavy manufacturing equipment for casting, forging and machining.

216. He went on to say that the light and medium-weight equipment may include mills for billets, bars wire rods, light structurals, merchants, transfer and cooling beds, coilers, shears, and saws. Finishing lines may include straighteners. saws shears, as well as bundlers for structurals, bars and rods. Rolling mill equipment includes repetitive items such as mill stands, cooling beds, roller tables, coilers, coil converys and straighteners.

217. He further pointed out that in preparing contracts for steel plant construction, consideration should be given to the inclusion of a heavy fabricating and machining workshop. In the course of the actual construction, a substantial part of the equipment could be manufactured in the workshop,utilizing mainly the contactors supervisory skills and local labour. Upon completion of the plant, the workshop could be operated by an appropriate organization as a separate antity to provide a national heavy engineering facility. The procedure might ensure the availability of an experienced and trained indigenoous labour force and of the tools that would permit locally made steel to be consumed in the manufacture of a large proportion of the capital equipment and spare-part needs of the national industrialization programme.

N. Monitoring of construction and of project implementation

218. In his presentation, Mr. Ojobor said that to ensure an organised programme of works and a timely realisation of the project the construction and implementation schedules should be closely monitoring consulting group to who should be attached a good member of indiginous personnel. Close monitoring is essential so that lagging activities could be corrected before it becomes late. Monitoring is also involved with checking the quality and quantity of supplies to ensure that they meet the conditions of the contract between the owner and the contractors. Monitoring helps to indicate how and when to press outside governmental agencies for accelerated actions on thier own contributions. Also, in cases where financial disbursement to contractors depend on volume of work executed, close monitoring ensures that contractor gets paid only for the actual amount of supplies and work done.

219. To make construction and implementation schedules meaningful, they must be up-dated at regular and fixed intervals of time.

220. Mr. Ojobor pointed out that; As part of the action guides and the setting of targets for realisation within a time-frame, a project implementation programme should be drawn up once the basic decision has been taken to proceed. Three broad classes of programmes will be necessary during the course of project implementation, namely:-

(a) Global programme;

(b) A master schedule of construction;

(c) Detailed schedules of construction activities

221. He went on to say that the global schedule is required at the early stage. It should contain the time-frame of execution of the following activities necessary for the realisation of the project:

(i) Initial planning and finalisation of concepts;
(ii) Investigations and full testing of raw materials;
(iii) Detailed project report;
(iv) Development of mines and quaries;
(v) Recruitment and manpower development;
(vi) Development of requisite in-frastructure including
- access roads
- railways
- housing schemes for construction and operation workers
- power supply for construction and for operation
- water supply for construction and operation
- contractor's construction bases.

O. Construction master schedule

222. In this connection Mr. Ojobor pointed out that the construction schedule is drawn up shop-wise and will contain the following activity versus-time inputs:

- design and elaboration of working drawings
- supply of all materials (civil construction materials, structural steel works, sheeting, equipment etc.)
- execution of civil works
- execution of civil structural erection
- execution of mechanical equipment erection
- execution of electrical installation
- execution of instrumenting installation
- execution of cold-tests
- execution of commissioning
- execttion of performance guarantee tests.

223. He went on to say that the master scheduled should show, explicity, the time of entry of facilities especially those under the direct control of agencies outside the steel company itself such as electric power, railway etc.

Detail schedule of construction

224. He further pointed out that the detailed schedule of construction will go into depth on various shop by having more activities indicated alongside the duration. Large constructior project use

General considerations on drawing up an implementation schedule

225. In concluding his presentation, Mr. Ojobor said for developing countries integrated direct reduction steel complex takes between 3½% - 4 years of construction, excluding all external facilities. Blast furnace plants take between 5 years - 6½% years. African countries embarking on steel projects should not press their contractors to compress the period unduly because of the problems of the owner will have in meeting his own obligations such as manpower, raw materials and general infrastructural works like housing.

226. In drawing up the global project schedule the time needed to obtain certain government approval and for execution of those obligations which are the obligations of the owner should not be optimistically under-estimated.

227. Developing countries should not take much in terms of bonus to contractors for early completion of construction.

228. He finally said that great surveillance must be placed on the progress and state of readiness of raw materials; trained personnel and the external facilities of power, gas etc. because the lack of any of these could frustrate the project even when construction has been completed.

P. Preparation of manpower for operation maintenance and management

229. As it was agreed upon in connection to planning of the manpower for industrial development. The planning of education training especially in the technical field must start earlier at least five years in advance. This planning include the different stages of education covering the technical schools institutes and universities. Before starting the construction of the steel plant we must start the recruitment of the manpower needed for construction and erection of the equipment. In the same time the key staff needed for the operation and maintenance of diffirent production units must be recruited and sent for training under the supervision of the equipment suppliers in similar steel plants. This training programme should be planned according to the schedule for the start of production units. On the other hand we must put in consideration to utilise the experience of the manpower who participate in the erection phase for the operation and maintenance. In connection with the management staff a plan must be put in advance for training courses in both top and middle management. These courses should be carried locally or in foreign countries. Also different visits to similar steel plants is recommended.

CHAPTER VI

PLANNING FOR AN ENGINEERING PLANT

Summary of presentation

230. Mr. A.K. Mitra gave a detailed presentation on the subject and elaborated the different stages of planning which includes market survey, policy, technology selections etc. which are to be carefully considered for the successful implementation of specific engineering projects.

231. During the study for Survey of Demand for product or services the important criteria should confine to four major areas e.g. (a) national demand - past five years and projected ten years in value and quantity, (b) subregional demand in few neighbouring countries as indicated in (a), (c) replacement of existing products due to obsolesence in value and quantity, and (d) requirement of spare parts and accessories based on a, b, c above in value and quantity.

232. With regard to the Policy of Import Substitution the author emphasized that the import substitution plays an important role in developing countries for industrial development. Therefore it is necessary to review the past import policy and to negotiate with the government to regulate the import of a particular engineering product which is proposed to be manufactured locally, at this stage it is necessary to highlight the foreign exchange savings and creation of local employment through the establishment of such proposed project.

233. In order to establish the Selection of Output and Product Mix for a particular product it is necessary to consider the following aspects e.g.

- to set an initial production target based on market survey (units to be manufactured/year);
- to assess the degree of external and internal technology, skill and investment requirement;
- to negotiate with existing importer to obtain foreign manufacturing source for particular product;
- to plan Bought-out-finish (BOF) and Machined own workshop (MOW) parts and component for that product.

234. During the preparation of Prefeasibility Study the author explained the need for the preparation of a document which should include all the important parameters stated above. Such an illustrated document will interest the potential collaborator and the market opportunity for this product which will eventually lead to possible investment participation. The pre-feasibility study should not be a complex write up. The purpose of the study will be to promote collaboration services. The author explained that the pre-feasibility study should also include important industrial incentives offered by the Government in order to attract the investment opportunity.

235. The author highlighted the necessity to prepare a study of existing engineering Back-up support facilities and Ancillary Industries support facilities within the countries. These facilities are foundry, forging, heat treatment, machine shope, tool room, repair and maintenance etc. which can benefit from greater sub-contracting arrangements in order to manufacture local parts and components of a particular product.

236. During this early stage of the project it is important to negotiate with the prospective collaborator so as to obtain design, drawing and process sheets (at least assembly drawing of the product) in order to assess the investment criteria. The detailed dialogue is also necessary with a prospective collaborator so as to establish cost involved in the procurement of (a) assembly/sub-assembly/parts drawings; (b) tools drawings; (c) process sheets for planning; (d) rough estimate of manufacturing costs in the collaborator's country.

237 The author then highlighted the modalities for the preparation of feasibility study. He mentioned that the cost of the feasibility study should be shared between the local company and the prospective collaborator. The cost/benefit or techno-economic study should be based on alternative technologies available in international market and adaptation required under local conditions. The equity participation should be clearly speltout in the feasibility study including the fund necessary for initial investment. The study should also indicate the pahsed expansion of the manufacturing plant. He elaborated that the feasibility study should include (a) basic investment (plant, machinery, working capital estimated volume of production per year); (b) estimates and list of plant and machinery and common service facilities; (c) estimated manufacturing time and cost (based on direct and indirect labour cost) and (d) estimated material cost; (e) estimated labour requirement (skilled, semi-skilled, unskilled, managerial staffs etc.); (f) other 'on' costs e.g. electricity, heating, light, services, manpower training, administrative etc. (g) contingencies.

238. The author highlighted that the Sign of Agreement should be worked in legal framework involving the local and foreign financial institutions. With regard to the Site Location, he pointed out that the major considerations should be (a) size of the plant in sq. meter; (b) vicinity of proposed plant to other manufacturing units; (c) existing facilities e.g. roads, electric supply, housing, water supply, railways, postal, telex, communication etc.; (d) type factory shed etc.; (e) transport for workers.

239. He then focused the need for the Selection of Technology. The technology selection should be based on product volume (a) small batch size; (b) medium batch size; (c mass production. Existing technologies available within the country should be assessed and employment criteria should be given priority.

240. He went on to say that the Selection of Machinery and Equipment should be based on (a) type of machine according to manufacturing technique considered; (b) skills of labour/operative to guide the selection of the complexity of machinery; (c) engineering processes to govern the major criteria for the selection of machinery; (d) maintenance level; (e) investment limitation.

241. The author then outlined the design of Plant Layout. In accordance with the machinery selection, the following consideration should be taken during the preparation of plant layout: (a) method of production (jobbing or mass scale) (b) establishment of various departments (foundry, machine shop, toolroom, fabrication, etc.); (c) disposition of these sections for effective movements; (d) water supply, electricity, maintenance shop etc. ; (e) stores and storing facilities; (f) mechanical handling; (g) administrative and walfare services etc. (h) preparation of plant layout either by consultants or by the collaborator participating in the project; (i) separate layouts for lelectric supply, water supply and air supply and submission of these layouts to the appropriate government authorities for approval.

242. He then pointed out the importance of obtaining the quotations and follow-up of the project. It is necessary to obtain quotations from three alternate suppliers indicating C.I.F., F.O.B. and F.O.R. prices. The following components of the project should be considered e.g. (a) quotations for building including land levelling etc.; (b) quotations for machinery and equipment; (c) quotations for tools etc.; (d) quotation for electrical installation; (e) quotation for water installations; (f) quotations for air installation and pipe work; (g) quotations of transportation and installation of machinery; (h) quotations for raw materials, semi-finished, finished boughtout and imported parts and components; (i) quotations for spare parts of machinery and equipment. At least 8 to 10 per cent spare parts by value should be ordered with machinery and equipment.

243. During the Establishment of the Company, he pointed out that a final plan should be drawn up to implement the project and to establish the ordering points. The Plan for Manpower Training should be programmed before the project implementation stage in the following areas e.g. manager, accountant, superintendents, foreman, charge hand and operatives including planners, designers and draughtsmen.

Summary of Discussions

244. During the discussion important points were focused by many delegates where selected projects failed due to lack of considerations of important parameters discussed above. In many countries in Africa, it is observed that projects are oriented on the basis of licensing agreement. The majority of such projects failed or had problems due to lack of interest on the part of the collaborator. The delegates agreed that it is better on the part of African investors to involve more of joint venture projects with equity participation from the foreign collaborators.

245. It was further agreed that the financial institutions should participate during the negotiation and contracting stage of the project.

246. Problems related to the selection of new engineering projects were also elaborated by some delegates. It was noted that the selection and location of plant should be directed to two areas i.e. (a) in vicinity to the existing infrastructure; (b) for regional and rural development within the country. A comprehensive assessment is required in selecting such areas.

247. In deciding a product for local manufacture, it was noted that existing importers of such product should be encouraged to be involved in local manufacture. The specific Indian cases were discussed where local importer of tractors and implements become the manufacturer of such products in joint ventures with the foreign companies from whom they used to import.

248. The development of ancillary industries which in the back bone of engineering industries development was discussed in detail. It was agreed by the delegates that an inventory of ancillary industries facilities should be considered before embarking on an engineering project. The Indian experience in this case is of great significance to the African countries.

249. The transfer of appropriate technology was discussed in great detail. It was agreed that UNIDO and ECA can assist in these important aspects. The delegates took note that it is essential that the countries should train their staff in selection of appropriate technology and related machinery and equipment.

250. Some of the delegates pointed out that in some engineering projects in Africa the same consultants were used for machinery selection and suppliers of machinery. It was decided that the feasibility study and selection of machinery and equipment should be assessed by third pary; UNIDO assistance on this can be requested.

251. The importance of manpower training was discussed in details by the delegates. The majority opinion was to train the personnel in the key positions before the implementation of the project, international assistance in this field can be well utilized.

252. The discussions concluded with a positive recommendation that in selecting various projects it is desirable that the joint venture projects should be encouraged from the developing countries under TCDC or ECDC.

CHAPTER VII

CONCLUSION AND RECOMMENDATIONS

A. Iron and Steel Making Technology and Manpower Development

Iron making

253. In view of the improved world record for DR plants, it should be given consideration especially for countries without coking coal but which have access to natrual gas or other reductants. It is not advisable that developing countries risk their scarce resources on any processes that are not in successful commercial operation. Therefore only commercially successful processes should be considered when selecting a DR process.

Steel making

254. (a) Noted that such processes like LD, EF, are well established. However developing countries should not exclude from considration Siemens Martins (open hearth), even though they appear to be falling out of fashion in developed countries. This is mainly because of its lack of complexity in addition to its flexibility in accepting charge materials. In view of the energy situtation and for countries wanting to start iron and steel works with EF melting scrap, the development of cheap sources of electric power, especially through hydro-electric stations, should be greatly encouraged.

(b) In view of the low scrap-generating rates of most African economies, in any project using scrap as an input, it is imperative to make a scrap inventory and a scrap-generating rate forecast, based on the same principles as the inventories of natural resources.

Ore preparation and coke preparation

255. (a) It is desirable to use the opportunity of the available techniques of ore benefication to process the raw materials as close as possible to specifications required for input for iron making.

(b) In order to avoid embarassment during the operation stages, the chemical and laboratory investigation of all intended raw materials must be thorough and exhaustive and should cover the entire deposits that should be well sampled. However it should be borne in mind that in actual iron and steel making process quality lower than those specified are still usable.

Coke-oven

(a) In view of the progress made in the commercial use of formed coke this alternative should be borne in mind by countries with poor coking coal. This should be considered along side with possibility of importing prime coking coals for blending with the local coal.

(b) Because of the many investigations and tests on coal that are usually required at the planning stages, subregional laboratories serving many countries of the subregion will be highly advantageous in raw material research and tests.

(c) In any consideration for charcoal-based iron making, it is important to ensure the replacement of the forest resource exploited for the making of charcoal, otherwise a serious and permanent damage to forest resources may take place and the plant will be grounded.

Reducing agents for DR plants

256. Natural gas has been well established as a source of CO and H_2 for DR plants. However CO and H_2 could also be obtained from coal gasification although such applications are not yet in commercial use for sponge iron production.

Ingot and continuous casting

257. Ingot mould casting requires higher investment than continous casting. However, because of the higher requirements of skill and experience needed for the operation of continous casting machine new plants, expecially with production higher than 1.0 million tons per year,should consider ingot mould casting as a recommendable soulution. This should however be considered in relation to the quality of products to be cast and the product-mix.

Special alloy steel

258. The requirement of alloy steel in African countries is low and the required know-how is high. However if there should occur, for strategic reasons a demand for such products, it could be met by small electric furnaces.

259. An immediate complimentary action aimed at long-term preparation for alloy steel production is the encouragement of local manufacture of ferro-alloys for export from the abundant raw materials in many African countries instead of exporting the ferroy alloys raw materials to developed countries.

Auxiliary facilities: Power and water

260. (a) In view of the influence of electric power on production cost all efforts should be made to tap any low cost source of power supply, especially hydro-stations.

(b) Limited self-generation of electricity within the plant continues to be recommendable so as to recoup energy (fuel) within the plant which otherwise could be wasted. Such a stand-by capacity will also protect power sensitive sections from total failure of the main electric power supply.

(c) Because of the importance of water to iron and steel making processes good and adequate sources of water must be given serious consideration in the location of the plant. As much as possible water re-circulation should be adopted to limit consumption to just make-up and thus reduce operating cost.

Refractores

261. Because of the high and consistent need of refractories in steel works Governments should give serious thought to the establishment of local refractory plants. Subregional centres for investigation of refractory materials and even for production are desirable.

Material handling

262. (a) The necessity for a good rail-network within the country for transporation of raw materials is obvious. When iron and steel works are located on green sites it is advantageous to link it up with rail lines for supply of raw materials and distribution of finished products.

(b) Sub-regional co-operation for development of iron and steel works require inter-regional rail and road links as well as harbour assistance for the transporation of raw materials from the participating countries to the location of the works.

(c) Care and detailed attention must be given to the design decision related to the supply and handling of important raw materials like ore and coal especially in respect of reliability of supply routes; adequacy of storages; and flexibility and adequacy of the discharging facilities.

Maintenance facilities

263. Because of the lack of opportunities of obtaining maintenance assistance from specialized agencies for steel plants in African countries, it is recommended that adequate provisions in facilities be invested upon including foundry, forging, machining etc. for repairs and the making of necessary spare parts. The need to develop an effective system of preventive and major maintenance should be tackled early before the start of operation the plant. Since in most steel plants well trained maintenance personnel are required and since they constitute abour 50 per cent of the total labour force, the early training of the maintenance staff should be given top priority.

Quality control

264. (a) The establishment of a strong and centralized quality control division in steel plant is paramount importance.

(b) Inspite of the high demand of steel products in developing countries which sometimes could lead to customers buying whatever they find, steel plants must nevertheless protect customer interests by ensuring good quality standards.

(c) At the same time developing countries should introduce a limited range of standard of steel products in accordance with international standards.

Instrumentation and automation

255. Considering the skill requirement for highly automated plants; the high investment cost and the decrease in manpower requirement it is not recommended to start steel industries in developing countries with a high degree of automation. Similarly, the over-use of automatic process control of operation is not recommended. There is the need to assist indigenous personnel to first grasp the fundamentals of decision-making in operating the equipments by using manual control before switching the process to automatic controls.

By-product of steel plant

256. (a) The recuperation of by-product for the products of coke oven is recommendable. However careful selection of the range of products to be manufactured in the by-product plant must be adopted on the basis of local demand for the products and other alternative sources, if available especially through perochemical industries.

(b) Slag cement industry located preferably close to the works is recommended for blast furnace routed plants as part of the down-stream industry. However, the suitability of the blast furnace slag for cement production should be determined in advance.

(c) Slag can also be utilized in bricks, slag wool manufacture and road construction.

Planning for an iron and steel plant

257. In planning of iron and steel works, its of great importance in the first phase of the study to obtain the following data:

(a) Actual demand and projections for 10-20 years;

(b) The available raw material in the country mainly (iron ore and coal).

(c) The infrastructure and its capability to the needs of steel industry mainly (railways; power; water).

The second point is the selection of technology. There are 2 main routes:

258. The first route is DR/EF. It has been assumed that most prospective users in the developing countries will be steel plants of capacity (100,000 tons/year).

This scale of production can be achieved by through the backward integration of a re-rolling or scrap-melting and EF operation.

The second route is blast furnace for annual capacity of 1.0 million ton/year and above. The availability of iron ore or coal is essential for this route.

Design of installations and selection of plant equipment

269. (a) In most of the developing countries design of installation and plant equipment is carried by foreign international companies however in some of them some of the designs and detailed drawings are done by local design offices. Considering the large equipment involved it is recommended to develop the design engineering and manufacturing capability and begin with the production of spare parts to meet local demands. This will need the putting in the plant the manufacturing facilities which include foundry, forging, machining, and electrical shops. In the course of the actual construction, a substantial part of the equipment and structures could be manufactured in the workshop, utilizing mainly the contractors supervisory skills and local labour.

(b) This procedure might ensure the availability of an experienced and trained indigenous labour force and help to manufacture some equipment and spare parts needed for the national industrialization programme.

(c) An integrated iron and steel plant is likely to be economical if built for a capacity of 200,000 tons/year or higher. This figure is about the minimum limit of economical production capacity of the main iron and steel making processes. Countries planning steel plant of capacities lower than this could consider scrap melting with electric arc furnace and rolling mill, supplemented if need be by imported billets. Such a complex could be converted to an integrated plant at a future date when the demand of steel products rises.

(d) It is desirable that any of the African developing country embarking on steel project should have at least one of the main raw materials because the economics of the project is likely to be unfavourable if both raw materials and machinery are all to be imported.

(e) A minimum proven iron ore reserve of 25-30 years ought to be available as a safe base for an integrated steel plant. Basing a plant on lesser reserve should be backed up by an assurance of other alternative sources which must be economical.

Implementation

270. (a) Either during the planning stage or the operational steps of implementation there is a need for an overall co-ordinating machinery with sufficient decision-taking power so as to help in solving interface problems between the steel project and other operations such as: educational system, transport system, water agency etc.

(b) In developing countries DR Direct Reduction plants would normally take 3½-4 years for construction. Blast furnace plants would take 5-6½ years. In drawing up the master schedule of construction, the contactors should not be pressed to unduly compress the construction period because the owner could by so doing create more problems for himself in meeting the obligations related to recruitment and training of personnel and in ensuring availability of the raw materials at the right time for commissioning the plant.

(c) In the course of project implementation, Governments should try to reduce the usually long periods needed to obtain Governmental approval on matters affecting the project because long delays would upset the implementation schedule.

Project financing and economics

271. (a) Governments should bear in mind, while examining the technoeconomic analysis of steel projects in the feasibility study that steel plants do not usually give good rate of return on investment, even in developed countries with long steel making traditions and experience. More consideration could therefore be placed on the strategic importance, the profit in the down-stream industries and the social benefit and foreign exchange savings.

(b) The budgetory provisions for pre-operatinnal expenses and contigencies should not be under-estimated.

(c) Joint-venture projects with contractors or equipment suppliers have inherent risks of causing project cost inflation. In view of the sad experiences of many countries in joint-venture business countries that are constained to adopt the procedure by financial or other reasons should have the project separately evaluated by a third and neutral pary. In this respect ECA/UNIDO's assistance in some form is recommended.

B. Metalworking Technologies and Manpower Development for Engineering Industries

(a) Metalworking Technologies

Casting

272. (a) Foundry technologies should be diversified in the Eastern and Southern African subregion particularly by the introduction of steel castings, malleable and S.G. iron castings. Greater attention is required to improve the technologies in pattern-making, mould/core making and metallurgical aspects. The pattern makers and mould makers importance should be recognized and better remuneration should be given to them.

(b) Moulding sand should be recycled in order to reduce the sand cost. For every one tone of metal casting two tons of sand are required.

(c) Particular attention is required at industry level to improve casting drawings so as to improve pattern making. It is recommended to improve the quality of casting grade in line with British or equivalent standard e.g. B.S. 1452:1961 Grey iron castings Gr.4; B.S. 3333:1972 Pearlitic melleable iron castings M.Gr.4; B.S. 309:1972 Whiteheart malleable iron castings M.Gr.4; and B.S. 2789:1973 iron castings with spheroidal or nodular graphite M.Gr.6.

(d) Existing foundry facilities should be properly utilized wherever possible at national level. The cupola technology should continue, but special attention should be given during selection of induction furnaces. The planners should be careful when recommending induction furnaces in countries where the procurement of selected scraps or good quality pig iron is difficult.

(e) The testing facilities for the foundry materials and finished products should be mandatory.

Hot farming

273. (a) The improvement of the blacksmith forging technology particularly in the rural sector is recommended. If possible mechanical power striker should replace the existing hand forging technology.

(b) The hot forging activities in engineering industries should be expanded. The closed die forging technology should be introduced as early as possible in order to produce local spare parts, automotive parts and agricultural implement parts.

(c) The local die and tool manufacture for hot forging operation should be developed. Wherever possible mechanical forging presses should be installed. Mechanical drop forging machine should be used for primary forming and to be followed by forging presses for secondary forming.

(d) The existing arc furnaces should be utilized for the production of steel ingots for forging. Eastern and Southern African countries do have arc furnaces in their steel mills with capacities ranging from 5-15 tons/charge.

(e) The appropriate die and forge material should be selected and standardized in the Eastern and Southern African subregional.

Cold forming

274. (a) All types of cold forming technologies in the Eastern and Southern African subregional countries e.g. upsetting, extrusion, metal spinning, thread rolling and wire drawing should be expanded and new ones have to be established.

(b) The metal spinning technology should be further developed and spinning technology to small-scale level should be provided. Appropriate machinery facilities (low cost) is of paramount importance to the establishments at village craft level.

(c) The non-ferrous metal extrusion technology for the manufacture of tube containers (for medicine, toothpaste, cosmetics) and the door and window aluminum frames sections should be developed.

(d) The existing bolts and fasteners manufacturers should introduce thread rolling and upsetting technology for hardware upto $\frac{1}{2}$" or approximately 12.5 mm dia. products.

(e) Particular attention should be given to the local manufacture and maintenance of dies and tools for cold forming.

Fabrication

275. (a) Although reasonable fabrication technologies are developed in the Eastern and Southern African subregional countries, particular attention should be given to introduce CO_2, submerge arc, stud welding technologies on wide scale to the existing engineering industries.

(b) Tool designs, press tools designs and complex formed bending tools designs in existing industries should be improved.

(c) The expansion and improvement of tools, press tools, formed tools and compound tools manufacture within the existing fabricating industries should be developed if the demand justify such production of tools is recommended.

(d) Appropriate machinery and equipment for fabrication shops should be selected. Careful consideration should be given not to install heavy machinery for light engineering products.

(e) More safety measures and quality control in engineering fabrication industries should be provided.

Metal cutting

276. (a) More rotating cutting technologies in existing machine shops should be introduced. It is also noted that single cutting technology has considerably developed in the Eastern and Southern African subregion.

(b) Surface broaching technology and external and internal broaching technologies in large repair and maintenance workshops and in selected machine shops should be introduced.

(c) Throughway tip cutters for milling and turning operations should be introduced. These technologies reduce tool setting, regarding and tool maintenance costs.

(d) At least one engineering industry that manufactures small cutting tools (drills, taps, cutter etc.) should be established in any one of the Eastern and Southern African subregional country. Subregional co-operation is an important parameter for such a project.

(e) Every machine shop should provide facilities for appropriate tool maintenance and tool design.

Tool making and heat treatment

277. (a) Existing railway workshop, large repair and maintenance workshops and industrial estates should intensify their toolroom activities.

(b) The existing toolrooms should produce jigs, tools, fixtures, dies, press tools, etc. Jigs, tools and fixtures technology should be expanded and incorporated in the majority of the production machine shops.

(c) Existing toolrooms should be upgraded and if possible should manufacture standard jib bushes, pins, clamps, bolts holders, supporting plates for other industries.

(d) The existing toolrooms or proposed toolrooms should cater to the supply of standard and special tools to other industries on hiring basis.

(e) Existing toolrooms should be reinforced with jig and tool design offices which should form integral part of the toolroom. Toolroom management should be separated from machine shop management.

(f) In every toolroom there should be heat treatment facility particularly the case-hardening and through-hardening technologies.

(g) A greater care should be taken in procuring appropriate materials for tools, dies etc., and proper measures should be taken to standardize the tool body and accessories wherever possible.

(h) Heat treatment technology and facilities should be expanded to all machine shop activities in the Eastern and Southern African subregion.

(i) A rigorous quality control in all toolroom activities and heat treatment should be introduced.

(j) At least one jig boring machines in each of the Eastern and Southern African subregional countries in Africa should be installed.

Metrology

278.9 (a) An inspection and quality control section should be installed in each machine shop in the Eastern and Southern African subregion.

(b) Adequate provision should be made in existing and proposed engineering industries to procure sufficient inspection and measuring tools.

(c) The existing machine shops should incorporate working and master gauges, and reference standards with appropriate inspection facilities.

(d) The local manufacture of simple inspection tools in existing precision engineering industries should be introduced and improved in the subregion.

Metal coating

279. (a) The existing galvanizing plants in the Eastern and Southern African subregion should be utilized and metal tining technology for the production of tin plates for containers should be indtroduced. Existing galvanizing plants should also extend their facilities to the steel door and window frames manufacturing industries.

(b) Nickel chrome plating plants and annodizing plants should be established for engineering consumer products. It is further recommended that these plants should cater for the needs of large number of engineering industries.

(c) The electroplating technology and manufacturing facilities should be standardized.

(d) Electric vat type or barrel type galvanizing equipments should be installed for small steel parts e.g. screws, bolts, nuts, etc.

Institutional Development

280. (a) Governments should designate a limited number of foundries, forging shops and toolroom facilities in the interest of serving national industries and manpower training. New ones have to be created in countries where such facilities are not available. These workshops must be equipped with the relevant equipment and manned by trained and experienced personnel.

(b) While these industries are being set up, training programmes should be formulated for local personnel both in local technical colleges as well as in colleges abroad. These programmes must culminate in well programmed industrial or shop floor training in well established industries in local regions or abroad.

(c) Government should gather information on all existing facilities to ensure proper direction and co-ordination of their functions on a national level. Also the related functions of metal coatings etc. need to be centralised or introduced in the subregion as a common service facility.

(b) Manpower Development

Castings

281. (a) To introduce in-plant training craft courses at national level to train pattern makers, mould and core makers in existing foundries.

(b) To introduce specialized training courses for foundry technology at polytechniques level.

Hot forming and cold forming

282. (a) To introduce hot forming and cold forming technology in the curriculum at university and polytechnique level.

(b) To train designers for hot and cold forming die design. At present this facility may not be available within existing industries in

Eastern and Southern African countries. Therefore, it is necessary to send nationals abroad for this type of training.

(c) To upgrade the skills of toolmakers in order to manufacture hot and cold forming dies.

Fabrication

283. (a) To train welders in CO2, submerged arc and other specialized welding technologies. This can be achieved through in-plant training courses organized at national or multinational level. The above special welding technological courses should be introduced at the polytechnique level and even at crafts level.

Metal cutting

284. (a) To organize in-plant training courses for turning, boring, screw cutting, drilling, planing, gearcutting, fittings, inspection and quality control, at operative level. Such courses should provide adequate appropriate tooling facilities so that the operators can learn the modern method of machine shop practice.

(b) To bolster trade courses on metal cutting technologies with appropriate curricula in order to supply industry with specialized skills.

(c) To create supervisory courses at polytechnique level for machine shop practice.

(d) To introduce production and industrial engineering courses at polytechnique and university level.

(e) To create institutional facilities to upgrade operatives from semi-skilled to skilled from skilled to supervisory and from supervisory to management cadre. This can be achieved by the creation of facilities such as evening classes in existing trade schools and polytechniques. Arrangements to offer time off for personnel to study in educational institution is highly to recommended.

Tool making and heat treatment

285. (a) To train high skilled operatives for fitting, turning, boring, milling, grinding and precision tool making. This can be achieved by the creation of toolroom facilities within existing trade school and polytechnique workshops.

(b) To introduce jig and tool design courses at polytechnique level.

(c) To send abroad tool room operators to obtain experience in press tool, die and mouldmaking technologies. It is proposed that these operatives during their training should work in large toolrooms in order to acquire necessary practical skills.

(d) To produce heat treatment technicians at polytechnique level. Heat treatment courses should reflect industrial necessity rather than theoretical aspects of heat treatment.

Metrology

286. (a) The quality control and inspection courses should be included at polytechnique level.

(b) To organize in-plant inspection and quality control courses with particular reference to improve capabilities in appropriate choice of inspection equipment and inspection method.

(c) At trades school level more appropriate curriculum should be established in inspection methods.

(d) At the university level, metrology should be taught within given courses with reference to industrial requirement.

Metal coating

287. (a) To train operators at trades schools for electroplating and galvanizing process. Such courses should be more oriented towards maintenance and running of plants and equipment.

(b) To include metal coating courses at polytechnique level.

(c) To organize in-plant training courses in metal coating processes where facilities are available.

C. Manpower Development Conclusions and Recommendations

288. A planned approach to the forecasting of technical manpower requirements should be adopted. Using a combination of macro projections, direct enquiry and labour coefficients and progressively increasing the degree of detail as well as accuracy, long-term and medium-term forecasts should be made to plan education and training facilities.

289. Technical Education and training institutions should be planned well in advance and action to set them up initiated 5-10 years before they are scheduled to contribute to the supply of manpower.

290. Institutional facilities, in the same manual industrial facilities, should be created in planned phases in terms of diversity of programmes as well as capacity.

291. New disciplines required for the industrial programmes should be identified e.g. metallurgy, mining and ceramics etc. for the iron and steel industry, and production and industrial engineering for the engineering industries, and facilities created for them.

292. Industrial training should be integrated with academic programmes. Period spent or industrial training should include industrial problem-oriented work.

293. In countries having a large potential for iron and steel industry, the possibility of developing multidisciplinary academic programmes for this industry should be explored.

294. Part-time courses for those employed in the industry should be started. These could be in the form of sandwich courses, evening courses or on day-release basis.

295. Large industrial units such as iron and steel plants should have their own training institutes. These institutes should provide training for worker, technician and engineer levels for the employees of the organisation as well as others.

296. When starting a large industry, production and maintenance staff should be associated with construction activities especially at the testing and commissioning stages.

297. Training of operation and maintenance staff should have 3 components - familiarity with all the processes and functions in the plant, intensive knowledge/skill development for the job, and actual work experience. For higher level manpower, training in managerial functions should also be a component of programmes.

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Factory Visits in Zambia and Zimbabwe - Engineering

1. Lusaka Engineering Company (LENCO), Lusaka, Zambia, 19 November 1980

The team was received by the General Manager Mr. S.K. Tamele of the Company. This is a light engineering establishment manufacturing sheet metal and tubular fabricating products e.g. tables, chairs, shelves, truck assembly, tanker assembly and bus body assembly. The company has the following shops:

- sheet metal cutting and fabricating shop;
- paint deepening booth
- tube manufacturing shop;
- nail manufacturing shop;
- toolroom and repair and maintenance shop;
- heavy fabrication shop for bus body, trucks, trailers and tanker

The various sheet metal fabrication techniques were demonstrated and explained to the team. Particular reference was made for the application of CO_2 welding, cold forming operations and tools and die manufacture in its toolroom.

2. Toolmaking and Engineering, Buluwayo, Zimbabwe, 24 November 1980

The team was received by Mr. Wilson, Managing Director of the Comapny. The company has specialized in manufacture of following items:

- prevision die and tools (for forging and press work);
- jigs and fixture (particularly for railway work);
- manufacture of hacksaw frames;
- manufacture of knives, cutlery and kitchen ware items;
- manufacture of automotive accessories;
- manufacture of children bicycles etc.
- manufacture of light defence parts and accessories.

The team saw the progressive manufacture of dies, press tools and moulds including the precision turning, boring, shaping, milling and heat treatment of various parts and components. Particular attention was focussed on the specific processes e.g. chrome plating, heat treatment of carbon steel, precision grinding and fitters assembly work for die and tool manufacture. The team also witnessed the importance of quality control and the wide range of inspection tools and gauges required for precision work. It was also pointed out that the toolroom operatives are highly paid in the company. The team also saw the jig and tool drawing office and discussed various aspects of tool design. The company has installed a fully automatic programme controlled chucking authmatic lathe for mass production.

3. United Spring and Forging, Buluwayo, Zimbabwe, 24 November 1980

The team was received by Mr. Dodd, General Manager of the Company. The following are the company's major activities:

- manufacture of hoes, spades, shovels, ladders;
- manufacture of heavy forge dies and tools;
- manufacture of heavy hot forged parts for railways;
- manufacture of heavy hot coiled and leaf springs;
- re-conditioning of used leaf springs;

The team witnessed the complete manufacture of spades, shovels, hoes, etc. from press work upto heat treatment and painting. The toolroom operations were studied very carefully particularly the manufacture of heavy hot forging dies and tools. Drop forging technology was explained during the actual working condition. Closed die hot forging for specific components was also witnessed by the team. Special attention was drawn to the manufacture of coiled and leaf springs with particular reference to the hardening and tempering operations.

4. Buluwayo Steel Products, Buluways, Zimbabwe, 24 November 1980

The team was received by Mr. D. Ferriman, General Manager of the Company. the company manufactures agricultural implements, e.g.

- ox-drawn plough;
- ox-drawn mouldboard plough;
- sledge hammer;
- various implements and tools.

Most of the machinery in this company is very old. The mission saw the complete manufacture of agricultural implements, parts particularly the mouldboard and share. The profile of the share is specifically manufactured in the form of rolled section by RISCO Steel Mill. This helps them to reduce the number of manufacturing operations. The company also manufactures heavy links of the chain $\frac{3}{4}$" thick by cold press work. Various heat treatment operations were explained particularly case hardening and through hardening of steel parts. The company does not have hardness testing equipment. The heat treatment on sledge hammer faces are carried out by induction hardening processes. The team witnessed the induction hardening machine and its function. The team also saw the toolroom operations particularly the manufacture of various press tools.

5. Rhobolts Ltd., Bulawayo, Zimbabwe, 25 November 1980

The team was received by Mr. Michel, the General Manager of the Company. The company manufactures the following hardware: e.g.

- high tensile bolt and nuts;
- high tensile castle nuts;
- nyloc nuts;
- high tensile studs and rivets;
- high tensile friction grip bolts;
- various fasteners specified by the customers.

The company is basically a jobbing shop and loads machinery and equipment according to customers orders. The team saw the planning, estimating and tooling section. The bolts and nuts manufacture is carried out by Capstan Lathe and single spindle bar automatic machines. The team witnessed various thread cutting tools particularly coventry die heads and external chasers for thread cutting. The materials used for bolts and nuts are EN 16 to EN 23T steels. The team saw the heat treatment of steel bolts.

6. <u>Steel Force, Bulawayo, Zimbabwe, 25 November 1980</u>

The team was received by Mr. Burroughs, the Senior Mechanical Engineer of the Company. The company has two plants, e.g.

(a) The plant reconditioning the railway locomotives, trailors under steam locomotive rehabilitation programme;

(b) The plant manufacturing rerolled coil for reinforced fabrication, steel doors and windows, roof strusses and heavy steel fabrication.

The mission observed various fabrication processes, particularly the application of CO2 welding and heavy plate rivetting.

7. <u>RESSCO, Nulawayo, Zimbabwe, 25 November 1980</u>

The mission was received by Mr. Morrison the Managing Director of the company. The company is engaged in complete reconditioning of 130 steam locomotives that were scrapped during the last 15 years. The reconditioned boilers are supplied by the Steel Force Ltd. The mission observed the various machining and fabricating operators during the process of reconditioning. The Company also manufactures hot forged parts required for railways. The company employes highly skilled operatives and has established a good quality control operation. The mission saw the heavy fabrication of railway wagon body including the application of submerged arc welding process.

8. <u>Radiator & Tinning Ltd., Bulawayo, Zimbabwe, 26 November 1980</u>

The mission was received by Mr. Brocken, the Managing Director of the Company. The company is engaged in manufacture of ferrous foundry, toolroom and press shop. The company manufactures its own die and tools. The mission witnessed the function of the spart erosion machine in the toolroom. The company did not show the manufacture of radiators.

9. <u>Railway Workshop, Nulawayo, Zimbabwe, 26 November 1980</u>

The mission was received by the Chief Mechanical Engineer of the Workshop. The major activity of the workshop is to repair the rail coaches, diesel locomotives, freight wagon, etc., The workshop is equipped with:

- foundry ferrous and non-ferrous (grey cast iron, brass and chromium);
- machine shop;
- pattern shop;
- fabrication shop;

- engine testing shop;
- upholstery shop;
- electrical repair shop.

The foundry and machine shops were of importance to the mission. The mission witnessed the pattern making technology, core and mould making technology and melting and pouring technology in the workshop. In heavy machine shop the gear cutting and gear grinding were of special interest to the mission member.

10. Bolt Manufacturers, Bulawayo, Zimbabwe, 26 November 1980

The mission was received by the Production Manager of the Company. The company is a part of GKN Group in UK and specialized in manufacturing of low carbon bolts, nuts, and fasteners on a mass production scale. The mission witnessed the thread rolling of bolts in mass production. The company has facilities for linear and circular thread rolling facilities. The company also has facilities for electric galvanizing plant.

11. Nimir and Chapman, Bulawayo, Zimbabwe, 26 November 1980

The mission was received by the General Manager of the Company. The company is engaged in manufacturing of heavy finished casting and fabricated parts for mining industries. The following facilities are available, e.g.

- high duty steel casting up to 6 tons capacity;
- preparation of ferro-manganese and ferro silican plant;
- heavy fabricating machine shop with a turning capacity of 14 ft. diameter;
- modern well equipped pattern shop;
- well equipped metallurgical laboratory.

The mission witnessed the CO_2 core making, large casting moulds, heavy machines particularly the vertical lathes and large gear hobbing machine. Casting technology was discussed in full coverage including the metal analyser in operation to show the major composition of a particular sample of steel.

12. G. Conolly & Company (Pvt.)Ltd., Bulawayo, Zimbabwe, 27 November 1980

The team was received by Mr. Conolly the Managing Director of the Company. The following are the major facilities within the company, e.g.

- heavy foundry shop;
- machine shop;
- fabrication shop.

The company manufactures heavy mining parts, mining machinery and accessories. The foundry facilities include grey cast iron, steel malleable, S.G. iron, brass and aluminium casting. The various processes were explained to the mission.

The fabrication shop has facilities for submerged arc welding and CO_2 welding operation. The company has procured a fully automotic N.C. turning machine with cirucular turret head. The mission also witnessed the fabrication and building of vibrating conveyors for ores handling and horizontal shearing and grating machines for mines.

13. Mathews Manufacturing, Bulawayo, Zimbabwe, 27 November 1980

The mission was received by the Managing Director of the Company. The company manufactures coins, models, badges, etc., in bronze, aluminium, and steel for the Government of Zimbabwe. The mission witnessed the coining operations in cold forming. Special attention was drawn on manufacturing of dies for coining operation. The mission returned to Lusaka on 30 November, 1980.

Factory Visit in Zimbabwe - Steel Mill

1. RISCO Steel, P.B. 2, Redcliff, Que Que, Zimbabwe

The visitors got very warm reception from the Management of the Comapany, headed by General Manager Mr. T. Harris.

Existing annual capacity is about 0.8 million tonnes of raw steel, produced by the basic oxygen method. RISCO is one of the country's major industries, with over 5,000 employees.

The works represents an integrated steel complex including:

- materials handling plant;
- coke oven and by product plant;
- blast furnace plant;
- steel making plant and foundry;
- heavy rolling mill;
- medium rolling mill;
- light rolling mill; and
- rod mill.

The main supporting engineering facilities are:

- mechanical and maintenance;
- electrical maintenance;
- transport;
- fuel, water, gas and electricity supply;
- refactories and civil engineering;
- stokes.

The company obtains iron ore, limestone, coal, alloying and other essential ingredients of steel-making from resources available within the country enabling it to produce steel very competitively.

The ores being used at RISCO contain more than 60% Fe and supplied from Buchwa mines situated near to Redcliff, deposits of which have been proved to be at 50 million tonnes. The limestone and dolomite of suitable grades supplied from Redcliff quarry, the deposits of which estimated to be at over 27 million tonnes.

The coal for coke production is supplied from Wankie coal mines. The materials handling plant equipped with dumps, conveyer belts, crushers, screens and weighing machines and open stores.

The capacity of coke oven plant with 2 battaries in operation is over 600,000 tpy. The sinter plant operates with capacity of about 1,000 tonnes a day of fluxed sinter totalling over 350,000 tpy. The blast furnace operation is done with charge consisting of lump ore added together with sinter, limestone and coke.

Blast furnace plant equipped with four blast ovens:

BF N 1 - the volume 116 m^3
BF N 2 - the volume 167 m^3
BF N 3 - the volume 563 m^3
BF N 4 - the volume 1267 m^3

The existing capacity of blast furnace plant is 960,000 tpy., including iron for steel making - 815,000 tpy. 5% of the BF plant's output was being used as pig iron for the foundry in the plant.

The capacity of pig-casting machines is 1,500 tonnes a month. Pigs are cast in two halves with mass of each 8.4 kg.

The steel making plant equipped with hot metal mixers, oxygen converters and casting devices. Capcity - 960,000 tpy. almost 100% of metal is killed steel.

The foundry is one of the largest in Zimbabwe, consisting of pattern shop, moulding and casting. The consumption of iron is 1,000 tonnes a month. Among the items which can be produced there are 5 tonne moulds and 12 tonne slag ladles, phosphor, bronze castings, etc.

The rolling facilities include:

- Soaking pits;
- Heavy mill;
- Medium mill;
- Light mill;
- Rod mill.

The product groups of the RISCO plant is:

(i) Heavy mill: (a) Billet mill, size 48x48 mm upto 100x100 mm
(b) Blooming, size 180x180 mm upto 200x200 mm
(c) Concast, size 110x100 mm upto 160x160 mm

(ii) Medium mill: (a) Angles, size 60x60 mm upto 100x100 mm
75x50 mm upto 100x75 mm
(b) Channels, size 3x1½" upto 6x3"

(c) Flats, size 100x6 mm upto 100x25 mm
130x8 mm upto 130x25 mm
150x8 mm upto 150x25 mm
180x10 mm upto 180x25 mm
200x8 mm upto 200x25 mm
230x10 mm upto 230x25 mm

(d) Rails, size 9 kg/m upto 22.3 kg/m
Beams, size 100x50 mm upto 140x66 mm

(e) Round, size 47 mm upto 100 mm

(f) Miscellaneous

Plough share 6.1 kg/m
Grader blade 16.2 kg/m

(iii) Light mill: (a) Angles, size from 25x25 mm upto 50x50 mm

(b) Flats, size from 20x4 mm upto 80x30 mm

(c) Fencing and window sections.

(iv) Rod mill: (a) Rounds 55 mm upto 40 mm

(b) Squares 10 mm upto 40 mm

The annual capacities of:

Heavy rolling mill	–	670,000 tpy.
Billet mill	–	600,000 tpy.
Medium mill	–	100,000 tpy.
Light mill	–	50,000 tpy.
Rod mill	–	180,000 tpy.
Conticast	–	170,000 tpy.

The technological achievements at RISCO are of a modern level. They include:

(a) the improvements of heat and mass transfer techniques (blast pressures and blast temperatures, fuel injections, etc.) introduced at BEN4 for achieved level of production with automatic system of control of charging;

(b) coke consumption is about 500 kg. per tonne of pig iron;

(c) the amount of liquid iron per tonne of crude steel produced at RISCO ascillates around 0.85 tonnes;

(d) steel making process is electronically monitored and supported by the most modern laboratory techniques, including a vacuum spectrometer with computer and telexing systems; with sufficient control of temperature;

(e) the laboratories are able to support technological processes and equipped with sample preparation plant to carry out analyses of all raw materials, semi-finished and finished products; secured by equipment and personnel to provide mechanical testings including tensile, hardness and elongation, to provide macro and micro-etching, metallographic and heat treatment specimens.

The bulk of its electricity supplies RISCO receives from Kariba Hydropower Station mainly. The water consumption of the works and township is more than 5 million cubic meters annually. The mechanical workshops house some of the largest and most up-to-date equipment in Zimbabwe. There are separate workshops for blacksmiths, welders, boilermakers, riggers, carpenters, transport, gas control and electrical and instrument techniques.

RISCO operates its own diesel locomotives. There are facilities for training at RISCO Company.

2. <u>26.21.80 Steward and Lloyds Ltd., Que Que</u>

The plant production is:

- seamless tubes (different size);
- metal structures of different design and size there is line of galvanization.

The explanation kindly were given by Plant Manager, Mr. P.W. Wells and his personnel.

3. <u>26.21.80 Rhomet, Union Carbide, Que Que</u>

The plant visit was conducted by Mr. X. R. Wordsworth, Plant Manager. The works equipped with materials handling including wagon tippler, four electro arc furnaces. Capacity of production is 35,000 tpy. of ferro-chrome. The ferro-chrome content is 92%, the rest are C=6%; Si=2%.

The ferroalloy contain 67% of chrome. Specific consumption of electroenergy 4 megawatt per tonne of ferrochrome. The estimated Norm of capital investment is US$ 660 per 1 ton of alloy.

Due to good sources of raw materials the production of the works is very competitive.