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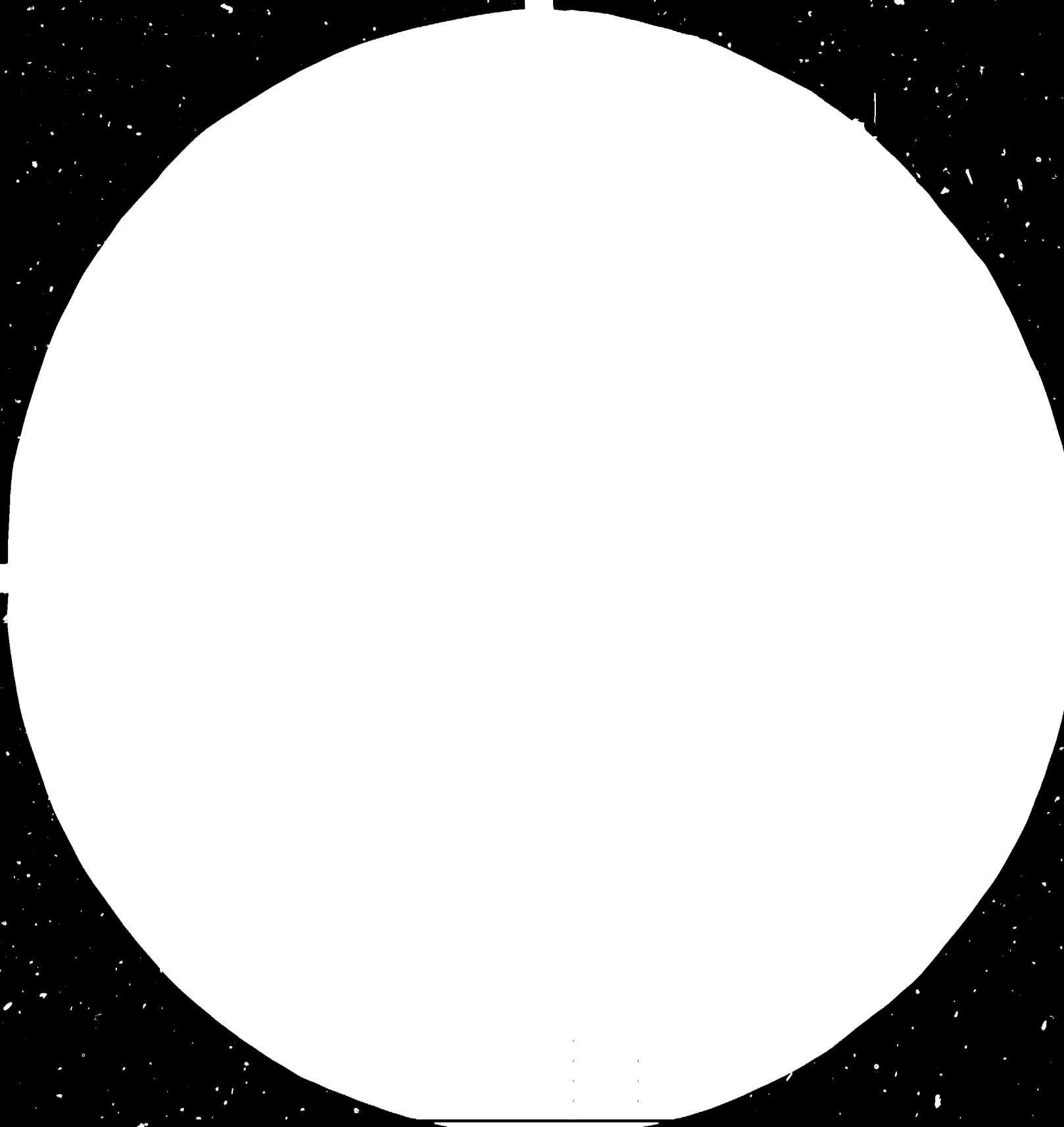
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MECHANICAL WOOD-PROCESSING INDUSTRIES
IN DEVELOPING COUNTRIES

PROBLEMS - CAUSES - SEARCH FOR SOLUTIONS *

by

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SUMMARY

The paper discusses the main sectors of primary mechanical forest industries concentrating largely on those aspects which favour or hamper their development in developing countries. Wherever applicable, the technical and technological developments relevant to these aspects are reviewed. The paper describes various problems of existing industries and constraints to their progress and expansion. It identifies the following overriding problems: in sawmilling - low recovery from raw material and incorrect choice of equipment; in plywood manufacture - the deteriorating pattern of raw material supply; in reconstituted wood panel industries - insufficient domestic markets. The overriding problem besetting all these industries is the scarcity of properly trained personnel. The interrelation of various problems and the possibility of solving several of them within the framework of solutions to the main problems is emphasised. The paper suggests some courses of action for overcoming the main problems of the primary forest industries and identifies the possible assistance which could be obtained in this respect from international organisations and through TCDC (Technical Cooperation among Developing Countries). The paper also indicates the various uses of wood residues and emphasises the importance of integration for fuller utilisation of wood residues.

1. SAWMILLING

1.1 GENERAL

1. Sawmilling is the natural first step in the development of forest industries. It is least capital intensive among primary wood processing industries and most flexible with respect to economy of size, degree of mechanisation and complexity of technology. In developing countries it is often the first stage in the whole industrialisation process and in this context, plays an important pioneering role with considerable economic and social development potential particularly in backward rural areas. The widespread occurrence of sawmills in developing countries, a great number of which have a primitive technical level, created the notion of the simplicity of the whole industry. In fact, the great diversity of the wood raw material with the various species, sizes and properties of logs, the multitude of specifications of final products and the wide range of types of equipment to meet both the raw material and market requirements makes the proper design of mill and selection of the best equipment and technology rather complex. This, combined with deficient skills, is responsible for a number of problems facing this industry. Sawmills in developing countries represent a wide range of sizes and technologies from huge computerized operations to medium and small size mills, modestly equipped or heavily undercapitalised. While difficulties may occur in any type of mill, most problems are related to mills with medium and small capacities which represent the bulk of this industry. The following chapters discuss these problems, their causes and some of the possible solutions.

1.2 MAIN PROBLEMS

2. The predominant problems of the sawmilling industry common in developing countries are:

- low production and productivity due to irregular log supply,
- low recovery from the wood raw material: 25 to 40 instead of generally obtainable 50 to 70 ,
- low quality of product,
- inappropriate selection of equipment,
- scarcity of skilled personnel, especially of saw doctors, head sawyers and maintenance mechanics.

3. Most of these problems are inter-related: selection of equipment influences the recovery and the skills of the workers are decisive for both yield and quality of lumber. All these problems combined are responsible for the fact that the contribution of the sawmilling industry to the national economy in developing countries is much lower than its realistic potential.

1.3 LOW RECOVERY FROM RAW MATERIAL

4. Low recovery from roundwood input results, to a considerable degree, from the choice of equipment. The main break down machines most commonly used in developing countries are either the circular saw headrig or the band saw headrig. The inserted tooth circular saw produces a kerf which is often more than twice the size of a kerf produced by a bandsaw and therefore causes almost a double amount of wood wastage in the form of sawdust. The yield of final product can be 10 to 20 higher for bandsaws than for circular saws. Improper installation and maintenance of the machines and of preparation of saws (saw doctoring) is an additional source of wood losses.

5. Optimum sawing patterns based on market requirements and related to the specific sizes, qualities, shapes and species of logs - are an important requirement for obtaining higher yields from the processed raw material. However, pre-determined sawing patterns can not be applied to logs from natural forests prevailing in most developing countries, particularly in tropical areas. Logs

from such forests are characterised by a great variety of species, large variations in diameter and length, in wood quality and properties in susceptibility to deterioration due to attacks by biological agents (fungi, insects) and in possible applications.* Some of these logs may have to be sawn for high grade lumber, others for volume recovery, some for both out of different parts of the same log. A look at the freshly opened surface after each cut allows to determine the best consecutive cut for obtaining the most decorative effect or the highest volume of lumber; it may also be a combination of the two, aimed at obtaining the highest value of the product. The whole operation which is crucial to the economic results of the sawmill depends on the skill of the operator: there is no substitute for a well-trained, experienced and conscientious head sawyer.

6. As a distinct from this type of sawing by individual cuts where the discerning eye of the sawyer is required throughout the whole process, predetermined sawing patterns can be applied to utility woods sawn largely for construction lumber.

7. There are further possibilities for recovery increases through improvement of operations both before and after the main headrig. Among them are: log sorting in the yard or pond, proper log turning and positioning for the sawing pattern; protection of logs and lumber from fungal and insect attack and from checking and splitting through proper stacking, treatment and seasoning of the wood material. All these measures do not require expensive facilities; their success hinges on the skills and conscientiousness of workers and

* Experts from industrialized countries with more homogenous forests, smaller diameter of trees, less variation in their size and more predictability of the quality of wood often make the mistake of trying to apply sawmilling technologies from temperate zones to tropical countries.

management.

8. The use of sawmill residues is still another means of increasing the recovery from the wood raw material. Slabs, edgings and trim ends are a potential source of material for artisanal operations. Solid wood residues could also be used for pulping if the wood species are right and there is a pulp mill within economic transportation distance. This is usually feasible only in relation to large sawmills and requires debarking of logs and the installation of a chipping machine. Residues could also be used for the manufacture of reconstituted wood panels if they are located in the vicinity of or integrated with the sawmill, as well as for fuel to power prime movers kilns etc.

1.4 CHOICE OF EQUIPMENT

9. Selection of equipment is a major issue which is often not properly dealt with in sawmills in developing countries. The appropriate choice of equipment depends on the nature and volume of the wood resource; the type, quality and volume of production; labour availability and skills; and availability of maintenance services and spare parts.

10. In many cases, equipment had been selected wrongly at the planning stage. This applies, for example, to the choice of circular saws for cutting highly valuable logs such as Teak or Jacaranda. The excessive losses in precious wood in such cases could easily outweigh the initial savings in investment capital within a comparatively short period of time.

11. Similarly, excessive savings on auxiliary equipment often prove counter-productive. Many mills in developing countries consist only of the headrig which is the most expensive piece of equipment and edgers. But a resaw can double the output of the headrig and costs much less than a second headrig; in addition, it also usually cuts wood more economically.

Recovery and quality of production require the inclusion in mill design and proper functioning of other auxiliary equipment from logyard machines to the docking saw, green chains and seasoning and drying equipment and facilities.

12. Another type of error in the selection of technology and equipment consists of designing a highly mechanised sophisticated mill in an area with abundant but unskilled labour, or selecting large capacity equipment for a mill with very limited raw material supply possibilities. Such "white elephants" are known in every region of the developing world. In some cases attempts were made to move them to another area where conditions were believed to be more suitable: while they were indeed in some respects, in others the contrary was the case. Eg. a richer forest would support the large capacity of the mill but the type and size of logs or market requirements would not be compatible with the equipment available. Once committed, the "original sin" would not be easily remedied. It is indeed essential that through independent advice and careful analysis such mistakes are avoided in the first place and pressures towards adopting mesmerising but inappropriate and costly solutions be resisted.

13. All these errors have one feature in common: they are committed at the design stage of the mill. But in a great many instances equipment correctly chosen some time ago becomes inappropriate with the change of conditions which determined the original design of the sawmill. A circular headrig may be a fully justified choice for sawing small volumes of utility logs due to its lower investment cost and comparatively simpler operation and maintenance. But, as larger volumes of lumber are required for the growing market and skills are developed in the existing operation, a bandsaw headrig will prove technically and economically more appropriate. There are examples that entire countries embarked on a programme aimed at replacing circular headrigs with

more wood efficient bandsaws. But in most countries circular sawmills continue to operate long after they outlived the technical and economic justification for their operation causing unnecessary losses in wood raw material and producing lumber of lower quality than would be possible with the use of modern bandsaws.

14. The changing pattern of raw material is another important factor calling for an adjustment in the equipment and technology of the sawmilling industry. In many developing countries, especially in the tropical areas, the sawmilling industry can no longer count on the sustained supply of large size hardwood logs from their over-exploited and partly destructed forests (examples: Nigeria, Paraguay). In fact, with the growing demand for sawnwood for domestic and export markets, an increasing number of countries will face the same situation. Increasing attention has to be given in such cases to processing smaller size logs both from natural forests and from plantations.*

15. Plantation programmes are expanding continuously and in many countries logs from them reached the size perfectly suitable for sawing. However, mill design and equipment selection must be different than in the prevailing number of presently operating sawmills built for large size logs from natural forests. Small size logs of decorative species are still best sawn with bandsaws, albeit of smaller dimensions. However, the homogeneity of plantations and uniformity of log sizes provided by them create now opportunities for the wider application of gangsaws for the production of construction lumber.

16. There are also increased possibilities for integrated operations with

* In addition, of course, attempts should continue to expand the use of hitherto unmarketable species.

chipping of slabs simultaneously with sawing and conversion of chips into reconstituted wood panels within the same wood processing complex. There are highly encouraging examples of such integrated operations in some developing countries which demonstrate the possibility of total utilisation of wood raw material provided that markets for residue based products could be developed.

17. In addition to changes in the selection of the main sawing equipment there are a number of other adjustments required by the changing raw material pattern; they concern both down-stream and up-stream operations (including end-uses and marketing). There are no universally applicable solutions and each situation has to be examined and analysed individually before a decision on the best option is taken.

One positive example of a widely applied adjustment to the changing raw material situation is offered by Peninsular Malaysia, which, through a concerted effort of industry and government and adoption of a variety of measures, managed to expand the raw material base for sawmilling by processing small-size logs, trees from clearance operations etc. thus maintaining its position on both domestic and export markets. The majority of developing countries, however, still have to meet this challenge through the adoption of appropriate policies and their implementation.

1.5 TRAINING

18. Training of personnel for the sawmilling industry in developing countries is needed mainly at the level of operators and foremen.* This can be achieved

*There is also a shortage of technicians and well-trained and experienced managers, but this subject should be dealt with on a broader inter-industry level.

through formal vocational training and on-the-job training.

19. Formal training must be part of the national educational system. Sawmill operators are best trained as mechanics first with subsequent specialisation in sawmilling operation and maintenance. Problems related to such training cannot be solved by individual mills; they require government involvement and cooperation of the whole industry. Most appropriate vocational schools within the country have to be identified and expanded by adding to them properly equipped sawmilling training centres. Depending on the size of the country and its existing and planned sawmilling industry, one or more such centres may be needed. Small countries may use training centres in larger countries or, by common effort, create sub-regional centres. Organisation of sawmilling training centres, preparation of the required curricula and training of instructors could best be done by international organisations specialised in training activities. The eventual goal, however, must be a complete take-over of training activities by local authorities and local professionals and instructors.

20. On-the-job training of skills for the sawmilling industry should follow the period of formal training. At present, however, such training is often the only one available in most developing countries. International assistance has a place in such type of training too, by facilitating the placement of candidates in most suitable mills and by training of trainers within the developing regions or in industrialised countries.

21. Training of saw doctors could be carried out at sawmilling training centres or at properly equipped large sawmills. In addition, there is also a possibility of training saw doctors on the spot, in their own sawmills through mobile saw doctoring units consisting of instructors and a van with the necessary equipment.

22. Investment in training and training facilities for sawmilling (and for other forest industries) promises to yield higher return than any investment in production facilities. Provision of trained personnel to sawmills would increase the yield and quality of their production as no other single technical factor. Yet, despite formal recognition of the importance of the subject, there is still no consistent action in this field, no realistic programme for the future in most developing countries. In fact, there are few other subjects in the field of forest industries where the discrepancy between enthusiastic pronouncements and disappointing inaction would be greater. It is, therefore, imperative to overcome this negative "training syndrome" and embark on long-term, consistent and well funded programmes in this field.

1.6 OTHER PROBLEMS

23. In addition to the three major groups of problems facing the sawmilling industry in most developing countries listed in paragraph 2 , there are a number of other problems which, although less common or pressing, need to be solved if this sector of forest industries is to make a full contribution to the economic and social development. In view of the inter-relation of various problems, some of them may be taken care of within the framework of solutions to the main problems. This applies particularly to issues which can be solved by training. There are also problems which, while not necessarily of great importance on a global scale, may nevertheless be crucial for particular countries. Some of the issues are therefore discussed below (paragraphs 24 to 30):

24.- Improvement and simplification of grading rules for forest products and broadening of their international acceptability

At a time of growing international trade in wood products, especially

in tropical timber, when products from various developing regions compete for the same markets in both industrialised and developing countries it is important that the basic principles of their classification are uniform and generally recognised. This would facilitate trade flows and strengthen the position of wood in world markets. There are grading rules at present agreed upon by groups of producing countries and tied to specific export markets but, generally, they do not have the global character required by the world-wide nature of the trade in wood products. In addition, there is also a need for developing grading rules for countries producing exclusively for domestic markets. It would be wasteful to use international grading rules for such purposes; they should be designed for local wood species and local uses and be acceptable to both producers and users thus facilitating trade in forest products.

Grading rules would be meaningless without graders and grading inspectors. Development of skills for these functions requires special training programmes.

25.- Improvement of the utilisation of the production capacity of sawmills.

The degree of capacity utilisation is low at present, often between 30 and 50 %. This is partly due to technical and human factors within the mills which could be taken care of through training, better maintenance and investment; a major role is played here by the insufficient log supply. This is a matter which requires the mill management to analyse the causes of log shortages and press for remedial actions or to undertake such actions if the sawmill is integrated with logging operations. Securing a steady and sufficient raw material flow into the sawmill is of equal importance to the mill's economic success as the operation of the mill itself.

26. - Up-grading of quality of lumber from small and insufficiently equipped sawmills through additional processing at central timber yards.

At such yards, defects are cut out, lumber seasoned or kiln-dried

and, in certain cases, planing or molding operations are carried out. Such central timber yards run as cooperatives or independent enterprises usually perform also marketing functions.

27. - Improvement of the output and quality of production of mobile sawmills through combining their operation with central, stationary re-sawing facilities.

Mobile sawmills based on circular saws usually have a low recovery ratio and generally, produce low quality lumber. They are mostly employed for salvage operations connected with land clearing schemes, road building projects, etc. The result of the operation could be improved if the mobile saws were confined to the production of intermediary products such as cants or flitches, which in turn would be converted into final sizes of lumber with more precise stationary re-sawing facilities.

28. - Increased contribution to rural development.

A sawmill usually located in a rural area and in constant touch with the local population through its labour force is in an excellent position to contribute to the social and economic development of the rural community. By supplying low priced lumber and large size residues local secondary processing facilities could be promoted providing joinery, furniture, fencing, housing components etc. to the neighboring markets. Wood residues could be used as domestic fuel and medical and other social facilities of the mill be made available to the local population.

29. - Expanded use of lesser known wood species.

Sawmills have an opportunity and an obligation to co-operate with appropriate authorities of the country in mitigating the effects of "forest creaming" (harvesting of the most valuable tree species). This could be done by trial sawing of lesser known species and promotion of their experimental

uses by the local population. Since such timber could be sold at cost value, the whole activity could have an additional effect of boosting artisanal manufacturing and contributing to the well being of the local population.

30. - Integration of sawmills with down-stream industries.

Such integration results in better and fuller wood utilisation and produces increased value added to the total operation. This is to be considered for larger sawmills conveniently located in relation to markets for such secondary wood processing products as joinery, housing components etc. Such integration also helps in the promotion of lesser used species which could be utilised in accordance with their properties and end-use requirements and with disregard of their botanical identity.

1.7 SEARCH FOR SOLUTIONS

31. As mentioned in paragraph 3 the various problems of the sawmilling industry in developing countries are largely inter-related, and this feature will have to characterise also solutions. While principal attention should be given to main problems listed in paragraph 2 some of the other problems discussed in paragraphs 24-30 may fit into proposed solutions with only minimal additional expenses.

32. Basically, two types of analyses would have to be carried out before preparing proposals for specific solutions: (a) analysis of appropriateness of the equipment in relation to the various factors determining its choice such as: the type of raw material and its changing pattern; market requirements, availability and skills of labour. (b) analysis of training needs and opportunities including; the determination of the most important areas of training (eg. saw doctors, head sawyers etc.); review of existing vocational facilities

within the country which could be adapted to or expanded for such training; possibilities of on-the-job training within the country or abroad.

33. Solutions proposed on the basis of these analyses would have to be prepared in both qualitative and quantitative terms including costing and cost-benefit calculations. Such an approach would be helpful at a later stage in preparing loan applications for the implementation of the programme.

34. For countries with insufficient expertise of their own, international assistance may be required for the analysis of the situation and preparation of exemplary solutions for typical sawmills. Inevitably, solutions would have to contain both technical and investment aspects as well as recommendations related to manpower development.

35. It is advisable that studies of the proposed type be carried out by teams of specialists from the same region or sub-region, or at least with the inclusion of such specialists in the teams brought in from outside the region. This would not only help in formulating realistic proposals compatible with local social and technical realities, but also strengthen the regional self-reliance in the sawmilling sector.

36. The inclusion of counterparts from the country concerned in all stages of the work is essential. Such involvement would allow local people to get on-the job training and later on follow up on the implementation of the proposed solutions and carry out similar activities in relation to other sawmills.

37. The magnitude of the problems involved will usually require long-term work on their solutions and therefore it is advisable to institutionalise these activities by including them into the programme of an appropriate national organisation responsible for forest industries development.

2. PLYWOOD AND VENEER

2.1 GENERAL

38. Plywood is the oldest type of wood based panels and still accounts for about 40% of the volume of all panels produced around the world. Plywood and veneer have the highest requirements from the wood raw material among all primary forest products. Over the decades, however, the continuous growth in production led to the general depletion of the high quality and large size logs on which the plywood industry was traditionally based. The trend is world-wide, but the degree of its influence on the industry varies depending on the size and type of forest resources in different regions of the developing world.

39. South East Asia is endowed with forests which are the best and richest source of peeler logs for the plywood industry in the developing world. They have a comparatively limited number of species per hectare and an abundance of large size logs mostly of good quality although in some areas they tend to have soft or rotten hearts and other defects. Most of the other developing countries of Asia have insufficient forest resources capable of supporting only a limited development of the plywood industry. A few of them, however, managed to build an impressive plywood industry based on imported logs; with the growing trend towards expanding processing in log producing countries their situation is becoming more and more precarious.

40. West and Central Africa is another rich source of precious logs for plywood and veneer. However, forests there are much more heterogenous and in many countries most precious species had been depleted in easily accessible areas due to exports to Europe. East Africa has very limited natural forests but successful plantation forests capable of supplying the industry with small size logs.

41. In tropical areas of Latin America, forests are still very rich but extremely heterogenous, with many species difficult to peel. Inaccessibility of some of these forests and large distances from ports and human settlements make the development of industries based upon them generally difficult. The subtropical part of this region is much poorer in forests, but wherever they occur they do not form an attractive base for plywood industries due to the great number of species, many of them unsuitable for plywood. In the moderate climate part of Latin America some countries possess softwood forests and successful softwood plantations on which special types of plywood production can be based.

42. Despite the extreme differences in the availability and type of wood resources suitable for plywood manufacture among the various parts of the developing world, the general trend is common to all of them: the volume of peeler logs available is diminishing rather rapidly and their quality is deteriorating constantly with respect to size, shape and occurrence of defects. Even in the forest rich countries engaged in large exports of logs and forest products, a shift towards logs of lower quality and size is taking place gradually but continuously as largest and best logs are removed from forests in more accessible areas.

2.2 MAIN PROBLEMS

43. The industry is facing a considerable change in the pattern of its raw material. The adjustment of the industry to this new situation is all the more important that the demand for plywood is growing continuously.

44. Due to the diversity of conditions among the various developing regions, the responses of the industry to the changing raw material situation and the possible solutions vary considerably. The situation is even more complex due

to the need of the industry to meet at the same time requirements of the market for improved properties and a wider variety of products. Conditions are never static, changes are occurring continuously and adjustments or restructuring of the industry must be efficient and timely. This requires highly skilled personnel at all levels.

45. In view of the foregoing, the principal problems of the plywood industry can be defined as follows:

- The changing pattern of the wood raw material which requires deep adjustments or complete restructuring of the industry.
- Scarcity of qualified personnel, especially skilled operators, maintenance personnel and technicians which calls for a variety of training programmes.

2.3 THE CHANGING PATTERN OF THE WOOD RAW MATERIAL RESOURCE

2.3.1 PLYWOOD

46. The changes in the raw material base have been causing continuous shifts in its use. In hardwood plywood the shift has been towards logs with smaller sizes and wider acceptance of certain defects. In softwood plywood there has been a continuing growth in the use of small diameter coniferous logs, particularly from industrial plantations, for the manufacture of construction grade plywood. Throughout the industry there has been a strong pressure for higher recovery rates from raw material. These trends resulted in and have been supported by a whole myriad of technical and technological innovations the understanding of which is essential for properly defining the future of the industry. A review of these developments together with the indication of the problems they can solve is contained in the following paragraphs.

47. The shift towards lower quality and smaller size raw materials was

possible through considerable development in machinery and technology to meet this challenge. Without these developments, and without the determination of plywood manufacturers to adopt them consistently and increasingly, the decline of the plywood industry would be inevitable.

48. The predominant feature of the progress in the plywood industry has been the improvement and refinement in equipment and technology of processing small size peeler logs. This development started in industrialized countries. It made it possible for Finland to maintain and expand its plywood industry based on birch logs with gradually decreasing diameters. It also enabled the southern pine plywood industry in the United States to meet the growing demand for construction plywood (to achieve this, the progress in the development of high speed chuck lathes had to be combined with the development of special drying and gluing techniques). Similar developments have been introduced in some developing countries and carry a promise of considerable expansion of their plywood industries based on plantation raw material and small size logs from natural forests.

49. The success of plywood production based on logs from man-made forests underlines the inseparability of planning the future development of plantations and industries based on them. This applies not only to the size of plantations, volumes and age classes of trees etc., but also to specific silvicultural measures, such as tree pruning, aimed at obtaining a log quality most suitable for plywood production. Government involvement is essential for encouraging such long term planning of plantations and industries through appropriate guarantees to concessions holders, fiscal and financial incentives etc.

50. The Australian plan for reorienting their plywood industry to structural

grade plywood based on plantation logs which contains concrete technical and technological details on manufacturing and uses, measures for financing, ways of promotion etc., may serve as an example of a rational approach towards solving long range problems of both industry and raw material supply development. In developing countries, similar programmes will have to involve governments to an even greater extent since, in addition to integrated planning of industries and industrial plantations, markets for structural plywood would depend on large housing schemes usually financed by governmental agencies.

51. Peeling of small size logs results in much reduced output as compared to large size logs. This drawback has to be offset by high efficiency of the operation in order to make the production economical. Machines and systems have been developed which made processing of small size logs not only technically possible but also extremely fast and efficient. High speed automatic peelers are equipped with dual hydraulic spindles and back-up rolls to enable them to peel down the log to a smaller core. High speed charging facilities are equipped with centering devices which help in obtaining higher veneer output from the raw material. This technology enables to process economically pine logs with an average diameter of 30 cm. or birch logs with an average diameter of 20 to 25cm and peel them down to restroll diameters of 6 to 7cm. The efficiency of peeling is three logs per minute. While these spectacular results may not be exactly repeatable in most developing countries due to the different characteristics of their fast growing trees, the wider acceptance of this trend will be highly beneficial for the development of their plywood industries.

52. Small size logs increasingly processed by the plywood industry include not only logs with smaller diameters but also with smaller length. Acceptance

of short logs which can be cut out from defective stems increases considerably the raw material base of the plywood industry but requires an additional operation in the production process. In order to provide longer veneer sheets required for the standard sizes of plywood, the short ends of the veneers are scarfed and glued together. Equipment for this operation has been improved to match the general efficiency of the whole production line. In general, peeling of short logs and scarfing and gluing together of short pieces of veneer is one way of expanding the raw material base for the plywood industry in wood poor (and poor wood) countries.

53. The trend in peeling tropical hardwood logs from natural forests is also toward better log utilisation and more efficient operation. Peeling lines for such logs include now log centering and charging devices, lathes operating with stepless drives and equipped with hydraulic clamping, telescopic spindles back-up rolls, and devices for fast changing of veneer thicknesses. Round-up veneer is removed from the lathes by conveyers for further usage (clipping or chipping).

54. One of the important defects of some tropical hardwood logs which usually makes their economical peeling difficult or impossible is a spongy, rotten or hollow heart. Such defects make the end-clamping and drive at the spindles in conventional peelers difficult. A Japanese made side-drive peeler avoids this problem by using a series of spoke-wheels which act on the circumference of the logs for driving and pressing them to the knife thus reducing significantly the pressure at the spindles. This new peeling technology enables not only the use of defective logs but also of smaller diameters (from 40 cm); it also secures a good recovery rate by peeling to a core size of 10 cm. Peelers of this type have been already introduced in developing countries and their wider application will go a long way towards expanding the raw material

base of the plywood industry.

55. Under the pressure of the diminishing raw material base the plywood industry had to accept not only lower sizes and qualities of logs but also a greater variety of species. For example, the plywood industry of India faced with a low capacity utilisation due to scarcity of raw material increased the number of species used from 12 to 40 within the last 15 years. In addition, 20 further species are being tested, many with promising results. This widening of the range of species was accompanied by lowering the minimum diameter of logs from 60 cm. to 30 cm. and by dropping the old requirements for a cylindrical shape of logs. Another outstanding example of successful expansion of the range of species for peeling is provided by Peninsular Malaysia which uses now 40 species for core veneer and 12 species for face veneer. Adopting of similar programmes will be necessary for many other developing countries in order that their plywood industries can survive and expand. The adaptation of technologies to a variety of species requires special investigations and measures applicable to specific conditions. In Japan, for example, a tenderizer is being used for eliminating stresses created during the peeling and drying of veneer from south-east Asian wood species with the resulting increase in yield. In all cases there is a need to adapt the technological process to the particular species with respect to the type of glue, pressing cycle and other process variables.

56. Veneer driers are still the most common bottleneck in plywood mills. Drying of veneer without degrade and with the efficiency required by the competitiveness of the market has led to the increased use of endless driers directly connected with the peeling operations through varying speed conveyers. Flexibility is rendered to the drying process by using endless driers for face

veneer and roller dryers for core-veneer and round-ups.

57. Control of moisture content of veneer is of critical importance to proper bonding and avoidance of failures in the final product, and in this respect, could be linked directly to the recovery from wood raw material. Overdried veneers absorb too much water from the glue mix at a later stage of the production process resulting in a weak bond. Excessive moisture in veneers can cause steam blisters, warping and delamination. Therefore, properly operating continuous moisture detectors are essential for keeping the share of defective plywood to a minimum. It is also important that in cases of pronounced differences between sapwood and heartwood veneers produced from them are dried in separate batches.

58. Glue is an expensive component of plywood but even the best glue can not prevent gluing deficiencies in plywood if the glue spread is uneven or improper. In order to secure optimum glue spread, high quality spreaders have been developed, equipped with soft and hard rubber rolls with special grooving designed for specific adhesives and with pressure control for rolls.

59. The lower quality of logs often results in a high proportion of narrow veneers. If these are fed through the center of the glue spreading machine, they cause accelerated wear of the rubber covered rolls with the resulting uneven spread of the glue. In order to avoid this, narrow veneer strips should be spliced into wider sheets using the full width of the glue spreader. This will help to avoid considerable losses in final product resulting from bonding failures.

60. With the general deterioration of the raw material the proportion of logs suitable for face veneers is diminishing causing an imbalance between the quality of face veneers and core veneers required for the final product.

Solutions are sought through peeling

of thinner face veneers; the flexibility in the system of dryers (mentioned in paragraph 56). . . . is also of help. Another solution which can be sought in response to this trend in the raw material quality is the change in product specification favouring larger thicknesses; this, in turn, would normally call for larger daylight in the hot presses; but since pre-presses are now widely used, larger daylight in main presses are not necessary.

61. Clipping of veneers is often a source of considerable losses of precious wood. Very accurate clippers have been developed using scanners and electronic control which reduce the losses to a minimum. However, traditional equipment (guillotines or cutterhead jointers) if carefully operated, can also exercise the cut without excessive wood losses; they would be preferable at this stage in developing countries.

62. Veneer mending including patching and plunging is a highly labour intensive operation since most mechanical equipment is not satisfactory. This operation offers considerable possibilities for accepting lower quality wood for face veneers for various types of plywood including construction plywood.

63. Yield of final product from peeler logs varies among countries even if they use the same type of logs. Eg. in large log producing countries of South East Asia, the yield amounts to 45 to 50 percent with the best among them like Malaysia reaching 55 percent; Japan achieves 65 percent from logs imported from the same countries. This is a result of a large concentration of the best technology and equipment, skilled workers, and experienced management. Also, marketing aspects play a role here; by adopting smaller sizes of plywood sheets, losses in log trimming are considerably reduced. The best results of some countries today must begin setting goals for other countries in the future if the challenge of the deteriorating raw material base for the

plywood industry is to be met efficiently.

64. Integration of plywood mills with sawmills can result in the increase of log supply for plywood production through cutting out high quality sections of logs destined for sawing. In view of the higher prices of peeler logs as compared to saw-logs, this procedure improves considerably the financial results of the integrated operation.

65. A comparatively recent development for maximizing the recovery from valuable peeler logs is a composite panel with veneer faces and a core of particles. Such panels resembling typical three layer plywood and often called particle-core plywood serve a number of the same uses as veneer-core plywood. Since the core is made of residues generated during the production process, the total surface of panels is approximately double the surface of veneer-core plywood produced from the same volume of logs.

66. Composite plywood is introduced only in some industrialized countries, so far. It may carry a promise for some developing countries in the future. At present, however, more attention should be given in developing countries to the expansion of production of solid wood-core plywood or blockboard with a core composed of narrow strips of solid wood. Since the strips are cut out of large residues (including the peeler core) this type of panel also increases the yield from logs. Blockboard is as old, historically as veneer-core plywood, has well established uses and is cheaper in investment and manufacturing than particle-core plywood.

2.3.2 DECORATIVE VENEER

67. Wood raw material for decorative veneer is becoming even more scarce than wood for plywood. With the recurrence of the trend towards natural rather than

artificial panel surfaces the demand for decorative veneers is strong and prices are growing continuously. This set of conditions creates the pressure on the industry for a higher recovery from raw material and a higher yield of the final product.

68. The main machine for producing decorative veneer is the slicer. The choice in slicers is among horizontal, vertical and slanted machines. Horizontal machines are considered most precise, vertical most efficient and slanted machines occupy a position between the first two.

69. New types of slicers are equipped with a vacuum table for flitches. This eliminates clamps and makes it possible to slice down flitches to a very thin rest plank raising the recovery considerably.

70. Production of decorative veneer through excentric peeling occupies a separate position in this field and is aimed at mass production and high recovery.

71. As in few other sectors of forest industries, the success in the manufacture of decorative veneers depends on the particular knowledge and experience of key personnel related to specific wood species and markets. There are considerable differences in opinion as to the best ways of carrying out some of the steps in the production process which often follow decades of experience of the producing companies. One subject of differences of opinion is the process of softening of wood. Some companies achieve this by cooking; others by steaming. While cooking maintains the wood moisture and softens it effectively, in some species it may affect the colour. Steaming, on the other hand, usually causes the undesirable loss of wood moisture, but does not affect its appearance. In practice, the way and length of wood heating before slicing depend on the properties of the particular species and are decided

upon based on the company's experience.

72. One way of increasing the total surface of decorative veneer from a given volume of logs is through reducing the thickness of veneer. Technology in this respect has been greatly perfected in some countries, particularly in Japan, where special horizontal slicers can produce veneers 0.2 mm. thick. Such extremely thin veneers, however, not only require special quality of wood, but also involve changes in the technology of veneer application. Therefore, their production does not seem attractive to developing countries at this stage.

73. In general, technical developments in the field of decorative veneer have not been as significant as in the field of plywood production. The key to success is still well trained and experienced personnel not only for such key functions as flitch cutting but also for other operations as well, including veneer drying, slicing sorting, storing and packing.

74. Conversion of logs into decorative veneer provides the highest value of the output among all primary forest industries. Therefore, their expansion is attractive to developing countries with a sufficient raw material base. For new industries, the initial operations and marketing are best carried out in conjunction with an already established and experienced company. Such connection would also enable the new operation to follow changes in fashion and preferences which are decisive for this industry with respect to export markets.

2.4 TRAINING

75. Technology of plywood manufacture is fairly complex. It involves a number of operations closely related to properties of wood: wood softening, peeling, slicing, drying, gluing and pressing: all of them require adjustments or changes

depending on the wood species processed. The need for such changes is greater at present than in the past, in view of the changed pattern of the raw material supply. To meet this challenge, a great variety of machines and technologies have been developed, end product diversified and new uses promoted. The success in adjusting the industry to the new situation and providing high quality panels despite the deteriorating raw material situation depends to a large extent on the availability of skilled workers, technicians and managers.

76. Training of operators of the main machines, particularly for peelers and slicers, dryers, presses and surface finishing lines should be carried out through formal training and on-the-job training as suggested for the sawmilling industry in paragraphs 19 and 20. However, there are fewer plywood mills in any country than sawmills and equipment is much more diversified. Therefore, training for the plywood industry has to bear some special features.

77. Training centres, preferably attached to outstanding vocational schools would have to have a sub-regional character. Only few countries with large plywood industries are capable of supporting strictly national centres. Since the establishment and operation of truly international training centres usually involves protracted and not always successful negotiations, simpler solutions may be adopted in the form of national training centres serving sub-regional needs on conditions mutually agreed upon by participating countries. The natural choice of location for such centres would be countries with strong and diversified plywood industries which could provide on-the-job training.

78. In each developing region plywood mills or integrated forest industries complexes can be found with most rational and modern equipment, appropriate technologies, good management and excellent technical and economic performance. Indeed, some of these mills are equal in every respect to some of the best

mills in industrialised countries. With the proper cooperation of the industry they could form a perfect basis for on-the-job training on a national or sub-regional scale.

79. Emphasis should also be given to training of instructors abroad which is usually facilitated by the machine suppliers. Such training, usually lasting from a few weeks to a few months should be followed in the country. The best opportunity is provided by the installation of equipment and start-up of new mills. The responsibility for this stage of training rests with the suppliers of equipment and know-how.

80. Training of technicians usually involves imparting specific knowledge of the plywood industry to wood technologists. This is done through formal training courses run by Consulting Companies, Institutes or Universities and by on-the-job training in several industrial operations with a wide range of technical and technological conditions.

81. In view of the importance of trained personnel for the plywood industry both government and industries must be involved in the promotion of training facilities, preparation of programmes and in securing a high level of the teaching staff. The eventual goal should be the development of local teaching staff for the bulk of the teaching programme with the short-term use of visiting teachers for highly specialized subjects.

82. Activities aimed at the promotion, expansion and improvement of training for the plywood industry are hampered by the insufficient information about the existing training institutions and facilities, their training systems and curricula, the quality of their staff and teaching aids. There is also insufficient knowledge of present and future requirements for skilled workers and technicians. Systematic action aimed at overcoming these shortcomings

is an essential prerequisite for sound training and education programmes for the plywood industry, both nationally and internationally. Assistance in this field should be sought from international organizations responsible for manpower development.

2.5 OTHER PROBLEMS

83. In addition to the main problems facing the plywood industries in developing countries of a global importance, there are a number of issues common to certain sub-regions or confined to individual countries. Several of them are related to the main problems and could be taken care of within the same framework of solutions. They will be briefly discussed in the following paragraphs.

84. Several forest rich countries particularly in South East Asia, which are the main producers and exporters of peeler logs for the plywood industry embarked on a programme aimed at the expansion of their own wood processing industries with the simultaneous reduction of log exports. This poses two problems. Firstly, the plywood industry in these countries will have to reach a high level of quality and efficiency so that the product can successfully compete on international markets. Investment capital for the expansion of these industries is already flowing to these countries from the former importers of logs and this makes it possible to build mills with the best equipment and the most suitable technologies. The real issue, however, will be the training of personnel which could properly use all this new technical potential. The possible ways of training were discussed earlier in this paper. The second big issue related to the shift of industries towards the raw material source is the great accumulation of residues amounting to 30 % to 50 % of the

total roundwood input. Larger solid wood residues could be converted into various products for domestic markets (furniture, stock, joinery elements, packaging etc.). Smaller residues could be used partly for power or heat generation in the mills themselves. But a large part of them will have no obvious economical outlet. In industrialised countries, such residues are often used for reconstituted wood panels such as particle board or fibreboard. But markets for these products in developing countries are very limited at present and need to be developed through consistent and long-term efforts.

85. It is generally considered that the shift of industries from log importing countries to log producing countries will create a big opportunity for the fuller utilisation of the raw material resources. Export logs for the plywood industry are produced in accordance with rather high quality requirements of importing countries leaving large volumes of lower quality trees unutilised or used for lower value purposes (eg. for sawlogs). Local production will enable the use of a wider range of log qualities for plywood, the lower grades of which would be sold on local markets.

86. Another effect of the trend towards limiting log exports is the considerable expansion of trade in a semi-product in the form of peeled veneer. Export of peeled veneer instead of logs constitutes a very useful first step towards forest industrialisation in some developing countries, while leaving part of the production facilities (veneer drying, jointing, gluing, lay-up, pre-pressing, pressing) in hitherto log importing countries. Such countries are trying to compensate the partial loss of processing by building up secondary surface finishing facilities (coating, printing, overlaying with various types of films etc.). The same trend is noticeable in "transit processing" countries eg. South Korea, Singapore, China (Province of Taiwan).

From the point of view of the developing countries, this intermediate stage alleviates their investment and training problems but leaves them with the full problem of the rational utilisation of the wood residues.

87. With the considerable expansion of plywood industries planned in many developing countries, mainly based on urea-formaldehyde adhesives, there will also be an increasing problem of formaldehyde release not only during the hot pressing but also from finished plywood panels especially when used in enclosed spaces. Formaldehyde in air, even in small concentrations is not only an irritant but also may pose some health problems. The responsibility for ill effects of formaldehyde given off by resins in the panel lies with the producer. This has been an important preoccupation of the industry in developed countries. The situation has been improved by the new formulations of the urea-formaldehyde resins. Developing countries will have to avoid the possible difficulties in this area by adopting the newest solutions developed in advanced countries and carefully following the further progress in this field.

88. Developing countries with limited wood resources and small markets can justify the establishment of plywood mills with only small capacities. Although simplified designs of such mills have been developed, their economics may often be marginal. In order to improve the economic indicators for such small mills, integrated complexes should be considered, producing a variety of wood products and using common facilities for power generation, maintenance etc. Such integrated "wood processing centres" exist in several developing countries and are successful both technically and economically.

2.6 SEARCH FOR SOLUTIONS

89. The main problems of the plywood industry in developing countries listed

in chapter 2.2 must be solved simultaneously at the technical and educational levels. The impressive developments and innovations in machines and technology of plywood manufacture gave the industry sufficient means for adaptation to the deep changes in the raw material pattern. But the proper use of these means depends on the parallel development of human resources, on their skills and experience.

90. In view of the profound differences between various groups of developing countries no single solution can be applied to solving the basic problems of their plywood industries and securing their accelerated development. Generally, at least two types of approaches will be required: (a) countries which have had a rich raw material base for the plywood industry in their natural forests, but suffer from the progressing depletion of the best logs, must concentrate on the adjustments and innovations which will make possible the use of logs with lower dimensions and qualities, processing a wider range of species and obtaining higher recovery from the raw material input. (b) Forest poor countries and countries which already have depleted their raw material resources traditionally used by the plywood industry, should prepare plans for a total restructuring of their plywood industries or building them anew based on a new type of raw material in the form of small size logs from plantations and natural forests.

91. Plans and programmes for solving problems impeding the development of plywood industries must be based on a thorough analysis of the progress made in technologies and equipment for plywood manufacture and its applicability to the specific situation in individual countries. They must also take fully into consideration the trends and prospects of domestic and international markets for plywood and the growing diversification of panel types and finishes.

An inherent part of such programmes must be a preliminary financial and economic analysis which will facilitate obtaining financing for the implementation and proposals for training skills and technicians.

92. The extensive and intensive work required for the preparation of these programmes calls for involvement of the best experts from industries and research organisations, consulting companies and equipment manufacturers, economists and educators. In addition to foreign expertise, concepts and ideas have to be solicited from within the country or the region, particularly from existing operations known for their high technical level and outstanding performance.

93. It is essential that programmes and plans for the development of plywood industries become part of overall forest industries development plans and incorporate to the extent possible the concept of integration of various types of production within one processing complex. Such integrated operations (eg. plywood production combined with sawmilling and a particle board or fibreboard mill) not only require lower investment expenditure as compared to separately built mills but are also more economical in operation and enable the most rational use of the wood raw material. Forest industries development plans have to be prepared in conformity with the national goals and priorities and make the optimum contribution to the social and economic progress of the countries concerned.

94. International assistance from appropriate United Nations Agencies in the preparation of development programmes for plywood and other forest industries will be required for countries with insufficient expertise or financial means of their own. A global approach to the solution of the various problems could result in considerable savings by preparing typical model solutions which would

then be adapted to specific needs of countries with similar conditions.

95. Countries receiving international assistance for examining their plywood industries and preparing plans for their restructuring or adaptation to the changing raw material supply should include their professionals in all stages of this work. This will enable their effective on-the-job training and facilitate follow-up activities at a later stage.

96. As in the case of sawmilling (see paragraph 37) there is a need to attach these activities to a national institution responsible for economic planning within the country. Many measures will require an interdisciplinary approach and be of a long-term nature, for example, the establishment or expansion of man-made forests as a source of raw material for the plywood industry, silvicultural measures, production of adhesives by the chemical industry, training of personnel, promotion of large scale outlets for the product through housing schemes etc.

3. RECONSTITUTED WOOD PANELS

3.1 GENERAL

97. The two types of reconstituted wood panels, particle board and fibre-board are much more modestly represented in developing countries than plywood: In 1980, plywood production in developing countries represented 19.1% of world production while particle board constituted 5.6% and fibreboard 10.5%. Reconstituted wood panels have been largely the products of the industrialised countries.

98. One overriding reason for this situation has been the fact that reconstituted wood panels can be produced from much lower quality raw material than plywood including a variety of residues. There has been an ample availability of this kind of wood raw material in industrialised countries while high quality wood was becoming more scarce and expensive. At the same time, the demand for wood based sheet materials for the expanding economies was growing continuously. This set of conditions resulted in an unprecedented growth of panel industries based on reconstituted wood. This is particularly true of particle board. As compared to plywood, this is a comparatively young product, started in the 1950's; yet, in 1980, its production worldwide reached the same level as plywood (over 40 million m³).

99. The same factors which favoured the expansion of reconstituted panels in industrialised countries - availability of raw material and markets-were hampering in the past their growth in developing countries: many of them still had enough raw material for sawnwood or plywood traditionally preferred in their markets and requiring for their production lower investment and manufacturing cost and comparatively lower level of skills and manage-

ment. Local markets, served by these products, had little room left for new types of products for the same end-uses.

100. There are signs in recent years that the situation is getting more favorable for reconstituted panels, at least from the raw material point of view. In forest rich developing countries a considerable growth of primary forest industries - sawmills and plywood mills - is expected to replace exports of logs with processed products and cater to the domestic markets. This will create large concentrations of residues which could be used for the manufacture of reconstituted wood panels. In forest poor countries, the growing domestic demand for forest products will have to be met, in time, by reconstituted wood products which can be manufactured from low quality and small size logs, tree branches, logging residues and residues from existing wood based industries.

101. While the changing raw material situation is increasingly conducive to the expansion of reconstituted wood panel industries in developing countries a number of constraints are still in force. They will be discussed in the following section of the paper together with other aspects influencing the development of these industries.

3.2 PARTICLE BOARD

102. The particle board industry has undergone a considerable change in its raw material pattern over the last two decades. The supplies of previously favoured raw materials in developed countries declined as a result of the competition from pulp and paper industries and of the growing demand for the final product. The industry was forced towards more diversified and inferior raw materials.

103. As the supply of raw material to particle board mills was getting more varied in type and quality the equipment needed to reduce it to suitable particles was also becoming more diversified and versatile. This applies to chippers, hammermills, atmospheric and pressurized refiners, ring-, drum- and disc flakers. Developments in this equipment created the present situation in which practically any type and shape of residues, from mills and from forests can be converted into particle board. This makes this industry one of the major contributors to the full use of the wood raw material resource.

104. The particle board industry can now use mixtures of tropical hardwood species, mixed thinnings from broadleaved and coniferous plantations. Only extra dense hardwoods with a high silica content are to be avoided because of the knife wear and high energy consumption (they are more easily processed for fibreboard). A certain proportion of multilayer particle boards still require small-size roundwood for large "engineered" flakes necessary for the special appearance of surface layers of the panels. But the general trend is towards the use of very small particles for the outer layers which provide a smooth surface particularly advantageous for covering it with thin veneers or thin decorative films. These fine particles can best be obtained from previously unutilisable residues such as sawdust or shavings processed in attrition mills.

105. The most common way of processing various solid wood residues is by chipping them and then converting chips into particles in a ring flaker; these particles are suitable for the core layer of the board while particles for the surface layers need additional grinding.

106. The use of different types of raw material in the same mill involves the installation of different machines for particle production. Eg. a plant

designed for sawdust and shavings cannot use solid wood residues. More machines affect the investment and production cost. Also, using a mix of species results in higher operation costs: to keep the properties of the board uniform a steady composition of species mix is necessary and this requires a number of measures, the final result of which is the higher cost of production. Therefore, while a diversity of types and species of raw material is possible, a more homogenous input is always preferable.

107. The enormous advantages of the particle board industry with respect to the wood raw material requirements are partly offset by the high cost of another basic input: binders. Two types of synthetic adhesives are basically used in particle board production: urea-formaldehyde (UF) and phenol-formaldehyde (PF).

108. Modifications in resins made in the last decade resulted in improvement of various properties of panels such as water resistance, strength, etc and in their more economical application. One improvement concerns the reduction in the release of formaldehyde which may cause similar problems as in urea-formaldehyde bonded plywood (see paragraph 87); the importance of this improvement is underlined by the fact that the amount of the resin in particle board is two to three times higher than in plywood.

109. There has been a trend towards producing glue by the particle board plants themselves. Normally, glue contains about 35% water which makes transportation over long distances expensive and, in addition, under certain climatic conditions, premature curing may take place. Purchasing powdered glue increases its cost by about 40%. Therefore, attaching glue manufacturing plants to particle board mills of a certain minimum size is a rational solution.

110. The high cost of synthetic resins in developing countries (which generally

constitutes 25 to 40 percent of the total manufacturing cost) caused interest in natural polyphenols (tannins) found in wood and bark of a number of species, eg. mimosa wattle from South Africa and quebracho from Argentina are used in many countries including Argentina, Australia, Brasil, India, Finland, UK. Investigations into other polyphenols have also been carried out including mangrove, radiata pine, some species of Eucalyptus, black wattle and others. The tannin-formaldehyde binders with a synthetic resin fortifier have been used for particle board production in various countries at different times. It seems, however, that operational and other problems prevent their sustained use. The importance of the subject to developing countries warrants a great and coordinated international effort towards solving them.

111. Modern particle board plants are based on a comparatively complex technology and sophisticated equipment. The whole production line is mechanised and partly automated. For each production stage there are several options, each offering advantages and involving different drawbacks. The selection of the optimum solution for each mill must, therefore, be based on careful analysis by highly experienced experts.

112. Particle board mills are usually offered by equipment suppliers or specialised engineering companies on a "turn-key" basis. The suppliers also offer the training of personnel. The proper formulation of guarantees for quality and quantity of production and consumption of various inputs is particularly important in view of the high cost of such turn-key plants. Eg. the cost of equipment delivered and installed for a 200 m³ /day particle board plant is in the order of US \$ 8.5 million, or US \$ 42,500 per each cubic meter of mill capacity; for a plant double that size, the cost would be 25 % lower or around US \$ 31,900. Particle board mills with large capacities are cheaper

than plywood mills with the same capacities. For small mills, however, investment in plywood is lower because of the easier adaptability of the production lines to smaller capacities.

113. During recent years, technologies of particle board manufacture have been adapted to the specific needs of developing countries with an abundance of labour and limited markets for the product. Several models of such labour intensive, small-scale plants have been developed by engineering companies and equipment suppliers.

114. Integrating particle board plants with other primary wood processing industries which generate a large proportion of residues, eg. sawmills or plywood mills would reduce the investment expenditures. It is estimated that such integration brings about investment savings in the order of 10% of the total investment cost. In addition, operational costs are lower due to fuller utilisation of wood and the use of common facilities (power, maintenance etc.); as a result, the price of particle board can be set at a more competitive level.

115. The size of a particle board plant in a developing country must be determined by the size of the domestic market. Export markets are usually not available. Industrialised countries possess, on the whole, well developed particle board industries themselves because the required raw material is amply available. In addition, the rather low value of particle board per unit of volume makes the transportation of this product over long distances uneconomical. Eg. the import value of particle board in Europe in 1982 was in the range of US \$ 150-200 per cubic meter. Freight cost from East Africa in the order of US \$ 40 per cubic meter would constitute 20 to 26% of the price which would be high enough to make particle board uneconomical in f.o.b. terms.

Freight would have much less impact on plywood which had at the same time a price twice as high as particle board. In general, the only international trade in particle board from developing countries could be among neighbouring countries.

116. Local markets in developing countries are mainly dominated by sawnwood and to a lesser degree plywood. Capturing part of this market for particle board is a long process and involves meticulous preparatory work. Users of particle board must get well acquainted with tools, finishes, screws, etc. required by this product. They must also be taught how to use the various advantages particle board offers in comparison with traditional products. One of the important tasks at this stage is also the identification of the best marketing targets where particle board could compete best in properties and prices. All this requires not only expertise, but also time, manpower and financing. Practical demonstrations should be organised in the user's plants and training courses given at specially organised training centers. There is no way of avoiding all these activities (and accompanying expenses) which were carried out in industrialised countries when the product was first introduced on their markets. A wealth of promotional material now exists which could be used by developing countries. It is important, however, that planning of promotional activities is started together with the planning of the particle board plant and that the cost of promotion is included in the cost of the establishment of the new operation.

117. The best promotional campaign will prove useless if the quality of the product is below the required standard, or if customers do not follow instructions for end-uses. Many particle board plants in developing countries failed because of the low quality of their product or because customers discredited

the product by using it in the wrong way or for the wrong purpose. Exterior uses of particle board, even with phenolic bond, proved particularly dangerous, and therefore the main markets should be sought within interior applications such as furniture, partitions, panelling and fittings etc.

118. Well trained personnel is an essential prerequisite for the proper operation of the mill and for maintaining the quality standard of the product. Machine operators and foremen should be trained, as in the case of plywood industries with the assistance of the plant suppliers. While foremen should be trained abroad, or if possible in well operated mills within the region, machine operators are best trained during the period of the installation and start-up of the plant; candidates for such training should be selected among mechanics and electricians with a formal vocational training. Technicians responsible for the supervision of production and for quality control should have a background in wood technology and a thorough training in particle board mills and laboratories. In addition to the production personnel, of great importance to the success of the plant is training of technical salesmen. They should have a practical knowledge in the various uses of particle board, be able to demonstrate them on the spot at the customers' facilities and provide a certain amount of "trouble shooting" whenever customers run into problems related to improper uses of panels. This type of training can be provided at the various types of factories and other facilities using particle board and having long-term and proven experience in this field.

119. Training of personnel does not necessarily have to be done in industrialised countries. There are many examples of particle board plants or integrated complexes containing a particle board plant in developing countries properly designed and well operated and managed which could be used for training personnel from other developing countries if appropriate arrangements for this

purpose could be agreed upon. A forest industries complex in Nigeria containing a particle board plant integrated with a sawmill and a plywood mill is one example of not only proper mill operations but also of effective product promotion. An integrated mill in Brasil, near Sao Paolo, combines a sawmill with two particle board lines, one for conventional panels, the other for thin panels - all based on plantation pine and Eucalyptus. There are no unutilised residues in this operation, particle board is of very good quality and used either as door skins (thin panels) or for various interior applications like furniture or fittings (thick panels). There are quite numerous other examples of outstanding particle board operations (Malaysia, Surinam, Philippines etc.); they demonstrate the realistic possibility of technical cooperation among developing countries (TCDC) in the field of particle board and other wood based industries.

120. The last decade has seen the development or expansion of new types of particle board: cement-bonded particle board, waferboard, thin particle board and oriented strand board (OSB). Thin particle board and cement-bonded particle board are already produced in developing countries. All types of these "new" panels could find a set of conditions in certain developing countries under which they could make a useful contribution to their economies. In each case, however, economic and technical aspects of their manufacture and uses and particularly their market acceptance have to be carefully examined and fitted into the general plans of forest industries development.

3.3 FIBREBOARD

121. Fibreboard, like particle board, can be produced from a wide range of types of wood and wood residues provided that they can be converted into chips. Sawdust can also be used and its proportion in the furnish up to 70% does not

affect adversely the quality of the panel. Softwoods and hardwoods are acceptable, separately or in mixture. Unlike particle board, fibreboard production is less sensitive to the density of wood. Before using untested wood species, research is required for determining the optimum parameters of the production process.

122. The key to the production process is the transformation of wood into fibres or bundles of fibres (defibering). In some cases, further refining of this material is needed. The most common equipment used is the pressurized refiner where wood chips are subjected to steaming and then to grinding between refining discs. The refining equipment may have to be adjusted to fit extreme variations in the raw material input.

123. The progress in defibering and grinding equipment has been towards larger capacity and efficiency and towards improvements in the grinding action to obtain better quality of pulp and increased life of the grinding discs.

124. The grinding operation is common to all types of fibreboard processes. The most common among production processes is the wet process which requires little (up to 1%) or no binders and enables the production of all three types of fibreboard: hardboard, medium density fibreboard (MDF) and soft board. In the wet process, water is added to the pulp so that a uniform quality mat can be formed on the wire screen of the forming machine; sections of this wet mat are then compressed in a hot press. The resulting product is a compressed fibreboard, either hardboard or MDF. If the wet mat is sent to a dryer instead of a press, the resulting product is softboard.

125. In the dry process of fibreboard production the mat is formed by a felting machine using air as a medium for spreading dry fibres. Addition of glue is essential in this process (2% to 3% for hardwood and about 8% for MDF).

126. One major problem associated with the wet method of fibreboard production is the danger of water pollution; to prevent it additional investment expenditure (up to 5% on the total investment) and operational expenses are needed. The main danger in dry process fibreboard mills consists of fires and explosions in the fibre dryers which involve the necessity of various measures of precaution including the installation of automatically activated control equipment. Even greater fire danger is posed by fines (small wood particles generated throughout the grinding and drying process) settled on horizontal surfaces within the mill; this problem is now taken care of by appropriate mill design and installation of fire detecting and extinguishing equipment.

127. It is generally considered that for developing countries where water pollution problems may not be as acute as in most industrialised countries, the wet process has distinct advantages of lower resin consumption, shorter start-up time, simpler operation, and lower investment cost for smaller capacities.

128. Energy consumption in fibreboard production is quite high, higher than for any other type of mechanical processing wood products. In comparison to particle board, hardboard consumes approximately 3.5 times more power and thermal energy per cubic meter of final product. If this energy could be produced from an excess of locally available wood residues, this would give producers in developing countries an advantage as compared to fibreboard producers who have to use imported oil for generating power. The importance of this aspect stems from the fact that the share of energy cost in hardboard production normally exceeds 20%.

129. Investment costs related to the fibreboard industry are higher per production unit than for particle board or plywood. The cost of installed equipment for a hardboard plant with daily capacity of 60 tons is around US \$ 10

million; for 120 tons per day - around US \$ 14 million; for 180 tons per day - around US \$ 17 million. Another 40% has to be added to obtain the total investment cost.

130. The sophistication of the production process is even greater than with the particle board manufacture. The whole production line is fully mechanised and equipped with devices for automatic process control. Even short time interruptions in the work of any machine or facility between pulp storage and the hot press cause the discontinuation of the production process and heavy losses for the enterprise. Therefore, personnel have to be well trained and experienced. The ways of training may be similar to those discussed in paragraph 118 in relation to particle board industries. Similarly, as in the case of particle board, there are examples in the developing countries of excellent fibreboard operations. Two large scale fibreboard enterprises in Brasil mastered the use of Eucalyptus as a raw material, achieved a high quality product, developed new types of panels not produced elsewhere and export about one third of their total production to industrialised countries. Thailand has been producing excellent quality hardboard for years, expanded the market through successful surface finishing of panels and recently added another line, more than doubling the production. These are modern mills which can match in every respect good mills in developed countries. There are also several small-scale mills in various developing countries based on the old batch system of production and geared totally to the small domestic markets. Some of them operate very successfully and can serve as an example of the wide variety of technical solutions which is required to fit the specific needs and conditions of developing countries. Every effort should be made to use the existing and proven experience of some developing countries

for designing the strategy for further expansion of panel industries and for training personnel for other developing countries with less experience in this field.

131. Marketing fibreboard in developing countries causes similar problems to those of particle board, and calls for seeking similar solutions (see paragraphs 116 and 117). Important elements of the market promotion programme are: the proper identification of end-uses and training of technical salesmen who can not only promote the product, but also demonstrate its applications practically.

132. Among comparatively new products on the market is MDF (medium density fibreboard) which can be produced both by the wet method (up to 12 mm thickness) and by the dry method (up to 35mm thickness). This product is not yet represented in developing countries. In developed countries, thinner panels of MDF (12 mm) are used in construction (siding); thicker panels produced by the dry method are used for furniture production. In this latter application MDF produced by the dry method is superior to particle board in several respects: it has greater homogeneity and better dimensional stability; the very smooth surface of MDF is suitable for applying thin veneers and the tight smooth edges can be finished without edge banding. However, MDF requires almost as much synthetic resins addition (8%) as particle board, is more energy consuming, more expensive in investment and production and more difficult to operate. Therefore, before making a decision on starting the production of MDF in a developing country, a very careful analysis of all marketing and production aspects should be made.

3.4 MAIN CONSTRAINTS TO DEVELOPMENT

133. The discussion of the various aspects of the reconstituted wood panel

industries contained in the preceeding chapter reveals a number of factors favouring these industries as well as obstacles to their development in developing countries. One of the main favourable factors is the raw material situation. The situation is shaping up differently in countries endowed differently in forest resources. The trend in forest rich countries is towards expanding their export oriented forest industries by building large, integrated complexes, producing sawnwood and plywood and its production generates huge volumes of wood residues which, in other parts of the world, are most economically used as a raw material for reconstituted wood panels. Forest poor countries are facing increasing difficulties in meeting their demand for sawnwood and plywood because of the shortage of suitable logs. But substitutes for these products - reconstituted wood panels - can be produced from inferior raw materials which can be found in most of these countries.

134. The most important constraints hampering the development of reconstituted wood panel industries are:

- Lack or insufficient size of domestic markets
- Lack or shortage of skilled personnel

135. There are also other problems involved in the development of the reconstituted wood panel industry: the high investment cost, high cost of synthetic adhesives, the difficulty in the most appropriate choice among the constantly growing varieties of equipment and technologies - to name just a few which were discussed earlier in this paper. But the overriding importance of markets and training is undisputable: without markets no production can even be contemplated and without proper training, the operation of the sophisticated production lines would be unthinkable.

3.5 SEARCH FOR SOLUTIONS

136. The development of markets requires that their planning and promotion

start before the construction of the mill; for this purpose limited quantities of particle board have to be imported. Lack of success at this early stage of market promotion may cause the delay or even abandoning of the project thus preventing an even greater and more costly failure. More detailed suggestions for the market promotion action are contained in paragraphs 116, 117 and 131.

137. The promotional action is usually difficult in view of the inherent opposition to new products and their higher price which cannot always be easily explained by quantifiable advantages compared to traditional products, higher skills and new methods required for processing new types of panels.

138. The other major issue related to the development of reconstituted wood panel industries is the need for training skilled labour and technicians for the various phases of the technological process which is more sophisticated than in any other sector of primary mechanical wood processing. Suggestions as to the best ways of training were made in paragraphs 118 and 130. Training for these industries cannot be considered in isolation from the training systems and facilities available within the countries concerned. It must be part and extension of these systems. Therefore, it cannot be solved by industries alone, it requires involvement and cooperation of relevant government agencies and must be given as high a ranking among national priorities as industrialisation itself.

139. There are great opportunities for international cooperation in solving the main constraints in the development of the reconstituted wood panel industries in developing countries. This applies to both the assistance from the United Nations and bilateral aid agencies and to the TCDC (technical cooperation among developing countries).

140. International organisations can mobilise the best and most relevant expertise in this field and provide assistance in the analysis and planning the development of this sector in which market considerations play a key role. They can reach for the best available models for market promotion and sponsor this action on the ground; their unbiased approach is a guarantee for sound solutions in the best interest of the developing countries.

141. International assistance can also play an equally important role in training skilled workers and technicians. In the highly specialised field of reconstituted wood panels, individual countries could rarely support training programmes on their own. International cooperation in this field is not only advantageous, it is also inevitable. United Nations Agencies responsible for education and training are in the best position to identify existing vocational schools which could be adapted to regional training centres for foremen, and technical schools for providing additional training to wood technologists in the field of reconstituted wood panels. Such training centres and technical schools could be confined to this sector or deal with all wood based panels (ie. with plywood in addition to particle board and fibreboard) or embrace all primary mechanical wood processing industries. This last variant seems preferable because it could provide a balanced approach to the various sectors of forest industries and help in the fostering their integration.

142. An important part of training activities under sponsorship of the United Nations Agencies is on-the-job training of national professionals through their inclusion in the international Teams of experts working in their countries. These counterparts should actively participate in all phases of internationally assisted projects so that they can acquire the necessary experience for similar jobs within their countries and for follow-up activities.

143. Developing countries themselves can contribute considerably to this international effort. In each developing region there are exemplary operations in the field of reconstituted wood panels which could provide a great deal of assistance to developing countries with less experience in this field. This applies to both technical facilities and human expertise which could be used as a source of advice in market analysis and promotion, planning new operations, training manpower and product development and application. Better understanding of the regional situation and greater cultural affinity can facilitate this task considerably.

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