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PARTICLE BOARD PRODUCTION FOR DEVELOPING COUNTRIES

by

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Acting as discussion leaders for this topic.

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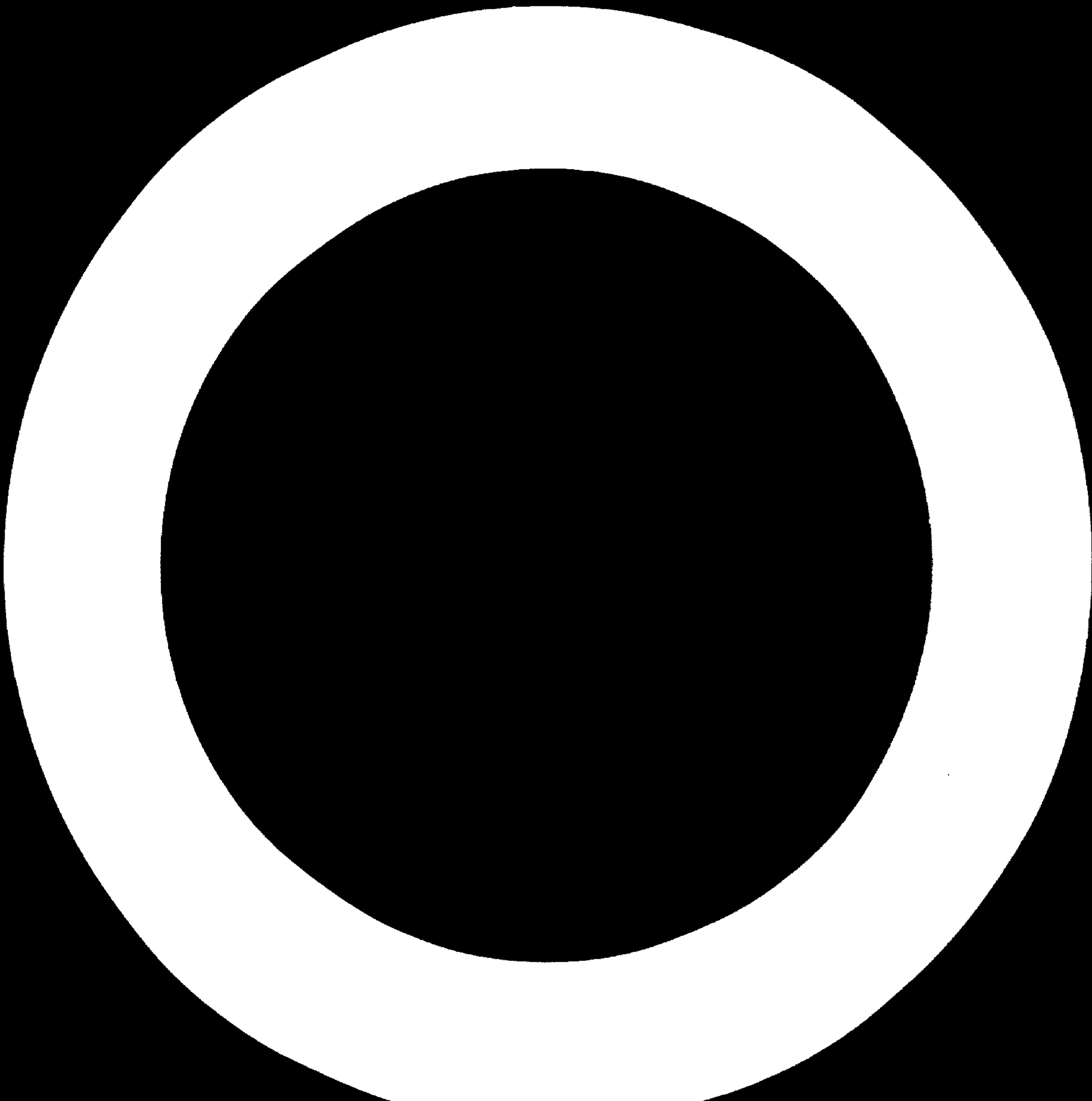


INTRODUCTION

UNIDO convened in Vienna from 3 - 7 November 1975 a Workshop on Wood Processing for Developing Countries. Messrs. D. S. Latta and P. E. Tack were Discussion Leaders for the groups discussing "Particle Board". For its discussion the group had available for study the following documents:

"Particle Board Production" by Mr. P. E. Tack (Document ID/WG.200/7)

"Adhesives" by Mr. J. Reinhardt (Document ID/WG.200/3), and

the report of a UNIDO expert working group on Production of Panels from Agricultural Residues in December 1970 (Document ID/79).

They discussed this topic in depth and requested the Discussion Leaders to prepare this study based on their discussions.

PARTICLE BOARD

1. Definition - The meeting decided that boards should not be defined as homogeneous or three-layer boards since this refers purely to the spreading process and not to the board structure, and since all boards have graded structure whether spread with a single machine or three or more machines.

2. Board types

The following main types of particle board exist:

(i) Extruded particle board:
A particle board made by extrusion through a die. The particles lie with their larger dimensions mainly perpendicular to the direction of extrusion;

(ii) Moulded Particle Board;

(iii) Flat pressed particle board, made in a wide range of thicknesses and density.

3. Board Standard Specifications

The following national standards exist in developed countries, as listed on attached appendix.

Machinery suppliers will normally base their operating guarantees on their own national standards and, in the absence of an existing national standard in the producing country, consideration should be given to adoption of the standards of the machinery supplying country. When export of particle board is being considered however, it will be necessary to conform to the national standards of the importing country although recommended methods of test should preferably not be altered for small consignments. Consideration can be given to adopting mean levels of quality for board supplied to the home market in order to take account of particular local requirements.

However, it is recommended that the technical standards used in one of the developed countries should be adopted as the basis for quality control in any new plant in a developing country where separate national standards do not exist.

WORLD PRODUCTION OF PARTICLEBOARD

1.000 m3	1962	'63	'64	'65	'66	'67	'68	'69	'70	'71	% of world output – 1971
World	4.313	5.377	6.639	8.404	10.091	11.588	13.855	16.359	18.377	21.932	
1. N.America	790	943	1.220	1.629	2.191	2.352	2.861	3.415	3.409	4.755	21,68
2. Centr.America	9	19	40	42	52	52	74	87	80	83	0,38
3. S.America	62	82	98	114	136	149	219	299	511	549	2,50
4. W.Europe	2.380	2.954	3.558	4.462	5.089	5.863	7.043	8.476	9.695	11.212	51,12
5. East Europe	543	696	783	910	1.010	1.157	1.326	1.416	1.577	1.766	8,05
6. USSR	343	433	592	791	1.035	1.302	1.507	1.707	1.994	2.349	10,72
7. Oceania	21	38	65	100	148	178	229	275	314	337	1,54
8. Africa	7	13	29	27	27	33	38	62	70	75	0,35
9. N.East Asia	5	5	9	23	30	46	77	98	108	122	0,56
10. Far East	9	24	33	50	67	76	62	69	68	75	0,35
11. Others	144	170	212	256	306	380	419	455	547	609	2,78

5. Consumption of particle board has been truly exceptional. This product appeared on the market at about the end of the Second World War and consumption has grown at a rapid rate in most countries ever since.

Total World Consumption Table ('000 tons)

	1950-52	1953-55	1956-58	1959-61
World	39	265	790	1800
Europe	27	165	495	1218
USSR	-	-	-	83
North America	12	80	224	388
Latin America	-	1.2	9.3	20.7
Africa	-	13.8	31.7	28.3
Asia	-	3.8	25.7	62.3
Pacific	-	-	4	11
kg per capita:				
World	0.01	0.15	0.35	0.8
Europe	0.07	0.4	1.2	2.9
USSR	-	-	-	0.5
North America	0.07	0.4	1.2	2.0
Latin America	-	0.01	0.05	0.1
Africa	-	0.06	0.14	0.11
Asia	-	0.00	0.03	0.06
Pacific	-	-	0.2	0.7

With the exception of Africa (and here it may be due to statistical inadequacy) all regions show very high relative rates of increase. For the world as a whole, consumption increased considerably every year but the world level was in 1961 still less than 1 kg.

Average Per Capita Consumption in Western Europe

1969	-	16.02 kg
1970	-	18.10
1971	-	20.76
1972	-	25.10
1973	-	29.26

Denmark and Germany have the leading position in Western Europe with 56.2 and 54.79 kg per capita respectively.

USES OF PARTICLE BOARD

The priority in developing countries is for increased housing to be achieved before less important markets such as the furniture industry are satisfied. With this in view, the use of particle board in the building industry was discussed.

6. Building Industry

In buildings such uses as doors, ceilings, wall-panels and underlayment panels are of major importance.

In general, the actual end uses in developing countries can be said to parallel those of other countries and this is also valid with respect to technical requirements.

In several developing countries resistance to decay, fungi and insect attack and humidity is required. There are preservative treatments that can be applied where the natural durability of the raw material is not sufficient.

Methods of treatment have been developed to fit particle boards for different exposures. Similarly, glues with a high degree of moisture resistance are available. These improvements in quality are, however, obtained at additional cost which will raise the price of the board.

In general, internal walls and ceilings and built-in furniture should not give rise to problems of humidity although it was noted that in certain countries such as Indonesia the open nature of the houses and the habit of frequent washing of all internal surfaces introduced a risk of excessive humidity.

For roofs and floors in particular but also for walls and ceilings correct ventilation to prevent build-up of humidity and condensation is very important. It is essential therefore that the end users, in particular architects, should be fully informed of correct installation methods so that failure of the board due to fungal attack does not occur.

In certain countries such as Singapore, regulations require fire-resistant building construction, and it was noted that it is possible to add fire-retarding products to particle board during the manufacturing process.

Urea-Formaldehyde bonded particle board when used for flooring must be of a higher density than standard structural grades and if used as a load-bearing floor, it is very essential that proper ventilation and damp protection measures are taken to avoid possible floor collapse and potential accidents. Since building regulations may not be fully established in developing countries and since local supervision of such regulations is in general insufficient, UF bonded board may well be incorrectly installed as flooring with serious consequences. It is therefore recommended that UF bonded particle board should not be used for flooring until such time as building regulations, codes of practice and proper inspection facilities have been established.

Phenol Formaldehyde Particle Board can however be used with a high degree of safety for flooring applications, but it should be noted that in nearly all cases PF Resins are more expensive than UF Resins.

If the manufacture of PF bonded particle board is being considered this intention should be made known to the machinery suppliers prior to placing an order for plant since the plant output capacity will be affected.

7. Furniture Industry

Flat pressed particle board presents properties of considerable importance.

Technical suitability of flat pressed particle boards for furniture manufacture:

- large dimensions, good machineability, uniform and low density;
- uniform thickness, freedom from warping and good stability;
- good strength normal to the surface, good screw holding characteristics, low swelling characteristics, and a minimum of show-through or telegraphing characteristics.

Present use practice:

- In the USA, where there is a relative abundance of wood residues (shavings, sawdust and other sawmill wastes), a high volume of cheap homogeneous flat pressed particle board is produced. This particle board is covered with a thick wood veneer and used in the furniture industry. Nearly all furniture panel cores are homogeneous particle boards for reasons of economy and technical suitability (stiffness, surface, etc.). About one third of the particle board output is used in the furniture industry.

- In Europe three or more layer particle boards with high quality surface properties are mostly used for furniture making.

  High surface quality is required. Imperfections of the panel surface could telegraph or show through the thin finishing veneer and be clearly detectable on the surface of the finished board. This applies to special overlay, laminate, foil, paint, especially if the final finish is glossy.

It was noted that the shortage of tipped tools and their comparatively high cost as well as a lack of knowledge in their use, made the machining of particle board difficult in furniture processing in developing countries.

8. Packing

There are regulations in some countries that no foodstuffs can be packed in particle board containers. Resistance to the use of particle board for packing tea can be expected from the tea industry despite the aluminium linings employed. Commercial experience had shown that no appreciable volume of sales to the foodstuff packaging industry could be expected. Experience however had been obtained in the satisfactory packing of tobacco in particle board containers.

9. Other End Uses

Possible markets for particle board could arise in the following industries: railways, motor transport, containers, shop fitting, shipbuilding, do-it-yourself and sundry uses such as switchgear mounts and coffin bottoms.

PREREQUISITES FOR PRODUCTION OF PARTICLE BOARD IN DEVELOPING COUNTRIES

The most important requirement prior to the establishment of a particle board industry is to have a feasibility study carried out by qualified consultants or institutions who are completely independent of any plant supplier. The feasibility study should cover the following three main factors:

- market feasibility study;
- technical feasibility study;
- a study to determine the feasibility of integration with other wood processing industries.

Reference was made to FAO document FOI WPP/70/4.1(rev) entitled "Guidelines before establishing a wood-based panels operation". This document sets out clearly a large number of factors which must be considered prior to the establishment of a particle board industry.

10. Raw Material Considerations

One of the main reasons for the almost unique success of the particle board industry is the fact that a wide range of raw materials can be used from wood residues to agricultural residues such as Bagasse, Flax, Hemp, Jute, Cotton Stalks, Kenaf. Each of these can be blended with wood and wood residues provided that the preparation line is suitably adapted.

Timber can be supplied in many forms ranging from round wood (both short and tree lengths) branch wood, split wood, saw mill residues such as slab wood, saw dust etc., joinery residues such as planer mill shavings, peelings etc., pulp chip fines, hogged chips, and plywood and veneer residues such as peeler cores, waste veneer, etc.

The suitability of different species depends on three aspects:

- certain species will affect the internal bond of particle board and also species which can be employed in the particle board plant should be tested during the feasibility study stage;
- the acidity of different species varies and if wide variations of pH are expected, steps will have to be taken to organise a constant species mix. If species of widely different acidity are fed to the plant at intervals, the glue chemistry will be affected and the board quality seriously impaired, also further processing;

- certain timber species would be uneconomic to flake due to their hardness and this factor should be determined during the feasibility study.

A small quantity of bark could always be included in the preparation line. A higher content of bark can affect the board properties and it is recommended that bark should where possible be confined to the core of the board; bark has different swelling properties to timber particles.

The supply radius for timber, the collection and transport methods and any possible seasonal influences on the supply pattern must be studied during the feasibility study stage.

The local manufacture of resin is not likely to result in lower resin costs. The raw materials such as urea and methanol cannot be bought as cheaply for a small capacity resin plant as they can be by an established resin manufacturer. A resin plant with a capacity of 20,000 tons per annum (at 65% resin solids) is accepted as being the minimum size plant commercially viable. The cost of the corresponding formalin plant is US$1.6 million to US$2.2 million and the cost of the resin plant is US$1.1 million to US$1.8 million. It was noted that the resin selling price in India was approximately four times the manufacturing cost in Europe.

It is possible to supply additives to act as insecticides, fungicides, fire-retardants, etc. but it was noted that the use of the first two products introduce considerable problems for handling due to their toxic effect; also the glue and board properties could be affected and no assurance can be given as to the durability of the treatment efficacy; there are also effluent problems. If problems of fungal and insect attack are expected it is necessary first to identify the species of fungus and insect and it is recommended that potential resin suppliers or competent research institutes are then approached for advice.

MARKET CONSIDERATIONS

Great emphasis must be placed on the necessity of carrying out a full and independent market feasibility study prior to deciding on the installation of the particle board plant. Many examples were given of the failure of plants where board consumption had been estimated from such details as per capita consumption

The participants reaffirmed that board for the building industry should have priority over board for the furniture industry, and it therefore followed that boards of a 4 ft. width (or multiple of 4 ft.) should be considered rather than the 6 ft. board width normally required for furniture production. Most developing countries install plants to produce board 4 ft. x 8 ft.

11. Choice of Board Sizes

The larger the board size, the lower are normally the cutting losses when processing the boards. There can be real advantages in manufacturing boards of large size in order to cut them immediately to final sizes particularly however for furniture production. If, however, unprocessed particle board is to be sold in standard sizes on the local market, the advantages of large sizes are limited and disappear completely.

The larger the size, the more difficult is board transport and handling. The limit for transport by lorry is about 1.830 mm x 3.660mm. In some countries - Greece for instance - between 1965 and 1970 boards of sizes greater than 4 x 10 feet (1.220 mm x 3.050 mm) could not easily be sold due to the handling problems in the narrow streets and small storage places in and around the capital.

While it is in theory possible to install a 6 ft. wide press and use it mostly for the manufacture of 4 ft. wide boards, it was highly recommended that this solution should not be adopted. All the other equipment in the plant must be sized to supply a forming and pressing line 6 ft. wide and if it is operating normally, only with a 4 ft. width, only approximately two-thirds of the equipment capacity is being used and consequently the costs of servicing the investment are relatively higher. Also severe damage to the press and associated equipment will almost certainly result if 4 ft. wide boards are manufactured in a press designed for 6 ft. wide boards.

12. Plant Output

The capacity of the plant must be determined by the results of both the market and technical feasibility studies. Neither of these two factors can be taken in isolation.

The capacity of a plant producing particle boards is subject to a number of qualifying factors, such as:

- production specifications, thickness and board size;
- raw material composition;
- number of operating days per year;
- technological factors such as pressing cycles;
- operating efficiency.

Capacities in tons/24 hr. of particle board plants are normally given on the basis of 19 mm (3/4 inch) board. Approximate relative capacities for other thicknesses may be accepted as follows:

60-65%	for 4 mm thickness
80%	for 10 mm thickness
100%	for 16 and 19 mm thickness
90%	for 30 mm thickness

In particle board plants, 3-shift operation in production units is quite general to reduce production costs. Some services, however, such as woodyard and workshop, work on a 1- or 2-shift basis.

It was recommended that any particle board plant should be run on a 24 hour basis since severe technical difficulties and losses of material and production time would result if the plant is started and stopped once a day i.e. for one or two shift operation.

Finally, two main factors determine plant capacity: the availability of raw materials and the operating efficiency. The operating efficiency in well organised particle board plants varies between 90 and 94%, and drops rapidly when organisation fails or when no qualified labour exists.

MANUFACTURING PROCESSES

13. Choice of manufacturing system

The following systems are mainly installed:

- steel belt system using a single daylight press in which the mat is spread continuously on an endless steel forming belt by volumetric, gravimetric, pneumatic or other combined system;
- the textile or flexiblo mesh belt system which allows the use of single or multi-daylight presses;
- the tray belt plant works with deckle boxes which are equipped with a bottom belt. The tray belt deckle box serves for the forming of the mat and the loading of the press. One forming frame is required for each daylight of the press;
- the tray system plants work with deckle boxes in the mat forming and pre-press sections. The mats compressed into rigid moulds are pushed in the loader one for each daylight of the press. The aluminium or reinforced PVC supporting sheets do not enter the press;
- the caul-type system operates in the mat forming section with cauls. The mats formed on the cauls are sometimes slightly pre-pressed but they remain on the caul. Mat and caul enter in the hot press. After pressing, boards are separated from the cauls. The cauls are cooled down and return for a next mat forming cycle;
- the flexible caul system operating on a similar principle to the rigid caul system above but offering the advantage that space can be saved since the cauls can return to the start of the line by passing underneath the press;
- various systems for the manufacture of thin particle board (thicknesses not exceeding 8 mm) such as the "Calender" press system, cold-hot pressing system etc. It was noted that a much higher proportion of low quality wood waste could be used in the "Calender" press system;
- continuous pressing systems;
- miscellaneous new systems.

The choice of a suitable system of press plant is rather difficult and depends mainly on the following factors:

- the type of board to be produced;
- the plant capacity;
- the basic raw materials;
- the investment lines;
- the plant location;
- the availability of technicians and qualified labour;
- the required flexibility of the board manufacture, e.g. in a three-layer spreading system, the glue content of the surface and core layers may be adapted to the requirements.

14. Choice of preparation system

Three basic alternatives are available, namely:
- direct flaking as shown under Alternative I, pages 14 and 15;
- the hogging/turboflaker system as shown under Alternative II, pages 16 and 17;
- the use of wood residues involving the necessary handling and storage equipment.

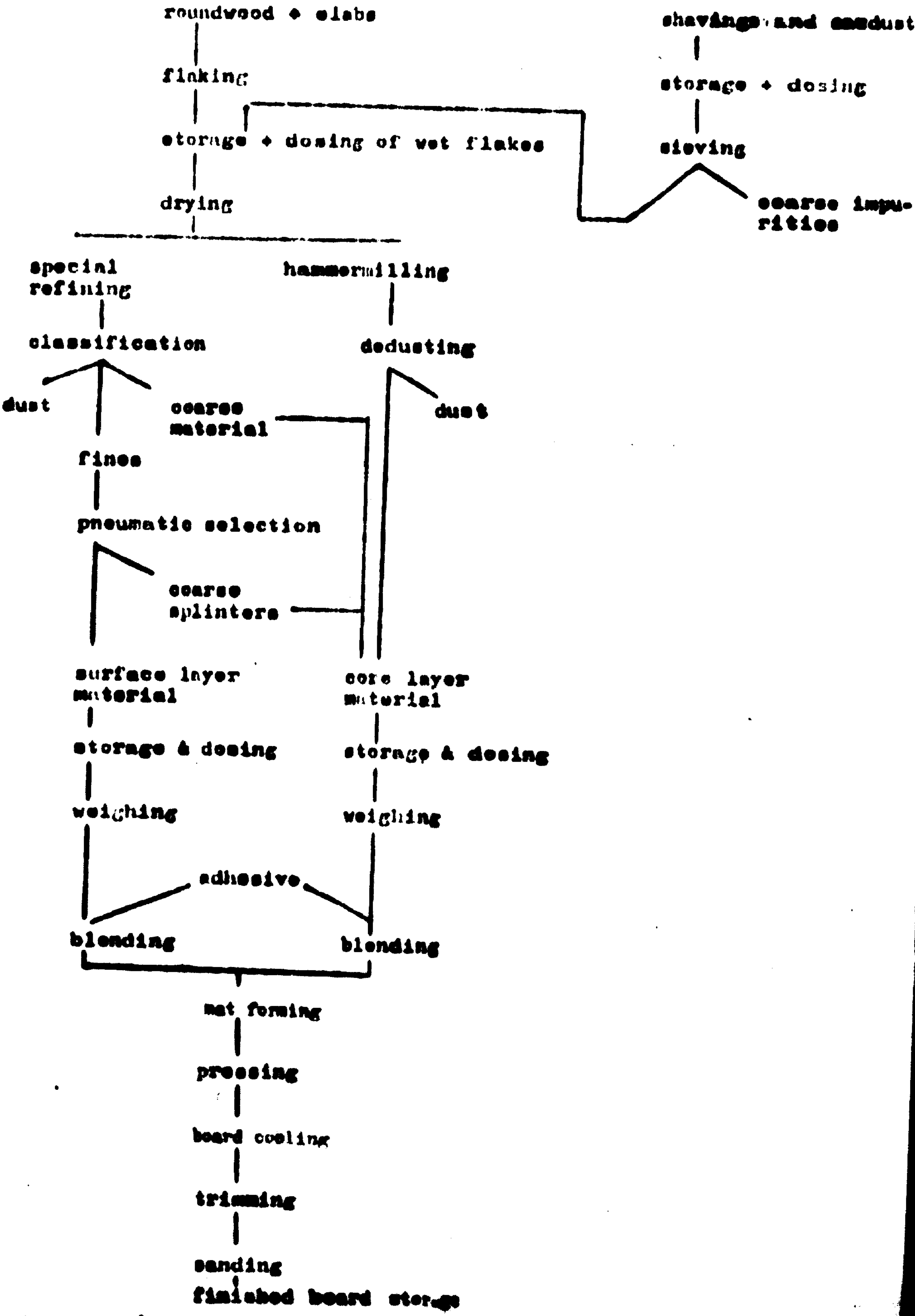
It should be noted that for a high quality board it will be necessary to increase the density of the board when using either Alternative II (hogging/turboflaker) or woodwaste. This does not merely imply the use of additional timber but also implies a proportionate increase in the consumption of resin and all other additives.

As already mentioned, there are two possibilities for flake production:

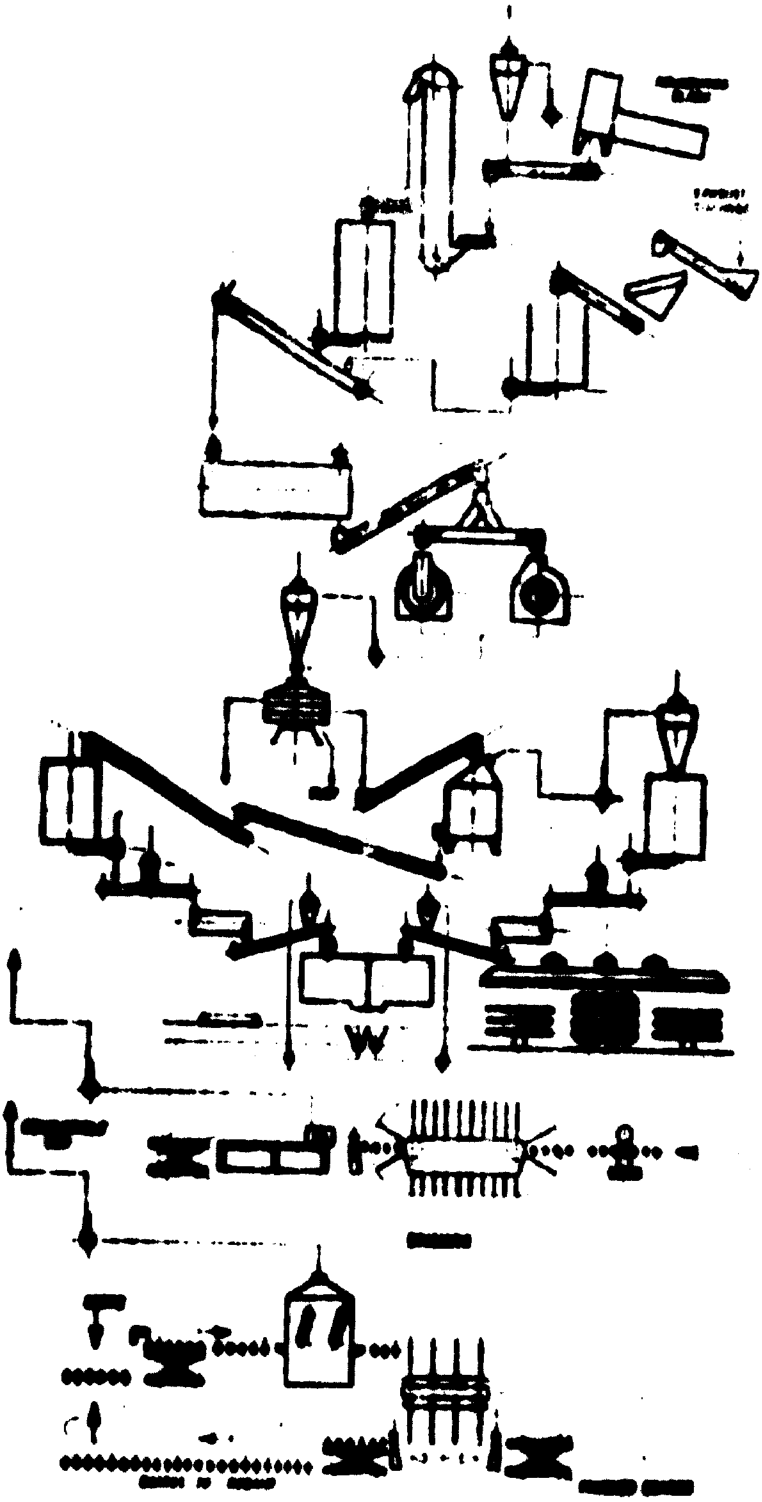
- Alternative I is the direct flaking of round wood, slabs, edging, branches by means of a drum flaker to obtain high quality flakes;
- Alternative II is a process in two steps. Raw material is first chipped and the chips are subsequently cut in a flaker by means of a knife ring flaker.

PREPARATION FLOW OF A THREE LAYER WOOD PARTICLEBOARD

ALTERNATIVE 1 : DIRECT FLAKING

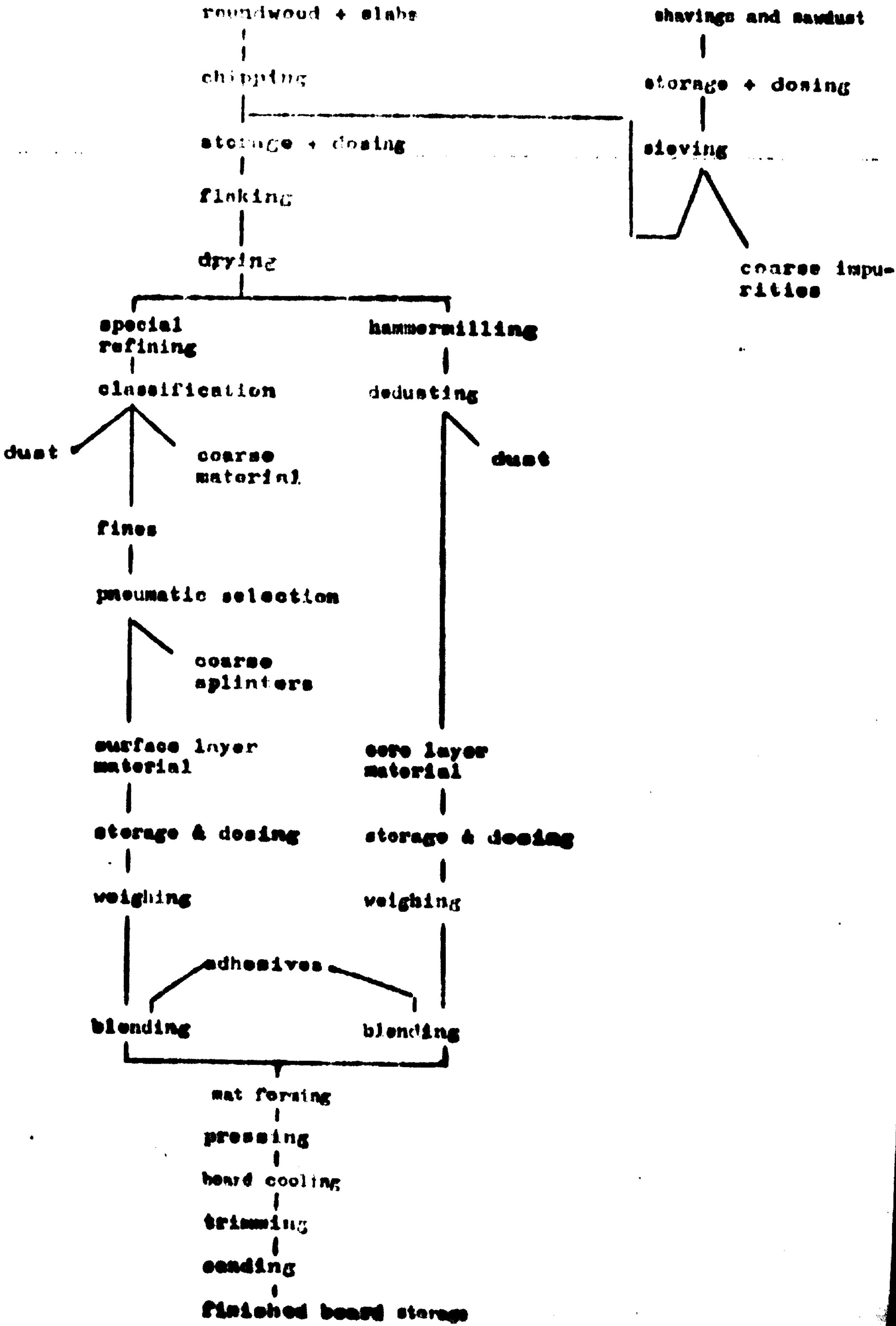


DIAGRAMATIC SKETCH OF PRODUCTION FLOW FOR FLAT PRESSED PARTICLE BOARD USING DIRECT FLAKING

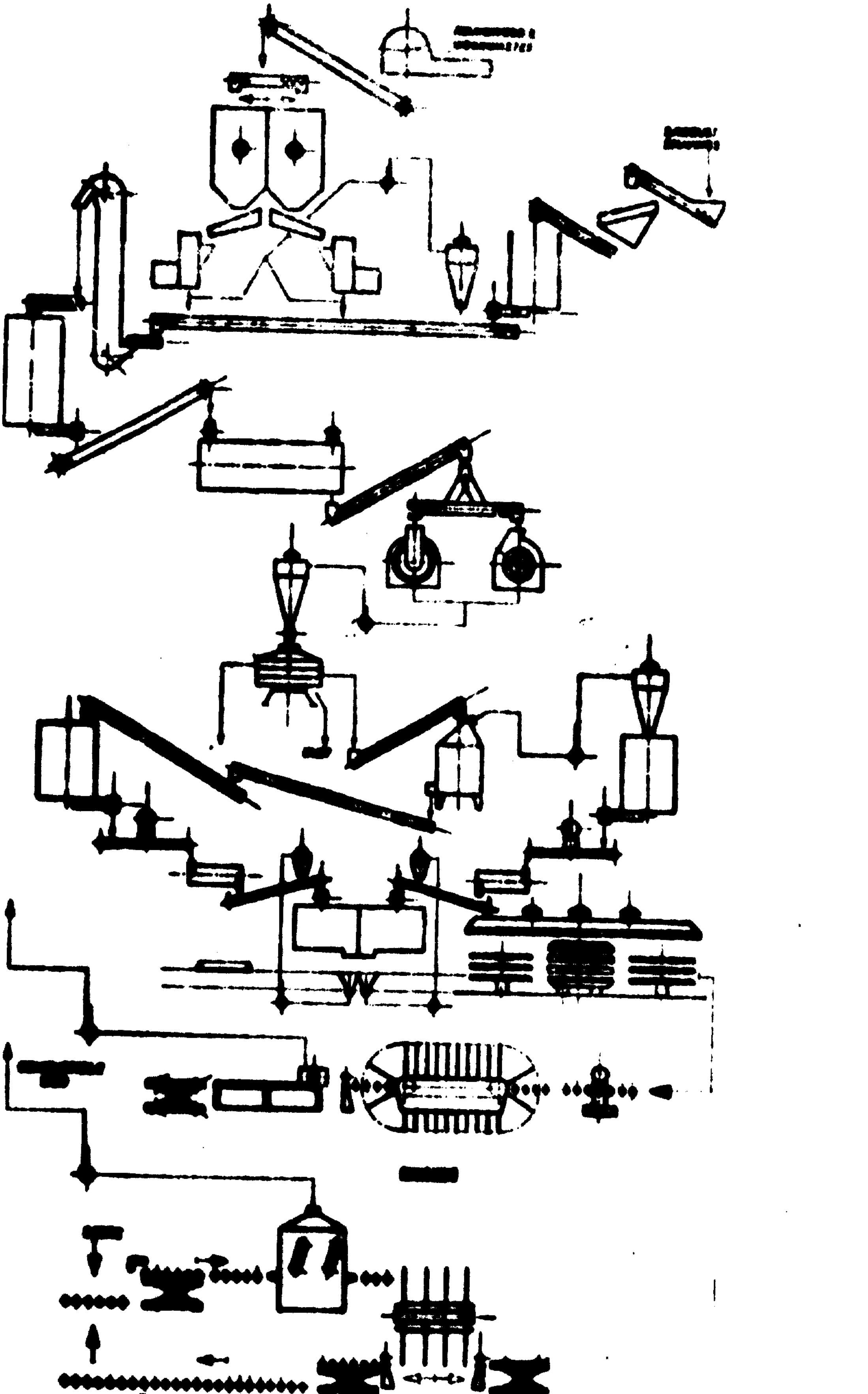


ALTERNATIVE II

PRELIMINARY CHIPPING WITH SUBSEQUENT FLAKING



DIAGRAMATIC SKETCH OF PRODUCTION FLOW FOR FLAT PRESSED PARTICLE BOARD USING PRELIMINARY CHIPPING WITH SUBSEQUENT FLAKING



Practical experience revealed the following disadvantages of Alternative II:

- the flake quality is considerably worse compared to the flakes produced by a drum flaker;

- the knife ring flaker has a lower efficiency compared to the drum flaker.

The quality of flakes made by a drum flaker is considerably better; the difference lies in the flake thickness fluctuation and in the flake form.

There is no doubt that the drum flaker offers the most economic means of producing flakes when only regular roundwood or straight slabs are available. However, when only inexpensive wood wastes such as branches, slabs, very thin wood from clear felling or wood of very irregular shape is available, priority should be given to Alternative I.

In this specific case, Alternative II offers some advantages, among which are:

- chipping is very fast and does not necessitate highly qualified labour;

- storage of chips is easy and can be done in an open storage area without risks or problems. Storage of branches and irregular wood logs is always difficult and necessitates high labour, hard work and an important storage area;

- automatic storage and recuperation of chips can be done and the whole flaking operation is completely mechanized;

- chipping can be done as soon as wood residues arrive during 1 shift per day, so that its storage may be avoided; flaking can be done in 3 shifts production.

A major problem, if wood residues in its various forms is used, is its handling, storage and reclamation for use. During all these three processes it is possible and likely for foreign matter such as stones to become mixed with the wood residues and this will lead to very severe problems in the follow-up processing operations. Further difficulties will arise if considerable management supervision is not given to the problem of "house keeping"; if wood residues storage is allowed to become untidy the whole manufacturing processes will be adversely affected.

It is advisable for saw mill and plywood mill residues such as slabs and waste veneer to be chipped where possible in the mill of origin so that the waste product can be transported in chipped form to the particle board plant.

15. Choice of machinery

(i) Transport

Machinery and equipment required for transport are for all incoming raw material and must be closely examined during the technical feasibility stage.

(ii) Woodyard handling

It is difficult to recommend the correct solution for woodyard handling as this will depend on local conditions, the size of logs and the size of the operation, also seasonal cost etc.

The use of a mobile crane for log handling was highly recommended.

(iii) Storage

The bulk storage of residues should be avoided if possible particularly in open storage. Smaller quantities could with advantage be stored in silos. If bulk storage in chip or flake form is however necessary, attention should be paid to the problems which can arise from fire hazard or fire degradation due to decomposition.

(iv) Flaking

If the output of the plant is such as to warrant the installation of a high capacity drum type flaker, it is essential that a mechanical feed system be installed to the flaker since manual feeding of these machines is not humanly possible. When manual feed is to be installed, as will normally be the case, it is recommended that space be left in the building for the later installation of a simple mechanical feed system; such a feed system could be manufactured locally.

(v) Wet flake conveying systems

Several different possibilities exist such as pneumatic conveyors using low pressure fans and cyclones, pneumatic conveyors using blowers and feed valves, drag chain conveyors, flat or profiled belt conveyors or screw conveyors. The low pressure pneumatic conveyors are not expensive to purchase but the power consumption is high, whereas high pressure pneumatic systems are very expensive and only chosen if the conveying distance is long. Belt or screw conveyors are in general recommended for developing countries since they are less complicated and can be manufactured locally, also power requirements are low.

(vi) Wet flake storage

It is not possible to recommend a suitable storage capacity since this will depend on local conditions and on plant size. They should however be of sufficient capacity to enable operation to be continuous i.e. to allow for blade changing times and flaker breakdown times.

It is very essential that the bin discharging device which feeds flakes to the drier should be manufactured by a company specializing in such bin dischargers. The bin itself can be manufactured locally but it is essential that the bin be designed by the manufacturer of the bin discharger since the proportions (diameter/height ratio) are very important if bridging of the material is not to occur.

(vii) Driers

Different types of driers are used in particle board production for drying wood particles, fibres, bagasse or other light-weight bulk goods. We distinguish amongst the following main types:

- The jet drier with its stationary horizontal cylindrical drying chamber into which the material to be dried is fed continuously through a rotary valve while heated gases are introduced at high speed through a long channel extending over the whole length of the cylinder and entering tangentially. The jet drier may be heated by oil, gas or a combined wood dust oil or gas system.

- The flash drier or predrier, normally installed before a jet drier. This consists of a vertical drying duct, the top bend, the cyclone and the recirculating gas fan and its furnace. The flash drier is normally used as a drier and is completely independent from the jet drier. Bypassing of the flash drier easily can be done when flakes of low initial moisture content are available.
- The rotary bundle drier with its single or double rotor. The rotor consists of a bundle of heating coils with peripheral scoops and paddles. Under the influence of scoops and paddles the particles travel through the drier chamber in a helicoidal path.

In Western Europe all the above-mentioned types of driers are installed. The rise in fuel oil prices has led to a change in the priority for driers. Preference is now given to driers heated by steam or hot water, which can use cheaper solid fuels.

For medium size particle board plants in developing countries the rotary bundle drier heated with steam, hot water or other heating liquids offers many important advantages:

- maintenence time and costs are extremely low;
- drying temperatures being low, flash and fire hazards are lower compared with directly heated driers;
- low consumption of thermal energy (750-800 kcal per kg water) because of effective heat transfer to the particles through direct contact with the tubular bundle;
- regulation of speed and temperature is simple;
- no special foundations are required;
- insulation is easy to apply;
- in large drying plants a series of small units will ensure continuous production, should one unit fail;
- its total investment cost is considerably lower than for other types of drying equipment.

If a rotary bundle drier is used with steam as the heating medium, it is extremely important that the steam be free of oxygen and that rapid heating-up of the drier is avoided. If oxygen, i.e.

air, is present corrosion of the tubes will take place and similarly excessive thermal shock to the tube bundle can cause cracking. Such damage to the tubes is extremely difficult to repair in tube bundles.

It should also be noted that it is extremely difficult to maintain an accurate output moisture content from a tube bundle drier due to the high dwelltime and thermal inertia. It is normally necessary therefore to install an oversize drier.

If a direct fired drier such as jet drier or flash drier is installed, it is essential that the sulphur content of the fuel oil should be made known to the drier manufacturers in advance since corrosion difficulties can occur leading also to fire and explosion hazards.

(viii) Milling and grading

It should be noted that for particle size grading both mechanical sieve systems and pneumatic air sifting systems are available.

(ix) Dry chip conveying and dry chip storage

The use of flat belt conveyors for dry chip transport can give rise to dust problems and is not in general recommended. A fully enclosed conveyor such as a screw conveyor (made locally) would be preferable. It is essential in order that production continuity be maintained, that the storage capacity of the dry flake silo should be adequate; it was suggested that a 30 cu.m. silo would be required for a plant of 20 cu. m. per 24 hours and proportionate for other size plants.

(x) Glue/chip mixers and dosing systems

In the past, several research teams have been fully occupied in finding out a better system for adhesive application. The conventional glue blenders, equipped with nozzles, presented a series of disadvantages and an imminent solution was required since 3-layer boards have been made with a high percentage of very fine particles, dust and shavings. The Switch from shavings to fine particles for the faces of the board called for the development of a new type of mixer.

The impressive compactly constructed newcomer is distinguished from the older type by:

- axial travel of the resin-coated particles;
- unusually high throughput rates;
- manifold time and moneysaving features.

Description and working method of this new type of blender can be found in prospects and brochures of the constructors of this equipment (Fa Drais Mannheim and Lödige-Paderborn). The main advantages of this new blender type can be detailed as follows:

- The equipment is very compact and extremely simple;
- Absence of nozzles and consequently no more need for cleaning of nozzles and the risk of glue sticking in them, as with the old blenders;
- No need for a compressed air supply;
- Cleaning requirements are reduced considerably in comparison with the old blenders;
- No heating up of the resin-coated particles due to the water-cooling of the whole system. The heating up of the particles in old blenders was considerable and caused drying of material and prepolymerization of glue.
- Improved blending rate and adhesives distribution. An adhesives economy of minimum 5% and sometimes up to 10% (compared with old blenders) is guaranteed.

The advantages of this new blender type can be illustrated by a calculation of the direct saving cost by installing the new blender instead of the older type.

Before deciding to install a blender of the new type the available cooling water temperature should be ascertained. It is not possible to install this type of mixer if cooling water of a sufficiently low temperature is not available.

It is strongly recommended that the new type of blender should be installed wherever possible rather than the older machine type.

The dosing system for proportioning glue and dry chips must be automated since otherwise excessive over-consumption of resin and consequent expenditure of foreign exchange could result;

likewise if insufficient resin is applied to the chips, board quality will be seriously impaired and losses can be incurred in this way also. In addition to the actual automatic proportioning system visually indicating meters for glue flow and dry chip flow should also be installed so that the proper function of the automated equipment can be checked.

The equipment in the glue kitchen can however be simply and locally manufactured to the plant supplier's design.

(xi) Forming and pressing system

The design of the forming and pressing system will be determined by the main plant suppliers.

(xii) Intermediate board storage

The design of the press line discharge system and board stacking system must be such as to allow the partial cooling of all UF bonded boards to a surface temperature not exceeding approximately 70° Centigrade; if this cooling is not properly achieved hydrolysis of the board will occur (a chemical breakdown of the resin) which leads to deterioration of the internal bond of the board and its possible subsequent disintegration. For PF bonded boards the board must be stacked whilst still hot without pre-cooling.

(xiii) Finishing line

Two basic sander systems are available namely one-sided drum sanders and double-sided wide belt sanders. It should be noted however that wide belt sanders are expensive and normally only installed for plants of larger capacity. However great care must be taken that a balanced sanding of the board is achieved, i.e. that the same amount is sanded off each side. If this is not achieved considerable reduction of board quality and possible scrapping could result. It is possible to install several centering devices on single sided drum sanders.

It was strongly recommended that a provision be made in the operating cost budget of a plant for a highly skilled sander operator to be employed on each shift. It is to be emphasized that sander operations should on no account be carried out by an unskilled man.

(xiv) Heat energy supply

For developing countries, special care must be given to the generation of the thermal energy required. As far as possible, new plants should utilize the waste products they generate (bark, sander dust or other low cost wood wastes) instead of relying on imported fuel oil.

(xv) Services

Severe production difficulties and potential fire hazards can occur if the electrical supply to the plant is unreliable. All steps must therefore be taken to ensure that power failures do not occur.

(xvi) Spare parts and wear parts

It is strongly recommended that a spare parts supply for at least two years' operation should be purchased at the same time as the main machinery and it is possible that the cost of this could amount to a maximum of 20% of the total machinery cost. During the feasibility study stage, the delivery time for spares including internal order processing and foreign exchange authorization time should be checked.

(xvii) Instruction books

It is essential that all instruction manuals, maintenance manuals, machine drawings etc. relevant to the whole plant should be supplied with the machinery.

16. Pollution Control

It is recommended that developing countries should give this subject full attention. A particle board plant has two potential sources of pollution, glue kitchen effluent and atmospheric pollution from pneumatic conveying systems and drier.

The effluent from the glue kitchen can be treated simply in a small plant made locally to the plant supplier's design but if atmospheric pollution is to be controlled effectively, appropriate capital provisions must be made at the feasibility study stage since high efficiency cyclones and similar equipment are expensive.

17. Fire and Explosion Protection

It cannot be too strongly emphasized that wood dust, such as sander dust and other small particles, can form highly explosive mixtures with air, and that cases of explosion in particle board factories have been recorded in several countries, often resulting in death of an operator and certainly resulting in loss of production. Full advice should be taken from experts in fire and explosion protection on suitable devices to install in the plant and buildings and this advice must be implemented without fail.

18. Quality Control

Quality control consists not only of inspection and testing of the finished product, but also of controlling the manufacturing process at different stages.

It is essential that quality control information be available without any delay since old information is completely useless. Such quality control information should be used as a management tool by plant management and shop floor supervision.

The appropriate quality control equipment can be expensive and proper provision for this must be made at the economic planning stage.

19. Turn-key Plants

It was considered that factory equipment delivered on the basis of turn-key operations is the best guarantee for a good production.

A "turn-key" plant normally implies that one contractor is legally responsible for all the items listed below and required to be effected before the plant can be handed over to the buyer in operating order, having fully met all the specification requirements of the single contract.

Buyers should be aware that serious problems may arise if any part of the supply of equipment or buildings is separately contracted for directly by the buyer. These may result, in the event of non-compliance of any plant of the total project, in the principal contractor disclaiming responsibility for such non-compliance.

Unless the "turn-key" plant contractors themselves sub-contract with the proposed local suppliers, serious and expensive problems such as this almost invariably arise.

The whole "turn-key" project should include the supply of:

- the production equipment
- preparation equipment
- gluing and mat forming equipment
- press plant
- finishing line
- the auxiliary equipment
- the electrical equipment
- high tension cabinet
- low tension distribution cabinet
- switchboards and complete steering equipment
- all electric cables and accessories
- cost and compensation equipment
- the heat energy supply equipment
- the compressed air equipment
- the cold water equipment
- the glue preparation equipment
- the transport equipment
- the fire extinguishing equipment
- the laboratory equipment
- the complete workshop equipment
- the erection equipment
- the surface improvement equipment, such as veneering, coating line, etc.
- the spare parts and consumption materials for a minimum period of 2 years

- the supply of buildings, including complete civil engineering
    - buildings for production equipment
    - buildings for auxiliary equipment
    - foundations, for above-mentioned equipment

- buildings for offices, stores, etc.
- complete office equipment
- the lighting equipment
- the lighting equipment for all buildings, offices, stores, woodyard, etc.

- training of buyer's technicians
- the complete erection and starting up of plant
  All costs for erection and start-up, including travelling expenses, board and lodging for seller's specialists, should be fixed and included in the contract total price.

- the technical assistance after starting up
- the complete process know-how
- the complete technical information for erection, start-up and running of the plant
- the total price should also include C.I.F. transport costs

The above recommendations are given to all responsible leaders in developing countries because it has been proven that in the past major errors have been made.

It is logically extremely dangerous and risky to divide a project into different groups of suppliers and subcontractors, for example:

- equipment to be imported
- equipment to be supplied at site by the buyer
- the construction of buildings with civil engineering

In several countries it has been observed that:

- the real co-ordination in all cases was never well done;
- some parts of equipment have been incomplete or completely missing at the proper erection time;
- some equipment to be supplied locally was not properly constructed and caused erection delays or high production losses later;
- buildings have been made either too luxurious or inadequate or were completed much too late;
- erection costs have been 3 or 4 times higher than originally estimated;

- spare parts and consumable parts, ordered much later than the main equipment, are incomplete and much too expensive;
- plant start-up and production started several months later than originally scheduled; this has led in almost all cases to financial problems within the company and serious discussions between seller, buyer and local subcontractor.

LABOUR AND MANAGEMENT

20. Labour

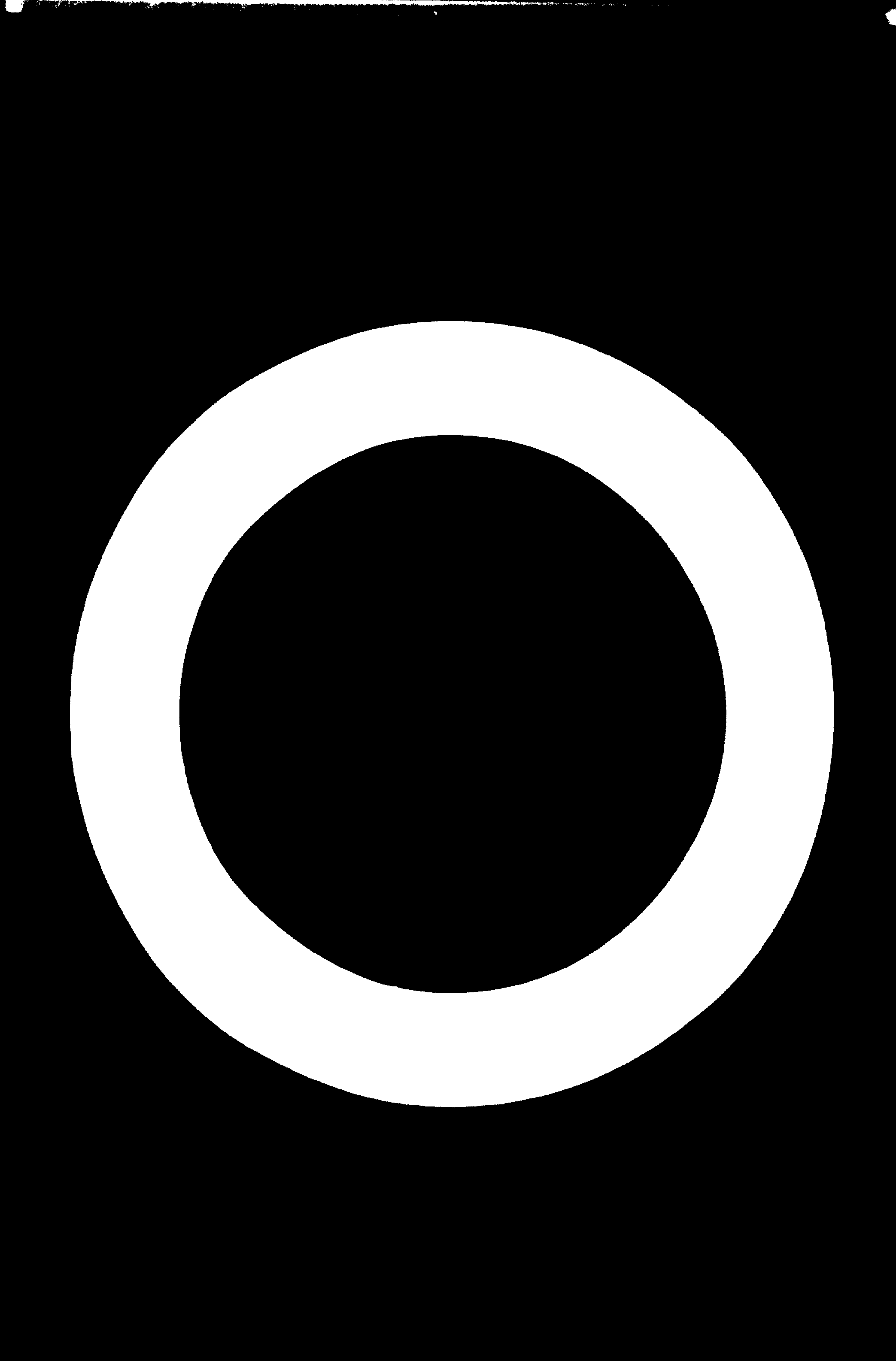
It is essential that a sum be allowed at the economic planning stage for the training of labour establishing a minimum of three first class mechanical maintenance fitters and three first class maintenance electricians.

21. Plant Management and In-plant Training

To obtain the best results from new or existing particleboard plant, in terms of output, quality and running costs, plant management must be knowledgeable not only in particleboard technology but also in the modern techniques of production and engineering management.

Most useful knowledge can be gained by visiting other particleboard plants. To produce satisfactory results in his own plant, however, a plant manager will inevitably require a much wider range of operational and organizational skills, adapted particularly to the plant for which he is responsible.

The foundation of a satisfactory plant performance, both initially and in future years, can best be laid by ensuring that all plant management receive expert in-plant training covering the organisation, production control, quality control and maintenance function of their own particular plant.



APPENDIX

LIST OF NATIONAL STANDARDS RELATED TO PARTICLE BOARD

	Standard	Title
CANADA		
	CGSB 11-GP-1	Particle Board - Building construction
CZECHOSLOVAKIA		
	CSN 49 2614	Wood Particle Board
FEDERAL REPUBLIC OF GERMANY		
	DIN 52360	Testing of particle board: general, sampling, evaluation
	DIN 52361	Testing of particle board: determination of size, density and moisture content
	DIN 68761 (Parts 1 and 2)	Particle board, density, quality requirements and testing
FRANCE		
	PN B 51-200	Particle Board: Definitions and classification
GERMAN DEMOCRATIC REPUBLIC		
	TGL 3130	Testing of Particle Board: Determination of Thermal Conductivity
	TGL 5772	Testing of Particle Board: Determination of behaviour in fire
	TGL 6487	Wood Particle Board products: Residue suitable for conversion
	TGL 7796	Particle Board - Dimensions
	TGL 11367	Testing of Particle Board
	TGL 11369	Testing of particle board: determination of thickness, squareness, weight per unit area and density
	TGL 11371	Testing of particle board: bending strength
ITALY		
	UNI 4866/67	Particle board: dimensions, tolerances, classification
	UNI 4869	Particle board: determination of thickness
	UNI 4870	Particle board: apparent specific gravity
	UNI 4871/72	Particle board: determination of moisture content (water absorption and swelling)

Standard	Title
JAPAN	
JIS [illegible]	Particle board
POLAND	
PN-[illegible]-[illegible]1	Three-layer particle board
ROMANIA	
STAS 5255	Particle board: static bending test
STAS 5[illegible]4	Particle board: determination of water absorption, hygroscopicity and swelling
STAS [illegible]	Particle board: determination of tensile perpendicular to the board
STAS 643[illegible]	Three-layer particle board
UNITED KINGDOM	
BS 1811	Methods of test for particle boards
BS 2604	Resin bonded chipboard
UNITED STATES OF AMERICA	
ASTM D 1037-63T	Methods of test for particle panel materials
CS 236-61	Mat-formed wood particle board (interior use)
YUGOSLAVIA	
JUS D.C5.030	Particle board
JUS D.A1.100/2/3	Testing of particle board: Sampling, Thickness Measuring and Humidity
JUS D.A1 104/5	Testing of particle board: Determination of water absorption and swelling and weight per unit area and specific density

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