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

06174

Distr.
LIMITED

ID/WG.200/7
31 January 1975

ORIGINAL: English

United Nations Industrial Development Organization

Workshop on Wood Processing
for Developing Countries

Vienna, 1975

PARTICLE BOARD PRODUCTION FOR DEVELOPING COUNTRIES 1/

by

P.E. Tack*

* Consultant in production of particle board, Kuurne, Belgium

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

.d.75-833

CONTENTS

Distr.
LIMITED

ID/WG.200/ / SUMMARY
31 January 1975

Original: ENGLISH

United Nations Industrial Development Organization

Workshop on Wood Processing
for Developing Countries

Vienna, 1975

PARTICLE BOARD PRODUCTION FOR DEVELOPING COUNTRIES [1]

by

P. F. Tack*

SUMMARY

It has been emphasized that in Western Europe the predominant use of particle board is in the furniture industry, while for developing countries the dominating end use is in its application in building and construction.

Special measures must be taken in developing countries to render the boards resistant to attacks by fungi and insects.

The production and consumption tables of particle board in developing countries show a very high relative rate of increase, although the annual world consumption per capita (in 1961) was still less than 1 kg, while Denmark and Germany keep their leading position in the world, with around [illegible] kg per capita and per year.

In the board manufacturing process itself, the choice of adequate equipment depends on many factors such as the type of raw material, the type of board produced, the technology of board manufacture applied, etc. Important cost savings can be made by installing new types of flakers, blenders, etc. Recommendations are made concerning the practical output of some equipment, such as flakers, driers, etc.

---

* Consultant in the production of particle board, Kuurne, Belgium

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

New trends in board manufacture are noticed, for example the progressive production of thin boards, medium density fibre board, etc.

Technical and economic advice is given, addressed to responsible project leaders in developing countries. It is recommended to install integrated plants. Projects for particle board plants should be "turnkey" and include all costs for equipment, know-how, erection costs, training of technicians, technical assistance after start-up of the plant, all transport costs, etc.

I. PARTICLE BOARD TYPES

Definition

The following general definition of particle board has been agreed upon internationally: a panel manufactured from particles of wood or other lignocellulosic materials, bonded by the use of an organic binder and one or more agents such as heat, pressure, moisture, catalyst, etc.

Types of Particle Board

The following main types of particle board exist:

(1) 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.

(2) Moulded Particle board

(3) Flat pressed particle board:

- Homogeneous or one layer flat pressed particle board: surface and core are made by the same homogeneous material.
- Three or more layer flat pressed particle board:
  - the surface layer is normally made by fine prepared material
  - the core layer is filled with coarser material, which is nevertheless well suited to obtain boards having good properties.

Flat pressed particle boards are made in a wide range of thicknesses and density.

New Tendencies in Particle Board Production

Some new tendencies have been noticed in the last 2-3 years.

(1) The progressive production of thin boards:

- The shortage of plywood and hardboard caused by the deficiency in the supply of wood and the anti-pollution restrictions imposed on hardboard production have resulted in a sharp rise in price of these products over the past few years. This development has induced several particle board manufacturers to produce thin boards as an alternative.
- Raw material availability for particle board production has diminished considerably due to the high increase of production capacity of different countries and wood prices have risen to the point that particle board producers try now to make thin boards (with low quantity of raw materials) at interesting prices especially for the furniture industry.

(2) New type of board:

- This new type of board is manufactured from wood and sawmill wastes (including bark) blended with a penetrating thermosetting resin and cured under pressure. It can be made in a wide range of thicknesses from 3-50mm. A density range of 450-900 kg/m3, depending on board thickness, is achievable. This new type of board is to be classified in a new category of boards between particle and fibreboard.

- It must be emphasized that the new product is basically different from particleboard in that a pressure-refined fibrous material is prepared, formed and pressed to form a consolidated material which has distinct advantages over that produced from chips in the traditional type of plants.

- The fibreboard is completely homogeneous. It has a flat, smooth surface, free of resin spots, of even porosity. thus providing an ideal base for the application of laminated, printed and painted finishes. Additional melamine resin can be included in the bonding medium to give increased exterior durability.

- The product is of uniform density, free of grain depressions and, importantly, core defects.

- Consequently, it has exceptional machineability and edge shaping and finishing characteristics since it will not chip, split or crumble. Indeed, in these respects it is equal or superior to most of the hardwoods presently being used, for instance in the manufacture of furniture.

- This new type of board is made in a dry process and is effectively a reconstituted wood. It is already widely used in the USA. More details on this process will be given in this background study.

II STANDARDS AND SPECIFICATIONS

Standards designed to define the quality of products are prepared at a number of different levels and for different initial reasons. They are:

(1) Factory standards set up by the individual factories themselves. They are set up to control production processes so that the finished product will conform to the specifications (set either expressly or through inference) and orders of the purchaser.

Buyers' specifications usually cover minimum quality acceptable.

(2) Industrial standards in which many or all the factories in a country or a group of countries conform to agreed standards, e.g. the British or German DIN standards.

(3) National standards which may or may not be identical with industrial standards and can be regarded as the official standard of a country. They may be sponsored directly by a Government department or by a semigovernmental or independent standard organization.

Test methods are an essential part of standards and specifications. United Nations organizations have already played a major role in effecting agreement between technical bodies in different countries and standardization of test methods. This activity is based in determining the properties of all wood and wood-based materials, in being able to compare tests carried out under different conditions and in having reliable research methods for studying and improving the whole range of materials. The German quality definitions are found in the DIN 68761. This is not the oldest standard - BS 2604, 1955 was a predecessor - but it is considered the most comprehensive because it includes various manufacturing processes (flat pressed and extruded boards, boards with and without veneer).

III USES

The quality of particle board employed for various uses on a percentage basis varies from country to country, but on a world basis by far the largest use is for furniture manufacturing.

Data and end uses of particle board products are neither sufficiently complete nor sufficiently accurate to justify precise comparisons from country to country or period to period.

Particle board consumption in 1973 and in Western Europe is tabulated under several main categories, as follows:

1 - Furniture industry (all movable pieces of furniture, cases for radio and television sets, etc.)

2 - Building industry as a whole

3 - Railways, motorcars, containers, etc.

4 - Shipbuilding

5 - Packing

6 - Do-it-yourself

7 - Miscellaneous

A. Use of Particle Board in Furniture Manufacture

Extruded particle board is normally not used in furniture.

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 boards are produced. These homogeneous particle boards are 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.

  Particle boards are extensively used in the manufacture of radio, television sets and in musical instruments where good sound reflection is required. Numerous tests by manufacturers of high fidelity equipment led to the conclusion that particle board is the preferred material for speaker enclosures and its sound absorption and reflection characteristics are highly appreciated.

B. Use of Particle Board in Building

Until 1971 a high expansion in the use of particle board has been noted in building since the practical and economic advantages of the material became more widely accepted on all levels in the industry. The wide use of particle board in countries like Germany and Scandinavia was largely due to their traditional use of timber and manufactured timber components in building.

The lesser use of particle board in building in other countries was due to the innate conservatism and the difficulty of convincing the local authorities and Government officials of the real advantages of using particle board in many applications.

In building, anyway, particle board is a material which is available in a wide range of large board sizes and a variety of thicknesses. It is strong and can be manufactured to specific demands for a wide range of applications (exterior grade boards, fire-resistant boards, termite resistant boards, etc).

Since 1971 the upward trend for the use of particle board in the building industry has progressively been retarded and rapidly changed into a noticeable decline. Two main factors had a decisive impact:

- the high rate of interest charged on credits and credit shortages
- the increasing saturation of the market

The following table shows clearly that the decline in Western Europe is quite general.

Application of Particle Board in Western European building Industry

(in % of the total board production)

	1969	1970	1971	1972	1973
Germany	46	49	49	44	45
Austria	29	32	33	32	32
Denmark	34	38	40	37	41
Spain	14	22	22	20	20
Finland	68	77	78	71	68
France	49	49.5	49.5	45	42.1
Greece	35	25	28	20	20
Great Britain	36	40	47	41.6	40
Ireland	50	43	45	30	35
Italy	7	8	14	10	8
Norway	55	82	82	65	77
Netherlands	39	30	30	30	30
Portugal	35	35	35	35	35
Sweden	35	40	45	46	46
Switzerland	35	40	45	46	46

For developing countries, the main problems to be overcome are:
- convincing local authorities and architects of the many advantages of using particle board in different applications in building;
- rationalisation of the building industry;
- need for more houses;
- shortage of skilled labour.

Other factors affecting non-traditional raw materials like particle board will eventually act in its favour, leading to particle board being accepted as a modern builing material due to its merits.

UTILIZATION OF THE NATIONAL PARTICLE BOARD OUTPUT IN MEMBER COUNTRIES OF FESYP IN 1973 1/

Country	1 %	2 %	3 %	4 %	5 %	6 %	7 %
Germany	47	45	1	1	1	3	2
Austria	62	32	1	-	2	3	-
Denmark	50	41	2	2	-	4	1
Spain	65	20	5	3	1	1	5
Finland	25	68	1	1	2	1	2
France	45	42	1	1	3	4	4
Greece	65	20	5	5	2	1	2
Great Britain	43	40	2	-	1	9	5
Ireland	60	35	←		5		→
Italy	88	8	1	-	2	-	1
Norway	13	77	-	2	2	3	3
Netherlands	40	30	5	10	-	10	5
Portugal	60	35	←		5		→
Sweden	26	65	-	2	1	4	2
Switzerland	43	46	←		11		→

1/ The numbers at the column headings refer to the use classification described on page 3, i.e.:

1 - furniture industry (all movable pieces of furniture, cases for radio and television sets, etc.)

2 - building industry as a whole

3 - railways, motorcars, containers, etc.

4 - shipbuilding

5 - packing

6 - do-it-yourself

7 - miscellaneous

The field of application of particle board in the building industry in Western Europe is subdivided as follows:

A. - walls and ceilings
B. - roofs
C. - floors
D. - built-in furniture
E. - miscellaneous

Percentages for each subdivision and each Western European country is given hereunder:

	Total %	A	B	C	D	E
Germany	45	4	4	3	27	7
Denmark	41	15	4	10	9	3
Finland	68	41	3	3	19	2
France	42.1	17.6	7.2	4.7	8.5	4.1
Great Britain	40	7.2	6.8	15.6	7.6	2.8
Ireland	35	5	10	10	10	-
Norway	77	38.5	15.4	7.7	7.7	7.7
Switzerland	30	5	10	5	5	5

Technical Suitability

Several factors determine the relative success of particle board when competing with other products for their use in construction. Such factors are: availability, cost price, cost of fixing and finishing, technical suitability, maintenance requirements, service life and full suitability to apply all kinds of acoustic and thermal insulation.

Since the introduction of the current building regulations with increased emphasis on fire precautions, the use of non-treated particle board in plain form is often prohibited and it is necessary to treat it to achieve the required characteristics. Particle board can easily be treated and made fire-resistant.

Present Use Practice in the Building Industry

Partitions, Walls and Ceilings

By far the biggest potential for particle board is for partitions, walls and ceilings as a sheet material; particle board will form partitions and line walls and cover large areas rapidly.

FESYP has published two very interesting brochures with recommendations on the use of particle board in partitioning walls:

"Surface Treatment of Particle Board Partition Walls"
October 1973

"Vertical Application of Particle Board in the Construction Industry"
May 1974

Roofing

The large board size and the consistantly flat surface of particle board render it very suitable as a base material for flat or low pitch roofs subsequently covered with asphalt on sheet material. By far the majority of roofs are laid as a deck and are covered with waterproof material on site.

Apart from protection it is sensible to fix the boards with a slight gap between joints to accommodate swelling, but most important of all is the necessity to provide adequate ventilation within the roof void; otherwise with an impermeable covering, condensation will cause deterioration of the board.

Floors

About 1/3 of total particle board output in the USA is used for floor underlayment in house building.

The hardness of the product makes the floor more resistant to denting from furniture loads or from heels than with normally used species of wood and synthetic floor covering materials. In underlayment, the function is to provide a smooth, continuous support for flexible finish flooring applied either in sheet form or in the form of tiles (linoleum, vinyl, rubber, vinyl-asbestos or other types). In addition, the underlayment also serves in some instances to raise the level of the finish flooring to that of other construction.

Thin sheets are sometimes used where the only function is to provide a smooth base over the rough wood flooring or concrete.

Particle board is also commonly used as underlayment under carpeting.

General

Although the main applications in furniture and building have been discussed there are many minor situations where the materials is being used: doors, shelving, tank covers and casings, signs, displays and fixtures, etc.

IV USE OF PARTICLE BOARD IN DEVELOPING COUNTRIES

During the transition from complete dependence on import to local manufacture, rapid changes in consumption are to be expected and may be caused by, for example, intensified promotion, in order to maintain an economic level of production.

Application in building construction is the entirely dominating end use. In buildings such uses as for doors, ceilings, walls, 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 (for instance bagasse).

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 an additional expense which will raise the cost price of the board.

In developing countries where consumption is much lower than would normally be expected, promotion is likely to have good response. Apart from promotion by manufacturers, significant action by others may vary from the removal or revision of rules and regulations that hinder the use of particle boards to active encouragement of consumption. Action by the authorities may lead to import restrictions and encouragement to manufacture boards locally.

V SURFACE IMPROVEMENT OF PARTICLE BOARD

The increase of the surface improvement of particle board in Western Europe was considerable during the last years. An inquiry made in 1973 has given the following results:

Type of surface improvement:

- a - boards with primed surface (i.e. pre-painted)
- b - boards with priming foil
- c - painted boards
- d - PVC surfaces
- e - boards coated with melamine resin impregnated papers
- f - boards with laminates glued on
- g - veneered boards
- i - printed boards

Quantity in 1000 m3 according to different types of surface improvement:

Country	Total production 1973	a	b	c	d	e	f	g
Germany	5580	80	40	25	75	930	-	100
Austria	868.2	5.4	-	12.7	-	221.9	-	9.7
Denmark	305	10	8.3	-	-	-	3.4	0.7
Spain	904	-	30	6	5	27	-	65
Finland	887	85.2	1	2.6	0.6	20.4	-	3.7
France	1964	5.5	-	-	0.7	160	-	60
Greece	182.6	-	-	-	-	-	-	20.6
Italy	1700	-	34	-	-	122.8	-	-
Norway	422	6	-	.5	.5	27	3	-
Sweden	842.1	14	15	.5	-	-	3	-
Switzerland	411.7	-	-	-	-	-	-	51.5

Impregnated papers can be used for interior or exterior applications and their purpose may be to mask defects, protect against weathering or other degrade, provide a base for paint and other finishes, increase the strength, hardness or abrasive resistance of the surface or to provide a decorative effect or a combination of any of these attributes.

The resins employed are usually melamine or phenol formaldehyde, polyesters or acrylic types.

The preceeding table shows very clearly that most of particle board surface improvement is done by melamine impregnated papers. They are produced in a wide range of types and qualities; they can be transparent, translucent, opaque or carry a decorative design.

The application of resin paper overlays to particle board imposes certain requirements on the properties of the board: the surface layer must be fine, smoothly sanded and of uniform density, the board thickness must be accurate and its density must be sufficient to withstand the laminating pressure (often 20 and up to 28 kg/cm2).

VI PRODUCTION OF PARTICLE BOARD

Production of extruded boards and flat pressed particle board varies considerably from country to country. On average, it may be said that the share of extruded boards in the total production of FESYP countries is only about 2%.

Volume of World Production and Geographical Distribution of Particle Board Production

For particle board, the most recent branch of the wood based panel industries, the last decade has been a period of establishment as a vigorous and expanding industry. Mills have sprung up in many countries of the world; official statistics, particularly regarding the first years of production, are rather incomplete. Nevertheless the following table indicates with reasonable accuracy the orders of magnitude and the approximate geographical distribution of production. In its early stages - between 1950 and 1963 - it means that particle board manufacture was confined to Europe and North America, although research in the development of particle board output occurred more in Europe than in North America.

% of World Output

	1950	1955	1960	1963	1967	1971
Europe	50	61	69	66	61	59
North America	50	27	20	18	20	22
USSR	-	-	6	8	11	11
Latin America	-	1	1	3	2	3
Africa	-	-	1	-	-	-
Asia	-	1	3	4	4	3
Pacific	-	-	-	1	2	2

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	2.300	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	318	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

In the late 1950's, particle board mills were also established in other areas of the world. However, Europe and North America maintained a high aggregate share of world production in 1972.

The share of Western Europe and North America has been 51.12% and 21.68% respectively (total - 72.80%) of the total world production.

Production of Particle Boards in Western Europe

Development of production was considerable in the past and the upward trend of production is given in the diagram on page 14.

Still in 1973, development of production was influenced to a considerable degree by the boom in consumption during the first 5 months and was able to succeed surprisingly well despite various restrictive measures taken to stablize the economy. During 1973 the preceeding year's output was again exceeded, namely by 2.3 million m3. Total production amounted to 16.5 million m3.

This favourable development was possible because of the suitability of this board material for further processing, either in its plain or improved state. For the evaluation of the structure, it is also helpful to know the respective share of the total output taken by particle board and flaxboard, as they are partly used for the same purposes and partly are applied in different fields. The ratio depends to a large extent on seasonal fluctuations in the supply of flax shives. The proportion of flaxboard compared with wood particle board has decreased considerably in 1973. The share of flaxboard was:

1969	-	7.8%
1970	-	8.9%
1971	-	6.9%
1972	-	6.8%
1973	-	4.3%

VII CONSUMPTION OF PARTICLE BOARD

The 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:

	1950-1952	1953-1955	1956-1958	1959-1961
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

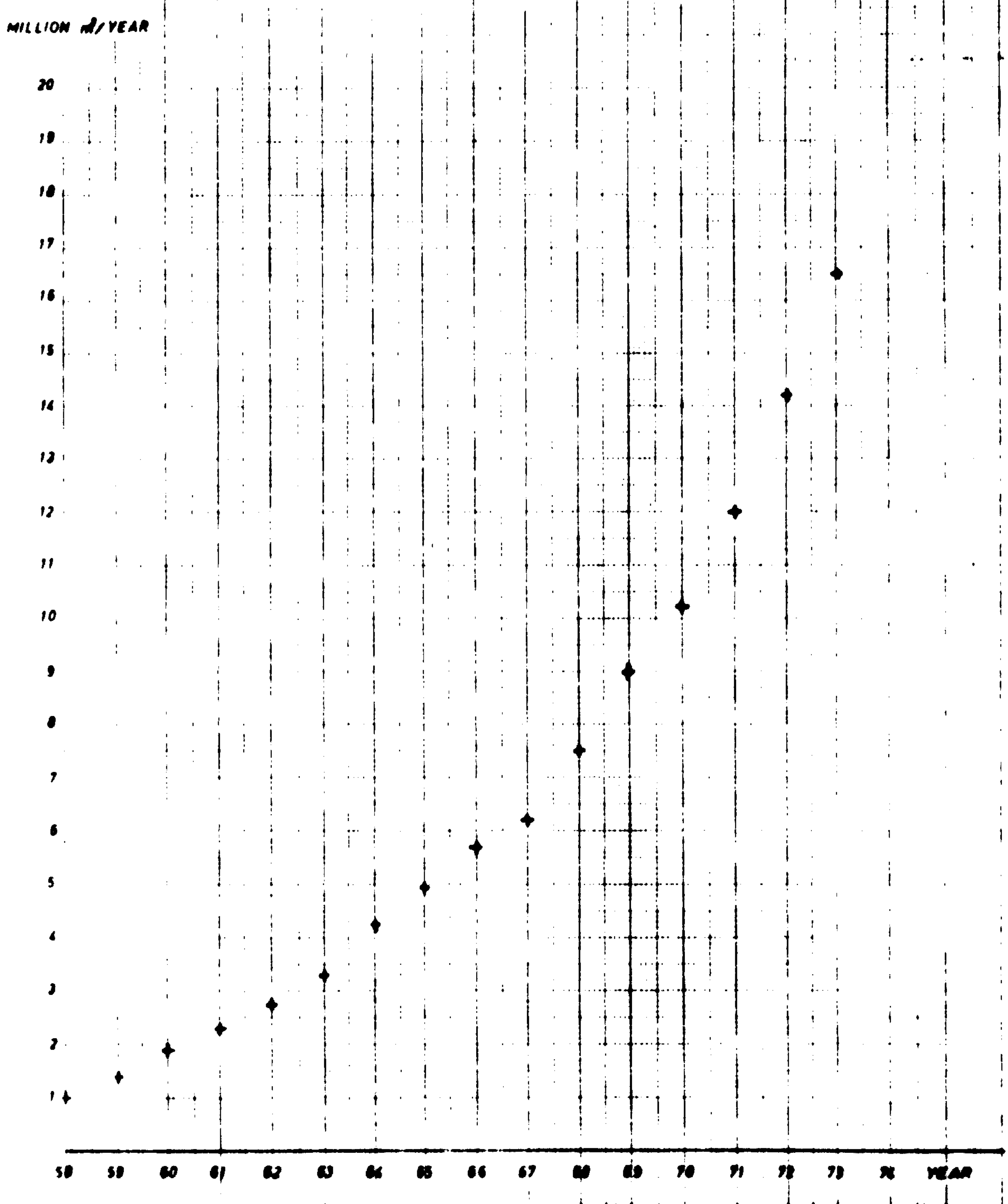
With the exception of Africa (and here it may be due to statistical inadequacy) all regions show very high relative rates of increase. For the world as a whole, consumption increased considerably every year but the world level was in 1961 still less than 1 kg.

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.

PRODUCTION OF PARTICLEBOARD IN WESTERN-EUROPE



VIII MANUFACTURING PROCESSES

A. Extruded Board

Preparation of wood and wood wastes for extruded board production is nearly the same as for flat pressed particle board production.

Process flow:

- wood wastes
- metal detector → metalic impurities
- hogging
- storage of wet chips
- flaking
- drying → water evaporation
- refining
- storage of dry refined flakes
- adhesives → gluing
- storage of glued particles
- feeding of press
- press plant → fumes
- trimming saw → sawdust
- storage of finished boards

Technical progress has been made in the manufacture of extruded boards. The width of extruders, as well as their speed of operation, has been increased. However a width of 1.22m (48 inches) predominates. In some cases the resin content has been raised from 4 - 5% to 6 - 8%, resulting in better and more uniform properties.

Extruded boards are generally veneered. Veneering is done with any kind of veneer on both sides of the board and the direction of the veneer fibres must be similar on both sides in order to prevent warping of the veneered board.

Standards for extruded particle board are given in the DIN norms.

B. Flat Pressed Particle Board

Preparation flow:

a) For all types of wood flat pressed particle boards (homogeneous, three or more layer or thin boards), preparation is nearly the same except for flaking, which can be done either by direct flaking or by chipping and subsequent flaking.

Both preparation flows are given on the following pages:

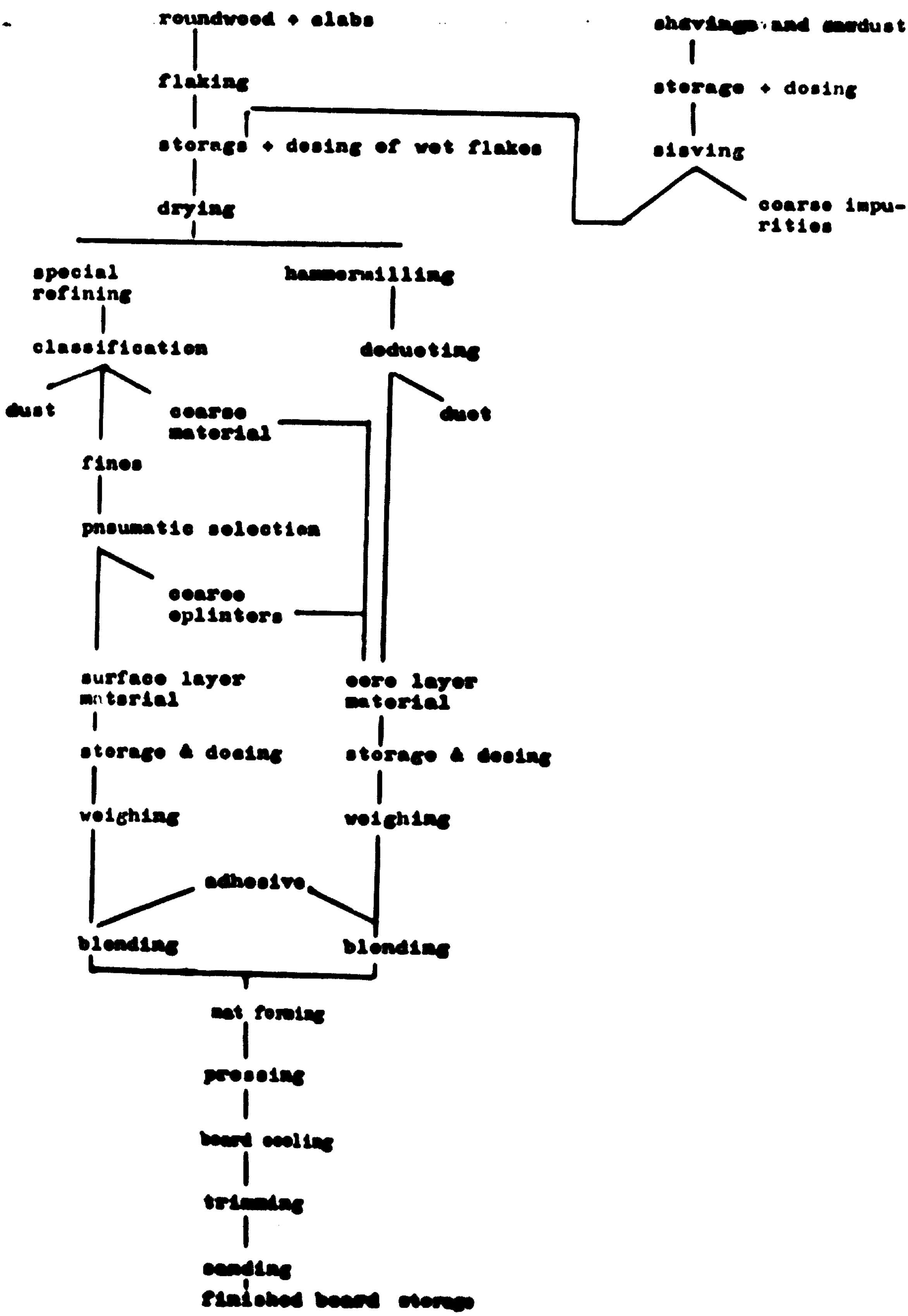
Alternative I - direct flaking
Alternative II - preliminary chipping and subsequent flaking

The main factors affecting the selection of the preparation process flow are: the type and nature of the available raw wood, the requirements of the finished product.

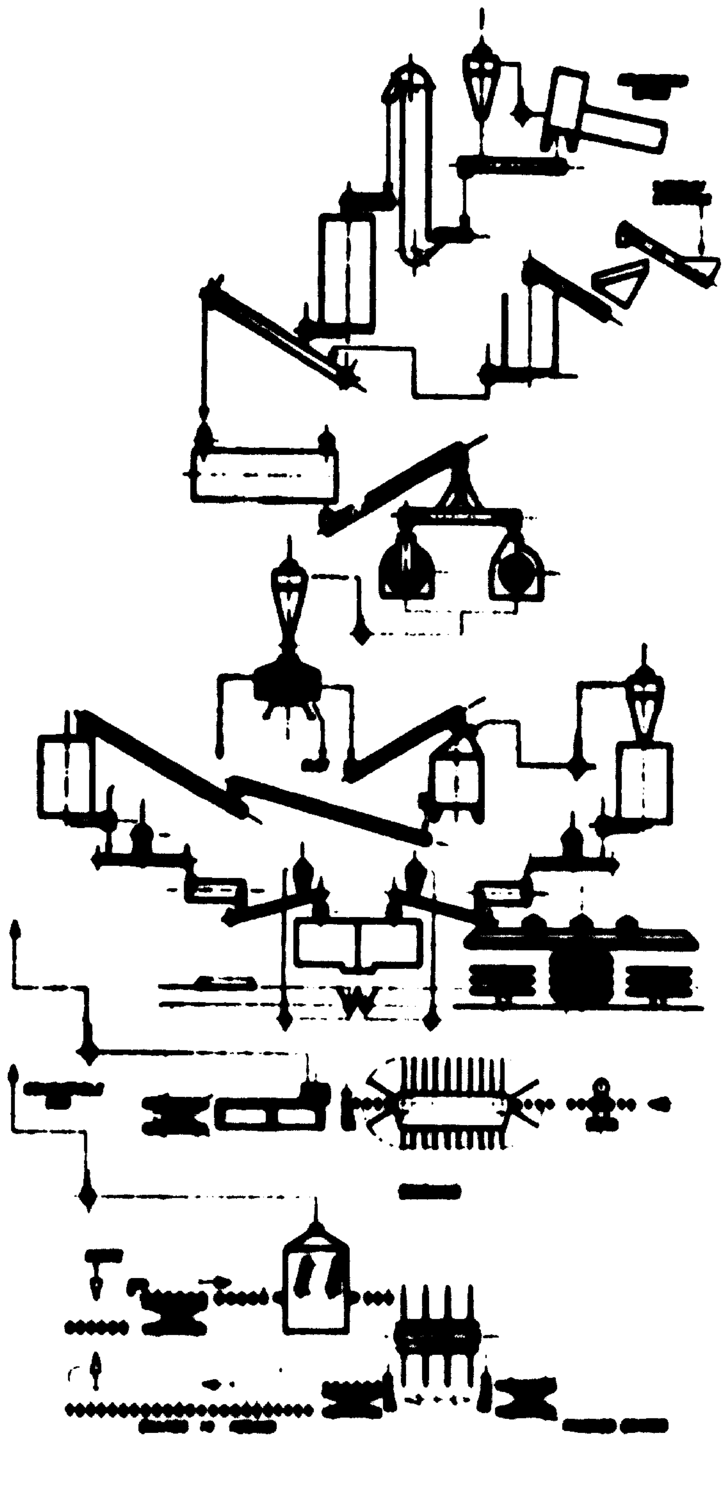
It is evident that changes in the above-mentioned preparation flows are sometimes introduced.

PREPARATION FLOW OF A THREE LAYER WOOD PARTICLEBOARD

ALTERNATIVE 1 : DIRECT FLAKING

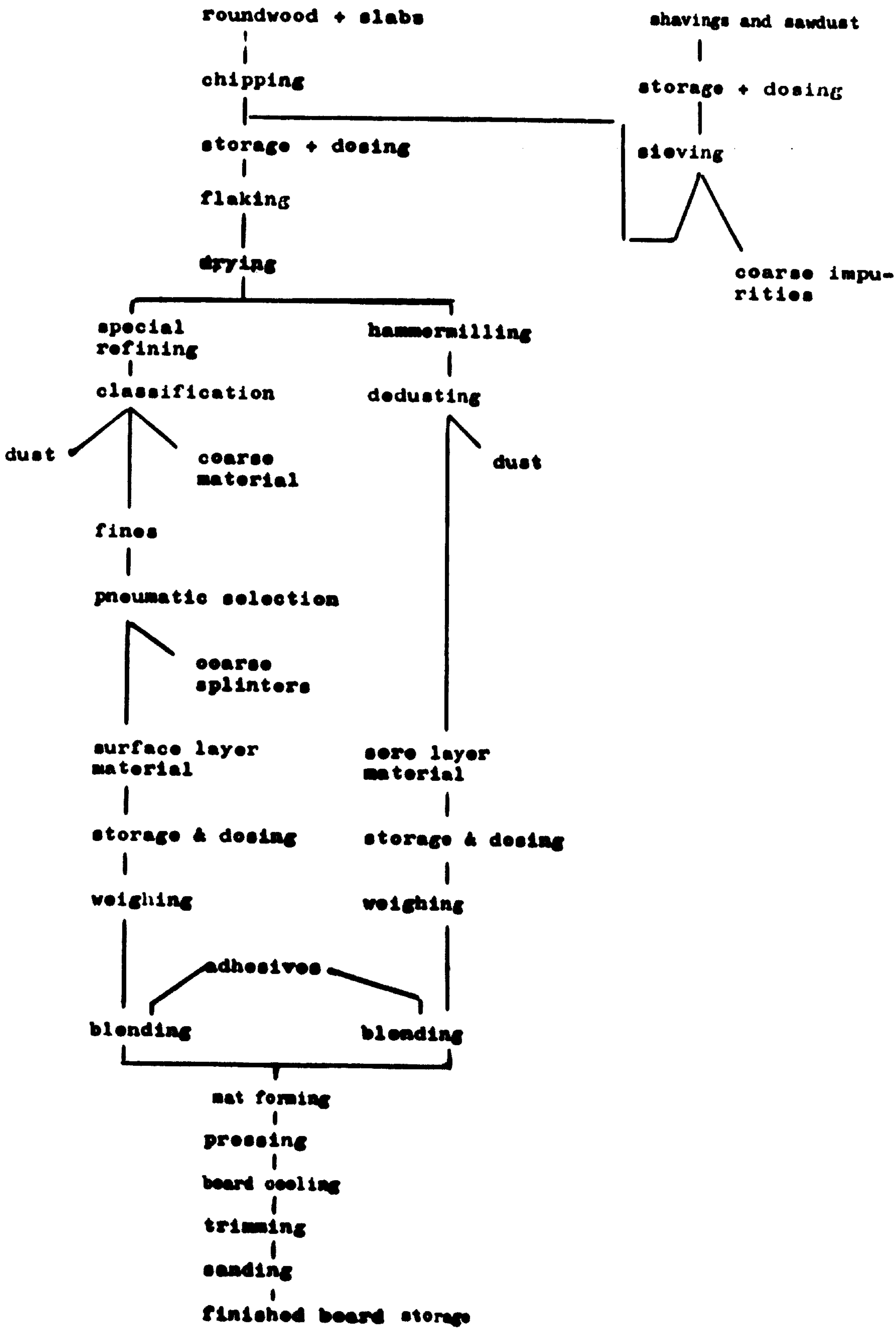


DIAGRAMATIC SKETCH OF PRODUCTION FLOW FOR FLAT PRESSED PARTICLE BOARD USING DIRECT FLAKING

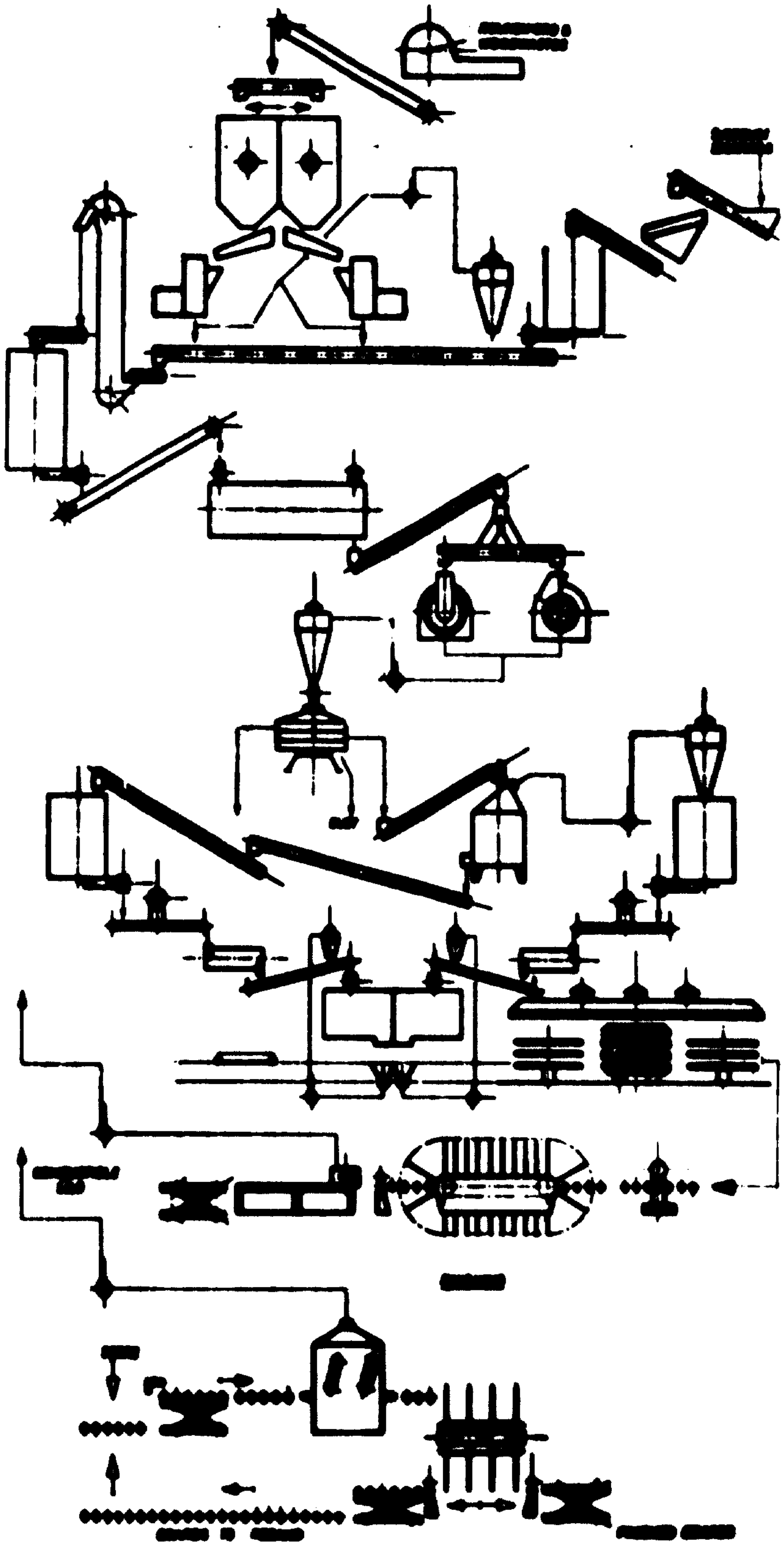


ALTERNATIVE II

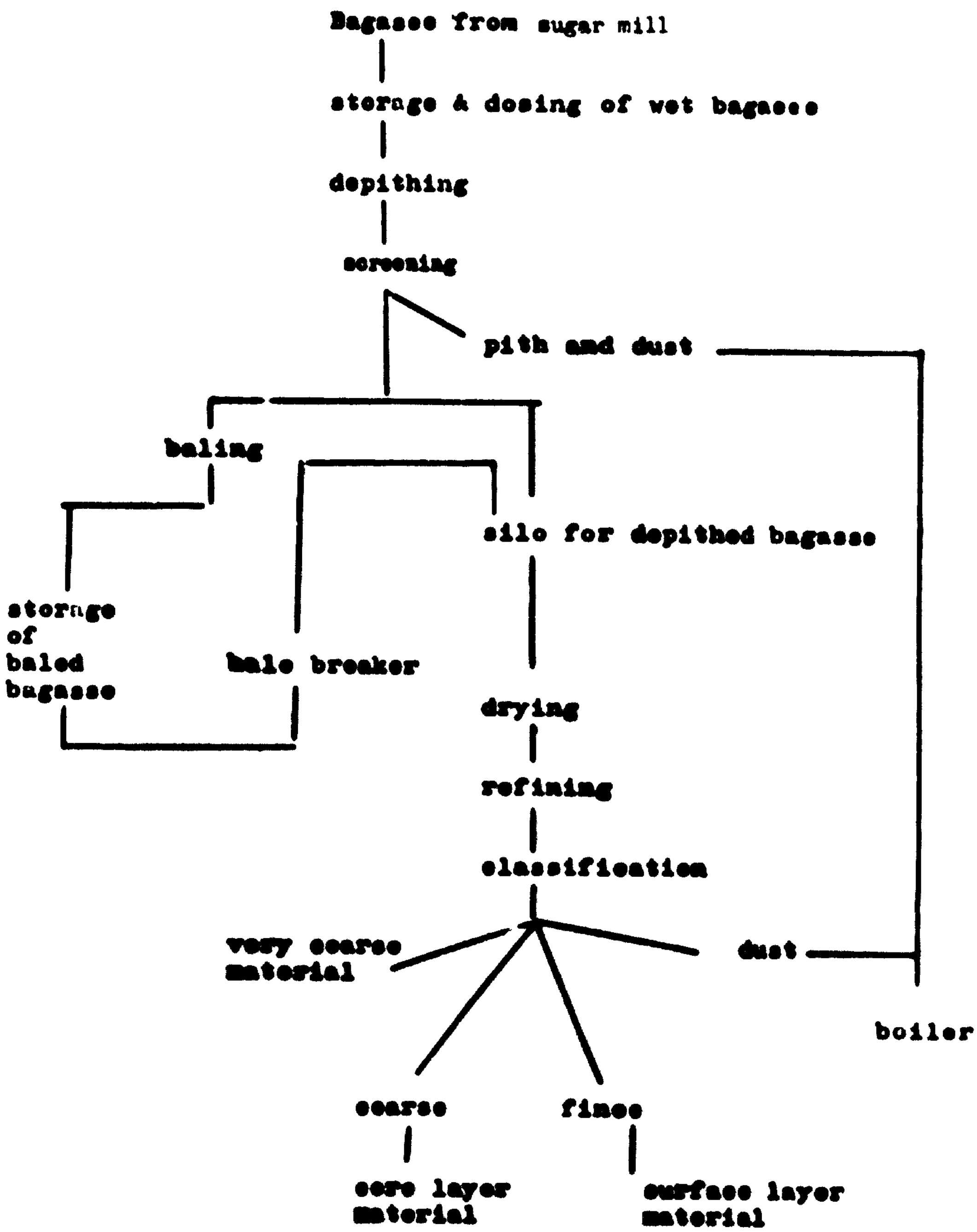
PRELIMINARY CHIPPING WITH SUBSEQUENT FLAKING



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



b) Preparation of flax shives, hemp, cotton stalks, and also bagasse is quite different. The preparation of bagasse, an excellent raw material, is in principle as follows:



Gluing

Flow of gluing process:

storage and dosing of prepared material
electronic control unit
weighing
adhesives
blending
transport to mat forming

Mat Forming

There are four main types of mat formers:

- volumetric spreading machines
- volumetric and gravimetric combined spreaders
- spreaders with pneumatic classification
- spreaders with combined volumetric and pneumatic classification

One of the most vital points of the particle board manufacturing process is mat forming.

Incorrect mat forming leads to lack of uniformity in the particles' distribution. This lack of uniformity leads to:

- density changes
- variations in physical and mechanical properties
- variations in compression and curing differences
- high liability to warp

Mat forming is apparently a simple operation, but great care should be given in the choice of this equipment.

Although mat forming equipment is machinery in its own right, the choice and arrangement of this equipment is partially dependent on the output and type of the pressing equipment and caul conveyor system and therefore brings one straight to the problem of presses and associated equipment.

Pressing

Apart from the very small number of continuous presses in operation, this paper is mainly concerned with boards in which the particles have their longitudinal axis parallel to the surface. Such boards are made in static, single or multi-daylight presses.

The following systems are mainly installed:

- The belt type system plant in which the mat is spread continuously on an endless forming belt.

  The belt type system allows single or multi-daylight presses combined with volumetric, gravimetric, pneumatic or other combined system of mat forming.

- 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 older or 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. This old caul-type system is no longer commonly being installed.

Tray belt, tray and caul system plants are equipped with volumetric, gravimetric spreaders or a combined system of both. Pneumatic spreading is only possible in plants using the belt system.

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

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

The comparatively high investment cost for single daylight presses makes it necessary to take advantage of all technological possibilities to obtain the highest possible capacity with the press. Accordingly, the "Fast Technology" as necessarily applied to single daylight presses is not the result of efforts towards an exceptionally perfect technology, but the forced result of economic circumstances. This means that in order to ensure economic operation, considerable technological concessions must be made when employing single daylight presses.

Compared to the normal technology, as usually employed with multi-daylight presses, the technology with single daylight presses differs in

- extremely short pressing times

which, again, can only be achieved by

- extremely low moisture content of chips
- extremely high press temperature
- utilisation of resins with high content of formaldehyde and high proportion of hardener.

C. Supplementary Information on Some Processing Stages

Chipping and Flaking

As already mentioned, there are 2 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.

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.

An economic study has been made and the results are given below.

Basic elements for the study:

- plant capacity 250 m3/day
- raw material 100% roundwood in different lengths (maximum 6,000 mm/min.)
- Alternative I: - chipping in 1 shift/day
  - flaking in 3 shifts/day by 2 knife ring flakers

  Alternative II: flaking in a 2-drum flaker type 74

	I	II
Total investment costs in DM	1,522,300	1,055,000
Output in tons atro 1/	9	10.[illegible]
Investment costs in DM ton atro	9.45	6.95
Wages in DM ton atro	1.33	1.75
Energy costs in DM ton atro	5.72	1.97
Wearing parts cost in DM ton atro	5.35	2.07
Total cost in DM per ton atro produced particles	21.85	12.74

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

1/ atro is an international term used in wood and wood processing industries and means oven dry weight

Drying

Type, nature, shape and size of particles and their moisture content vary considerably with board production processes.

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 post 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:

- maintenance 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

Gluing

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 nossles, 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 nosslee and consequently no more need for cleaning of nossles 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 prepolymerisation 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. This is done on the following pages.

Calculation of saving-costs by installing the new type blender instead of a conventional one in a [illegible] board plant (capacity 5000 kg dry material/hour)

		Conventional glue blender	New type blender
Technical data			
Installed motor power	Kw	37	22
Energy consumption	Kwh	200.000	120.000
Compressed air	m^3/h	180	-
Water consumption	l/h	-	2.500
Time for cleaning per week	man-hours	16	2
Running cost per 7000 working hours per year			
energy costs	0,10 DM/kwh	20.000 DM	12.000 DM
compressed air cost	0,015 DM/m^3	18.900 DM	-
cooling water cost	17.500 m^3 x 1,5 DM	-	26.200 DM
cleaning-cost		13.824 DM	1.252 DM
		52.724 DM	39.452 DM
Investment cost			
- equipment		165.000 DM	138.000 DM
- compressed air		10.000	-
		175.000 DM	138.000 DM

Direct saving cost by adhesives economy

- capacity of blender 5.000 kg dry wood
- normal rate of adhesives applied in case of conventional blenders: 9.5%
- rate of adhesives applied in case of the new blender type: 8.5%
- economy of adhesives 1%
  - per hour 50 kg
  - per year (7000 working hours) 350.000 kg
- total cost savings DM 157.500 DM

Summary of cost savings

- running cost	13.272 DM
- investment cost	37.000 DM
- adhesives economy	157.500 DM
- total cost savings per year :	207.772 DM

Information

Actual prices of a complete new gluing type equipment with a capacity of 5 Tons dry particles per hour

1 x blender ca	60.000 DM
1 x weighing device ca	40.000 DM
1 x glue dosing	25.000 DM
1 x electric equipment	20.000 DM
accessories	6.000 DM
1 x cooling group	20.000 DM
	171.000 DM

Conclusion

- by installing the new type blending equipment a cost saving of max 207.772 DM per year can be realised
- Board production will be more regular and homogeneous and less second class boards will be made.

D. New Developments and Trends in Manufacturing Processes

After the extension of existing production facilities had brought a certain degree of saturation onto the market, the manufacturers were forced to look for new methods of securing their sales. A number of manufacturers engaged in the finishing industry (coating, painting, veneering, lacquering, etc.)

Production of Thin Boards

Some other manufacturers supplemented their ranges by boards which were thinner than traditional types. The considerable price rise of African timber and of plywood stimulated some particle board manufacturers to modify their plants to produce boards thinner than 6 and 8 mm. Production of thin board (4 mm and less) in traditional plants was technically quite impossible due to the mutual dependence of loading and pressing times and also economically due to the high sanding losses of boards made by traditional methods.

Several press manufacturers' research departments are at present fully occupied in adjusting their own system for thin board production.

Already more than 30 calender process units (Mende System) have been installed. The main advantage of this continuous pressing system is that it produces daily up to 150 m3 representing 50,000 m2 particle boards per day (3mm thickness basis).

Boards can be pressed to an accuracy of ± 0.2mm, a subsequent sanding operation being unnecessary. The working width's range is from 1350mm to 2500mm. Board thickness range is from 2 to 8 mm. The furniture industry immediately realised the advantage to be gained by using these boards. Thin boards are used especially for door manufacturing and back panels. Some companies use thin particle board as core layer in blockboard instead of plywood. Apart from that, a high amount of thin boards are veneered and covered with laminates for use in the furniture industry and for exhibitions and shop fittings supplies. Finally, the packing industry uses a lot of thin particle board also for fruit cases.

Another new trend in board manufacture is the production of the so-called medium density fibre board. Some details of this product have already been given previously. This process accepts a wider range of raw materials than traditional plants. It is important to note that some 95% of any one tree can be processed into medium density fibreboard compared with a figure of 60 - 70% in a traditional particle board plant; thus wastage is virtually eliminated. The use of a percentage of bark in this process represents a significant advantage.

Description of the process:

The key features of this dry process are pressurised refining and dielectic radio frequency heating. It is understood that in some countries authorities may restrict the use of radio frequency heating but other means of providing the heat to cure the boards can be applied.

Single or multi-opening presses are used.

Preparation and production process is shown on page 29.

Investment cost of a plant does not rise proportionately with its capacity. In the following table (page 32) total investment costs (without buildings and civil engineering) are given for different sizes of particle board plants.

Investment cost per ton of output drops considerably as capacity increases, as shown on page 33.

Remark: As the capital costs of a plant do not rise proportionately with its capacity, unused capacity is expensive and the selection of proper plant size is very important.

Plant Size

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 of particle board plants are normally given on the basis of 19mm (3/4 inch) board. 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.

In most countries, the capacity of particle board plants is planned on 280 working days per year and a 3-shift basis. In the past few years, press cycles for wood particle boards have been reduced radically. Press cycles of 13–15 seconds per mm board thickness are achieved on single-opening presses. Fast multi-daylight presses normally have slightly higher pressing cycles (about 20 seconds/mm board thickness) and work at lower temperature than fast single-opening presses.

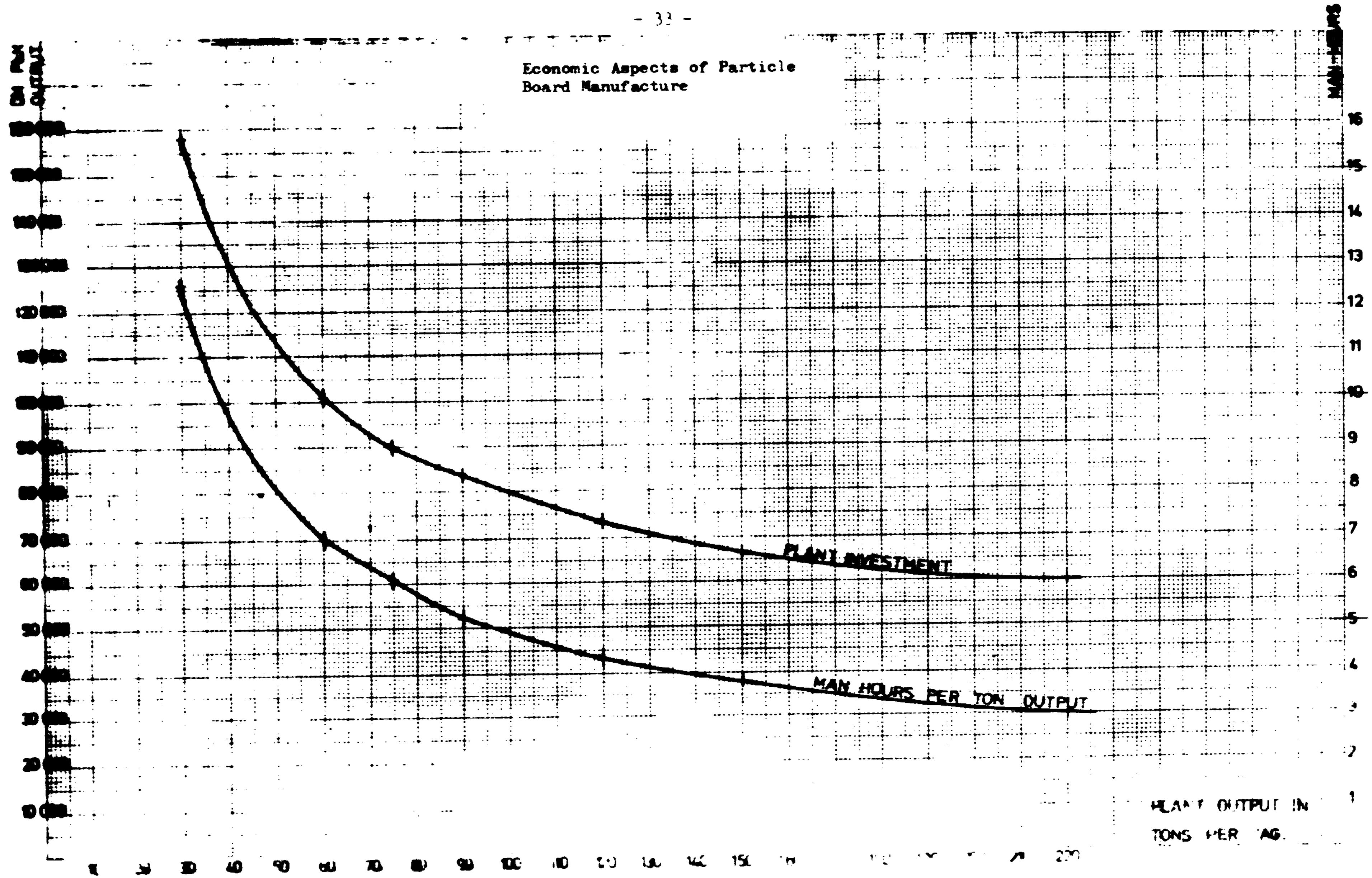
Finally, two main factors determine plant capacity: the availability of raw materials and the operating efficiency. The operating efficiency in well organised particle board plants varies between 90 and 94%, and drops easily and rapidly when organisation fails or when no qualified labour exists.

New plants, also those in developing countries, should be built taking account of the problems created by the local labour and the steady increase of wages. New plants should be simple but well automated, even when abundant local labour is available. They should be easy and simple to run and special care should be given to the capacity of each individual machine in order to avoid bottlenecks in the main operations, like flaking, drying, gluing and mat forming. The bottleneck points in most particle board plants are the flakers and driers, which should have an overcapacity.

ESTIMATED TOTAL INVESTMENT COSTS FOR PARTICLE BOARD PLANTS

Daily Capacity in Tons	Total Investment Cost in DM (without buildings)	Total Investment Cost per Ton Output (DM)	Labour per Ton Output (man hours)
30	4,764,000	158,800	12.5
60	6,060,000	101,000	7
75	6,800,000	90,660	6.1
90	7,680,000	85,330	5.25
120	8,800,000	73,300	4.50
150	10,000,000	66,600	3.95

Economic Aspects of Particle
Board Manufacture



Production flow for medium density fibreboard

logs, branches & slabs	joinery units	sawmill
chipper	shavings	sawdust
storage & dosing	storage & dosing	storage & dosing

metallic separator

screen

oversize grinder

drier

refiner

cooling

blender

dosing & storage bin

mat-forming stations
vacuum felters

press plant (belt system)

trimming

cooling of board

sanding

finished board storage

The development of the pressurised refiner is a very significant feature of the process which permits the refining of wood with a moisture content of 20-40% (dry basis) and the subsequent production of a superior fibreboard. The high temperature within the refiner melts the lignin, which is re-deposited on the fibre surfaces and improves the bond quality.

An important feature of the pressurised refiner is its ability to make fibre of relatively low bulk density which, after pressing and bonding, gives a reconstituted wood product.

Another feature of the high-pressure refining system is that horsepower requirements are less than with atmospheric refining systems.

The most significant factor influencing board quality is the bulk density of the fibre and this bulk density of the fibre is not necessarily related to the species or source of the raw material but to the method of refining.

The resin is a solution of high solid content or largely unreacted components of an amino resin with melamine, in the presence of an acid catalyst. The melamine content can be increased to give exterior durability.

The quantity of resin can be varied to suit the end use of the product and can be calculated on 6% of the dry fibre weight, depending on whether the product is for industrial or building use, and of interior or exterior grade.

The fibre felters consist of belt feeders to vacuum screens and they have adjustable deckles to lay various widths of mat.

Continuous pre-pressing, mat trimming and pressing are done in conventional presses or HF presses.

The medium density fibreboard are characterised by good internal bond, screw withdrawal resistance and low linear expansion, which are three of the most important features for the furniture maker and exterior panelling producer.

Laboratory and research teams are also studying a new production process for thin board manufacture. The key features of this dry process are:

- Production of a very strong dry particle board out of 100% sawdust.
- Production of a smooth dry particle board without the conventional gluing system. Chemical products are used in liquid and gas form. The applied amount of chemicals varies around 2 - 2.5%, calculated on the dry weight of wood.

Preparation of sawdust is also done in a pressurised refiner.

More process details will be known after the realisation of a first plant.

Discussions for a 100 ton capacity plant now have a good chance to lead to completion. This new type of particle board plant will probably be integrated into an important complex comprising a paper mill, sawmill and particle board plant.

IX ECONOMIC ASPECTS OF PARTICLE BOARD PRODUCTION

Analysis of Sources of Expenditure

The main sources of expenditure in particle board manufacture are:

- raw materials
- utilities
- labour
- maintenance
- depreciation
- interest
- miscellaneous: administration costs, insurances, property taxes, communications, etc.

Assuming a plant of a given size, the main distinction which can be drawn between the sources of expenditure is that:

- for the first 4 sources, expenditure increases with rising output, while it remains stationary for the last 3
- the relation of expenditure to output and unit cost

Raw Materials

Raw materials being the biggest item of expenditure (sometimes more than 50% of total expenditure), they are the only source of expenditure directly related to output.

Utilities

Consumption of cooling water in particle board manufacture is negligible.

Electric power consumption of continuously operating plants does not vary in direct proportion to output. The cost of electric power per unit of production will be minimal when the rate of production is at its maximum.

Similar reasoning is applied to steam and fuel; energy costs represent roughly 10% of the total manufacturing expenditure.

Maintenance

Although maintenance falls in principle into the group of high expenditure and lower unit cost per item with rising production rate, in practice the differences may be considered negligible.

Labour

Labour is not proportional with increased production. In the table on the next page man hours per ton of output for different plant sizes are given.

Depreciation, Interest in Capital and Miscellaneous Items

These can be considered more or less constant irrespective of the level of output.

Interest and depreciation rates being related to fiscal and monetary policies and therefore being variable according to country, period and time, they account for a fair proportion of the manufacturing cost.

Profitability

The prerequisite for establishing a new plant and for its profitable operation is naturally that a market exists and can be developed for the products. While this fact is in many cases overlooked and while plant design should allow for a break-even point below rated capacity, it is assumed that the plants can operate and sell at their rated capacities.

Special Considerations for Developing Countries

It is particularly important for developing countries that the following aspects be studied and realistic facts established before any financial commitments are undertaken for a new development.

- A domestic and/or export market for the products
- Availability, cost and types of raw material
  - (a) Wood or other cellulose materials:

    Since particle board technology has made considerable improvements during the last years, it is extremely important to study the recovery of all kinds of inexpensive wastes such as wood wastes, bagasse, cotton stalks, coconut fibres, flax, hemp, jute, etc.
  - (b) Adhesives when no local production is available:

    A study should be made on transport costs, storage possibilities, storage life, import taxes, etc.
- Plant location

  Plant location is very important and especially the following factors should be taken into consideration:

  - Location with respect to raw material area, to sea ports, important traffic roads, railway connections
  - Availability of water
  - Low cost of electric power
  - Environmental protection
  - Transport facilities, etc.

  All these factors influence the plant location decision.
- Availability of qualified labour

  Also when fully automatic plants are installed, a minimum of highly qualified labour is always indispensable. The profitability of a plant depends to a large extent on the operating efficiency.
- Labour, power and material prices
- Duties on materials and products
- Taxation and other financial regulations, rules and customs
- Capital cost, total investment, manufacturing cost and return on investment
- Decision as to profitability needed or desired for the development
- Influence on foreign exchange
- Domestic purchasing power limits

When a favourable answer has been given on all the above-mentioned items, a preliminary projection should be made and the following main basic data should be determined:

- plant capacity and board size
- manufacturing system and know-how
- total investment cost calculation
- possibilities for financing the project

In order to help responsible project leaders in developing countries, special questionnaires have been published by FAO 1/ services to help them by collecting all required information to make a profitability study and a financial investment plan of the project.

X ADVICE FOR DEVELOPING COUNTRIES

A. Technical Advice

As already mentioned in this study, new plants in developing countries should be technically up-to-date plants taking into account the actual and future problems created and to be expected by local labour, increase in wages, etc.

The capacity of each individual machine should be well studied.

- Flaking and drying equipment should have over-capacity. Moisture content in the wet season may sometimes exceed all normal provisions.

  The choice of a bigger type of flaker or drier will not influence the total investment cost too much, but will help later on to reach the required capacity in all seasons.

- Gluing equipment should be the most modern equipment in order to achieve efficient and economic gluing. In most developing countries adhesives, being imported, are very expensive and utmost care should be taken to use a minimum possible of adhesives while producing good quality board.

- For press plant capacity and number of daylights, responsible people must keep in mind that normally in all the factories even only a few months after starting up plant management is looking for increases in capacity. Thus the press must have a considerable capacity reserve.

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 utilise the waste products they generate (bark, sander dust or other low cost wood wastes) instead of relying on imported fuel oil.

1/ FAO document WPP/70/4.1 "Questions that must be answered before investing capital in a wood-based panel operation" by A. Schmits and F.C. Lyman

Finishing

Exceedingly fast and fully automatic finishing lines are nowadays installed in most particle board plants. Sanding on wide belt, very modern equipment is fine and very accurate, but big errors are sometimes made in the calculations of the cost for wearing abrasive papers.

For wide belt sanding, abrasive papers must normally be imported and they are very expensive.

The life of sanding paper depends on such factors as: sanding speed, board density, board thickness tolerances, type of raw material, board temperature, etc. Board sanding requires full attention.

Choice of Board Size

Choice of board size is also very important. Most developing countries instal plants with 4 x 8 or 4 x 10 foot sizes and these seem to be justified in most developing countries.

The larger the board size, the lower are normally the cutting losses when processing the boards. For a furniture factory there can be real advantages in manufacturing boards of large size in order to cut them immediately to final sizes 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 1,830mm x 3,660mm. In some countries - Greece for instance - between 1965 and 1970 boards of sizes greater than 4 x 10 feet (1,220mm x 3,050mm) could not easily be sold due to the handling problems in the narrow streets and small storage places in and around the capital.

B. Economic Advice

Integrated Plants

A careful examination of the economic aspects of integrated units is recommended in most developing countries before a final decision is taken. In Eastern Europe most particle board plants make up part of a wood and wood industry complex. The horizontal and vertical integration of these enterprises is normally quite well done. Numerous examples of such integrated units can be given. Vertical integration of wood-based panels production with further conversion has received much attention during the last few years.

The Belgian Government recently decided to offer, as help to developing countries, a complete turnkey integrated unit to the Republic of Indonesia. This so-called "low cost housing project" comprises:

- supply of equipment
  - a complete particle board unit
  - a complete veneering line
  - a complete workshop for prefabricated housing elements
- erection costs (travelling expenses, wages, board and lodging, etc.) for erection specialists of the seller
- training of several Indonesian technicians in Europe

- technical assistance after start-up of the plant (technical management, technological assistance, etc.)

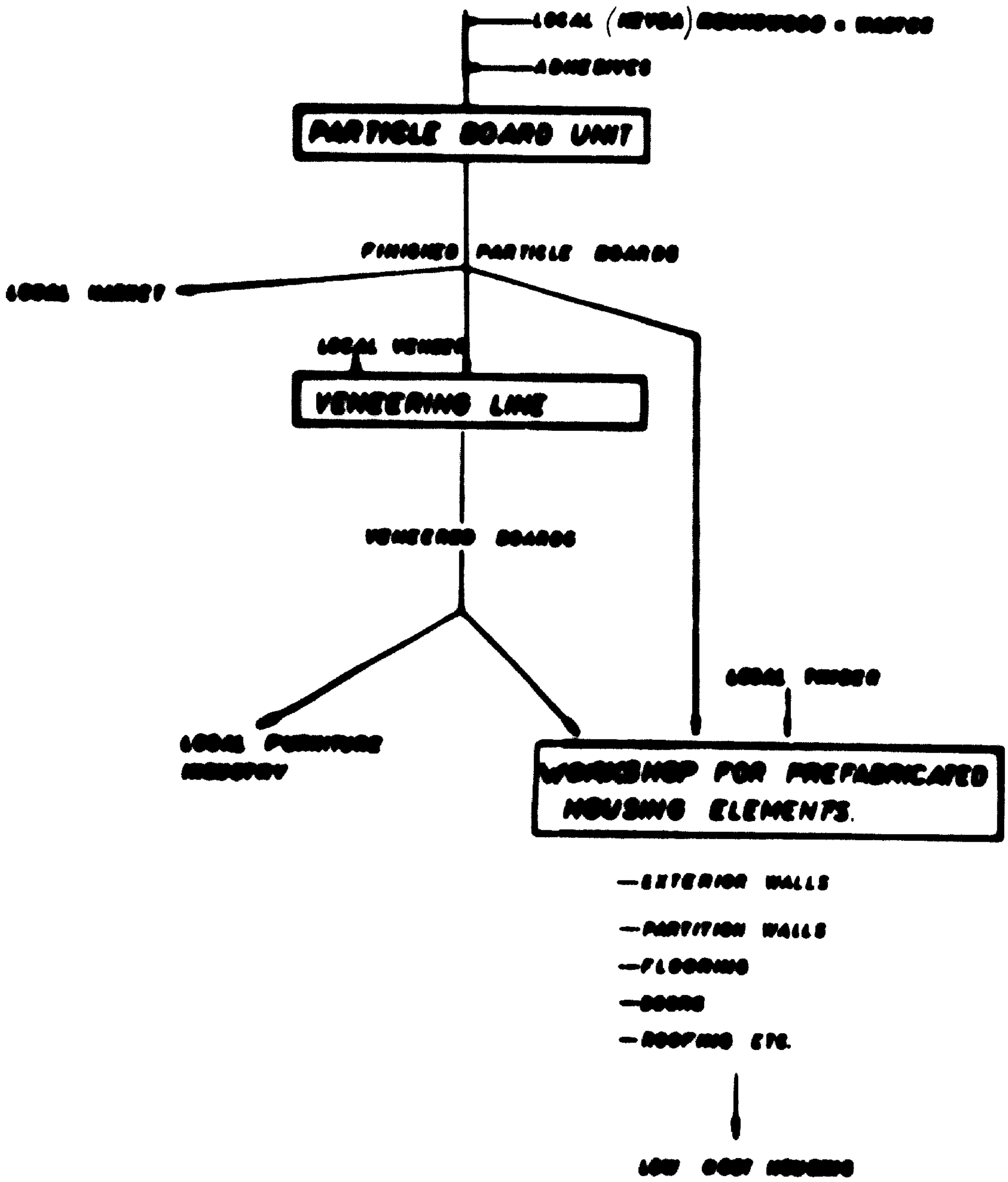
As given in the table overleaf, local Hevea round wood and wastes are transformed into 3-layer particle boards. Local veneer is available in Indonesia and veneered particle board will be employed in local furniture and in the prefabricated housing elements.

Turnkey Plants

It must be emphasised that developing countries should buy "integrated turnkey plants". The whole turnkey project must include:

- the supply of:
  - the production equipment:
    - preparation equipment
    - gluing and mat forming equipment
    - press plant
    - finishing line
  - the auxiliary equipment
    - the electric equipment
      - high tension cabinet
      - low tension distribution cabinet
      - switchboards and complete steering equipment
      - all electric cables and accessories
      - cos φ 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, wood yard, 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

INTEGRATION OF PLANT



- 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 capital 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 subcontractors.

We wholeheartedly recommend to authorities of developing countries to buy only "turnkey plants".

Some countries, e.g. Algeria, have already set good examples by buying turnkey integrated plants (with incorporated sawmill and particle board unit).

75.06.06