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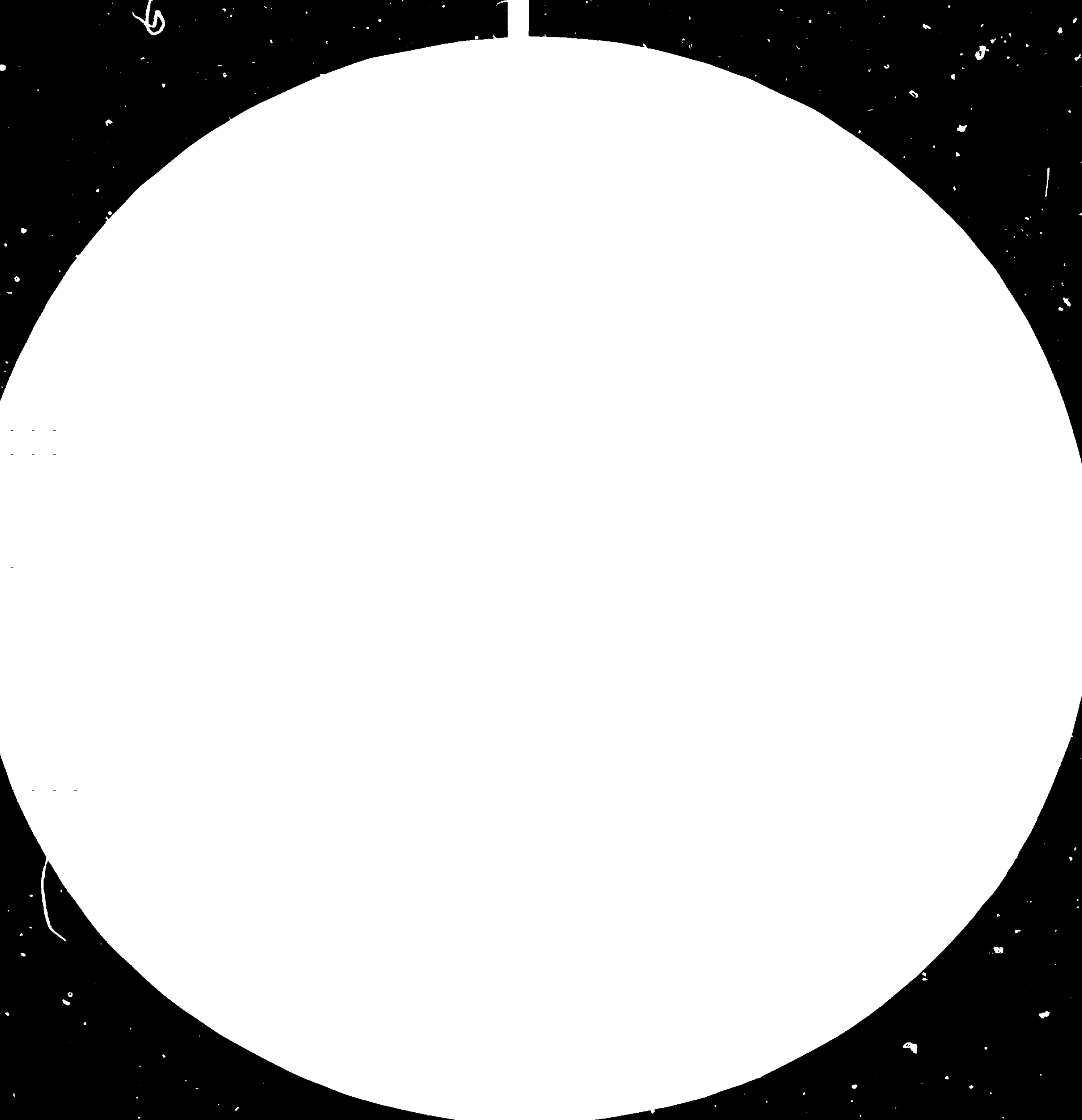

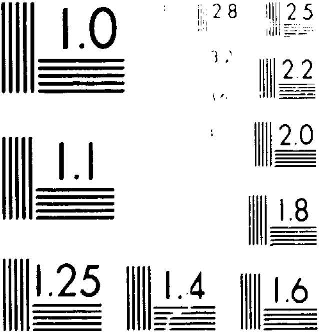
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LIMITED

ID/WG.335/5
19 February 1981

ENGLISH

United Nations Industrial Development Organization

Seminar on Wood Based Panels and Furniture Industries

Beijing, China, 20 March - 4 April 1981

THE MANUFACTURE OF FLAT-PRESSED PARTICLE BOARD IN THE BEIJING WOODWORKING PLANT*

by

Ba Ru-You **

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** Beijing Woodworking Plant, Beijing, China.

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I. General description:

1. Basic conditions of the particle board industry in China:

The particle board industry in our country was initially developed in the late 1950s and then developed further in the early 1970s. In recent years, the production of particle board has increased continuously and there are also some improvements in technology and equipment. Particle board is developing more rapidly than other wood-based panels. The reasons for this are the comparative simplicity of the technology and equipment, less investment and increasingly available raw materials; besides, one of the important factors is the rapidly growing scope of applications.

The raw materials for the production of particle board are mainly wood residues from woodworking plants, wood of lower quality is also used. Recently, particle board with fine particles in the face layers is developing rapidly, so that the rational utilization of shavings and sawdust is possible. In some places the range of raw material is enlarged, agriculture wastes such as flax stems etc. are used for the production of particle board.

2. The significance of the development of particle board to the national economy:

The wood processing industry plays an important role in the national economy. China is a country with limited forest resources. With the development of socialist construction, and the continuous rising of the living standards of the people, the imbalance between supply and demand for wood becomes more crucial. Therefore, the long-term strategic goal is to increase production and practise economy of raw material utilization in the woodworking industry, so as to safeguard our country's wood resources and to develop an integrated utilization of wood.

The present production methods used in woodworking plants result in a utilization ratio from log to plywood and furniture of usually about only 30 to 40 percent. The remaining 60 to 70 percent of the wood is considered waste. Formerly this was burnt as fuel. This shows that the development of particle board production is one important way for obtaining an integrated utilization of wood. This is especially important for countries with limited resources of wood like China.

Particle board has recently been widely used for the manufacture of furniture, movable floor boards, boards for sewing machines, etc. It is a good substitute for solid wood.

3. Physical-mechanical properties of Chinese particle board:

Item	Unit	Flat-pressed particle board	
		first class product	second class product
Moisture content	percent	9 ± 4	
Density (bone dry)	g/cm^3	0.45 - 0.75	
Static bending strength	kg/cm^2	> 180	> 150
Tensile strength perpendicular to the plane of the board	kg/cm^2	> 4	> 3
Thickness swelling after immersion in water	percent	< 6	< 10

Note: (1) Static bending strength of board with thickness over 25 mm should be 15 percent lower than the figure indicated.

(2) Tensile strength perpendicular to the plane of single layer board should be 20 percent more than indicated.

4. Method used in China for testing physical and mechanical properties of particle board:

A. Item being tested:

(1) moisture content;

(2) density;

(3) static bending strength;

(4) tensile strength perpendicular to the plane of the board;

(5) thickness swelling after immersion in water.

B. Size and quantity of specimens

Item of test	Size in mm	Quantity
moisture content	50 x 50	3
density	50 x 50	3
static bending strength	width: 50 length: 10 times the nominal thickness plus 50	6
tensile strength perpendicular to the plane of the board	50 x 50	3
thickness swelling after immersion in water	25 x 25	3

Note: The angle between two neighbouring edges of specimens should be a right angle and its edges should be straight and flat. The accepted tolerance in width and length of specimen is ± 0.5 mm.

C. Method of test:

(1) Determination of moisture content: after weighing the specimen it is dried at a temperature of 100 to 105°C to constant weight. (accuracy in weighing 0.01 g).

The moisture content of the test specimen (W) is calculated by the following formula (to the nearest 1 percent):

$$W = \frac{G_1 - G_2}{G_2} \times 100\text{percent}$$

Where:

W = moisture content of the specimen (percent)

G_1 = weight of the specimen before drying (g)

G_2 = weight of the specimen after drying (g)

(2) Determination of density:

After the moisture content of the specimen is determined, measure its length, width and thickness to the nearest 0.1 mm, taking arithmetic mean values for the length and width. Its thickness is the mean value of the center of four sides. The volume of the specimen is then calculated.

The density of the specimen (γ_0) is calculated by the following formula:

$$\gamma_0 = \frac{G_2}{V} \ (g/cm^3)$$

Where:

γ_0 = density of the specimen (g/cm^3)

G_2 = weight of the specimen after drying (g)

V = volume of the specimen after drying (cm^3)

(3) Determination of static bending strength:

Determination of width and thickness:

The width is measured along the center line of the length of the specimen to the nearest 0.1 mm. The thickness is measured on the center line of length (10 mm from the side) to the nearest 0.05 mm.

The distance between supports in testing should be ten times the nominal thickness, but not less than 150 mm. The length of the specimen should not be less than 200 mm. The radius (R) of hemisphere of the loading head and the supports should be 12.5 mm. In testing the loading head must be directed to the center line of length of specimen. The loading speed is controlled and should be in the range of 30 to 90 seconds. The load is increased at an even speed until the rupture of the specimen. The reading of the rupture load on a dynamometer is taken to the nearest 0.5 kg.

The static bending strength of the specimen (γ) is calculated by the following formula to the nearest 1 kg/cm^2

$$\gamma = \frac{3PL}{2bh^2} \quad (kg/cm^2)$$

Where:

γ = static bending strength of the specimen (kg/cm^2)

P = rupture load of the specimen (kg)

L = distance between the supports (cm)

b = width of the specimen (cm)

h = thickness of the specimen (cm)

(4) Determination of tensile strength perpendicular to the plane of board:

The length and width of the specimen are measured along the center line of width and length respectively to the nearest 0.1 mm. The specimen is glued with cold setting adhesive on the wood grip. The test begins only after the complete setting of the adhesive. The loading speed in testing is 20 to 60 seconds. The load is increased evenly until the rupture of the specimen. The reading of rupture load on a dynamometer is taken to the nearest 0.5 kg. The tensile strength perpendicular to the plane of the board (Z) can be calculated as follows: (to the nearest 0.1 kg/cm^2)

$$Z = \frac{P}{\alpha \cdot b} \quad (kg/cm^2)$$

Where:

Z = tensile strength perpendicular to the plane of the board (kg/cm^2)

= rupture load of the specimen (kg)

α = length of the specimen (cm)

b = width of the specimen (cm)

(5) Determination of thickness swelling after immersion in water:

The thickness h_1 of the specimen is measured at its center to the nearest 0.05 mm. The specimen is immersed in water for 4 hours. The temperature of the water is 30 $\pm$ 3°C, and the water level is 1 - 2 cm above the specimen. The thickness after immersion h_2 is measured at the same point after wiping the absorbing water.

Thickness swelling after immersion in water (D) may be calculated by the following formula (to the nearest 1 percent):

$$D = \frac{h_2 - h_1}{h_1} \times 100 \text{ percent}$$

Where:

D = thickness swelling of the specimen after immersion in water (percent)

h_1 = thickness of the specimen before immersion (mm)

h_2 = thickness of the specimen after immersion (mm)

II. Technology and equipment:

The particle board production line of the Beijing Woodworking Plant was established and went into operation in the late 1950s. Following the continuous development of technology and in order to meet the increasingly higher expectation concerning quality by the consumer, the buildings, technology and part of main equipment were improved in 1975. Thus, the scope of waste utilization has been enlarged, the production parameters and labour intensity have changed, while at the same time, the production efficiency andquality of product have been further raised.

Size and structure of the product:

The product is 2440 mm long, 1220 mm wide and 19 mm thick (this can vary from 8 to 25 mm). This size of panel permits its use for many applications. For the purpose of furniture manufacturing, not only have the physical-mechanical properties of particle board reached the quality standard set by the government, but the surface quality also has basically fulfilled the requirements. The particle board production is either of the three layer or the graduated structure type.

Calculation of output:

The size of production depends on the source and quantity of the raw material available. The following basic data are considered:

1.	Annual working days	280
2.	shifts per day	2
3.	Size of panel	2440 x 1220 x 19 mm (about 0.056 m^3)
4.	Pressing cycle	10 min.
5.	number of daylights of hot press	7

$$Q = V \cdot N_1 \times \frac{t_1 N_2 \times 60}{t_2} \times D$$

Where:

Q = annual output (m^3)

V = volume per sheet (m^3)

N_1 = number of sheets pressed per cycle

N_2 = number of shifts per day

t_1 = working hours per shift (hours)

t_2 = duration of pressing cycle (minutes)

D = number of days worked per year

$$Q = 0.056 \times 7 \times \frac{7.75 \times 2 \times 60}{10} \times 280 = 10{,}000 \text{ m}^3\text{/year}$$

Block diagram for manufacture of particle board from residues in integrated wood industry complexes:

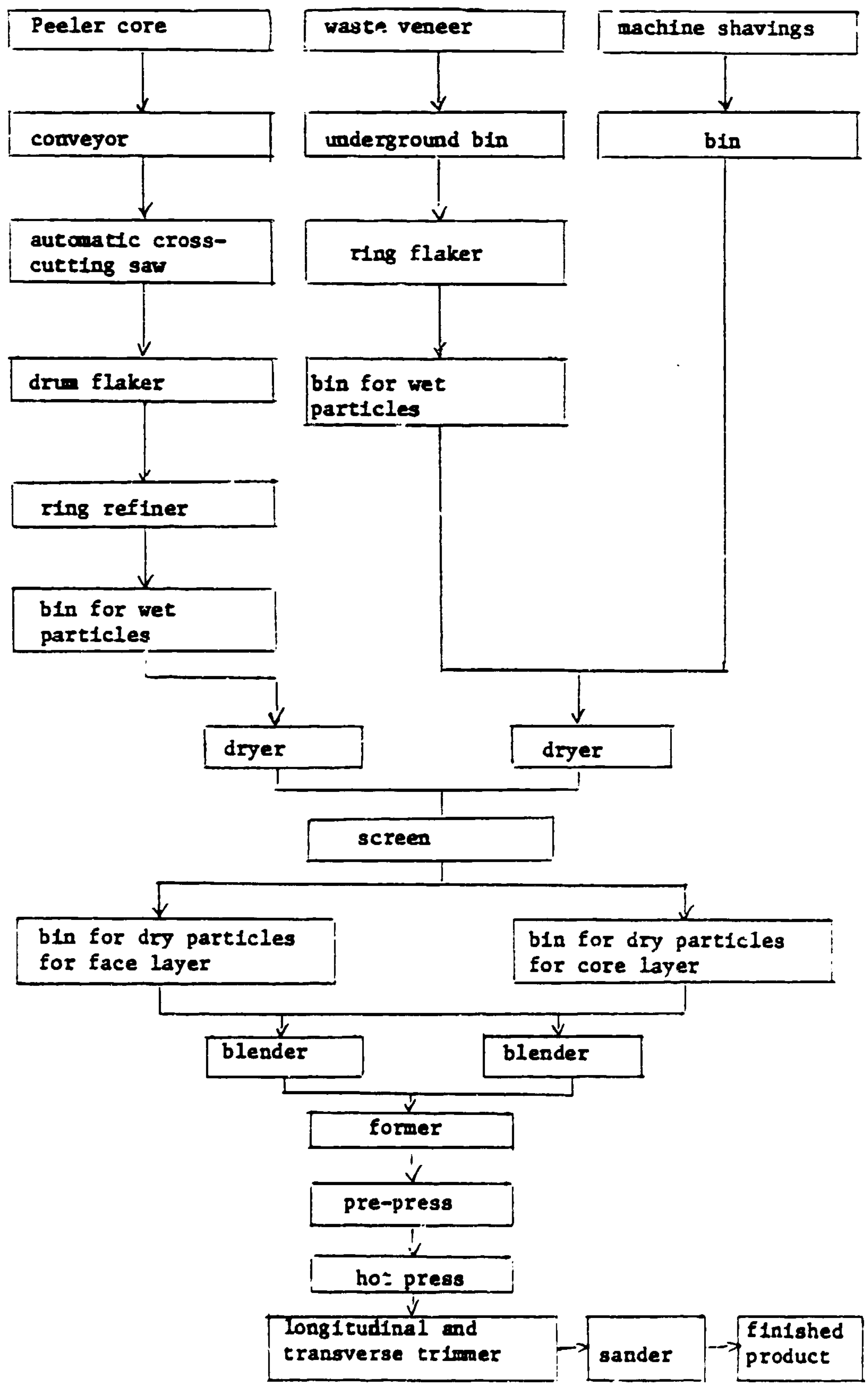
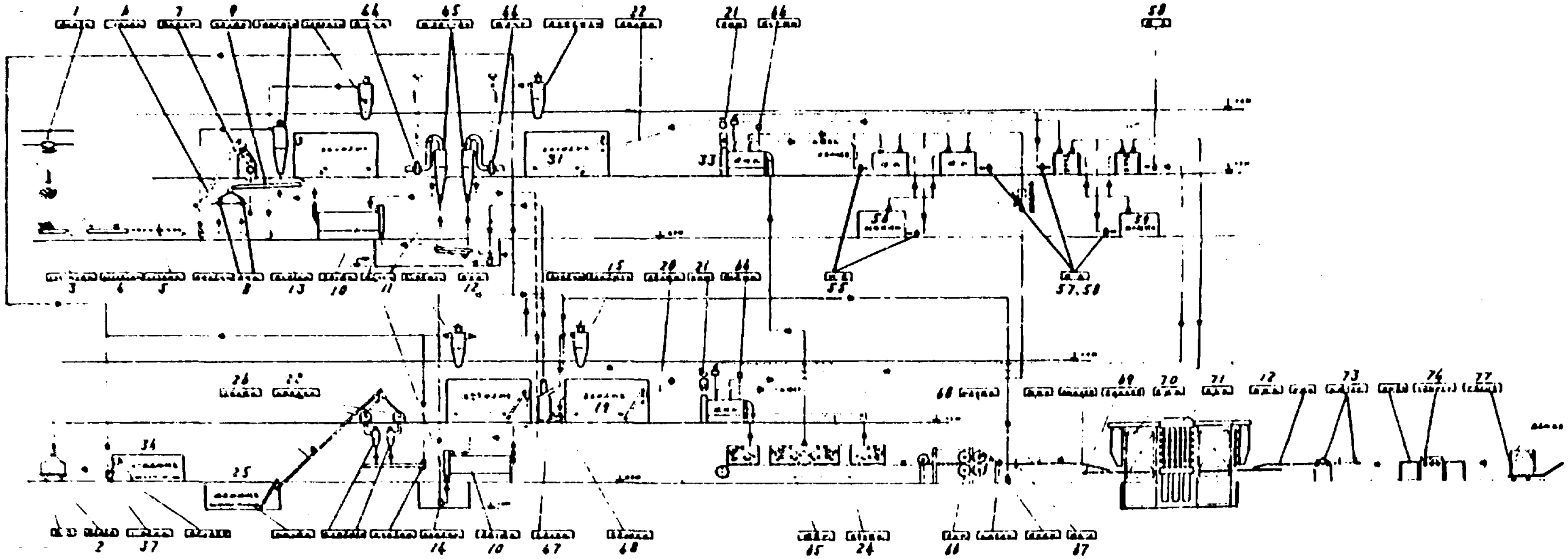


Fig.1. Schematic drawing of the technological process in the production of particle board.



Legend:

1. Gantry crane;
2. loading bin for machine shavings;
3. charging conveyor for peeler cores;
4. belt conveyor for peeler cores;
5. automatic cross-cutting saw for peeler cores;
6. inclined conveyor for peeler cores;
7. drum flaker;
8. refiner;
9. belt conveyor no. 1;
10. rotary drum dryers nos. 1 and 2;
11. particle dischargers nos. 1 and 2;
12. screen;
13. blower for particles of face layer no. 1
14. blower for particles of core layer no. 2
15. cyclone for particles of face layer;
16. particles for core layer;
17. machine shavings;
18. cyclone for air classifying;
19. bin of particles for face layer;
20. belt conveyor no.2:
21. automatic scale
22. belt conveyor no. 3;
23. glue blender no.1;
24. belt conveyor no. 4;
25. bin for waste veneer;
26. belt conveyor no. 5;
27. hopper;
28; ring flaker;
29. belt conveyor no. 6;
30. belt conveyor no. 7;
31. bin for dry particles of core layer;
32. belt conveyor no. 8;
33. glue blender no. 2;

34. bin for machine shavings;
35. lifter;
36. particle separator;
37. blower for machine shavings no. 1;
38. particle switching unit;
39. metal detector and separator;
40. bin for machine shavings;
41. discharger;
42. blower for machine shavings no. 2;
43. buffer bin;
44. blower for removal of moisture;
45. cyclone for removal of moisture;
46. particle dischargers nos. 3 and 4;
47. air classifier;
48. blower for particles;
49. lifter;
54. resin filter;
55. glue pump;
56. glue storage tank;
57. glue pump;
58. pump [illegible] liquid wax;
59. wax melter;
60. gravity tank for wax;
61. resin tank;
62. glue pump;
63. glue controller;
64. tank for curing agent;
65. former;
66. pre-press;
67. cross-cutting saw;
68. accelerating conveyor;
69. conveyor for return transport of caul;
70. loader;

71. hot press;
72. unloader;
73. longitudinal and transverse trimmer;
74. sander;
75. gantry crane;
76. monorail hand carriage;
77. lifting hand car.

Main techno-economical data:

No. Item	Unit	Quantity	Remarks
1. Particle board, 2440 x 1220x19mm., with graduated structure	m^3/year	10,000	
2. Annual working days	day	280	
3. Working shifts per day	shifts	2	
4. Consumption of raw materials and auxiliary materials: a) peeler core, waste veneer and machine shavings	m^3	13,000	solid m^3
b) urea-formaldehyde resin	T	1,500	solid content 55-58%
c) wax	T	105	
d) ammonium chloride	T	7.2	
5. Total area of building	m^2	3,300	including 800 m^2 shed
6. Area occupied by production line	m^2	2,500	
7. Number of pieces of equipment	sets	91	
8. Rated capacity of motors	kw	730	
9. Consumption of steam	T/hr	4.6	saturated steam at 10 kg/cm^2
10. Production water	T/hr	5	
11. Total labour force required		60	
a) production workers	persons	35	
b) auxiliary workers	persons	19	
c) administrative personnel	persons	6	
12. labour productivity	m^3/man year	133	(by total staff)
		228.2	(by production worker)
13. Production cost	¥/m^3	200,16	(approx. US$ 133)
14. Profit	¥/m^3	14,94	(approx.US$ 10)
15. Price	¥/m^3	250	(approx US$ 167)

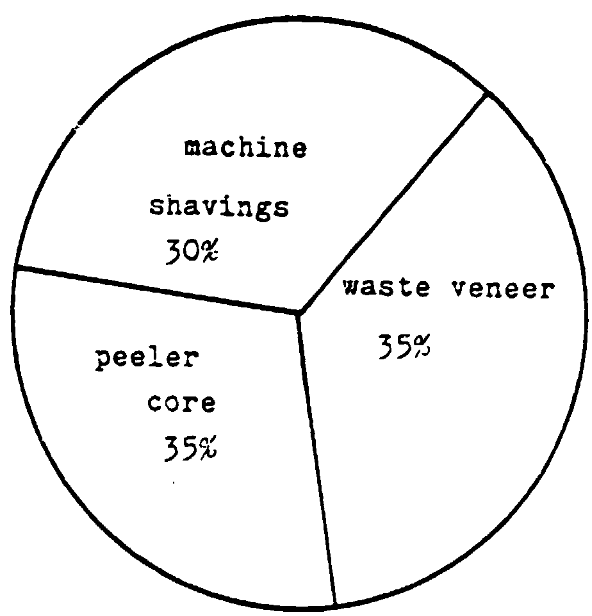
Types of raw material:

Three types of raw material for particle board are used by the Beijing Woodworking Plant.

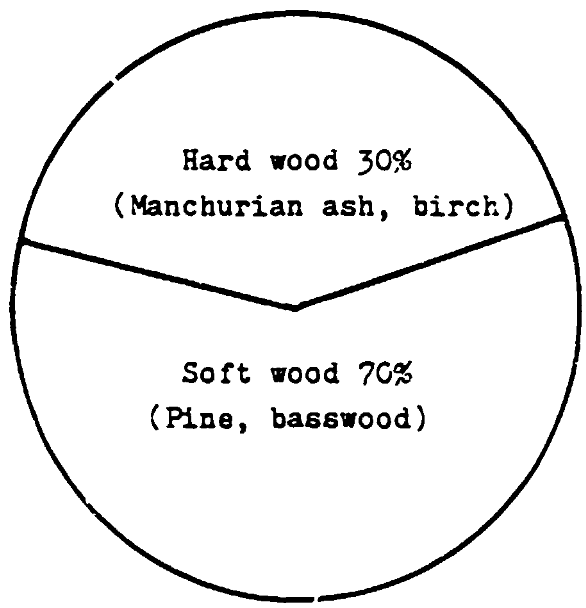
1. Peeler cores from plywood manufacture;
2. Waste veneer from plywood manufacture; and
3. Machine shavings and sawdust from the cabinet workshop.

Raw materials are reduced to acceptable fine particles for face layer and coarse particles for core layers as described in the above mentioned process.

The approximate proportion of three types of raw material is:



The approximate proportion by species of wood is:



A. Particle preparation:

The technology and equipment used in particle board plants vary with the types of raw materials supplied. However, there is a basic method to prepare face and core particles separately in order to obtain the desired particle geometry. For preparing face particles, veneer peeler cores or short offcuts from round wood are usually reduced to flakes by drum or disc-type flakers. These are further processed by refiner. The particles used for core are normally prepared on ring flakers without refining and put into use directly. In practice, particles within the size limits are used in the core and particles that are over size are eliminated by screening, reduced, and classified into coarse and fine furnish used for face and core respectively.

Mainly three types of raw materials are used in this design: veneer peeler cores, waste veneer or chips, and machine shavings.

According to the requirement of manufacture technology, these three types of materials are processed separately in a certain proportion. For three-layer board, the particles produced are separated into coarse and fine sizes for use in board core and faces respectively, while for board with graduated structure, various particles are mixed in a certain proportion.

The transport and processing method for the three types of raw materials are described as follows:

The veneer peeler cores are residues from the complex 's own plywood factory in our plant. The species consists of basswood (65 percent), manchurian ash (30 percent), birch and aspen etc. (5 percent). The peeler core diametres range from 80 to 150 mm. The peeler core lengths are 1020 and 2020 mm.

The peeler cores are transported into a stock shed on trailers. A gantry crane (lifting capacity 5 tons, lifting height 5 m) lifts them in bundles with cable and puts them on the deck with a chain feed conveyor.

There are two chain feed conveyors nos. 1 and 2. They run alternately: when one is in operation, the other remains idle, i.e. when the operating feed conveyor has fed all the peeler cores, it stops, and the other conveyor starts. Each feed conveyor consists of a horizontal deck and an inclined conveyor. The horizontal decks transfer peeler cores to the inclined conveyors, which in turn feed them onto a belt conveyor individually. Then, the peeler cores are cut to the required length by an automatic cross-cut saw. The operating principle of the cross-cut saw allows peeler cores to be transported to it by belt conveyor one at a time. The belt conveyor feeds peeler cores onto the roll conveyor of the cross-cut saw in such a way that there is always one peeler core positioned before the saw waiting to be cut. After a peelor core is cut, the one waiting comes to the cutting position immediately. Thus, this process is controlled by automatic interlocks or hand-controlled electric buttons. The production line from feeding peeler cores to cross-cutting consists of two chain feed conveyors, nos. 1 and 2, a belt conveyor, and a cross-cut saw.

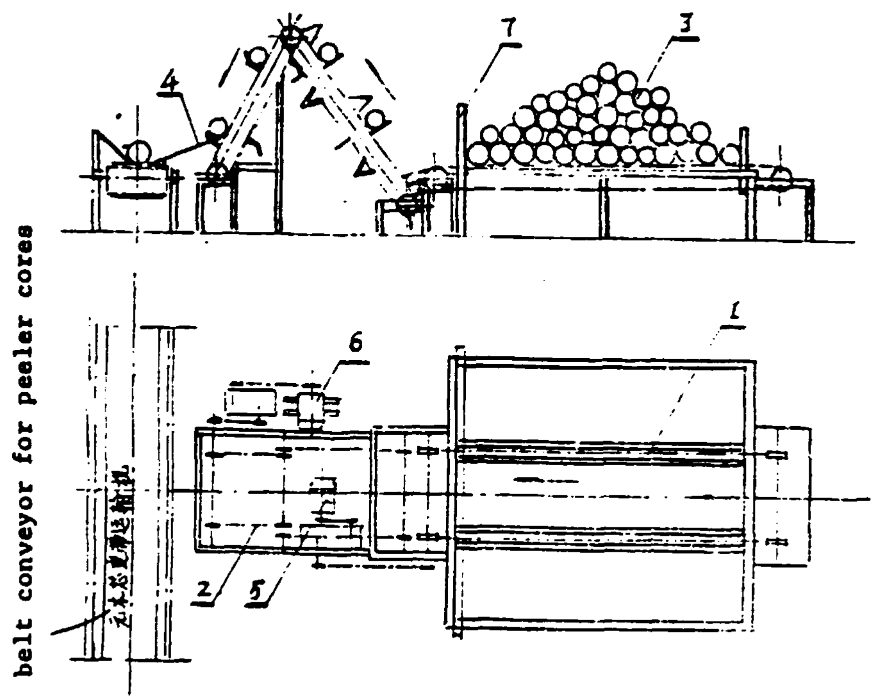


Fig. 2. Schematic drawing of a feed conveyor for peeler cores

Legend: 1: Horizontal chain deck; 2. inclined chain conveyor; 3. peeler cores; 4. slipway; 5. motor for the horizontal chains; 6. motor for the inclined chains; 7. backstop.

(1) Operating process of the cross-eut saw:

The automatic cross-cut saw unit consists of a motor for the saw blade, a motor for the roller-conveyor, a clamping device for peeler core, a motor for moving the saw, an air cylinder for pushing peeler cores and a store chute for peeler cores:

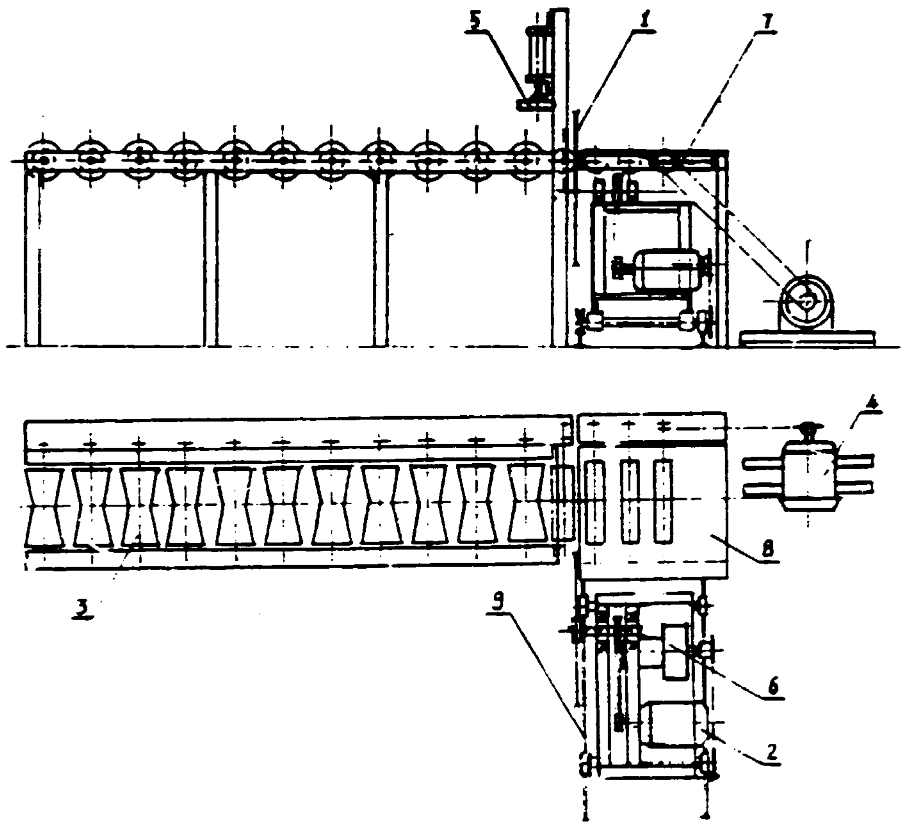


Fig. 3. The automatic cross-cut saw unit.

Legend: 1. circular saw blade; 2. motor for the saw blade; 3. roller conveyor 4. motor for the roller-conveyor; 5. clamping device; 6. motor for moving the saw blade: 7. wood turner: 8. unloading plate; 9. rail.

Peeler cores are fed onto the saw table by the roller-conveyor. After the peeler core enters into the cutting position, the air piston of the clamping device is extended downwards to clamp it. Then the saw frame moves forward to saw it. When the peeler core has been sawn, the saw frame returns to its original position and another air cylinder is actuated to push the sawn core section away. After this, the pushing device retracts, the clamping device is released, and the roller-conveyor restarts to begin the next working cycle. The core sections are pushed down to the store chute. The optimum for sawn core sections is 550 mm. The automatic saw can position a peeler core lengthwise to some extent for proper cutting.

Rotating speed of the saw blade, rpm	1440
Diameter of the saw blade, mm	800
Motor power, kw	5.5
Motor speed, rpm	1440

An inclined chain conveyor transfers the core sections to the inlet of the drum flaker on the second floor. Here, a switch control is also provided for feeding. The chain conveyor is inclined at an angle of 47° and has a chain speed of 0.39 m/s. It can handle core sections from 400 to 600 mm in length and up to 220 mm in diameter. The transfering chains are provided with lugs at intervals, which bring the core sections to the second floor in accordance with the output of the drum flaker.

(2) Drum flaker:

The drum flaker is used to reduce core sections into thin flakes. It consists of four parts: a feeder, a knife drum, a machine housing and a drive system.

The allowable sizes of core sections to be reduced by the drum flaker are up to 220 mm in diameter and up to 570 mm in length, but the optimum lengths are 520 to 550 mm. The core sections are fed crosswise to the knife drum by four sharp-toothed chains which clamp them from top and bottom. The chains are inclined at an angle of 75° to the horizontal. The speed of the chains can be regulated manually through a hydraulic motor by varying the flow from its oil pump. The size of the feed inlet is 245 x 590 mm.

Power of the feed motor, kw	3
Speed of the feed motor, rpm	1430
Flow of the axial plunger pump, ml/r	0 - 40
Pressure of the axial plunger pump, kg/cm^2	210
Speed of the oil motor, rpm	0 - 80

The knife drum has a diameter of 600 mm and a length of 601 mm. There are 12 knives distributed evenly on its periphery. The size of each knife is 576 x 60 x 6 mm. (length x width x thickness). The hardness of the knives is Rc62. The angle of the knife edges is 28 ± 1°, and the knife projection is 0.2 to 0.3 mm. Generally, knives are changed once every shift. The knife shape is like a comb. All knives are set on the drum in such a way that the knife edges are arranged in staggered rows. The width of knife edges is 25 mm, equivalent to the flake length.

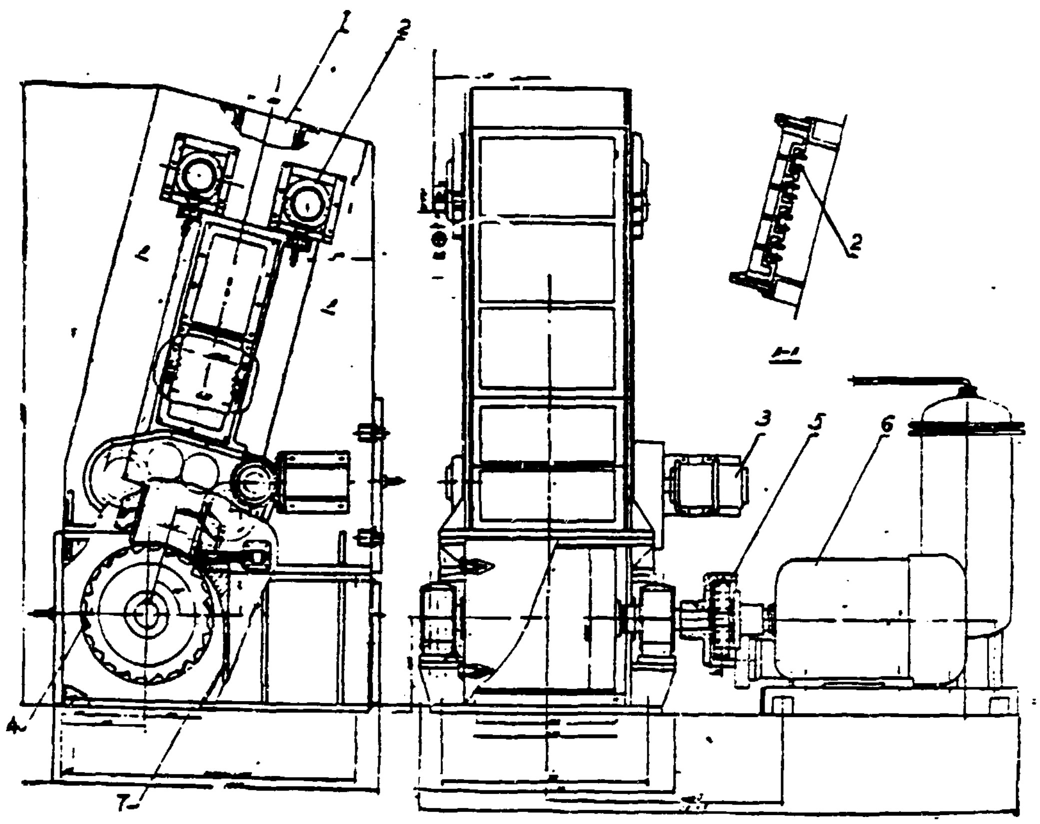


Fig. 4. The drum flaker

Legend: 1. feed inlet; 2. feed chains; 3. hydraulic motor; 4. knife drum; 5. coupling; 6. main motor; 7. outlet.

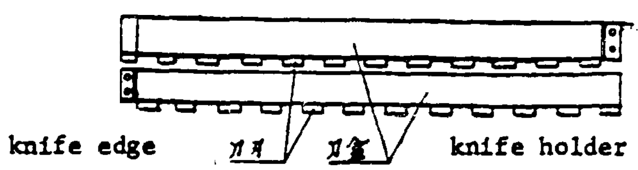
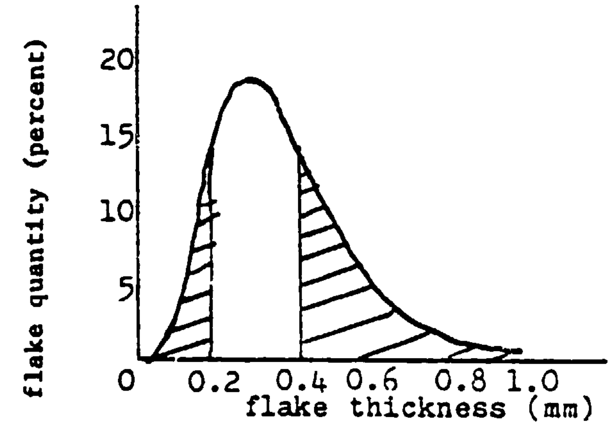


Fig. 5. Schematic drawing of the set positions of the knives.

The knife drum is driven directly by the main motor through a centrifugal coupling.

Power of the main motor, kw	75
Speed of the motor, rpm	980

Hourly output of the drum flaker is 600 to 800 kgs of bone-dried flakes. The flake quality meets the technological requirements (shown in the following figure):



Generally, the moisture content of wood is 30 to 50 percent.

(3) Ring refiner:

A ring refiner is used to refine the flakes produced for changing their geometry and decreasing their dimensions.

The ring refiner consists of an inner impeller and an outer ring, which are counter-rotating. The flakes pass through the center of the impeller and enter the grinding zone between the impeller and the ring. The clearance between the impeller and the ring and the size of the screen mesh vary in accordance with particle size. For three-layer boards, very fine particles are required for face layers. The amount of fine particles for two faces consists of 30 percent of the total.

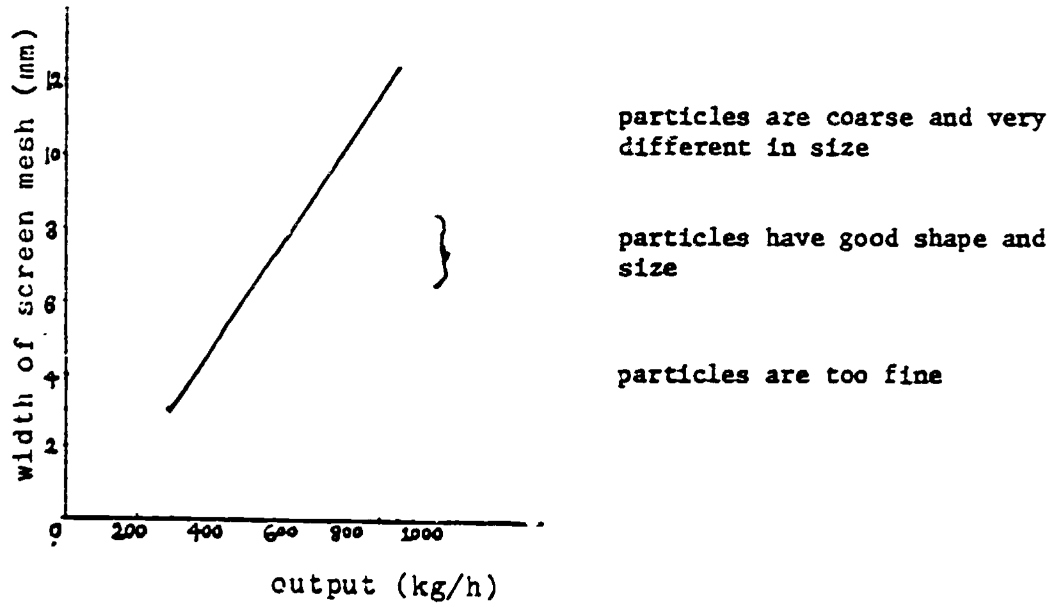
The ring refiner has a production capacity of 500 to 600 kg/hour.

Diameter of the impeller, mm	596
Speed of the impeller, rpm	1400
Motor power, kw	30
Inner diameter of the grinding path of the outer ring, mm	600

Rotating speed of the ring rpm	570
Motor power, kw	13
Working width of the grinding zone, mm (includes the 140 mm grinding path)	300
Size of the slit screen, mm	80 x 4 to 6

The production output of the ring refiner is balanced with that of the drum flaker. There are two ring refiners in the plant.

After refining, particles are discharged through a bottom outlet by the air flow created by the rotation of the ring, and then blown to the bin for wet particles through a pipe.



The relation between outputs of the ring refiner and widths of its screen meshes.

(4) Storage bin and transport of waste veneer:

The waste veneer produced from the plywood plant is cut into scraps about 20 to 40 mm in size. Then, the veneer scraps are transported into a material shed of the particle board plant by trailers and unloaded into an underground storage bin for use.

The effective storage volume of the bin is 52 m^3, corresponding to 11 tons or so of veneer scraps. Inside the bin, veneer scraps are carried by a bottom horizontal scraper conveyor to the outfeeding end, from there an inclined scraper conveyor elevates them up onto a belt conveyor. Then the belt conveyor feeds the veneer scraps through a fork-shaped hopper to two ring flakers.

(5) Ring flaker:

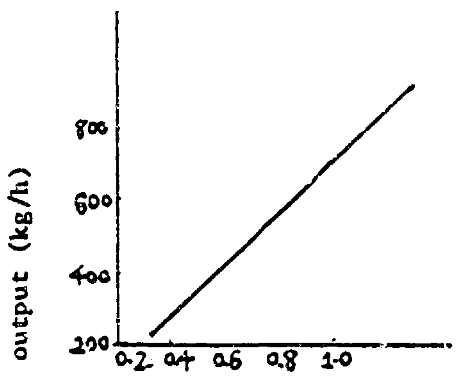
The ring flaker reduces the veneer scraps into particles in various shapes, which are mainly used for the core material of particle boards.

This type of flaker comprises a machine housing, an inner impeller and an outer knife ring. The impeller and knife ring are counter-rotating. The particles produced are discharged from a bottom outlet.

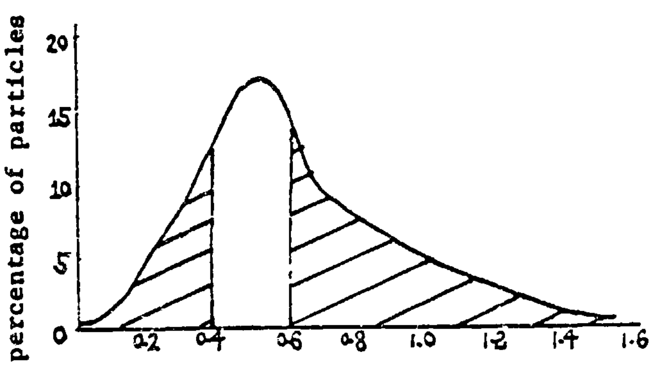
Diameter of the knife ring, mm	600
Number of the knives on the knife ring	26
Size of the knife, mm	
length	139
width	56
thickness	7
Grinding angle of knife edges	36°
Outer diameter of the impeller consisting of 6 blades, mm	597
Rotating speed of both the knife ring and the impeller, rpm	1200
Power of the knife ring motor, kw	22
Power of the impeller motor, kw	22

The materials to be reduced by the ring flakers consist mainly of veneer scraps and partly of wood chips from other chippers. The particles produced, in various shapes, are mainly used as core material. However, a certain amount of proper fine particles, obtained after drying and separating, can be used for faces.

The veneer scraps are 1.21 to 3.7 mm in thickness and 30 to 50 percent in moisture content. The particles are discharged from a bottom outlet of the machine. The production capacity of each ring flaker is 300 to 600 kg/hour. The thicknesses of particles produced are shown as one of the following figures:



projection of knife edges (mm)
(corresponding to particle thickness)



particle thickness (mm)

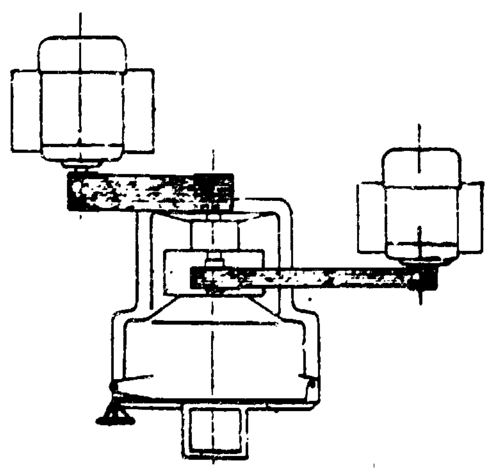


Fig. 6-1. Vertical view of ring flaker.

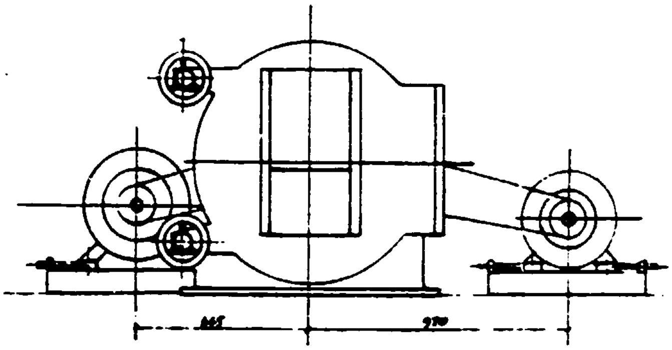


Fig. 6.2 Side view of ring flaker

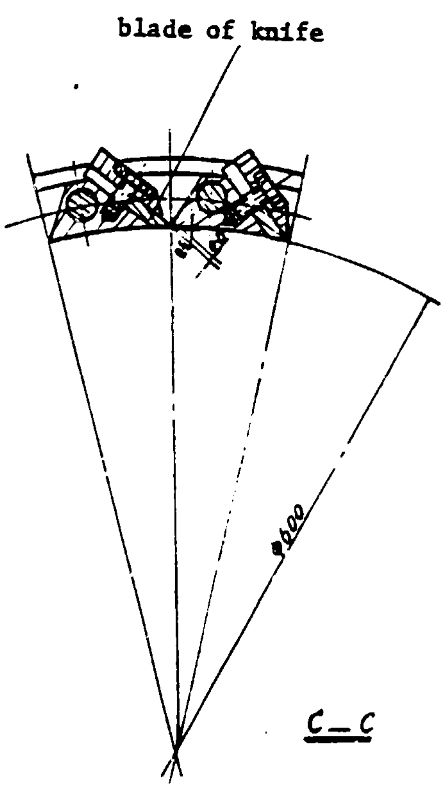


Fig. 6.3 Assembling angle of knife of ring flake

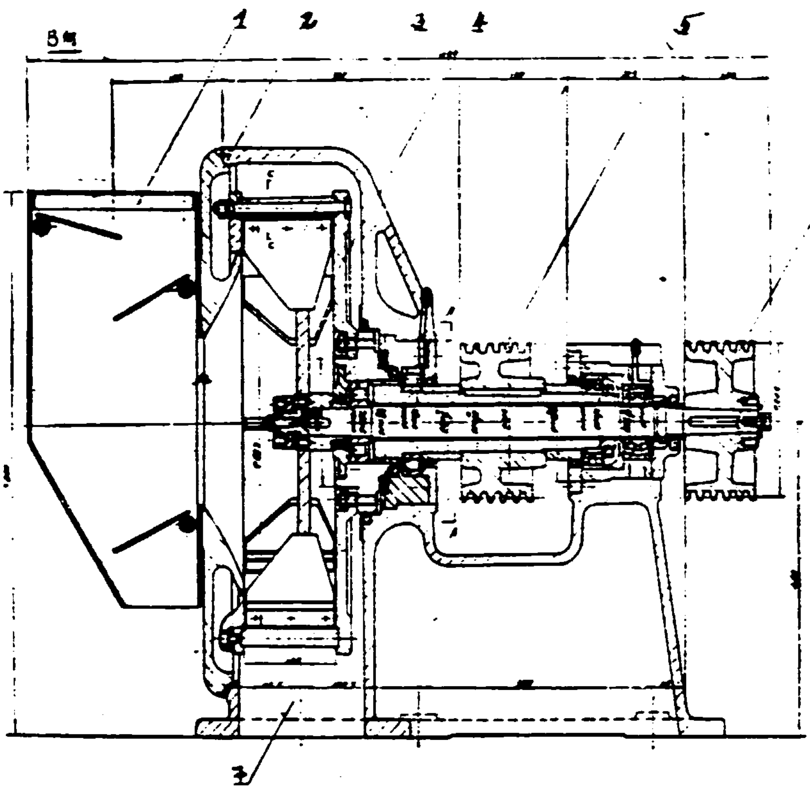


Fig. 6.4 Ring flaker

Legend: 1. inlet; 2. lid of path; 3. impeller; 4. knife ring; 5 and 6. V-pulley; 7. outlet.

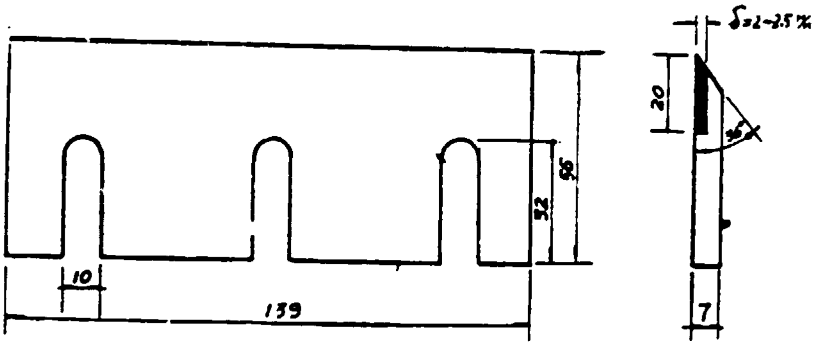


Fig. 6.5 Knife of ring flaker

(6) Machine shavings:

Machine shavings are planer shavings and small amounts of saw-dust produced in woodworking plants. Shavings are transported to a covered storage point near the particle board plant by a special trolley and from the storage point to the bin by an inclined conveyor. These shavings and particles produced on a ring flaker are conveyed simultaneously to the wet bin, and are mixed proportionally to be used as core material. The moisture content of machine shavings is 8 to 15 percent. Some 60 to 70 percent of this material is of coniferous origin.

B. Drying of particles:

The particle board plant is equipped with two rotary drum dryers, one is used for drying furnish produced by the drum flaker, another is used for drying furnish produced by the ring flaker and machine shavings.

The particles are heated indirectly by steam in tubes located inside the rotary drum. Wet particles enter the rotary drum through the inlet. The rotary drum has a slope of 1/100, so that particles tumble under the action of pushing plates fixed on the interior wall of the drum. The blower for drying is fixed at the end of the dryer. The blower moves the particles gradually from inlet to outlet and they are dried during their movement.

The rotation speed of the drum, the air speed and its temperature can be adjusted according to the moisture content of the wood to maintain the moisture of the particles discharged in the range of 3 to 5 percent. The capacity of the dryer is 1600 kg/hour. The dried particles are then conveyed to the next process.

Steam pressure	8 to 10 kg/cm^2
Steam consumption	1 to 1.5 t/hr.
Heat transmission area of steam tubes	200 m^2 (100 tubes Ø5cm)

Temperature inside rotary drum	140 to 160°C
Diameter of drum	2100 mm
Length of drum	8800 mm
Rotation speed of drum	2.4 to 12 rpm
Power of main motor	10 kw

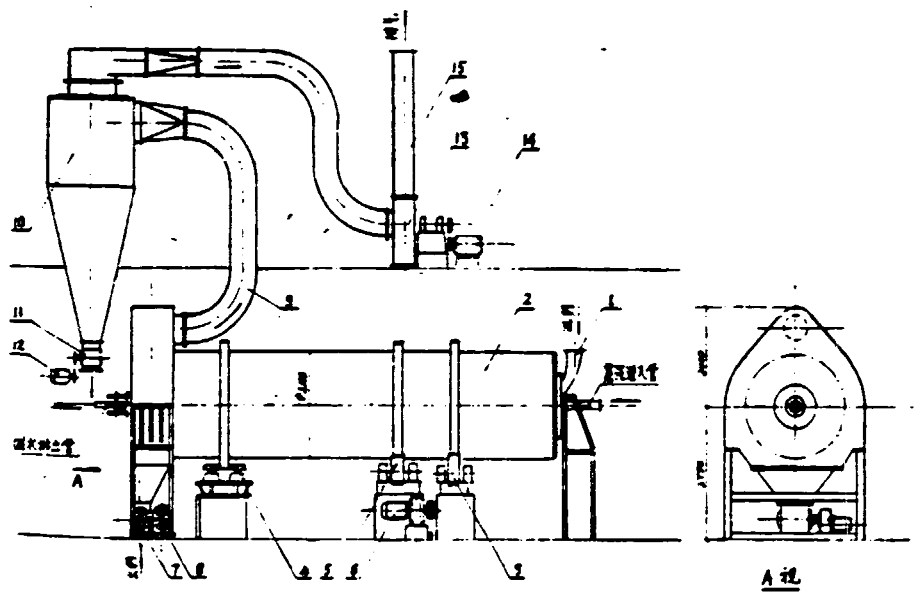


Fig. 7 Rotary drum dryer

Legend: 1. Charge hopper; 2. drying drum; 3. supporting roller; 4. cross guide roller; 5. gear; 6. main drive motor; 7. discharger; 8. motor for discharger; 9. air pipe; 10. cyclone; 11. rotary discharge valve; 12. motor for discharge valve; 13. blower for removal of moisture; 14. blower motor; 15. exhaust pipe.

C. <u>Classification of particles</u>:

Dried particles for the manufacture of three layer boards are screened by mechanical oscillation and then air sifted.

First particles are separated into coarse and fine furnishes. The coarse particles are used for core matetial, but the fine particles are sifted by air. The thicker particles are still used for the core layer and the thinner particles are used for the face layers.

Particles for the manufacture of board with graduated structures can be handled as a single entity until the mat forming station. During spreading, the blended particles are formed into a mat which has a gradual structure, from fine on both faces to coarse in the core.

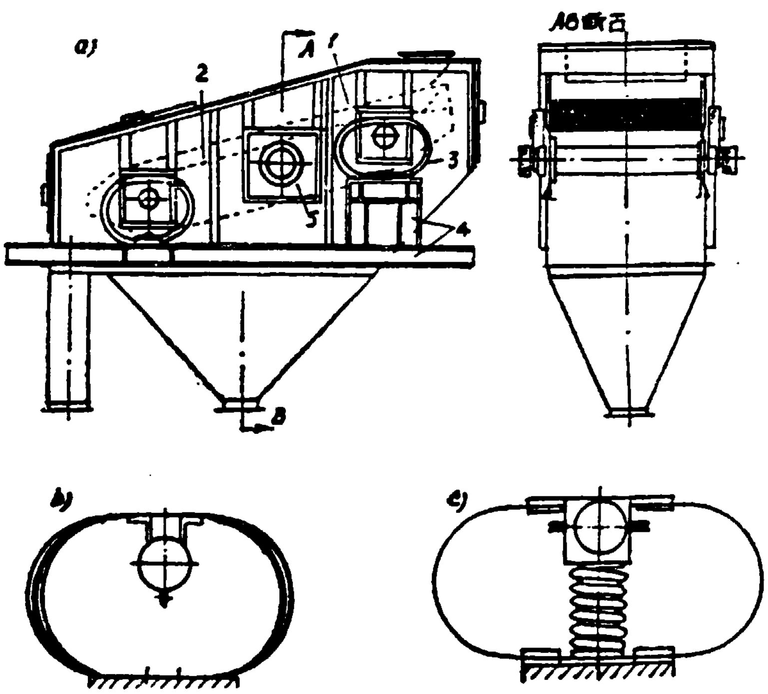


Fig. 8. Oscillating screen

a) oscillating screen; b. ring spring;

c) compound spring.

D. Particle bins:

There are various bins for different kinds of material:

(a) bin for wet particles from drum flaker;

(b) bin for wet particles from ring flaker;

(c) bin for machine shavings;

(d) bin for dry face particles;

(e) bin for dry core particles.

The structure of above mentioned bins is basically the same. They all have rectangular shapes, with a bottom chain conveyor and an inclined discharge conveyor.

Scrapers are fixed on the horizontal chain conveyor at regular distances. The conveyor moves along two rails and transports particles slowly from one end to the discharge end. The scraper conveyor, inclined at 70°, is located at discharge end of the bin. The transport speed is adjusted by a variable speed motor. The power of the motor is 5.5 kw. The speed of the conveyor is adjustable - it depends upon demand for the production.

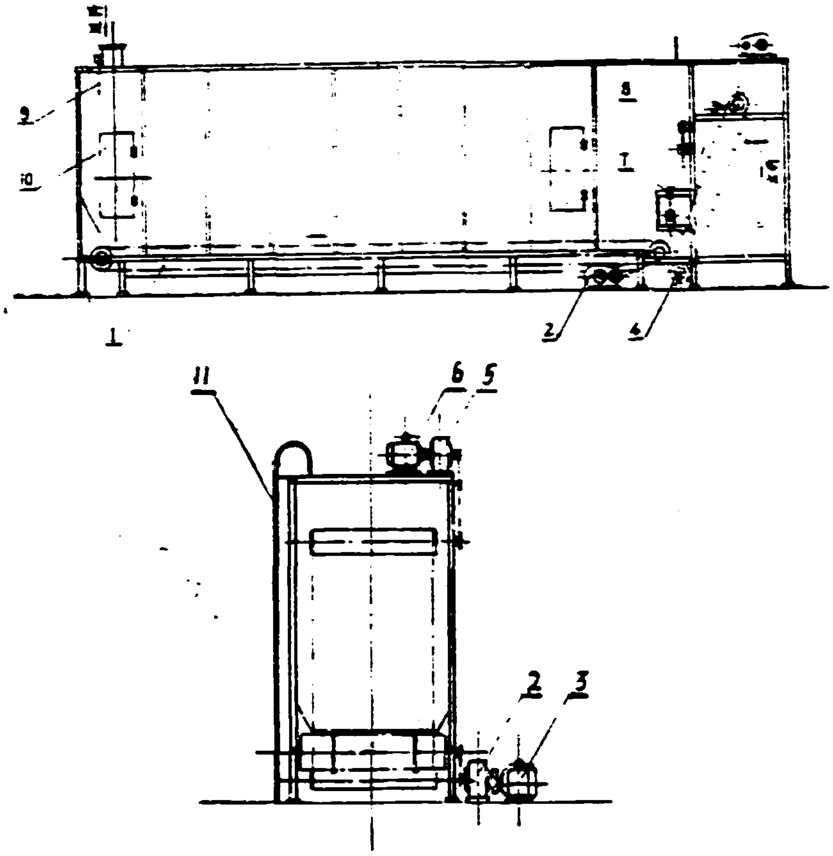


Fig. 9. Bin for particles.

Legend: 1. bottom horizontal conveyor; 2. gear box; 3. drive motor; 4. inclined discharge conveyor; 5. gear box; 6. motor; 7. switch regulating lower level of material; 8. switch regulating higher level of materials; 9. switch for maximum level of materials; 10 access hole; 11. ladder.

E. Blending:

The blending of the particles is a continuous operation. It consists of mixing and dosing the materials. Weighted particles are fed to the inlet of the blender while at the same time dosed quantities of adhesive, curing agent and water-proofing agent are sprayed continuously on the particles' surface through tubes and spraying nozzles. Particles are fed into the blender through its inlet at the top part of one end, while they are ejected from the outlet in the other end, after being blended and mixed. The ejection is done through a needle roller.

Weighing of particles: particles are transported to the auto-weighing hopper by a belt conveyor. This sets in motion the timing relay. As soon as required weights of particles has been attained, the belt conveyor stops moving. At this point the hopper opens automatically and the particles are fed into the blender.

System for supplying the adhesive: The adhesive used is urea-formaldehyde resin. A gear pump is used for supplying resin. An over-flow pipe is fixed at the outlet of the resin tank. Excessive resin flows back from overflow pipe to the resin tank by an adjusting valve so as to maintain resin in the dosing apparatus to be fed to the blender.

Water-proof agent: Solid and liquid wax are put in the melting tank to be melted into a compound liquid. This liquid is fed to the blender by the apparatus used for transporting resin.

Curing agent: Ammonium Chloride is sued as a curing agent. The ratio of the Ammonium Chloride to water for this formulating solution is 1 : 4. The storetank is located above the blender and the solution flows to the spraying nozzles by gravity.

The amount of the above mentioned resin, wax and Ammonium Chloride is proportional to the weight of the particles. The order in which these materials are blended is as follows: wax, resin and Ammonium Chloride. Six nozzles are used; they are arranged in the following sequence: 1,4,1.

The formulation of this blend is as follows:

(a) amount of solid resin used: 11 to 13 percent (on the basis of bone-dry particles);

(b) amount of wax used: 1 to 1.5 percent (on the basis of bone-dry particles);

(c) amount of solid Ammonium Chloride used: 0.4 to 0.6 percent of the weight of the liquid resin.

(After blending these liquids represent 11 to 14 percent of the weight of mixed materials).

Volume of blender	1.17 m^3
Speed of rotation of the discharge roller	352 rpm
motor power	0.6 kw
Speed of rotation of the major axis	70 rpm
motor power	9.5 kw
Pressure of compressed air used for spraying resin	3 to 4 kg/cm^2

The design of the blender is shown in figure 10 hereunder:

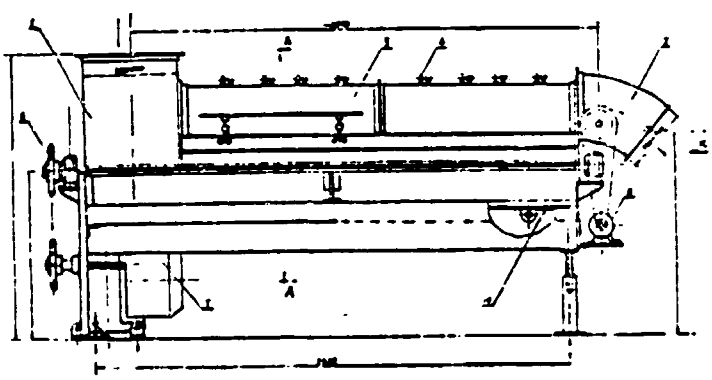


图 10—1

A—A

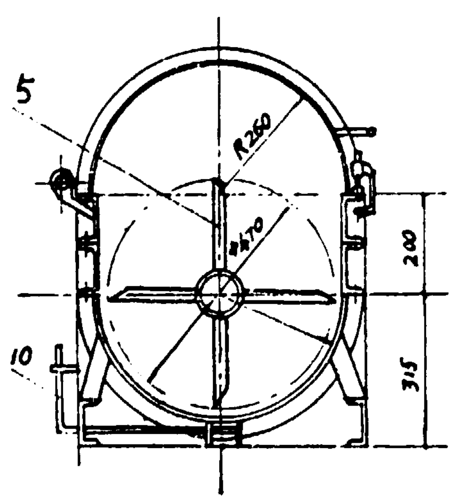


图 10—2

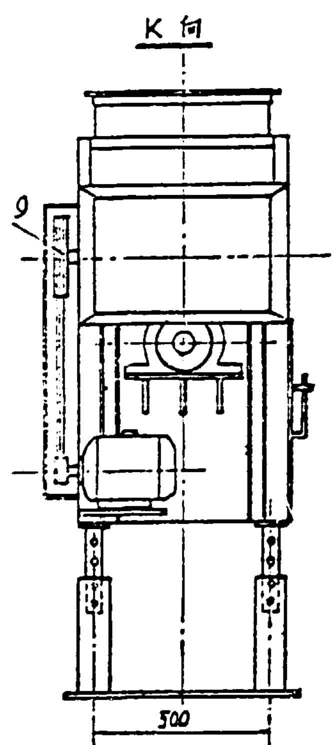


图 10—3

Fig. 10. Design of the blender

Legend: 1. inlet; 2. outlet; 3. top cover of blender; 4. spraying nozzle; 5. impeller of blender; 6. chain wheel of major axis; 7. motor for drive of major axis; 8. motor for drive of discharge roller; 9. V-belt of discharge roller; 10. handle of cleaning hole.

F. Mat forming equipment:

The former is suitable for spreading a three layer particle mat. Particle mat is composed of two face layers and two core layers by four forming heads. The characteristics of the former are as follows:

(a) The particle board produced has the obvious appearance of a graduated structuer and three layers, namely two face layers of fine material and a core layer of coarse material;

(b) The board has a better surface for decoration. The density of the mat is homogeneous and the mat's surface is flat and smooth.

(c) The physical-mechanical properties of each board result in its stability. Therefore each forming head is equipped with an auto-metering device and a volumetric control system.

The structure of the four forming heads is basically the same; the only difference between them is that there is a pair of additional rollers in the forming head for the face layer to smoothen any irregularities.

Blended particles are deposited in bin of the spreading head through an oscillating feeding device (62 cycles/minute), from which these particles are transported to the auto-metering device by a top conveyor belt. During their transport, the surplus particles are removed by a top scraper roller (comb-roll), in order to render the particle volume uniform.

Since the time for the transport of particles to the auto-metering hopper according to a given weight of particles is different, it is necessary to adjust outfeed speed of the conveyor belt so that the particle mats meet the requirements with respect to weight and volume.

The auto-metering device operates discontinuously, but particles are spread continuously. Therefore a buffer bin is located for the continuous transport of particles through the discharge roller to the outfeed conveyor belt, the surplus particles are removed by the scraper roller. Particles for spreading are discharged downwards by the outfeed brush roller. At last these particles are spread by the spreading roller onto the steel belt of the pre-press. Four forming heads operate at the same time so as to form mats with symmetrically arranged particles.

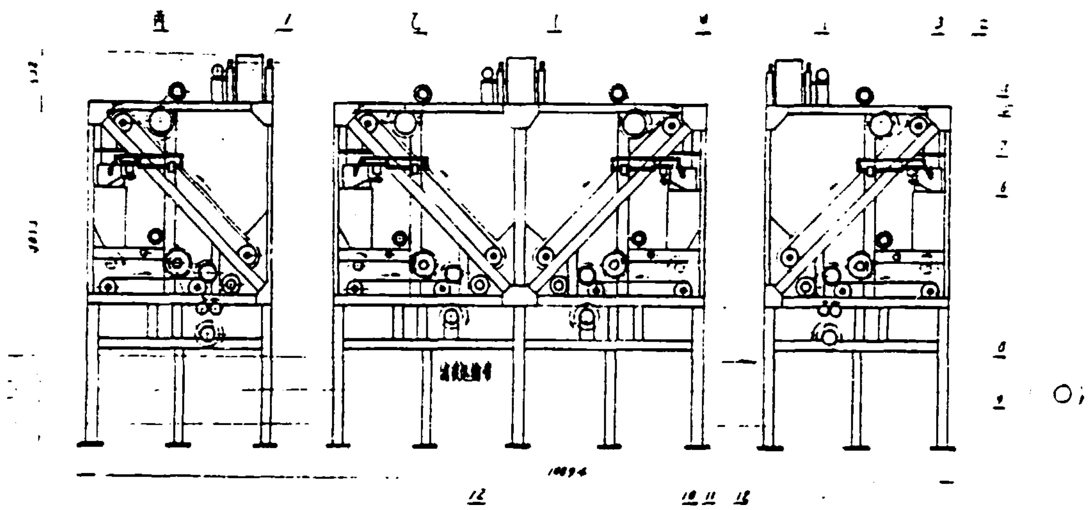


Fig. 11. Former for three-layer board.

(a) forming head of the upper face layer

(b) forming head of the core layer

(c) forming head of the lower face layer.

Legend: 1. Oscillating feeder; 2. infeed conveyor; 3. top scraper roller; 4. hopper for stopping feed of furnish; 5. auto-weigher; 6. discharge roller; 7. device for correcting the speed of discharge conveyor; 8. discharge conveyor; 9. bottom scraper roller; 10. out-feed brush roller; 11. roller for smoothing; 12. spreading roller.

Main technical data of former:

Spreading width of mat	1270 mm
Speed of infeed conveyor belt	1.27 m/min
Outside diameter of top scraper roller	340 mm
Speed of rotation	260 rpm
Speed of discharge conveyor belt	0.83 - 1.66 m/min
Outside diameter of bottom scraper roller	340 mm
Speed of rotation	260 rpm
Outside diameter of the discharge roller	266 mm
Speed of rotation	Varying with the discharge conveyor belt's speed.
Outside diameter of brush roller	235 mm
Speed of rotation	394 rpm
Outside diameter of spreading roller	300 mm
Speed of rotation	176 rpm
Metering with auto weigher	2 to 5 kg/weighing
Total rated power of former's motors	23,2 kw

G. <u>Pre-press</u>:

The front part of the bottom steel belt of the pre-press moves inside the frame of the former and this area is used for spreading the mat. The length of the steel belt has a close relation to the length of the former. The function of the pre-press is as follows:

(a) To increase strength of the loose mat after passing through the top and bottom pressure rollers for the convenience of the mat transport.

(b) to reduce the distance between the platens of the hot press;

(c) to relieve air in the mat in favour of hot pressing.

To manufacture 19 mm thick particle board, in general, the thickness of the loose mat is 70 to 80 mm. After pre-pressing its thickness is reduced to about 40 to 50 mm.

The structure of the pre-press is shown in Fig. 12 hereunder;

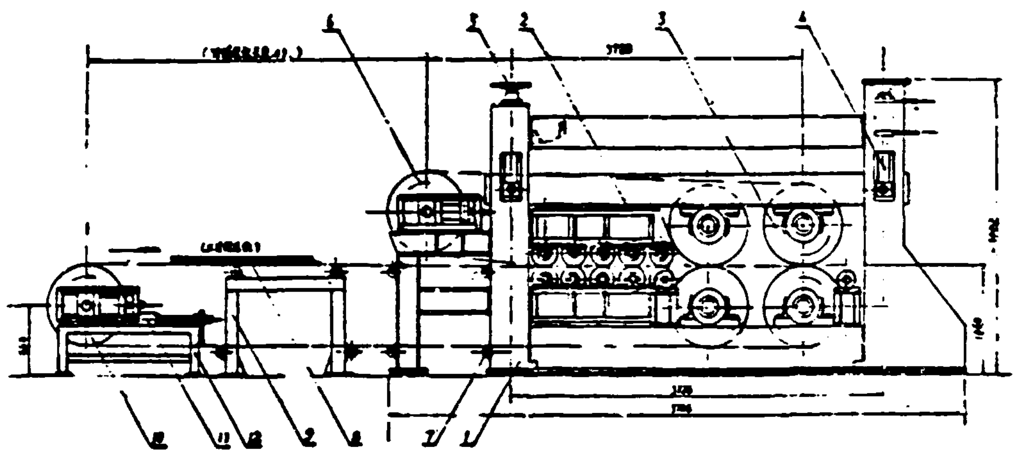


Fig. 12. Side view of pre-press.

Legend: 1. frame; 2. guide for the couch roller; 3. roller for pre-press; 4. hydraulic pressure cylinder; 5. wheel for adjusting distance between rollers by hand; 6. follower roller of the top steel belt; 7. supporting rollers of the steel belt; 8. steel belt; 9. intermediate frame; 10. follower roller of the bottom steel belt; 11. device for adjusting tension; 12. tail frame.

The pre-press consists of a frame, top and bottom steel belts, a transmission and a hydraulic system. The speeds of the top and bottom steel belts are equal. Both steel belts are driven by a stepless variable-speed motor through a decelerator and a gear train. The speeds of the steel belts are adjusted according to the thickness and the output of particle board.

Speed of steel belt	1.25 to 3.5 m/min
Linear pressure of the pre-press roller	about 190 kg/cm^2

The gap between top and bottom pressure rollers is 0 to 250 mm, and is adjusted by the hand wheel.

The hydraulic system consists of an oil pump, pipes and valves. Its main technical data is as follows;

Oil pressure	140 kg/cm^2
Diameter of oil cylinder (two)	160 mm
Power of oil pump motor	5.5 kw

H. Cross-cut saw, accelerating transport of mat:

After pre-pressing the continuous particle mat is transported. It is then sawn by a cross-cut saw according to a given pre-determined length in order to load the mat into the hot press.

The length of the mat is 2490 mm (giving, after trimming, a length of board of 2440 mm). Defective mats are rejected from this line broken down again into particles, and transported by blower to a collection bin for re-use.

Once sawn to the required length, the mat must be accelerated to a speed of 24 m/min., so that the mat lands on its caul, and then the caul with the mat is loaded onto the loader by a chain conveyor.

I. Hot pressing:

Hot pressing is one of the main processes' stages in the manufacture of particle board. It affects directly the quality and output of the particle board produced. The hot press has seven openings. The loader pushes seven mats into the hot press simultaneously.

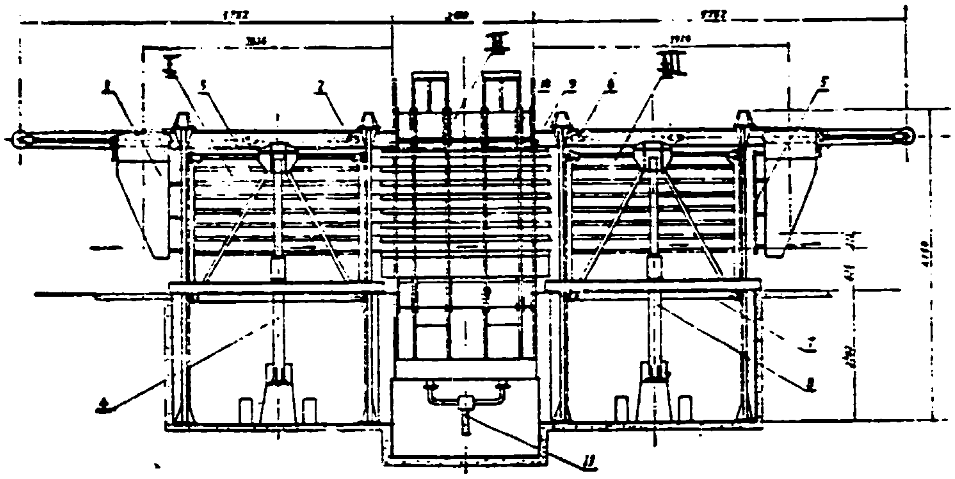


Fig. 13. Hot press with loader and unloader.

Legend: I. Loader; II. hot press; III. unloader; 1. pusher; 2. hydraulic cylinder for pushing mats in; 3. loader; 4. hydraulic cylinder for lifting; 5. discharger; 6. hydraulic cylinder for discharging boards; 7. unloader; 8. hydraulic cylinder for lifting; 9. hot platen; 10. frame of hot press; 11. hydraulic pressure pipe.

The hot platens are heated by saturated steam (9 to 10 kg/cm^2). After pressing, particle boards are extracted from the hot press simultaneously, by the unloader, the unloader then operates opening by opening and the boards with their cauls are transported one by one. The caul is separated from its board by the separator. Pressed boards are transported to the trimming saw by a roll-conveyor. Cauls are transported back for re-use in the next pressing cycle.

The technical data for manufacturing 19 mm thick board is as follows:

Pressing cycle	9 to 10 min.
Temperature of hot platens	175 to 180°C
Specific pressure	20 to 24 kg/cm^2

The pressing cycle consists of three steps of decreasing pressure.

Rate of application of the pressure:

Elapsed time from the moment when the platen starts rising to the moment it closes 5 to 10 sec.

Time from when the platen has closed to the end of the application of the pressure 21 to 22 sec.

Function of the hot press:

The function of the hot press is that the blended and pre-pressed mats are compressed in it. During this process the adhesive in the mat cures and, at the same time, particles are glued to each other. After pressing the board has the desired thickness and density.

Factors, such as species of wood, dimensions and shape of particles, pH value, moisture content, type of adhesive, density and thickness of board, affect hot pressing technology. Pressing cycles for hot pressing, namely pressure, temperature and time are selected according to different conditions. The cycles for hot pressing have important influences on the quality and output of the products manufactured.

During hot pressing the hot platens are closed as rapidly as possible, otherwise, the adhesive will cure before compression and the surface of the board appears rough and the quality of the board deteriorates.

Total pressure of hot press	1000 t.
Dimensions of the hot platens	2600 x 1480 x 70 mm
Diameter of the two pistons of hydraulic cylinders for lifting	100 mm
Diameter of the six pistons of the hydraulic cylinders for pressing	280 mm

The hydraulic system consists of two axial piston pumps and a complete set of valves and pipes.

Operation of the press:

Two hydraulic pumps lift rapidly the auxiliary cylinder until the hot platens are closed and oil from the hydraulic circuit enters the pressure cylinder through the back pressure valve under the vacuum. Most of the oil enters the main pressure cylinder through the main valve to further increase the pressure till the pressure reaches its top level.

J. Trimming saws:

Particle boards, once discharged from the hot press, are transported through a roller-conveyor to the trimming saw. After trimming (first along the longitudinal direction of the board and then along its transverse direction, the dimension of the particle board sheet is 2440 x 1220 mm.

K. Sander:

After trimming the sheets of particle boards must be stacked for a definite time (in general not less than 24 hours). They are then sanded. At present two types of sanders are used: three roller sanders and wide belt sanders.

III. Technical improvements:

Small-scale particle board plants suited to the conditions of developing countries have been operating in China for a long time. The particle board plant in our complex is one of the results of this development. But there are still some problems in our plant. In order to keep pace with the advances in world technology, the following problems should be solved in the near future:

1. Developing particle board with face layers having fine particles is a common trend in China. The production technology and equipment must be further improved to adapt to this change of board structure and guarantee the products' quality.

2. Improving the working accuracy and resistance to wear of the flaker to provide the required shape of particles.

3. Developing new mixers to improve the homogeneity of the blending and decrease glue consumption.

4. Studying developments in technology and forming equipment to reduce deviations of mat weight and density.

5. Increasing the efficiency of the hot press operation: mainly to shorten the pressing cycle, but also developing and using fast setting glues, using high temperature water and thermal oil as heat carriers to raise the temperature of platens, using high frequency electric heating or a combination of high frequency electric heating and steam heating to accelerate the curing of the mat.