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Particleboard Industry - Facts and References

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PARTICLEBOARD INDUSTRY--FACTS AND REFERENCES

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Introduction

This publication presents a general summary of facts and references about the fastest growing segment of the forest products industry in this country--particleboard manufacture. In spite of a great effort for completeness, the bibliography does not encompass all literature on this subject. Undoubtedly, many foreign language documents and articles not included here exist.

Definition

Wood particleboards are relatively dense material (density range of 26 to 50 lbs. per cu. ft.), usually in panel form, made from dry wood particles that have been coated with a binder, formed, and bonded to shape by pressure and heat.

Denser boards, those in the 51 to 75 pounds per cubic foot density range, are classified as hardboards, and those boards (density of 15 to 25 lbs. per cu. ft.) that are not as dense as particleboard are called insulation board.

History

1941 - The first recorded particleboard plant was opened in Bremen, Germany.

1943 - A French patent was granted for a three-layered board developed by Fahrni. This board had coarse particles in the core and thin flat particles on the outer surfaces.

1945 - Particleboard production was introduced to the United States.

1949 - The Bartrev horizontal continuous compression type process that produced board in a continuous sheet was developed in London, England.

1951 - Boards produced by the Kreibaum vertical extrusion system became available. This system was developed in West Germany.

Production Methods

In general, there are three primary particleboard manufacturing processes:

1. flat-pressed (also known as the multi-platen process);

2. the vertical extrusion process;

3. the horizontal extrusion process. These three production processes differ principally in the method of pressure application during fabrication.

The flat-pressed or multi-platen method is a batch-type of production utilizing press equipment similar in appearance, construction, and operation to a modern heated plywood press. To produce a board utilizing this system, resin coated chips are formed into mats and loaded into a press. The resin is cured under pressure (usually 175 psi and upwards) for 5 to 18 minutes at 250 to 400°F. At the completion of the press cycle, the board is removed from the press. Usually the flat-platen presses are large hydraulic presses with 1 to 20 openings. In this country, the platens are commonly heated with hot water. The 4 by 8 foot size of board comprises the
preponderance of this country's multi-platen board output. Boards 5 by 20 feet are now unusual but available. Thicknesses vary from 3/8 in. to 1 1/4 in.

The vertical extrusion process and the horizontal extrusion process are quite similar in principle. As a matter of fact, the vertical extrusion process evolved from the horizontal system. As the names imply, the main difference between these two manufacturing techniques is the plane in which the board is formed; in the horizontal extrusion process the board is formed in the horizontal plane, and in the vertical extrusion process the board is formed in the vertical plane. Advocates of the vertical method claim that this system is superior to the horizontal manufacturing process because fine particles reportedly do not accumulate on the lower surface of vertically extruded board. This accumulation is reportedly found on the lower surfaces of horizontally extruded board. For this reason, vertically extruded boards are claimed to be more homogenous and less subject to warping.

The extrusion process (both vertical and horizontal systems) can be generalized as follows: resin coated chips are fed continuously to the "breech" of the extrusion press and forced by a reciprocating ram between two paralles heated plates, 6-18 feet long. The chips are rammed at a constant rate of 20-80 inches per minute. The temperature of the platens is approximately 350°F. In this country, steam is most commonly used to heat extruded presses. The stroke of the ram may pulsate 30-120 times a minute. The width of extruder boards is limited by the orifice of the extruder, usually 50 inches. Extruder boards are manufactured in thickness that range from 3/8 inch to 1 7/8 inches. However, they are generally produced in greater thicknesses (3/4 in. to 1 1/4 in.) than are common for multi-platen boards. To achieve even greater thicknesses, heated tubes are centered between the plates to help cure the board from the inside out. They form longitudinal continuous tubular openings which take the cross-sectional shape of the heated tube. These thicker boards with tubular openings are referred to as tube-type or fluted boards. Since these boards are manufactured as continuous sheets, their length is governed only by practical limits. Both the horizontal and vertical extruded boards exhibit definite orientation of the particles (usually perpendicular to the direction of movement of the board through the extruder) and a grain direction.

The specified moisture content of particles prior to pressing varies somewhat from manufacturer to manufacturer; however, the reported range of moisture content is 5-10%.

Urea-formaldehyde resin is the most widely used particleboard binder, although an increasing amount of phenol-formaldehyde resin is being used in those boards destined for products that will be used under high moisture conditions.

A general diagram of particleboard production that is applicable to the three common methods of fabrication is shown in Figure 1.

![Diagram of particleboard production](image)

Figure 1. A general diagram of particleboard production that is applicable to the three common methods of fabrication.
Particleboards are commonly classified today by the method of production and composition, i.e. the form and distribution of wood particles used in producing the resultant board. Figure 2 is an example of such a classification technique.

General Board Properties

Particleboard, like any other material that does a job, can be subjected to only four general force systems: push, pull, bend, twist. A material's resistance to rupture when subjected to one or a combination of these four force systems is broadly defined as that material's strength. Presently, to determine uses for particleboard we need to know, in addition to its strength, the board's hardness (mar and dent resistance), dimensional stability properties, and its screw or nail

Figure 2. A classification technique for particleboard based on method of production and composition, i.e. the form and distribution of wood particles. All are of the flat press process except three designated on extruded.
Table 1. Properties of flat-platen and extruded particleboards and yellow poplar compared to the appropriate properties of ponderosa pine. The properties of ponderosa pine are assigned the value of 100.

<table>
<thead>
<tr>
<th>Property</th>
<th>Ponderosa Pine</th>
<th>Yellow Poplar</th>
<th>Flat-Platen Board</th>
<th>Extruded Board</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bending Strength</td>
<td>100</td>
<td>110</td>
<td>16-87</td>
<td>19</td>
</tr>
<tr>
<td>Stiffness</td>
<td>100</td>
<td>125</td>
<td>12-56</td>
<td>Less than 12</td>
</tr>
<tr>
<td>Hardness</td>
<td>100</td>
<td>122</td>
<td>218</td>
<td>About 218</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>100</td>
<td>107</td>
<td>27-54</td>
<td>28</td>
</tr>
<tr>
<td>Tension Perpendicular to Surface</td>
<td>100</td>
<td>135</td>
<td>17-35</td>
<td>Higher than Flat-Platen</td>
</tr>
<tr>
<td>Screw Withdrawal</td>
<td>100</td>
<td>103</td>
<td>43-51</td>
<td>97</td>
</tr>
<tr>
<td>Thickness Dimensional Instability</td>
<td>100</td>
<td>105</td>
<td>1110-4160</td>
<td>Much less than Flat-Platen</td>
</tr>
<tr>
<td>Linear Dimensional Instability</td>
<td>100</td>
<td>114</td>
<td>7-21</td>
<td>1000-4000</td>
</tr>
</tbody>
</table>

withdrawal resistance. For new uses it may be necessary to ascertain other characteristics of the board, e.g. thermal and electrical conductivity. Table 1 compares these essential properties for flat-platen and extruded particleboards and yellow poplar lumber to ponderosa pine lumber whose properties have been assigned a value of 100. The result of this general comparison is a table of relative values.

By adding cross-banding and back and face veneers, the bending strength of particleboard is approximately tripled and the stiffness almost doubled. Veneering also improves the screw withdrawal resistance of most particleboards. Extruded boards are almost universally cross-banded with straight-grain veneers.

Uses

Both flat-platen and extruded boards are utilized as furniture corestock, display fixtures, kitchen cabinet cores, flush door cores, acoustical panels, decorative paneling and counter tops. Flat-platen boards are being manufactured into wall and roof sheathing, underlayment and finished flooring. One of its most recent uses is as Federal Housing Authority approved house siding.

Particleboards that have been treated with fire retardant chemicals and preservatives are now available.

Production Requirements

As it would be expected, the cost of a particleboard plant varies according
to desired capacity, type of manufacturing process employed, end use of the manufactured board, etc. Available information indicates complete plant cost varies from $1/2 million to $6 million. Cost of an extrusion system per unit of capacity may be less than for a multi-platen system.

Raw wood requirements also are essentially affected by these same variables. Approximately 3 tons of green wood are necessary to produce one ton of finished board. Both flat-platen and extrusion plants are reportedly using hardwoods and softwoods; in most cases only one species is used in fabrication. Hardwoods being used are: aspen, gum, walnut, oak, birch, hard and soft maple, and yellow poplar. Most native softwood species lend themselves to satisfactory board fabrication. The source of raw wood material is one or a combination of the following: green roundwood, green mill waste, and dry mill waste. The optimum moisture content range for chips is 5-8% prior to the addition of the binder.

One reference states that a flat-platen board plant had a variable cost 20% higher per unit of production than an extrusion plant. These figures should also be viewed in the light that the flat-platen plant had two and one half times the capacity of the extrusion plant. Plants utilizing both manufacturing processes are normally highly automated. One designer of flat-platen particleboard manufacturing systems estimates a labor requirement (exclusive of supervisory and administrative personnel) of 0.5 man day/M sq. ft. of production.

Trends

Review of the literature on particleboard yields some distinct production trends—first the European and then the American trends:

European trends:

1. In 1956, 60% of all core stock used in West Germany was particleboard. It was predicted at that time that for all practical purposes, use of solid lumber cores in West Germany would disappear by 1961.

2. At the end of 1961, in the more than 200 European particleboard plants, 90% produce flat-platen particleboard of the three layer type (flakes in center layer, fines on the surfaces).

American trends:

1. Flat-platen manufacturing accounts for about 86% of all particleboard production.

2. It is generally thought that the flat-platen particleboards will find their greatest use, and hence be manufactured in thicknesses greater than 3/8 in.

3. Extruded boards are manufactured almost exclusively in thicknesses of 3/4 in. or more. It is reported that fluted boards as thick as 4 in. are economical.

4. There is a definite swing to the manufacture of particleboard from engineered particles like flakes or wafers.

5. Use of fine particles on surfaces of boards to reduce telegraphing through face veneers is becoming increasingly common practice.

6. One of the most important trends is the manufacture of particleboard for a particular use.

7. The last important trend is the use of particleboard in the construction market. It is interesting to note that in England particleboard was first introduced
Table 2. A comparison of three flat-platen boards of the same specific gravity but made from particles of different geometry.

<table>
<thead>
<tr>
<th>Property</th>
<th>Splinter</th>
<th>Planner Shavings</th>
<th>Flake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>.64</td>
<td>.64</td>
<td>.64</td>
</tr>
<tr>
<td>Bending Strength (psi)</td>
<td>2000</td>
<td>2200</td>
<td>3500</td>
</tr>
<tr>
<td>Stiffness (psi)</td>
<td>175,000</td>
<td>350,000</td>
<td>500,000</td>
</tr>
<tr>
<td>Tension Perpendicular to Surface (psi)</td>
<td>140</td>
<td>80</td>
<td>70</td>
</tr>
<tr>
<td>Hardness (Lbs.)</td>
<td>1200</td>
<td>1200</td>
<td>1200</td>
</tr>
<tr>
<td>Screw Withdrawal (Lbs.)</td>
<td>250</td>
<td>250</td>
<td>300</td>
</tr>
</tbody>
</table>

as a general building board material, and later, it became a specially developed material for use in furniture fabrication. Recently, particleboard panels were used as structural sheets in the construction of a Norwegian Tourist Center.

Variables and Research Findings

The properties of particleboard are affected by variables related to the raw materials, production system, and post-manufacturing treatment. Obviously then, the list of variables affecting the properties of particleboard is quite lengthy. A partial list of these variables is: resin content, particle moisture content, particle geometry, board density, wax content, pressure application system, and wax and resin application, press cycle, etc. In other words, all of the inherent variables associated with any gluing operation plus a number of unique problems. Many research findings are confusing because reports on essentially the same subject conflict. Furthermore, there is essentially, a complete absence of basic research information pertaining to extruded boards. This, undoubtedly, is partially due to the unavailability of laboratory size extruders - consequently research dealing with the extrusion process is probably more expensive.

One point on which most researchers seem to agree is that boards made from engineered flakes are the strongest in bending and linearly are the most stable. However, flakeboards are weaker in tension perpendicular to the surface than the splinter or sliver boards. Table 2 compares three boards of the same specific gravity by each made from particles of different geometry.

In order for the particleboard industry to expand and fully realize its market potential, more basic scientific knowledge is needed to predict the performance of a particleboard before it is produced. An alternative "cut and try" program is wasteful and an impediment to rapid progress in developing boards in terms of their requirements.

Growth and State of Industry

In Europe, the number of plants has increased from 1 to over 200 during the period from 1941 to 1960.
In the U.S., since its start in 1947, the particleboard industry has expanded, and by 1960 there were about 67 producing plants.

Production-wise, in 1955 the U.S. produced 90 million square feet (3/4 in. thickness basis). During this same year, West Germany alone produced about 75 million square feet. In 1959, the U.S. produced a record 298 million square feet but there was an accompanying increase in the country's overall production capacity of particleboard from 500 million square feet in 1959 to 560 million square feet in 1960. Particleboard production for 1962 has been estimated to reach 350 million square feet (3/4 in. thickness basis). One large particleboard manufacturer has further predicted that particleboard production will exceed 800 million square feet with product value of more than $100 million by 1970.

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+ Includes English summary


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