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TB67: Pilot Study of the Use of Pulpwood Chipping Residue for Producing Particleboard in Maine

Craig E. Shuler

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Craig E. Shuler[1]

Continuing pressures on our forest resources have emphasized the need for more efficient and complete utilization of these resources. One area of the forest products industry which has been particularly effective in this regard is the manufacture of particleboard. Since its establishment in this country shortly after World War II, the particleboard industry has been well known for its widespread utilization of end trim, edgings, veneer waste, and other residue as a primary source for its raw material.

There have also been extensive efforts to utilize other fibrous residues (wood bark, corn husks, straw, sunflower seed hulls, etc.) in the manufacture of a suitable building panel (2). These attempts can best be summarized by stating that with the adhesives presently available, a panel-type product can be produced from practically anything; however, the quality of the panel may severely limit its end utilization. Therefore, investigations such as the one reported here are concerned more with product quality than with factors of production.

BACKGROUND OF STUDY

The study was conducted at the School of Forest Resources, University of Maine at Orono, as part of an extended project on the use of northeastern species for particleboard. This particular investigation served as a means to establish a laboratory board production system, as well as to gather useful information regarding a specific wood resource of the state of Maine.

At the present time there is no particleboard industry in Maine.[2] This is due, in part, to the conversion of wood residues to pulp chips for the long-established pulp and paper industry. It should be noted, however, that even where pulp chips are produced from wood residues,

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[1] Assistant Professor, Wood Technology, School of Forest Resources, University of Maine.

[2] Since this project was initiated, at least two sawmills in the state have initiated plans to supply residue material to out-of-state particleboard plants.

there is still residue remaining from the chipping operation. Chipping residue is that material remaining after debarked logs or scrap wood have been converted to chips of a size suitable for pulping operations. This residue is commonly referred to as "sawdust" although it has not been produced through sawing. It consists primarily of fairly large slivers, small cube-like particles, small slivers, dust-like particles, and some residual bark. Thus, a utilization or disposal problem remains although it is reduced considerably.

An extensive particleboard feasibility study for the state of Maine was conducted in 1961 (7). The conclusion of that study was a favorable recommendation for a particleboard plant to be built. This, of course, would have to be re-evaluated in light of the current economic situation. A recent projected plan includes a particleboard plant as part of an integrated wood processing complex (10). As far as is known, however, no firm steps have been taken as yet to implement this plan.

QUALITY FACTORS IN PARTICLEBOARD

The quality of particleboard is found to be most obviously affected by its basic ingredients, i.e., the solid material and the adhesive binder. Urea-formaldehyde adhesive formulations are the most commonly used, but panels made with this binder are intended for interior use only because of the limited water resistance of the adhesive. For added water resistance, phenol-formaldehyde formulations are employed which permit exterior use and also provide increased strength. With either resin type, the adherend remains an important variable. In the case of wood as the solid, quality is affected by such factors as chip geometry, species or species mix, moisture content, acidity and extractives (6, 8, 12, 14). Less obvious factors are found in the production process. Some of these variables are: platen pressure, press time, press temperature, press closure time, adhesive spray time and spray atomization (5, 13).

Platen pressure and press time and temperature are effectively determined by the desired board density and adhesive specifications. The other process variables will be limited by the mechanics of the particular system. Adhesive formulation will also depend somewhat on the characteristics of the species involved (acidity, extractives, etc.) Once these factors have been determined, the in-process flexibility is limited to resin quantity and chip geometry.

Particleboard is produced primarily from the softwood species and the lower density hardwoods. This is partly the result of the quantity of residue from the softwood lumber and plywood industries; however, the lower density of these species is also a factor, as the increased compressibility of the mat assures better bonding of the particles.

The following definitions of particle shapes are taken from the standards developed by the American Society for Testing and Materials (4):

chips—small pieces of wood chopped off a block by ax-like cuts as in a chipper of the paper industry, or produced by mechanical hogs, hammermills, etc.

flake—a small wood particle of predetermined dimensions specifically produced . as to produce a particle of uniform thickness, essentially in the plane of the flakes, in over-all character resembling a small piece of veneer.

particle—the aggregate component of a particleboard manufactured by mechanical means from wood or other lignocellulosic material (comparable to the aggregate in concrete) including all small subdivisions of wood such as chips, curls, flakes, sawdust, shavings, slivers, strands, wood flour, and wood wool

shaving—a small wood particle of indefinite dimensions developed incidental to certain woodworking operations involving rotary cutterheads usually turning in the direction of the grain; and because of this cutting action, producing a thin chip of varying thickness, usually feathered along at least one edge and thick at another and usually curled.

slivers—particles of nearly square or rectangular cross-section with a length parallel to the grain of the wood of at least four times the thickness.

Presently, most particleboard is produced primarily from chips, shavings, and slivers, as these particles are readily formed from residues and roundwood by disc chippers, mechanical hogs, or hammermills. It has been fairly well established, however, that thin long flakes produce the strongest panels (12). Unfortunately, the technology is not yet available to economically produce engineered flakes of consistent thickness and length other than from roundwood.

EXPERIMENTAL PROCEDURE

The chipping residue utilized contained both softwoods and hardwoods. The softwood portion was primarily eastern spruce (Picea spp.), and maple (Acer spp.) and birch (Betula spp.) comprised most of the hardwoods. Owing to the area from which the pulpwood was harvested it is probable that other softwoods and hardwoods were present in very limited amounts, but these species were not specifically identified.

This material was dried in a revolving drum dryer placed in a small experimental dry kiln heated to 150°F. After drying, the material was separated in a vibrating screen shaker. All material which passed through an 8 x 14-mesh standard window screen was discarded while all material remaining on the screen was utilized in the project with the exception of extremely large chips that were arbitrarily removed. Two series of random samples of particles were taken to 1) estimate the moisture content and 2) to determine the respective softwood-hardwood contents. The remaining particles were stored in sealed plastic bags.

The liquid urea-formaldehyde resin used was especially formulated for particleboard production. The adhesive was applied to the chips by spraying in a revolving drum. It was necessary to decrease the viscosity of the liquid resin slightly to facilitate the spraying operation. Except for the first few boards made, this was done by adding 10 percent by weight of water to the desired amount of resin for each board.

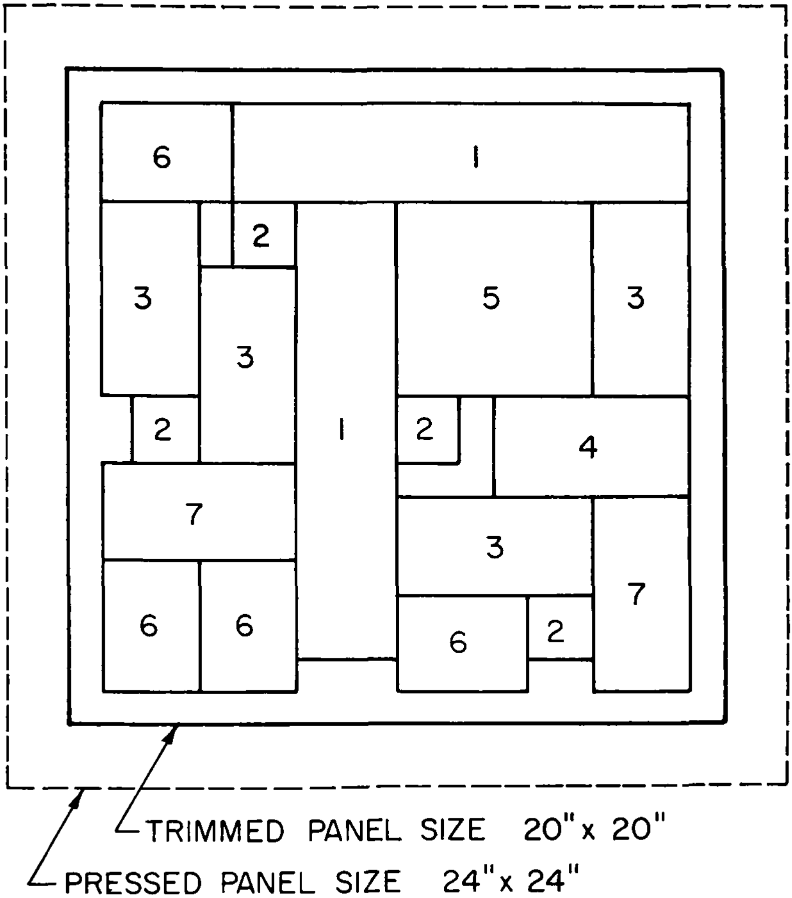
After adhesive application, a mat was formed by placing the chips on a 24 x 24 inch aluminum caul in a forming box. The mat was pre-pressed by hand, and then the box was removed. Another caul was placed on top of the mat, and the mat was placed in the press. The press was a 90-ton hydraulic press with electrically heated platens, capable of producing a maximum pressure over the 24 x 24 inch mat of 312 psi. Press temperature was 325°F., and the press time was 7 minutes including closure time of 1.5 minutes. Metal stops one-half inch thick were used to govern board thickness. The press opened automatically at the end of the press time.

Eighteen sample boards were made. The moisture content of the chips ranged from 8 percent to 13 percent, with the average being 9.4 percent. Chip moisture content was not considered one of the variables in this project. It was felt that the moisture content effects would be hidden by the resin content and board density effects. Resin solids contents were 2, 3, 5, 6, 8, 10, and 12 percent on the basis of ovendry weight of chips. The boards were designed to be nominally 0.5 inch thick at densities of 40 and 50 pounds per cubic foot. After the pressed boards had cooled, the edges were trimmed so that the experimental panels were 20 x 20 inches. They were then cut into test specimens, and these samples placed in a conditioning room at 72°F. and 68 percent relative humidity for at least four weeks before testing.

The physical properties evaluated were static bending, internal bond, hardness, screw withdrawal (face and edge), thickness swell and linear variation with changes in moisture content. Testing procedure followed standard D 1037-66 as published by the American Society for Testing and Materials (3). The cutting pattern for sample procurement is shown in Figure 1.

It was recognized that even if satisfactory boards could be produced, any practical application of these data would be dependent upon an adequate supply of chipping residue. Thus, an effort was made to estimate the potential quantity of this material. This was done by contacting several paper mills and sawmills in the state equipped with chippers. These plants were queried as to their estimated production volume of chipping residue and present disposal of this residue.

Figure 1. Location of physical test specimens in experimental particleboard panels.



Sample number	Test
1	Static bending
2	Internal bond
3	Hardness & surface screw withdrawal
4	Linear expansion
5	Thickness swell
6	Edge screw withdrawal
7	(Not utilized in this project)

RESULTS AND DISCUSSION

The boards produced were of the homogenous type in that particles were randomly distributed throughout the cross-section without regard to size. Figure 2 shows typical surface and edge appearance. The boards were not sanded; hence, the thickness exhibited considerable variation among boards. This was the result of differences in amount of springback, possible mislocation of the stops on the press and the need for more pressure for the 50 pounds per cubic foot boards. Table 1, which summarizes all the properties evaluated for the boards, also indicates the planned and actual densities, resin content and particle moisture content.

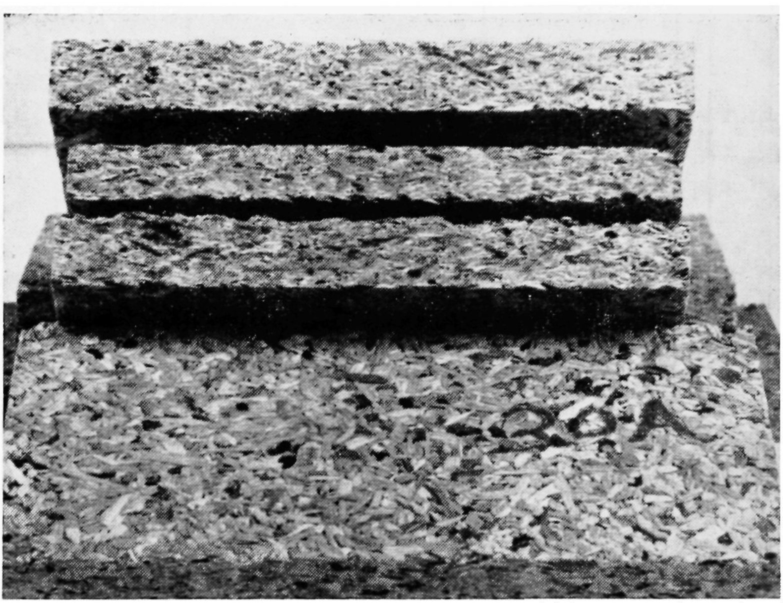


Figure 2. Typical edge and surface appearance of particleboard panels produced from wood chipping residue.

The scope of the project as planned limits the extent of conclusions formed to general statements indicating some apparent trends. No effort was made to determine specific production factors, but rather to explore general limits within which a satisfactory board can be made with this particular residue material. The specific factors are, of course, dependent upon the individual commercial process employed in manufacturing. In the following discussion, board performance is judged, when appropriate, by comparison with the property requirements as found in the Commercial Standard CS 236-66 for Mat-Formed Wood Particleboard (11).

Table 1

Physical Data and Strength Test Results of Particleboard Produced from Chipping Residue

Board	Actual Thickness (in.)	Density (#/ft.^{3}) Programmed	Actual[2]	Resin Solids[1] (%)	Moisture Content Particles (%)	Panel at Test[2] (%)	Static Bending MOE[2] (psi x10^5)	MOR (psi x10^3)	σpl (psi x10^3)
1	0.569	40	36.9	2	8.0	8.0	1.120	0.758	0.296
2	0.674	50	41.0	2	8.0	7.3	1.481	0.846	0.363
3	0.530	40	40.2	3	8.0	6.3	1.750	1.060	0.480
4	0.594	50	40.2	3	8.0	6.8	1.726	1.284	0.544
5	0.659	50	46.0	3	10.5	9.7	2.420	1.433	0.697
6	0.521	40	45.0	5	10.5	8.8	2.524	1.746	0.646
7	0.522	40	34.4	5	8.0	7.0	2.438	1.606	0.714
8	0.598	50	43.3	5	8.0	7.7	2.484	1.876	0.866
9	0.660	50	41.8	5	9.0	9.3	2.492	1.626	0.830
10	0.562	50	53.6	5	13.0	8.4	3.834	2.222	0.944
11	0.516	40	43.0	6	10.5	8.8	2.376	1.524	0.587
12	0.494	40	40.8	8	10.0	8.5	2.091	1.332	0.666
13	0.517	40	44.2	8	9.0	8.7	2.639	1.514	0.710
14	0.570	50	44.0	8	10.0	8.8	3.098	2.148	1.159
15	0.564	40	41.8	10	10.0	8.6	2.775	1.842	1.059
16	0.520	40	45.4	10	10.0	8.6	3.326	2.190	1.263
17	0.544	40	37.8	12	10.0	8.9	1.650	1.409	0.608
18	0.546	40	42.0	12	9.0	8.6	2.850	1.814	0.891

Continued

Table 1

Physical Data and Strength Test Results of Particleboard Produced from Chipping Residue (Continued)

Board	Internal Bond[3] (psi)	Hardness[3] (#)	Screw Holding[2] Face (#)	Screw Holding[2] Edge (#)	Thickness Swell[3] After 2 hr.	Thickness Swell[3] After 24 hr.	Linear Expansion[4] (%)
1	68.3	768	178	133	63.8	80.0	1.29
2	51.8	692	144.5	124.5	70.4	88.6	0.99
3	75.8	834	182	104	52.4	69.8	1.09
4	102.2	965	236	250	46.2	58.4	0.81
5	70.6	794	186.5	208	35.8	54.8	0.93
6	146.5*(3)	1157	276	223*(1)	30.5	48.2	0.75
7	153.4*(2)	929	272.5	260.5	21.6	35.6	0.70
8	154.6	1171	321	349.5	21.2	36.4	0.46
9	52.1	786	191.5	129	31.8	49.8	0.51
10	60.2	1400	267	234	28.2	53.4	0.55
11	158.4*(2)	1190	277.5	225.5	25.0	42.5	0.75
12	85.4*(3)	774	203.5	149	9.6	28.2	0.47
13	126.8	764	203.5	188.5	15.2	40.1	0.68
14	180.2	1104	396.5	297	10.6	27.8	0.45
15	47.7	962	258.5	158	5.6	20.3	0.40
16	178.5	1200	304	251.5	6.3	28.1	0.50
17	73.4	798	281	184.5	10.0	21.4	0.55
18	145.4	855	246.5	212	10.1	30.0	0.47

1. Expressed as a percent at the ovendry weight of the wood.
2. Average of 2 readings per board.
3. Average of 4 readings per board.
4. Based on one sample per board and reflects change from 51% to 91% relative humidity.

* Indicates average based on fewer data than others in that particular column (numbers in parentheses indicate actual number of samples).

Raw Material Profile

A single sample of green residue taken from the residue pile was measured for moisture content and usable material. The green weight of the sample was 49 pounds. The material was dried, and four random samples were subsequently taken to determine the original and dried moisture content. These values were found to be 123 percent and 6.7 percent respectively. It is possible that the original moisture content was considerably higher than the normal wood value as a result of water use in the debarking process and exposure of the residue pile to rainfall It does provide an indication, however, of the amount of drying that might be necessary, depending on handling conditions.

The dried sample (23.5 pounds) was then separated by the screening process described above. Twelve pounds of material were particles of sufficient size to be considered usable while 11.5 pounds passed through the screen and were discarded. This latter portion consisted primarily of ultrafine slivers and fine dust-like particles. Much of the discarded material could have been used for board surfaces and interior filler if a layered board had been made.

Random samples of all the usable material collected were analyzed for softwood-hardwood composition and particle size distribution. Even though an attempt was made to gather the residue when it was known that the mill was chipping softwood, the samples showed a hardwood composition of from 2 to 20 percent by weight. The individual boards produced in this study were not characterized according to softwood-hardwood composition because it was evident that varying mixes would be a more normal situation with this raw material. The hardwood component mentioned above seems a logical range to expect.

The particle shapes could be described as ranging from small cubes to slivers. During the visual examination of samples, the particles were arbitrarily separated into three groups according to length (parallel to grain direction). After separation, the particles in each group were measured. The short group ranged from 0.062-0.187 inch, the medium group from 0.156-0.437 inch, and the long group from 0.344-0.780 inch. The respective groups comprised 35, 36, and 29 percent of the total by weight.

Bark content was estimated to be approximately 5 percent of the total furnish. A noticeable amount of sand and grit was also present which became particularly apparent when the test samples were cut.

Static Bending

Two static bending specimens 3 x 14 inches were taken from each panel. Both of these specimens were tested in the dry condition. The rate of crosshead movement in the test machine was 0.2 inch per minute, and deflection readings were taken every 0.005 of an inch. From values obtained from the load-deflection curves the modulus of elasticity, modulus of rupture, and the stress at proportional limit were calculated. Figures 3 and 4 show the relationship of density to modulus of elasticity and modulus of rupture, respectively, as these properties were affected by resin content. Also depicted on these graphs are the minimum values a particleboard must have to meet the prescribed quality standards.[3]

The typical dependence of bending strength on the resin content and board density is evident. There is an indication that a suitable low density board could be made with as little resin as 3 percent. It appears however, that a minimum of 5 percent resin solids is necessary for suitable boards of all densities. No obvious advantage was noted by increasing the resin solids beyond 10 percent. This may be an application of optimum surface coverage by the adhesive for the size and shape of particles used and the pressing conditions employed, i.e. higher resin contents could be more significant at higher pressures, temperatures, and press times. This range of resin solids has been found to be the most satisfactory (9).

Internal Bond

Four internal bond specimens, each a nominal 2 x 2 inches, were cut from each panel. These specimens were bonded to aluminum gripping blocks using a standard hot-melt adhesive. Load was applied at the rate of 0.2 inch per minute. The actual dimensions of the specimens were measured to the nearest 0.001 inch before testing, and the loads obtained during the tests were converted to stress values.

The test results showed no apparent consistent relationship between internal bond strength and either density or resin content. This is contrary to what is accepted as the normal relationship for these factors. It does not seem likely that there was a major failure of either the wood particles or the adhesive to perform as expected as three-fourths of the values obtained are higher than the minimum required. Thus, any abnormal responses are most likely related to the production process or normal variation.

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[3] The complete table of property requirements is shown in Table 2 on pages 14 and 15.

Of the 72 specimens tested, only 6 produced unusable results due to adhesive failure between the specimen and the gripping block, 30 exhibited failure at the mid-depth level, 9 failed at an estimated distance of between 1/16 and 1/8 inch from the surface, and the remaining 27 failed within the specimen approximately 1/16 of an inch from the surface. It was noted that most of the values fell in two groups: 50-85 psi and 125-280 psi. Each group, however, had all resin content levels and a range of densities.

The internal bond strengths were evaluated against such factors as initial chip moisture content, board moisture content, date of manufacture, location of failure and percentage of water added to the adhesive to improve spray application. Only the date of manufacture and the added water percentage showed the possibility of any separation.

It was observed that all the boards made on two particular days had values that fell in the low group. On two other days all the values fell in the high group. The other two days had both high and low values. The three boards made on the first day had higher percentages of water added to the adhesive, and these were some of the lower values. Once a suitable percentage was selected (10%), this was no longer a factor, but as indicated above the variation still existed.

Within these sub-groups of production dates there was no consistent relationship as far as resin content or other factor was concerned. Since the production technique was the same for all boards except for the variables already mentioned, it is possible that the inconsistencies observed may be due primarily to the hardwood-softwood composition of the boards. As stated previously, the percentage of hardwood particles present could have ranged from 2 to 20. The differences in compressibility and glueability of the hardwoods and softwoods present may be sufficient to produce noticeable effects. Obviously, the internal bond test is more sensitive to these factors than are the other tests which were conducted. It should be emphasized, however, that even with the inconsistencies that were present, most of the boards met the minimum performance standards. Unsatisfactory performance was primarily observed among the boards with the lowest resin contents.

Hardness

Hardness specimens were 3 x 6 inches. Four were cut from each panel and two of these were glued together to make a specimen of a nominal one inch thickness. The standard modified Janka ball test was run to determine hardness. The rate of loading was 0.2 inch per minute. Two readings were taken on each flat surface of the specimen. The values shown in Table 1 are the averages of all four readings for the specimen.

Table 2

Property Requirements for Standard Grades of Particleboard

(Reproduced from Commercial Standard CS 236-66 for Mat-Formed Wood Particleboard)

Type (use)	Density (Grade) (min. ave.)	Class	Modulus of Rupture (min. avg.)	Modulus of Elasticity (min. avg.)	Internal Bond (min. avg.)	Linear Expansion (max. avg.)	Screw Holding Face (min. avg.)	Screw Holding Edge (min. avg.)
	A		psi	psi	psi	percent	lbs	lbs
	(High Density, 50 lbs/cu ft and over)	1	2,400	350,000	200	0.55	450	–
		2	3,400	350,000	140	0.55	–	–
	B (Medium Density, between 37 and 50 lbs/cu ft)	1	1,600	250,000	70	0.35	225	160
1.[1]		2	2,400	400,000	60	0.30	225	200
	C (Low Density 37 lbs/cu ft and under)	1	800	150,000	20	0.30	125	–
		2	1,400	250,000	30	0.30	175	–

A (High Density 50 lbs/cu ft and over	1	2,400	350,000	125	0.55	450	–
	2	3,400	500,000	400	0.55	500	350
2.2							
B (Medium Density, Less than 50 lbs/cu ft)	1	1,800	250,000	65	0.35	225	160
	2	2,500	450,000	60	0.25	250	200

1 Type 1. Mat-formed particleboard (generally made with urea-formaldehyde resin binders) suitable for interior applications.

2 Type 2. Mat-formed particleboard made with durable and highly moisture and heat resistant binders (generally phenolic resins) suitable for interior and certain exterior applications.

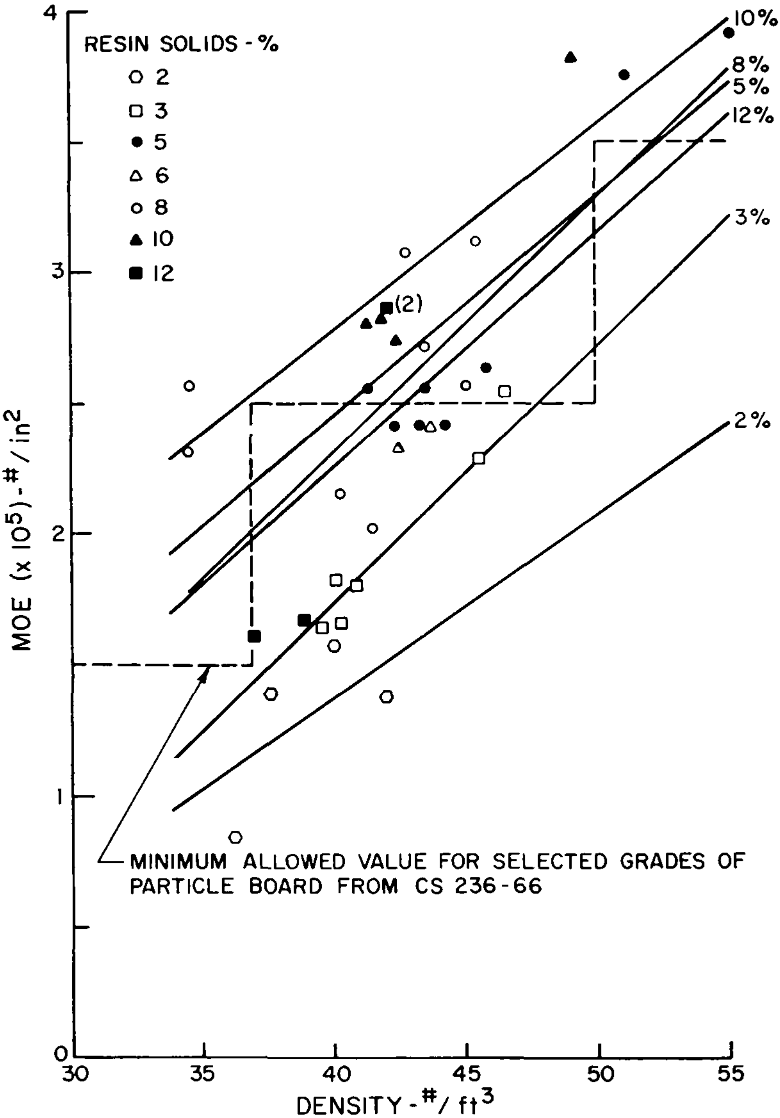

Figure 3. Relationship of density and modulus of elasticity in bending for experimental particleboard panels.

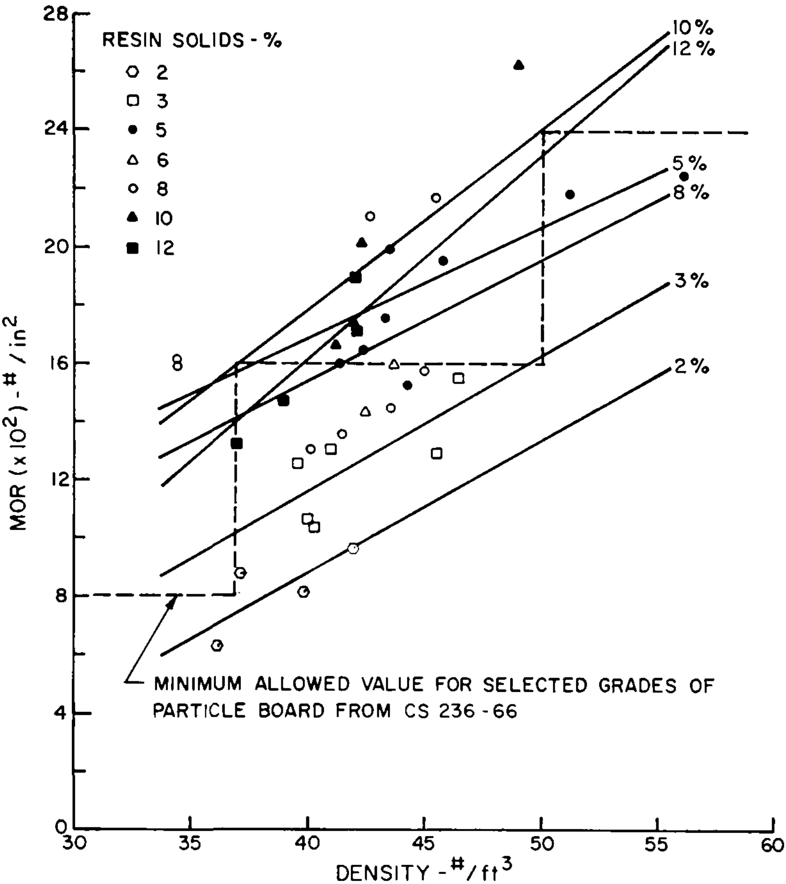

Figure 4. Relationship of density and modulus of rupture for experimental particleboard panels.

As shown in Figure 5, hardness is primarily a function of board density as would be expected. The regression line shown has an "r" value of 0.61. Although there is no obviously apparent relationship between hardness and resin content, it is important to note that of the seven panels made with 2, 3, or 12 percent resin content, only one specimen falls above the line. This supports the trend that was seen in the static bending tests that the optimum resin content appears to be in the range of 5-10 percent.

Hardness is an optional property in the commercial standard. When specified, the minimum values are 1,800 pounds for boards over 50 pounds per cubic foot and 500 pounds for boards between 37 and 50 pounds per cubic foot (11). All specimens except one met these minimums.

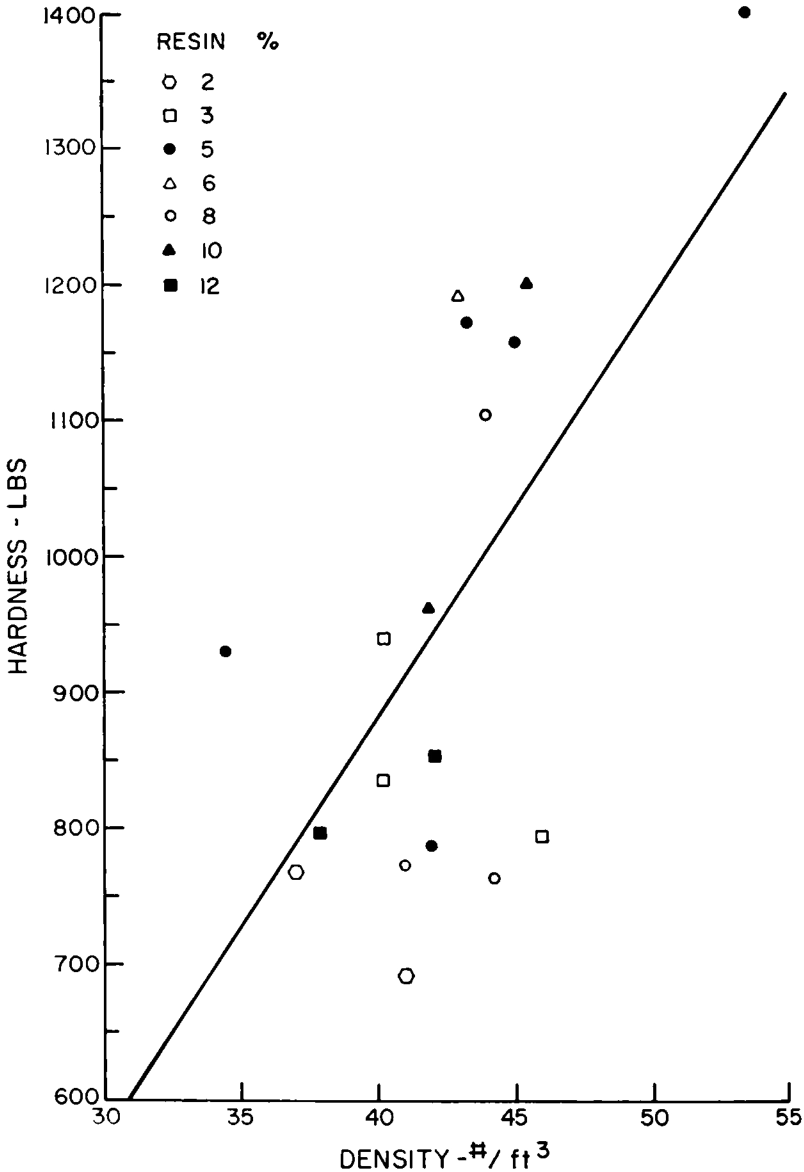

Figure 5. Relationship of density and hardness for experimental particleboard panels.

Screw Withdrawal

Standard screw withdrawal tests were run on the face and edge of dry specimens. The same specimens used for the hardness tests were used for the withdrawal from the face. This provided adequate thickness for the required depth of screw penetration. Screw placement was such that the results were not affected by the previous hardness tests. Loading rate in both face and edge tests was 0.05 inch per minute.

In general the edge values were lower than the face values, as expected, since the screw is embedded only in the less dense core portion of the panel. Once again, however, there was no apparent relationship between the test value and the board density. The type of internal stress placed on the material during screw withdrawal is similar to that in the internal bond tests. This is apparent in that the relative distribution of values with respect to density is very similar in all three tests. Obviously, the same factors are at work in producing the variation encountered. In both the face and edge tests the majority of specimens met the minimum values as listed in the commercial standard. The 2 and 3 percent resin boards composed 5 of the 12 specimens which did not attain the minimum values.

Linear Variation

One 3 x 6 inch sample from each panel was conditioned at a temperature of 72.5°F. and a relative humidity of 51 percent until weight equilibrium was obtained. Then the longer dimension of the sample was measured to the nearest 0.001 of an inch using a comparator. The samples were then conditioned at 68.9°F. and 91 percent relative humidity until weight equilibrium had occurred (approximately 3 weeks). The longer dimension of each sample was remeasured and the percent linear variation calculated on the basis of the dimension at 51 percent relative humidity.

The average moisture content of the samples increased from 8.6 to 18.0 percent as the relative humidity increased from 51 to 91 percent. All but one specimen exceeded the maximum allowed by the product standard. There was a slight inverse relationship between linear expansion and board density. Resin content played a larger role in the amount of expansion. The lower resin content boards (2 and 3 percent) had approximately twice the expansion of any other group.

No additives were used with the adhesive in this project. The results of this test indicate the need for a wax additive to decrease the absorption of water vapor.

Thickness Swell

The samples used for measuring thickness swell in liquid water were 6 x 6 inches in size. They were suspended horizontally in barrels of tap water maintained at a temperature of 72.5°F. Thickness was measured at the mid-length, one-half inch from each edge of the sample. Readings were made to the nearest 0.001 of an inch and were taken after 2 hours of soaking and after 24 hours of soaking. Percent swelling was then calculated based on the original dimension. Final moisture contents ranged from 71.6 to 178.2 percent

It was readily apparent from visual observations during testing that the resin content was a major factor in the amount of swelling that took place. This was confirmed when the thickness swell was plotted against the resin content as shown in Figure 6. The curves shown depict the trend but are not based on a calculated equation.

The commercial standard does not list any maximum values for thickness swell. These tests emphasize the problems encountered with urea-formaldehyde resins when exposed to liquid water. The swelling can be decreased or at least retarded by including additives to the adhesives mix, but it must be emphasized that urea adhesives are intended for protected, interior uses.

Resource Survey

Ten firms were contacted by telephone. Three of these firms reported they did not separate the finer residue from pulp chips and a fourth indicated that they would also utilize the residue when new filters were installed in the digesters. Of the six remaining firms, four were presently utilizing the residue by burning it for in-plant energy needs while one other was burning it as waste. The last firm was simply piling the residue. Several indicated that limited quantities of residue were utilized in the local area for agricultural purposes.

None of the firms contacted had ever accurately surveyed the quantity of slivers produced, but there seemed to be a "rule of thumb" that one percent of the material going into the chippers became residue. This figure was used in conjunction with the Maine Timber Cut Summary for 1971[4] to develop an estimate for the total potential of residue availability as shown below. These figures are estimates of wood chipping residue only and do not include bark from debarking operations.

[4] Maine Timber Cut Summary for 1971. Maine Forestry Department, Augusta, Maine.

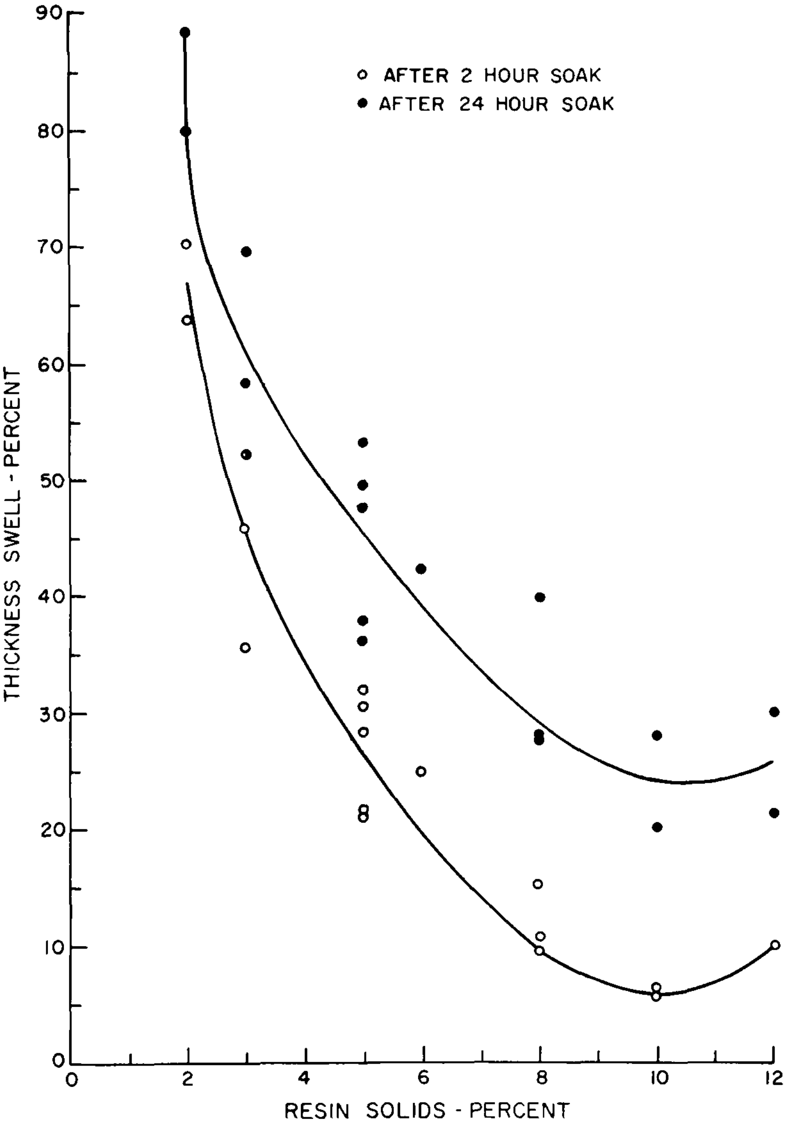

Figure 6. Thickness swell of experimental particleboard panels as affected by resin quantity.

	Softwood & Aspen	Hardwood
	(converted to "peeled" or debarked cords)	
Pulpwood (roundwood)[5]	1,772,555	677,303
Mill Residue[1]	199,796	60,310
Export-Import Balance[5, 6]	(+) 144,848	(−) 1,545
Total	2,117,199	736,068
Chipping Residue (1% x Total)	21,172	7,361
Estimated Weight per Cord	2.15 tons	2.7 tons
Total Potential	45,520 tons	19,875 tons
Ovendry Weight (Assuming 70% Moisture)	26,776 tons	11,691 tons

This last figure must be further altered to allow for groundwood mills, which do not chip their roundwood, and those mills not separating the slivers. Another factor is usable portion of the residue. As mentioned, previously, approximately 50 percent of the raw material gathered for this project was considered ultrafines and dust. Although the ultrafines were not utilized in the production of homogeneous board, much of it could have been utilized on the surfaces if a layered board had been made.

Considering the above factors it is thought that a conservative estimate of potentially usable residue would be approximately 60 percent of the final figures above or 16,065 tons of softwood and aspen and 7,015 tons of hardwood (both ovendry). Although considerably more data must be collected for even an initial estimate of economic feasibility, a previous study in another part of the country indicated an annual requirement of 25,000 tons (ovendry) for a specialized particleboard plant producing 20.8 million square feet on a 3/4 inch basis or 62,500 tons (ovendry) for a standard plant producing 52.1 million square feet (1). Thus, the chipping residue presently available in the state probably could not support a plant completely, but it could provide a high percentage of the annual raw material requirements if other factors such as plant location with respect to material accumulation, handling, and transportation were favorable. The effective use of residue, whether it be from logging or processing, is highly dependent on its concentration and accessibility to a secondary processing facility.

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[5] Maine Timber Cut Summary for 1971. Maine Forestry Department, Augusta, Maine.

[6] Bones, J. T. and D. R. Dickson, 1973. Pulpwood production in the Northeast 1971. USDA For. Serv. Resources Bulletin NE-29, Northeastern Forest Experiment Station, Upper Darby, Pa.

SUMMARY

Experimental panels of mat-formed wood particleboard were made with residue from a pulpwood chipping operation. This residue consisted of the fine wood particles produced when debarked logs were converted to chips prior to the pulping process. The particles varied from small cubes to slivers and were primarily softwoods although hardwood content may have been as high as 20 percent in some panels. A urea-formaldehyde resin was used in quantities varying from 2 to 12 percent by ovendry weight of the wood. Actual board densities ranged from 34.4 to 53.6 pounds per cubic foot. Physical tests were made of the static bending, internal bond, hardness, screw withdrawal, thickness swell and linear expansion properties of the panels.

Two principal general observations were made in the physical property tests. First, resin contents below 5 percent were generally unsatisfactory; those above 10 percent did not show sufficient improvement, if any, to warrant the additional adhesive. This evaluation was made by comparing the test results with the minimum values required in the commercial standard for mat-formed particleboard. The tests indicated that satisfactory boards could be made within the limits stated above, for all properties except linear expansion. This indicated the need for including some type of additive in the resin to retard water vapor absorption.

The second observation was the amount of variation exhibited. It is recognized that much of the apparent variation is the result of the limited number of samples involved. In the internal bond and screw withdrawal tests, however, there was absolutely no correlation with board density or resin content. This points up one of the major problems in utilizing residue, i.e., the lack of quality control on raw material results in a variable quality end product. In this case the variation might be attributable to hardwood-softwood composition, particle size and shape, bark content, and gluing properties of the different components and surfaces. The practical magnitude of this problem is highly dependent upon whether or not the end use can tolerate this amount of variation.

An estimate was made of the quantity of this residue material available in Maine based on the total quantity of material chipped and the present disposition of this residue by the pulp mills. This estimate was 16,065 tons of softwood and 7,015 tons of hardwood (both ovendry) annually. The applicability of this as a resource base for an industry would depend on plant location, the particular production process employed, the end product, and the economic factors of residue accu-

mulation, handling, and transportation. In any case, this residue would have to be supplemented with additional raw resources. If future evaluation proves satisfactory, these additional resources might obviously come from low quality trees, branches and tops, thinnings, and bark as well as some higher quality roundwood. There is every reason to assume that this chipping residue would be compatible with particles prepared especially for particleboard.

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