Hardboard from Extracted Juniper Chips[1]

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Chips from western juniper that had been steam-distilled for recovery of volatile oil were ground in an attrition mill and then made into hardboard—some without additives, some with resin, and some with resin plus wax. The boards possessed exceptional bending strength and water resistance but inferior toughness properties compared with boards made from other species. Additives and higher pressing temperatures increased specific gravity values. Surfaces were uniformly colored and semiglossy without use of a water spray.

IN LARGE AREAS of central and eastern Oregon, the principal tree species is western juniper (*Juniperus occidentalis,* Hook), which is now practically unused. In an effort to find economic uses for this tree, the volatile oil content has been studied.[2]

The present report is on a study of hardboard production from juniper chips extracted by steam distillation. Harvesting the tree solely for hardboard manufacture might be uneconomic, but the practicality would be increased if the raw material could be obtained as a byproduct from another manufacturing process, such as extraction of the wood for its volatile oils.

Principal uses for the wood are restricted at present to fence posts, novelties, and fuel. Most large trees are decayed internally, thus making difficult the recovery of lumber for pencil stock.

Experimental Procedure

The work was divided into two parts, each part being analyzed separately. Part I was a short study designed to determine which of three grinding runs and chip cooks produced the best fiber for board making. The additive combinations were the same for all grinds, and two pressing temperatures (320° F. and 400° F.) were used. The plan of action followed during Part I is shown in Fig. 2.

Part II was an attempt to determine the influence of three additive treatments (no additives, resin only, and resin and wax) and temperatures on boards made with fiber from cook and grind number three. The plan of action for Part II is shown in Fig. 3.

Equipment: The chips were fiberized in a 24-inch, double-rotating-disc Bauer attrition mill. The mixing was done in a propeller-type mixer equipped with two spray heads for additive distribution. The mat felter was laboratory-designed, as was the pre-pressing equipment. All boards were pressed with mats at 40 per cent volatile content in a steam-heated hydraulic press.

Preparation of Fiber: Chips were supplied as a by-product from volatile oil extraction. All chips used had been screened to 5/8-inch size and cooked under one of the following conditions:

1. Steam pressure, 25 psi for 6 hours.
2. Steam pressure, 25 psi for 5 hours.
3. Steam pressure, 45 psi for 8 hours.

The chips were fiberized hot. Cook number one was ground using a plate setting of 23 mils, which was the same setting used on previous studies of lodgepole pine and Douglas-fir.[3] Be-

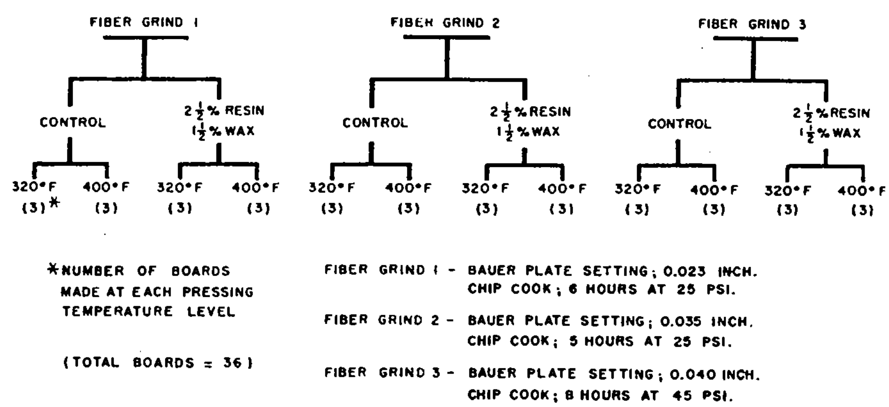

Fig. 2.—Plan of action used in Part I.

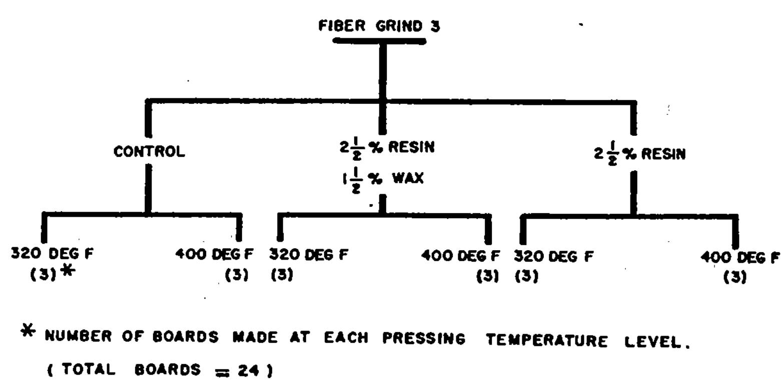

Fig. 3.—Plan of action used in Part II.

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[1] A contributed paper.

[2] Kurth, E. F., and Ross, J. D. Volatile Oil from Western Juniper. Report No. C-3, Oregon Forest Products Laboratory. April, 1954.

[3] Nixon, G. D. 1953. Suitability of Lodgepole Pine for Dry-formed Hardboard. Report No. L-3, Oregon Forest Products Laboratory.

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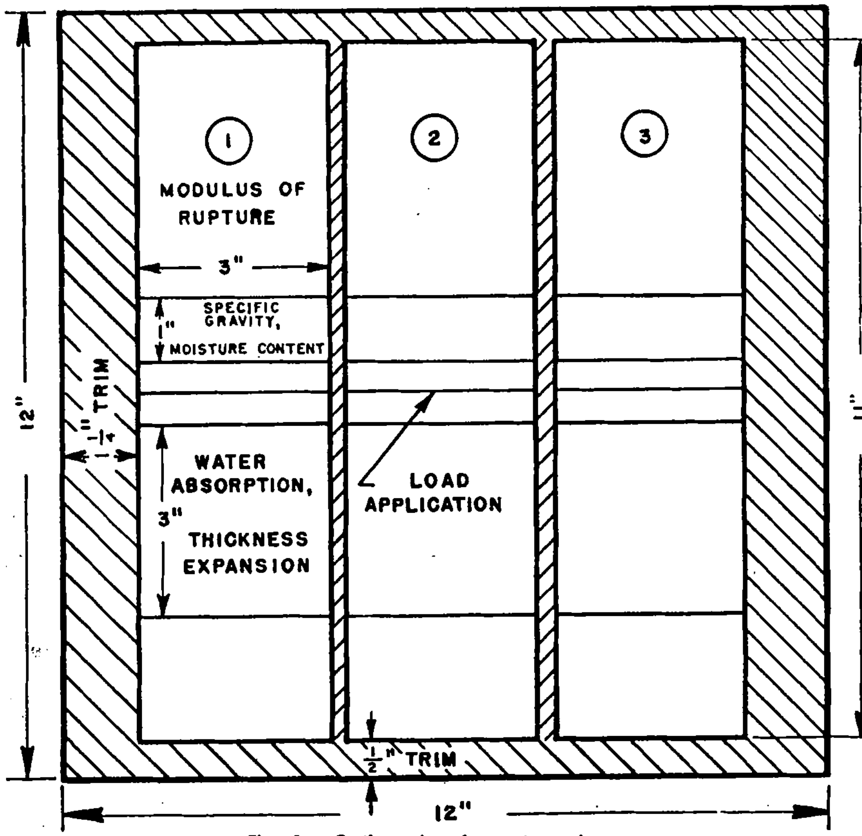

Fig. 1.—Cutting plan for test specimens.

the chips were soft and pliable, yielding short fiber with a high percentage of fines.

The second cook was ground at a faster feed rate and with a plate setting of 35 mils. The objective in increasing the plate setting was to produce a coarser fiber. This grind gave fiber which appeared to approximate the fiber-size distribution obtained from lodgepole pine and Douglas-fir.

The third cook, which was steamed at 45 psi, was ground at a plate setting of 40 mils to give a fiber with distribution comparable to that of cook number two. In order to maintain a full load on the Bauer mill, it was necessary to further increase the feed rate. The extracted juniper chips required less power for grinding than did lodgepole pine or Douglas-fir.

All grinds were analyzed for fiber distribution in a Bauer-McNett fiber classifier, and the results of the analysis are shown in Table 2.

Preparation of Boards: The wet fiber from all grinds was dried to below 15 per cent moisture content (on a dry-weight basis) before further processing. The dried fiber was mixed with the necessary amounts of resin, wax, and water. The mixed fiber was felted into a loose mat by means of a shaker box and pre-pressed by an air-operated ram. Following the pre-pressing, the mats were pressed into screen-backed boards in a steam-heated of 1000 psi for 45 seconds, then released to 100 psi for 9 minutes, 15 seconds. This was the same pressing cycle used on previous studies of lodgepole pine, Douglas-fir, and West Coast hemlock. The volatile content of the fiber at time of pressing was about 40 per cent (oven-dry weight basis).

Forty-two boards were made, 12 by 12 by 1/4 inches, and smooth one side. No pH control was used with these boards because of the low pH of the raw material. A phenolic resin binder was used throughout the study and a wax emulsion was used to reduce water absorption. The combination of resin and wax was used because it had given satisfactory results in hardboard using lodgepole pine, West Coast hemlock, and Douglas-fir fibers. The amounts of additives were kept constant throughout the work at either 2 1/2 per cent resin, or 2 1/2 per cent resin plus 1 1/2 per cent wax emulsion.

Testing of Boards: Test values for modulus of rupture, water absorption, specific gravity, and moisture content at time of testing were obtained for all boards. Test specimens were cut from the 12- by 12-inch boards in accordance with the pattern shown in Fig. 1. All boards to be tested were conditioned for one week at 65 per cent relative humidity and 70° F.

Modulus of rupture values were obtained from 3-inch by 11-inch test specimens, broken on an 8-inch span with a head speed of 4 inches per minute (Federal Specification LLL–F–311).

Water absorption test specimens were cut as 3- by 3-inch pieces, taken from the broken bending specimens. After initial weight and thickness measurements were taken, the pieces were immersed for 24 hours under 1 inch of water at 70° F. Upon removal from the water the pieces were set on edge and allowed to drain for 10 minutes. Final weights and thicknesses were recorded and values for water absorption and thickness swelling calculated as percentages of the original weight and thickness. The standard size for a 24-hour water absorption test specimen is 12 by 12 inches; therefore the values obtained from these smaller pieces should be somewhat higher than would be expected from full-size test pieces.

Specific gravity values were determined from 1- by 3-inch sections that were taken also from the bending specimens. The pieces first were weighed, then oven-dried and weighed a second time. Volume measurements were made by immersion of the piece in mercury, and the weights and volumes were used to calculate moisture content at test, and specific gravity. Specific gravity values were based on oven-dry weight and oven-dry volume.

Results and Discussion

Part I

Data pertinent to the steaming, grinding, and fiber-size distribution from the four digester loads are shown in Tables 1 and 2. The fourth digester load was run as a continuation of load 3 and the resultant fibers were considered the same.

The data in Table 2 show that the juniper chips produced a shorter fiber with more fines than in fiber from any of the previous anlayzed species. Where a comparable plate setting was used (grind 1) an extremely fine fiber resulted, but when coarser plate settings were used the fiber-size distribution more closely approached that of previous species studied.

All the juniper boards were characterized by a glossy, uniformly colored surface on the smooth side, regardless of the pressing temperature used. Boards made from the extremely fine fiber of grind 1 produced superior surface characteristics, although the boards from grinds 2 and 3 were comparable to commercial products. It was unnecessary to water-spray the mat for uniform surface color of boards.

Because of the extended cooking times (5–8 hours), somewhat more water solubles than previously experienced with other species were deposited on the screen back. The deposits did not cause serious sticking of the fiber to the screen, but in a commercial operation it would seem desirable to brush off this somewhat sticky material.

Test results of boards made during this part of the project are shown in Table 3.

Each value given in the table represents an average of nine test values. The modulus of rupture, Izod toughness, specific gravity, and water-absorption test data were analyzed statistically by an analysis of variance with the grinding run, additive treatment, and press temperature set up as the major sources of variation. The results of the analysis of each property follow.

Modulus of Rupture: The bending strength of the boards containing additives was well above Federal Specification LLL–F–311 (5500 psi). The juniper boards were somewhat stronger than lodgepole pine boards and weaker than West Coast hemlock boards pressed under the same conditions.

The inclusion of resin and wax significantly increased the bending strength of the boards regardless of the fiber grind or press temperature used. Boards made with fiber from grind 3 were slightly lower in strength resin and wax were used, but exhibited the same strength as the other grinds where no additives were used. In addition, resin and wax effected a greater strength increase where the boards were pressed at the lower press temperature (320° F.) The boards pressed at 400° F. possessed significantly greater bending strength than did those pressed at 320° F. Although small differences occurred between the average strength values of the boards made with the different fiber grinds, there appeared to be no important effect caused by chip steaming conditions or Bauer plate settings.

Izod Toughness: The most interesting result of the toughness test values was the superior toughness exhibited by the boards made with fiber from grind 2, irrespective of press temperature or additive treatment. This property was apparently influenced by both fiber-size distribution (grind 1) and chip steaming conditions (grind 3).

As expected, the boards pressed at the higher temperature were considerably lower in toughness. Boards containing no additives showed a greater drop in toughness than did those with resin and wax added. The inclusion of resin and wax lowered toughness values in boards pressed at both temperatures. The lowering of toughness because of the influence of additives was more pronounced in boards pressed at the lower temperature (320° F.)

Water Absorption: The juniper boards were superior in water resistance to either lodgepole pine or West

Table 1.—JUNIPER CHIP STEAMING AND GRINDING DATA

Run	Initial chip moisture content Per cent	Steam temperature Deg F.	Steam time Hours	Steamed chip moisture content Per cent	Bauer plate settings Mils	Fiber moisture content Per cent
1	30–40	267	6	162	23	111
2	30–40	267	5	---	35	85
3	30–40	300	8	---	40	130
4	14	300	8	---	40	95

Table 2.—SCREEN ANALYSIS OF JUNIPER FIBER COMPARED WITH OTHER SPECIES

Species	Plate setting Mils	Mesh size; openings per inch				
		Retained 20	Passed 20 Retained 35	Passed 35 Retained 65	Passed 65 Retained 150	Passed 150 (by difference)
		Per cent				
Western juniper (Grind)						
1	23	(0)*	50.6 (61.6)	19.9 (24.2)	11.6 (14.1)	17.9
2	35	36.6 (43.6)	27.6 (32.9)	12.7 (15.1)	7.0 (8.3)	16.1
3	40	37.7 (46.7)	21.3 (26.4)	14.0 (17.3)	7.8 (9.6)	19.2
4	40	39.6 (49.0)	19.0 (23.5)	13.9 (17.2)	8.3 (10.3)	19.2
Lodgepole pine	25	58.7 (67.8)	17.7 (20.4)	7.1 (8.2)	3.1 (3.6)	13.4
Douglas fir	25	50.2 (56.2)	22.0 (24.6)	11.1 (12.4)	6.1 (6.8)	10.6
West Coast hemlock	25	57.2 (62.9)	20.5 (22.5)	9.3 (10.2)	4.0 (4.4)	9.0

*Values inside parentheses indicate percentage if last fraction containing water solubles is ignored.

Table 3.—TEST RESULTS OF BOARDS MADE FROM THREE FIBER GRINDS, WITH AND WITHOUT ADDITIVES AND PRESSED AT 320 AND 400° F. (COMBINED VALUES FOR PARTS I AND II)

Press temperature Degree F	Property	Grind No. 1		No. 2		No. 3*		
		No additives	Resin and wax	No additives	Resin and wax	No additives	Resin and wax	Resin only
320	Modulus of rupture (psi)	3740	6840	3730	7020	3880	6170	6950
	Toughness (in.-lb.)	10.25	6.56	12.25	7.30	10.50	6.61	8.56
	Specific gravity	0.98	1.04	0.96	1.04	0.98	1.00	1.00
	Water absorption (%)	52.4	17.7	61.5	18.9	51.6	17.7	35.2
	Thickness swell (%)	21.9	7.0	29.5	5.9	21.7	4.7	11.0
	pH of fiber	4.0	5.4	3.9	5.1	4.1	5.5	5.5
400	Modulus of rupture (psi)	5060	7310	5400	7270	5380	7270	7490
	Toughness (in.-lb.)	7.00	5.60	8.00	6.24	7.25	5.54	6.33
	Specific gravity	1.00	1.03	0.98	1.00	0.99	1.02	1.04
	Water absorption (%)	40.4	13.7	44.3	13.7	38.1	13.6	32.6
	Thickness swell (%)	13.8	4.3	16.6	4.1	12.8	3.5	9.3
	pH of fiber	4.0	5.4	3.9	5.1	4.1	5.3	5.8

*Values for grind 3 include results from Parts I and II.

Coast hemlock boards pressed under similar conditions. As expected, the addition of resin and wax produced boards with superior water resistance. The magnitude of this effect was influenced by the press temperatures. At 400° F. press temperature, the actual reduction in water absorption brought about by the addition of additives was less than for boards pressed at 320° F.; however, the percentage reduction was about the same.

Boards pressed at the higher press temperature showed superior water resistance. All boards with resin and wax pressed at this temperature were well within the proposed commercial specifications (16 per cent) while those pressed at 320° F. were close to meeting the standard when the small (3- by 3-inch) specimen size was considered. The type of fiber used had no significant effect on water absorption.

Specific Gravity: The addition of resin and wax significantly increased the specific gravity of the boards, regardless of the pressing temperature used. Increasing press temperature from 320 to 400° F. increased the specific gravity in boards containing no additives, but did not effect a significant change in those boards containing additives. Fiber ground at the closest plate setting (23 mils) produced boards with significantly greater specific gravity than that of those ground at the coarser plate settings (35 and 40 mils).

Tables showing average values for the previously mentioned combinations are presented in the appendix, with their respective LSD (least significant difference) values. The LSD values are used as a yardstick to measure the magnitude of change necessary to constitute a significant difference.