Effect of Peeling Temperatures on Douglas Fir Veneer

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Purpose . . .

Fully utilize the resource by:

- developing more by-products from mill and logging residues to use the material burned or left in the woods.
- expanding markets for forest products through advanced treatments, improved drying, and new designs.
- directing the prospective user's attention to available wood and bark supplies, and to species as yet not fully utilized.
- creating new jobs and additional dollar returns by suggesting an increased variety of salable products. New products and growing values can offset rising costs.

Further the interests of forestry and forest products industries within the State.

Program . . .

Identify and develop uses for chemicals in wood and bark to provide markets for residues.

Improve pulping of residue materials.

Develop manufacturing techniques to improve products of wood industries.

Extend service life of wood products by improved preserving methods.

Develop and improve methods of seasoning wood to raise quality of wood products.

Create new uses and products for wood.

Evaluate mechanical properties of wood and wood-based materials and structures to increase and improve use of wood.

Table of Contents

SUMMARY

To study the effect of heating logs on quality of veneer recovered, bolts from No. 2 Douglas fir sawmill logs were peeled into veneer at 4 temperatures ranging from 70 F to 200 F, with pressure on the nosebar either light or heavy. Some of the logs were coarse-grained, others were fine-grained.

Quality of the veneer was judged according to roughness, splits, depth of lathe checks, variation in thickness, strength in tension perpendicular to the grain, and strength in bending parallel to the grain.

Heating the bolts did not affect greatly roughness or variation in thickness, but lessened the depth of lathe checks and amount of splitting. Heated bolts yielded veneer with increased strength in tension across the grain and in bending along the grain.

Heavy pressure on the nosebar reduced depth of lathe checks, but apparently weakened the wood by excessive compression.

Results indicated about 140 F would be the best temperature for peeling Douglas fir veneer bolts.

ACKNOWLEDGMENTS

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EFFECT OF PEELING TEMPERATURE ON DOUGLAS FIR VENEER

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INTRODUCTION

When the study was made, most Douglas fir veneer was peeled from blocks that were unheated, or were near room temperature. Three plywood plants in Oregon, out of a total of about 90, were heating Douglas fir blocks before peeling veneer.

Several investigators (9, 17, 19, 22, 24)* have studied the effect of temperature on peeling of veneer. Most investigators have reported that the main advantage in heating peeler blocks is that a smoother and tighter veneer is obtained with less wear and damage to the knife than when unheated blocks are peeled.

Grantham (12) reported a greater proportion of A-grade veneer was obtained from heated Douglas fir blocks than from matched unheated blocks. Net gain in value of veneer was $4-12 a thousand board feet, net block scale, for the heated blocks. A subsequent test was conducted in 1961. This test, results of which were unpublished, gave a similar increase of A-grade veneer resulting in an increase in value of veneer of $6 a thousand board feet, net block scale, for Douglas fir blocks peeled at about 140 F, compared to the value of veneer from matched blocks peeled at 40 F.

Objective

Although some past information was available on the effect of temperature in peeling Douglas fir veneer, there was not sufficient information to determine the best temperature. The objective of investigation was to study the effect of peeling temperatures between room temperature and 200 F on the quality of Douglas fir veneer.

Scope

Six logs were selected and each was cut into 4 blocks nominally 4 feet in length. Each block from a log was peeled at a different temperature. Veneer was evaluated for depth of lathe checks, splits, roughness, variation in thickness, strength in tension perpendicular to the grain, and strength in bending parallel to the grain.

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*Numbers in parentheses refer to references cited.

Principles

Cutting action of the veneer knife in rotary peeling forces the veneer to make a sharp bend at the point of the knife. Pressure of the nosebar causes a direct compressive force perpendicular to the veneer and an additional frictional force parallel and opposite in direction to the movement of the veneer. The above combined forces cause 4 major types of stress in the wood.

First, there is a tensile stress directly in front of the knife edge which is perpendicular to the path of the knife moving through the wood. If failure of wood results from such tensile stress, a continuous, smooth-cut veneer will be produced.

A second stress developed is direct compression at the point of the knife caused by the knife being forced into the wood. For wood weak in compression, and under some conditions of cutting, failure of wood occurs by "compression tearing," and a rough or torn surface will result. Leney (16) shows excellent photographs illustrating "compression tearing," and other failure of wood during veneer cutting.

A third stress results from bending the wood abruptly at the point of the knife. Bending the wood at the knife's edge causes a compressive stress on the face or "tight" side of the veneer, while a tensile stress is produced on the back, or "loose" side of the veneer. This tensile and compressive stress is perpendicular to the grain in a tangential direction. If the tensile stress resulting from bending exceeds the strength of the wood, failure will occur, and result in typical lathe checks. Lathe checks not only cause veneer to be weak perpendicular to the grain, but also influence development of surface checks. Batey (3) remarked, "The quality of peel influences face checking to such a great extent that every effort should be made to manufacture face stock with as tight a peel as possible." Jayne (14) also concluded that over 90 per cent of checks in finish in hardwood panels were directly traceable to lathe checks.

In addition to the 3 main stresses developed near the cutting edge of the knife, there are shear stresses, as explained and illustrated by Leney (16). Although shear stresses exist in the wood, Leney concluded that typical lathe checks gave the appearance of being a tension break.

Increasing compression of the wood by the nosebar causes a reduction in tendency for lathe checks to develop (6, 16, 22, 24). This reduction of lathe checking is a result of compressive forces that tend to counteract the tensile bending stress on the underside of the veneer. Note in Figure 1 that friction of the veneer on the back side of the knife could set up compressive forces on the loose side of the veneer that

would reduce tensile stress from bending. Pressure by the nosebar also tends to reduce or limit splitting ahead of the knife edge. Excessive pressure by the nosebar, however, will result in "compression set" in the veneer and increased wood failure by "compression tearing."

Strength of wood is reduced markedly at elevated temperatures. Greenhill (13) reported that unseasoned beech was only 44 per cent as strong in tension perpendicular to the grain at 180 F as at 70 F. Stiffness at 180 F was reduced to 38 per cent of its value at 70 F. Goulet (11) found that unseasoned oak, beech, and spruce were only 20-45 per cent as strong at 212 F in transverse tensile strength as at 68 F. McMillin (22) found similar decreases in strength at elevated temperatures for yellow birch and redwood.

Reduced strength of wood at elevated temperatures causes veneer cutting to take place with lower stresses in the wood. Veneer-cutting forces are, therefore, reduced at high temperatures. Reduced cutting forces result in lowered requirements for power, and less wear on the knife when veneer blocks are heated.

Moist heating causes wood to soften, or plasticize, so that it can be deformed more easily before failure occurs. Fleischer (7) pointed out that heating caused a plasticising that permitted wood to bend sharply near the knife edge with reduced tendency for formation of lathe checks.

Chemical and structural changes occur in wood when steamed, according to Plath (23). He pointed out that both time and temperature are important factors in steaming wood. Optimal steaming times for beech were given as 100-120 hours at 176 F, or 35-50 hours at 212 F.

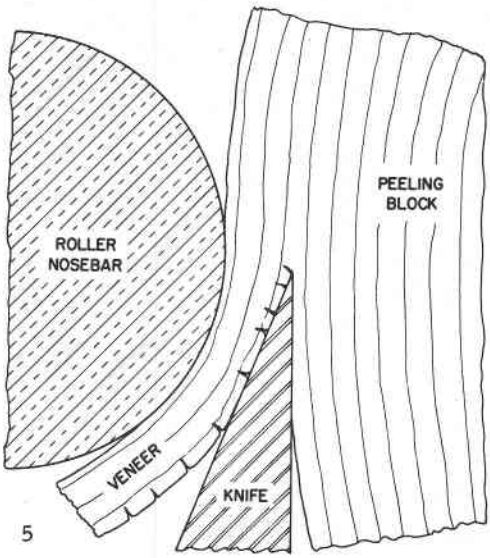


Figure 1. Relationship of roller nosebar, knife, and wood when peeling rotary-cut veneer.

PROCEDURE

The general plan was to select Douglas fir logs 20-24 inches in diameter, each of which was uniform in appearance and from which 4 blocks 4 feet in nominal length could be obtained. Each was heated to a different temperature, then all blocks from a given log were peeled under the same conditions on the same lathe. Veneer obtained was evaluated and compared for quality.

Tests were conducted at 2 plants by the same general plan, but with somewhat different details.

Log selecting

A Number 2 Sawmill log about 26 inches in diameter, with 262 annual rings (Figure 2), was selected from the log pond of plant I. Four blocks of nominal 4-foot length were sawed from the test log.

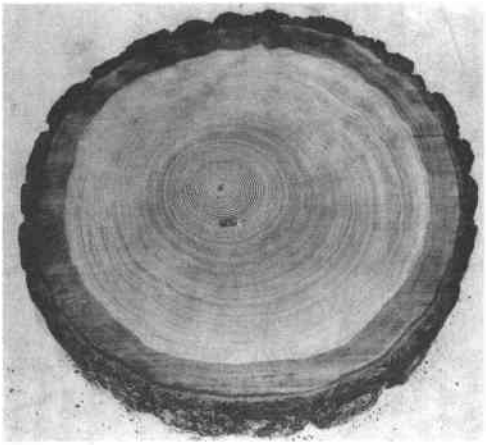


Figure 2. Section from log tested at plant I.

At plant II, 4 logs were selected from the mill pond to include fast and slow growth. Fast growth was represented by log A, which was 24-26 inches in diameter with 125 annual rings, and log C, which had 117 rings and was about 24 inches in diameter. Slow growth included log B with 383 annual rings and diameter of 24-26 inches, and log D with 379 rings and diameter of about 26 inches (Figure 3). Four blocks of nominal 4-foot length were sawed from each log (Figure 4), then debarked.

Block heating

Three of the debarked blocks from each log were placed in plywood boxes (Figure 5) for controlled-temperature steaming (Figure 4). The fourth block of each log was wrapped in wet burlap and maintained at room temperature.

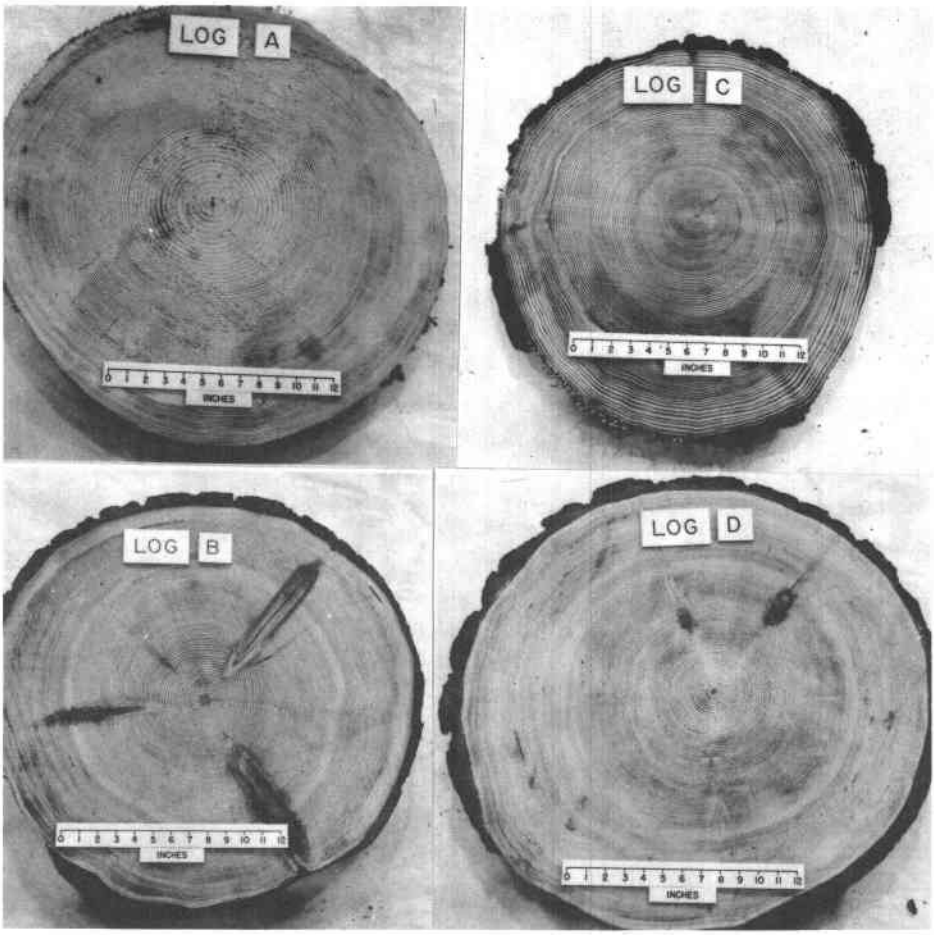


Figure 3. Coarse-grained log sections (A and C) and fine-grained log sections (B and D) at plant II.

Steaming boxes were maintained at constant temperature until thermocouples at depths of 2 and 10 inches mid-length of the bolt demonstrated differential in temperature less than 10 degrees F.

At plant I, blocks were heated for 103 hours. Temperatures of blocks at time of peeling were about 70, 120, 160, and 200 F.

At plant II, heating time was 68 hours. Temperatures of these blocks when peeled were about 70, 115, 142, and 178 F. Control of temperature was erratic for blocks from logs A and B at 115 F. These blocks were, therefore, omitted in final evaluation.

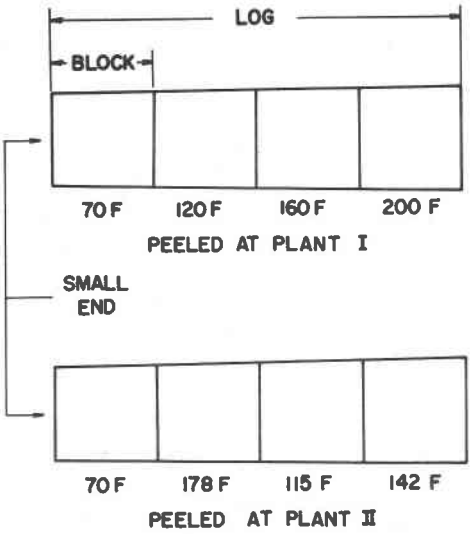
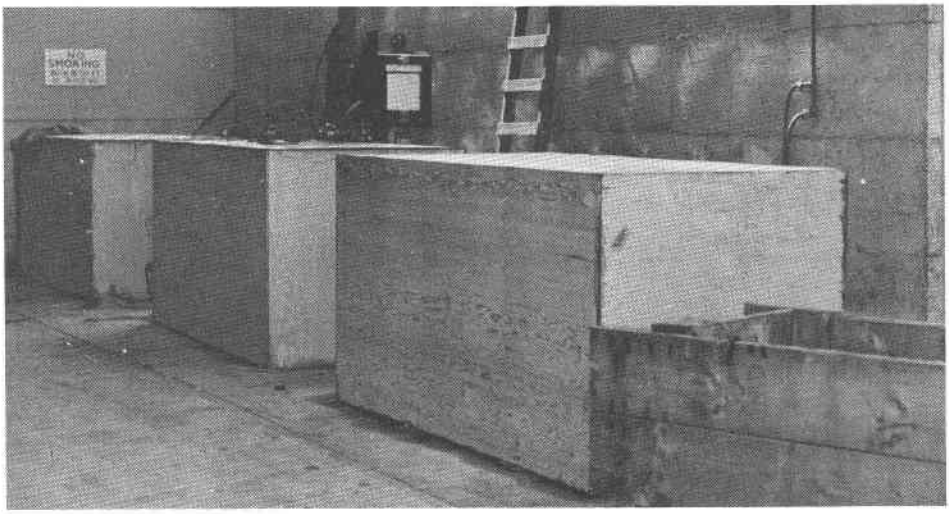


Figure 4. Location of peeling blocks in relation to logs and peeling temperatures.

Lathe setting

Lathes were a Coe Model M 242 at plant I, and a Bamford Premier at plant II; both were 66 inches in length. To peel nominal 1/10-inch veneer, the lathe at plant I advanced 0.100 inch each revolution and at plant II, 0.106 inch a revolution. Lathes at both plants had 5/8-inch diameter, power-driven, roller nosebars.

Figure 5. Plywood boxes for controlled-temperature steaming.



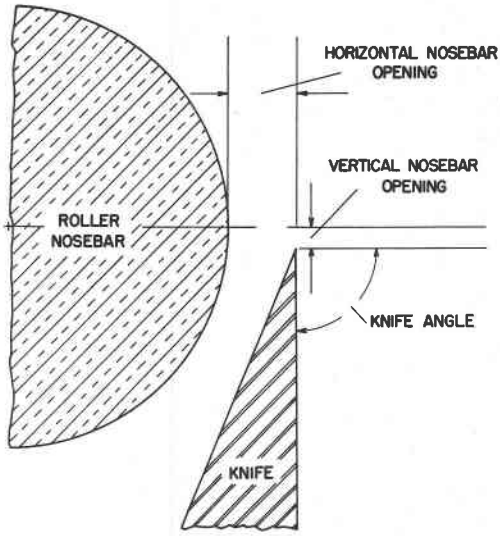


Figure 6. Angles and openings measured to describe settings of the lathes.

Prior to peeling for test, a newly sharpened knife was installed. The 5/8-inch-thick knives were ground with bevels of 22 1/2 degrees at plant I, and 23 degrees at plant II (Figure 6).

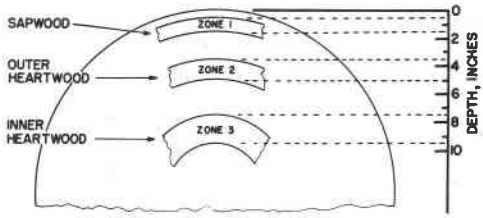
Several preliminary blocks were peeled while the operator adjusted the lathe so that, in his opinion, a good-quality peel was being obtained. The settings then were measured.

Angle of the knife was measured with a machinist's protractor. At plant I, the angle varied from 89 3/4 to 90 1/2 degrees, depending on position of the carriage. At plant II, the angle was virtually 90 degrees at all carriage positions. When angle of the knife is 90 degrees, the knife surface facing the block being peeled is vertical.

Vertical opening of the nosebar, or height of the center line of the nosebar above the edge of the knife, was 1/32 inch at plant I and 3/32 inch at plant II. Vertical opening of the nosebar at plant II was greater than normal.

Horizontal opening of the nosebar was 0.070 inch without a block in the lathe at plant I. A larger opening likely existed when there was pressure on the nosebar during peeling. At plant II, 2 settings for opening of the nosebar were made for each block peeled. With a block in the lathe, a horizontal opening for the nosebar of 0.095 inch measured at ends of the block was selected for low pressure, and a horizontal opening of 0.080-0.085 inch was selected for high pressure. An indicator was placed on the adjusting mechanism so the same setting could be obtained for each block.

Figure 7. Locations of zones in peeler blocks at plant I where veneer was obtained for testing.



Veneer peeling

Test veneer was obtained from sapwood and 2 zones in heartwood, as shown in Figure 7 for blocks at plant I. Zones were similar at plant II, except that zone 3 was 2 inches nearer the periphery of the log, adjacent to zone 2.

At plant I, all blocks were peeled at 150-250 feet a minute within 15 minutes after being removed from steaming boxes. Lathe settings were not changed during peeling. Veneer peeled from each zone was marked with an appropriate color at the lathe so it could be separated and identified after clipping. All veneer was clipped to nominal width of 27 inches.

At plant II, the horizontal opening of the nosebar was set at 0.095 inch for zones 1 and 2, but for zone 3 the lathe was stopped, and the horizontal opening of the nosebar was set at 0.080-0.085 inch. Other procedure in peeling was the same at both plants.

All veneer was dried at the plant on a normal schedule for sapwood of about 20 minutes at 350 F.

Veneer evaluating

Strength, thickness, and condition of the veneer were measured for veneer from all bolts.

Thickness. Thickness of undried veneer was measured at 3 locations at about 6 inches from either end and at mid-length on 16 sheets

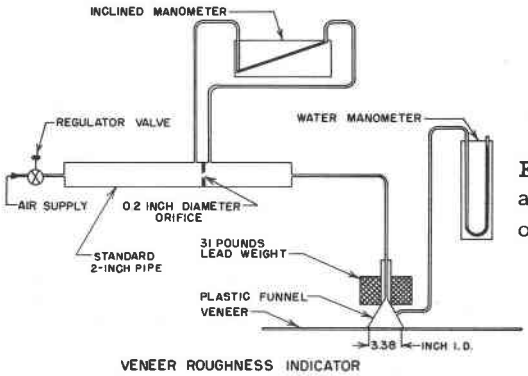


Figure 8. Schematic diagram of apparatus for gauging roughness of veneer.

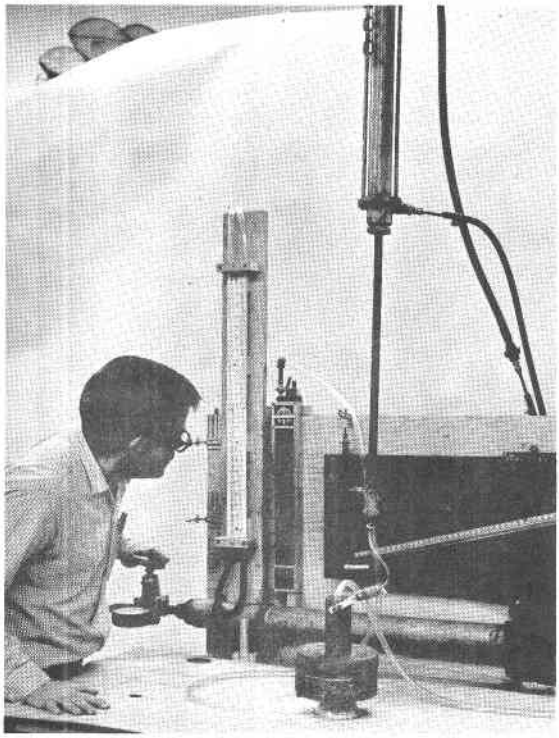


Figure 9. Measuring roughness of veneer by relating it to flow of air between the veneer and the lips of a weighted funnel.

from each lot at plant I and on 20 sheets from each lot at plant II.

Veneer from plant I was measured for thickness in the dried condition after storing at conditions for 12 per cent equilibrium moisture content. About 50 sheets of heartwood only were measured.

Splits. Number and length of splits in each sheet were determined after drying. At plant I, some sheets of sapwood veneer were folded over in clipping, so only heartwood was included in results from that mill. At plant II, splits were measured in undried as well as dried veneer from logs C and D.

Roughness. Relative roughness of veneer was measured by an air-flow arrangement similar to one used by Collins (4) (Figure 8, 9, 10).

A plastic funnel 3.38 inches in diameter was held by a 31-pound lead weight on the veneer surface to be measured. Air flowing into the funnel was regulated by a valve so that a constant pressure of 10 inches in a water manometer was maintained inside the funnel. Flow of air required to maintain this pressure was indicated by drop in pressure across a 0.2-inch orifice in a 2-inch pipe. Since flow of air is proportional to the square root of drop in pressure, relative roughness was

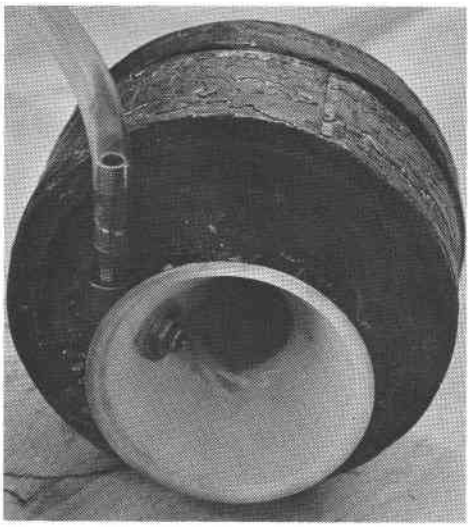


Figure 10. Weighted plastic funnel for measuring roughness of veneer.

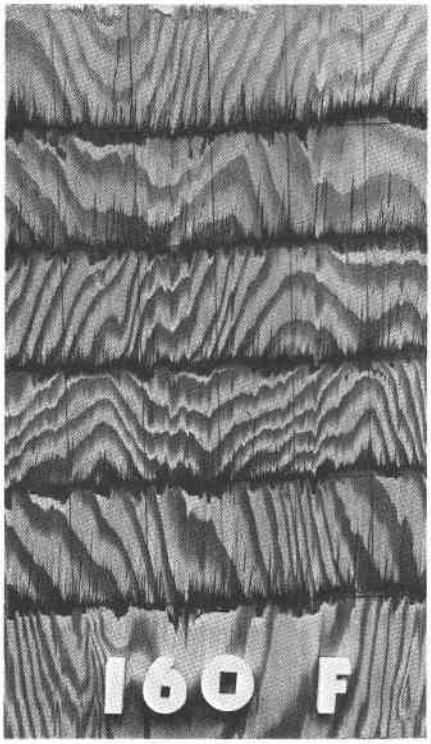


Figure 11. A scarfed specimen of stained veneer from plant I, marked for measuring lathe checks.

calculated by taking the square root of the difference in pressure across the orifice.

At plant I, up to 20 sheets of veneer were measured for roughness from each lot of heartwood, and 10 from each lot of sapwood. In some lots, fewer sheets of veneer were measured since the number indicated was not available. At plant II, 20 sheets of veneer from each lot were measured for roughness.

In measuring roughness, the funnel was placed at the approximate center of each sheet. Knots or splits in the veneer were, of course, avoided.

Depth of lathe checks. The stain-scarf technique described by Batey (2) served for evaluation of lathe checks. Ten pieces of veneer from each lot, each 8 by 12 inches in area, were brushed with an alcohol-soluble dye (nigrosine) on the loose side. For scarfing, 5 veneers were glued together, trimmed, and then planed to a slope of about 1 in 12. Scarfed surfaces were marked into divisions each one-inch wide (Figure 11). Maximum and average depth of lathe check was measured in each division and expressed as a percentage of the veneer's thickness.

Tensile strength across grain. Twenty specimens of veneer 1 inch wide by 8 inches long were tested from each lot for tensile strength perpendicular to grain (Figure 12). Head speed of the universal tester was 0.05 inch a minute, and load was measured to the nearest 0.1 pound with an air cell. If a specimen broke at the grips, that specimen was discarded and another tested. Specimens were tested after storage at conditions for 12 per cent equilibrium moisture content.

Bending strength. Specimens for bending were 1 inch wide by 8 inches long and were tested with a 6-inch span (Figure 13). Head speed was 0.3 inch a minute with veneer from plant I and 0.1 inch a minute with veneer from plant II. One bending specimen at plant II and 2 at plant I were tested from each of 10 sheets of veneer from each lot. All specimens were tested after storage under conditions for 12 per cent equilibrium moisture content.

Modulus of rupture was calculated for all lots of veneer, but modulus of elasticity was calculated only for veneer from plant II.

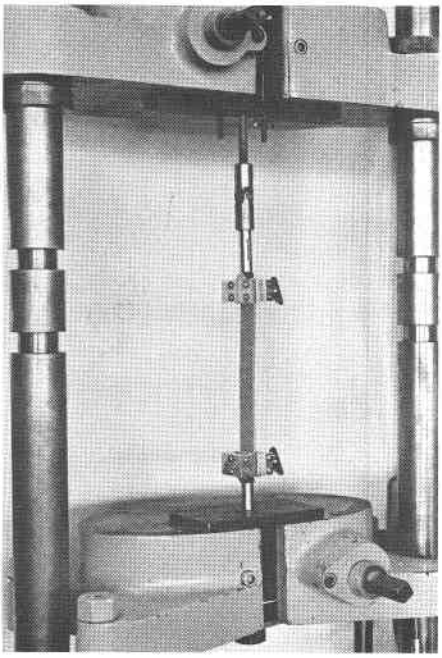


Figure 12. Veneer in test for tensile strength, with grips 6 inches apart.

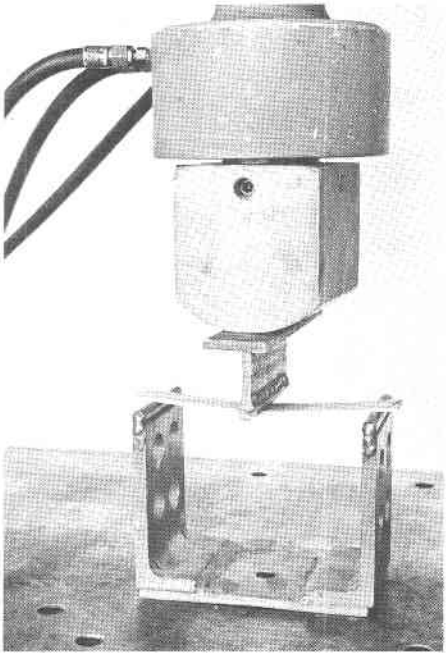


Figure 13. Veneer in test for bending strength over a 6-inch span.

RESULTS AND DISCUSSION

When examining results of tests, note that conditions were not the same at the two plants. There were different lathes, different lathe settings, different lathe operators, different logs, and probably different handling of the veneer during processing. Handling and processing of blocks and veneer at each plant were held as constant as possible from block to block. Precise control of peeling conditions and veneer handling was impractical, however.

Thickness

Average thickness of dried heartwood veneer from plant I was 0.096 inch. Temperature at peeling caused little variation in average thickness of veneer (Figure 14). Variation in thickness was greatest at 200 F and least at 120 F.

Average thickness of undried heartwood veneer from plant II was 0.106 inch with low pressure on the nosebar, and 0.102 inch with high pressure. Temperature at peeling did not appear to affect average thickness of veneer. There was no noticeable difference in average thickness between coarse- and fine-grained logs. There was a difference in average thickness of heartwood veneer at different horizontal openings of the nosebar. Veneer peeled with a horizontal opening of 0.080-0.085 inch was about 0.004 inch thinner than veneer peeled with a horizontal nosebar opening of 0.095 inch.

At plant II, undried heartwood veneer from coarse-grained logs showed more variation in thickness of veneer than did veneer from

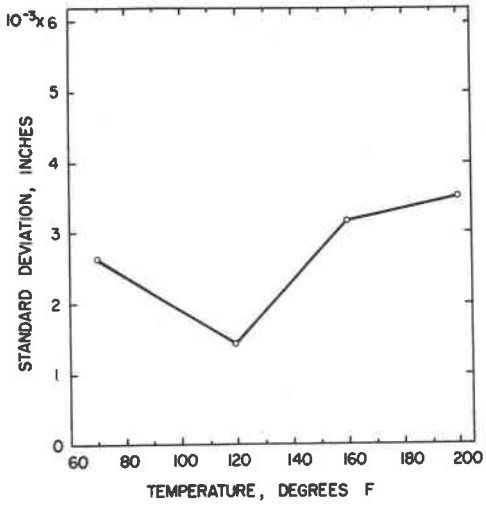


Figure 14. Standard deviation in thickness of dry veneer (12 per cent moisture content) with peeling temperature for veneer peeled from heartwood at plant I.

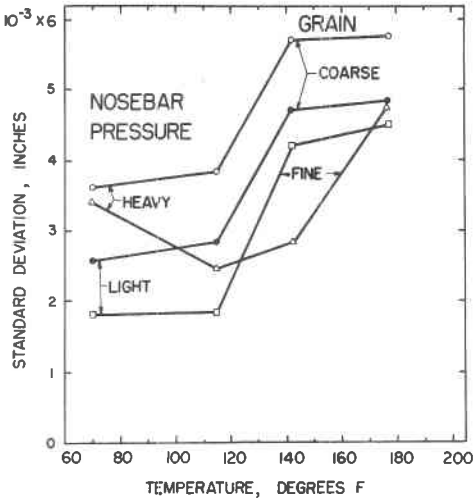


Figure 15. Effect of peeling temperature on variation in thickness of undried veneer peeled from heartwood at plant II.

fine-grained logs, and peeling temperatures of 142 F and 178 F resulted in greater variation in thickness than did peeling temperatures of 70 F and 115 F (Figure 15).

The significance of standard deviation is that normally 2/3 of all thickness readings would fall between the average thickness minus the standard deviation, and the average thickness plus the standard deviation. Also, 95 per cent of all readings for thickness would be expected to be between the average minus twice the standard deviation, and the average thickness plus twice the standard deviation. For example, if a certain group of veneer had a standard deviation for thickness of 0.004 inch and an average thickness of 0.100 inch, 95 per cent of all measurements of thickness taken on that lot of veneer would be expected to be between 0.092 and 0.108 inch.

Variation in thickness of veneer was not improved when blocks were heated before peeling. In fact, variation in thickness of veneer increased when blocks were peeled at 140 F and hotter. Fiehl (5) has pointed out that heated logs transmit heat to the lathe knife, nosebar, and carriage, which results in unequal expansion and nonuniform positions of the knife and nosebar. Thermal expansion of lathe components would help explain increased variation of thickness in veneer from heated blocks. Fiehl (5) also suggested methods for minimizing or eliminating distortion of the lathe.

Splits

In heartwood veneer at plant I, there was least splitting from blocks peeled at 160 F and most splitting at 200 F (Figure 16). Veneer peeled at 160 F at plant I had less than half as much splitting as veneer peeled at room temperature.

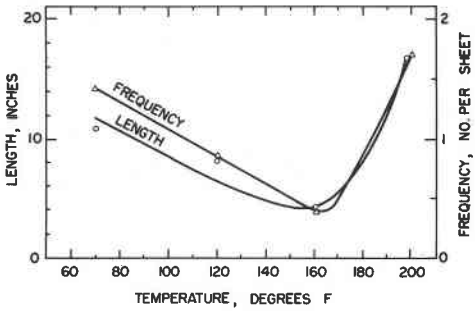


Figure 16. Effect of peeling temperature on average number and length of splits in a sheet of heartwood veneer after drying at plant I.

At plant II, depth in the log from which veneer was peeled did not appear to affect significantly splits in veneer. Splitting was about 40 per cent less in veneer from coarse-grained logs peeled at 115 F and 142 F than in veneer peeled at room temperature and 178 F (Figure 17). Veneer from fine-grained logs had about the same average length of splits when peeled at room temperature and at 142 F. Veneer from fine-grained logs, in general, exhibited less splitting than veneer from coarse-grained logs. A comparison of veneer from 2 logs before and after drying indicated about the same extent of splitting. Splits in veneer, at least for these 2 logs, must have occurred mainly before drying.

Veneer split least, in general, when peeled at 120-160 F, except for fine-grained logs from plant II peeled at 115 F. Reduced splitting in veneer from blocks heated to intermediate temperatures may be explained in part by the fact that heated veneer has shallow lathe checks and should, therefore, be strong perpendicular to grain. Strength of wood is reduced as temperature increases, so the weakening effect of temperature may be more important than reduced lathe checks at temperatures over 160 F. The explanation of weakening of the wood across the grain caused by lathe checks would also help explain the exception of the fine-grained log having more splits at 115 F, since it also had deep

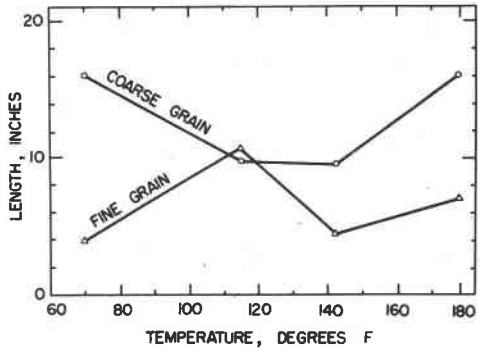
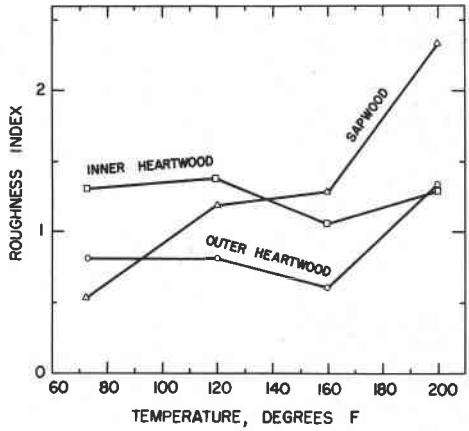


Figure 17. Effect of peeling temperature on length of splits in veneer from all zones after drying at plant II.

Figure 18. Effect of peeling temperature on roughness of veneer from test at plant I.



lathe checks at that temperature. Amount of splitting in the veneer appeared inversely related to tensile strength perpendicular to the grain.

Roughness

Temperature when peeled had only slight effect on roughness of veneer peeled from heartwood (Figure 18). Sapwood veneer gave higher readings for roughness when peeled at high temperatures. Veneer surfaces at different values of relative roughness are shown in Figure 19.

At plant II, there was little effect of peeling temperature on roughness of veneer from fine-grained logs (Figure 20). Coarse-grained logs, however, showed increased roughness when peeled at high temperatures (Figure 21). Veneer from coarse-grained logs was rougher than that from fine-grained logs.

The increased roughness found at high peeling temperatures is contrary to findings of other investigators (9, 19, 22). One factor that might explain this difference in findings is perhaps that different settings of the lathe and type of nosebar would result in a different roughness-temperature relationship. Another consideration is that roughness was measured by different methods. Most investigators have reported values for roughness of veneer measured by the light-shadow technique of Lutz (20), but an air-flow system was used in this study. A check with a professional veneer grader showed that only a small portion of veneer would have been degraded for roughness, even though the roughness index was high.

Roughness of veneer was not related directly to lathe checking. In fact, rougher veneer was obtained at high temperatures when lathe checks had minimum depth.

Lathe checks

In heartwood veneer from plant I, average depth of lathe checks

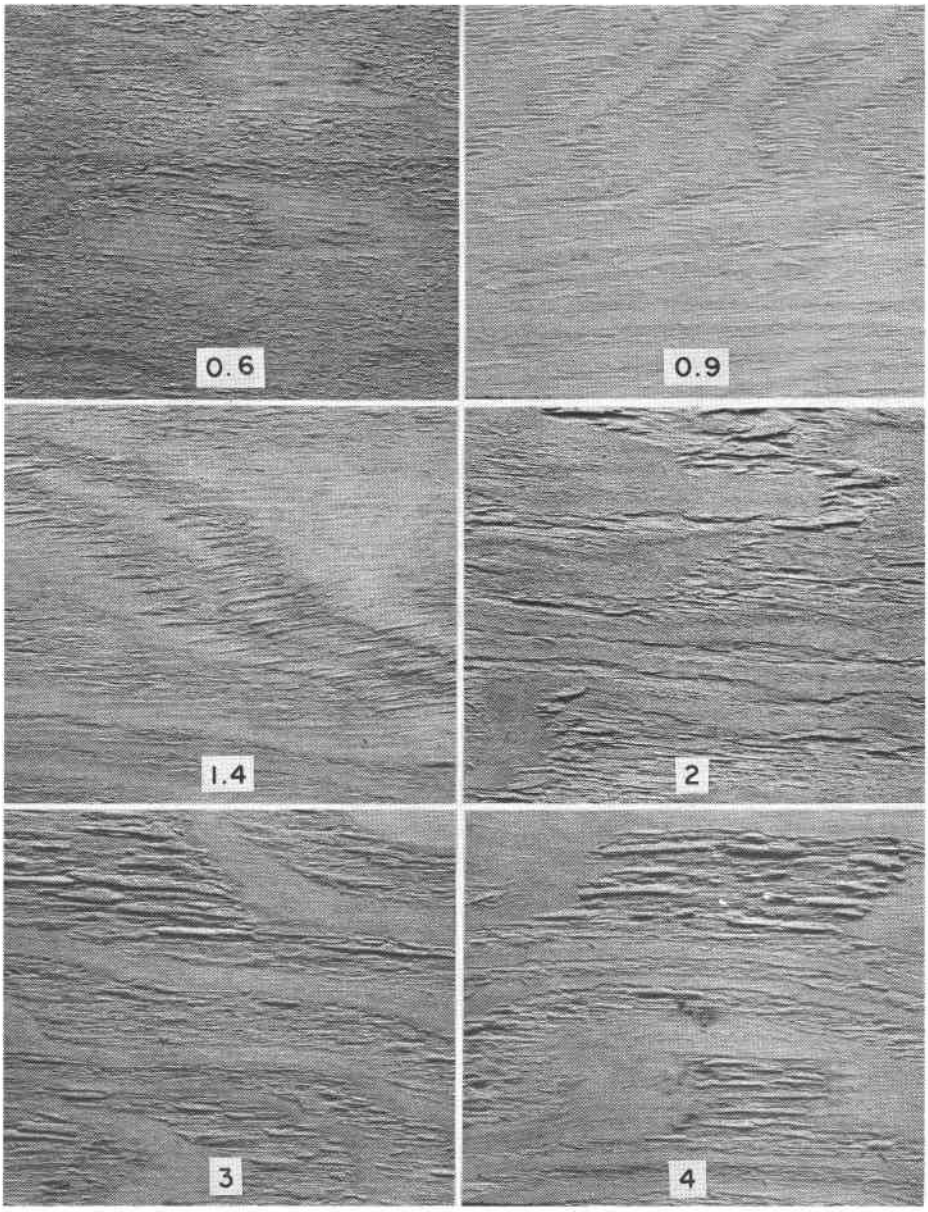


Figure 19. Photograph showing surfaces of veneer with numbers for relative roughness as indicated by apparatus for measuring flow of air.

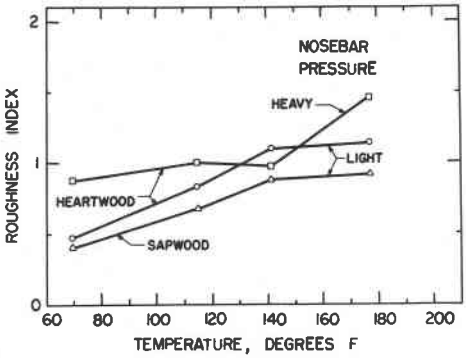


Figure 20. Effect of peeling temperature on roughness of veneer from fine-grained logs peeled at plant II.

decreased as temperature at peeling increased (Figures 22, 23).

In general at plant II, sapwood veneer had lathe checks deeper than those in heartwood veneer; veneer from coarse-grained logs had lathe checks deeper than those in veneer from fine-grained logs; heavy pressure on the nosebar and high peeling temperatures reduced depth of lathe checks (Figures 24, 25, 26, 27).

The relationship of peeling temperature to average depth of lathe checks was similar to that shown in Figures 22, 24, and 26 for maximum depth, but average checks were about 20 percentage points less in depth.

Depth of lathe checks in the veneer, in general, decreased as peeling temperature was increased. Other investigators (9, 10, 12, 13) have reported a similar effect of peeling temperature. Batey (3) and Jayne (14) suggested an average depth for lathe checks of about 50 per

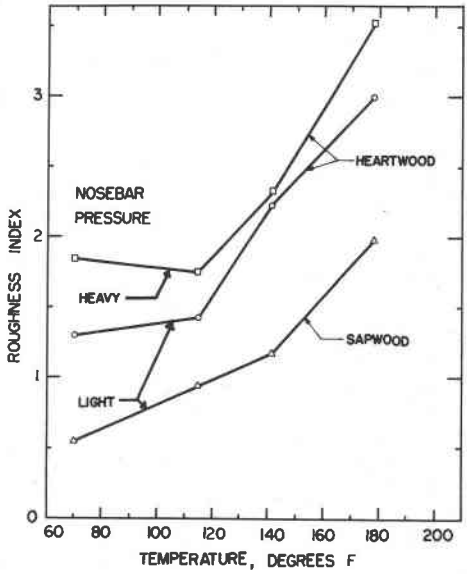


Figure 21. Effect of peeling temperature on roughness of veneer from coarse-grained logs peeled at plant II.

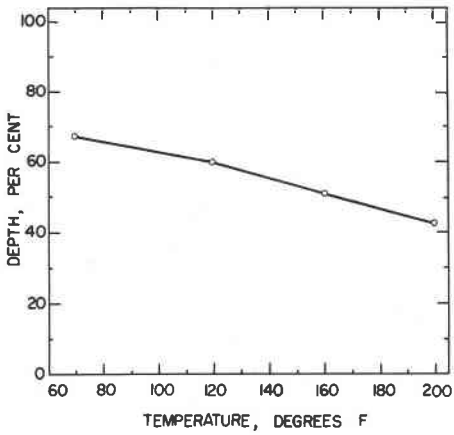


Figure 22. Averages of maximum depths of lathe checks, based on thickness of veneer, at various peeling temperatures for heartwood from plant I.

cent of the veneer's thickness as the dividing point between loose and tight veneer. By this criterion, fine-grained logs peeled with light pressure on the nosebar produced veneer that was about at the dividing point between tight and loose veneer. At peeling temperatures over 140 F, all veneer from fine-grained logs would have been considered tight at all pressures tried on the nosebar. Increased pressure on the nosebar resulted in heartwood veneer from fine-grained logs that was decidedly tight, even at room temperature.

Veneer from coarse-grained logs (Figure 26) would have been considered loose when peeled at room temperature with light pressure on the nosebar. When peeled at temperatures over 140 F, the heartwood veneer would have been considered tight even at light pressure on the nosebar. Heartwood veneer from coarse-grained logs peeled at room temperature and heavy pressure resulted in veneer that also would have been considered tight.

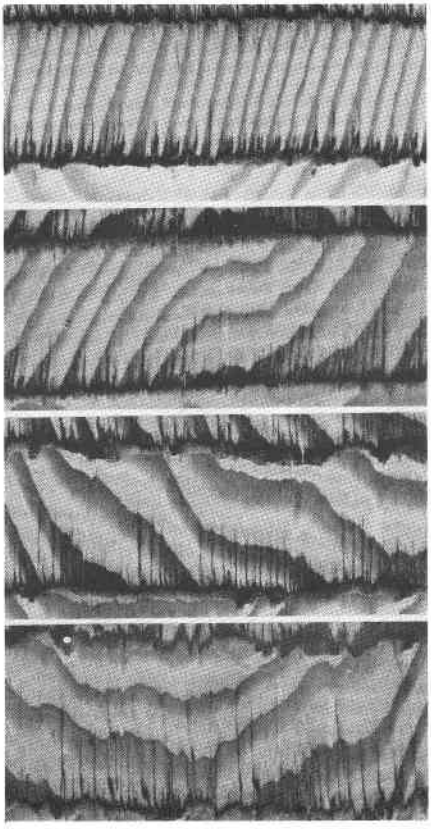
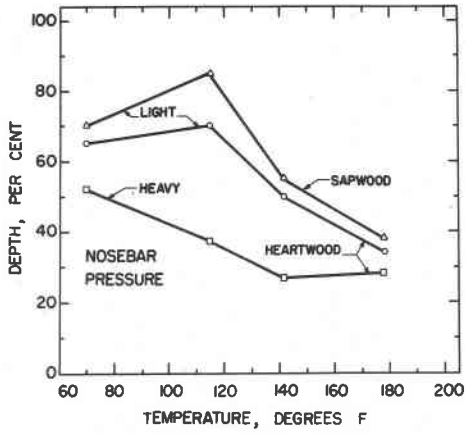


Figure 23. Stained and scarfed veneer from plant I, illustrating effect of peeling temperature on lathe checks. Peeling temperatures (from top to bottom) were 200 F, 160 F, 120 F, and 70 F.

Figure 24. Averages of maximum depths of lathe checks, based on thickness of veneer, at various peeling temperatures for veneer from fine-grained logs at plant II.



Lutz (19) stated, "Perhaps the most important beneficial effect of heating the bolts is that tight veneer may be cut without excessive nosebar pressure." Results from the present study lead to the same conclusion. Tight veneer is stronger across the grain, so less splitting and breakage occur through all veneer-handling operations. Batey (3) and Jayne (14) have pointed out the importance of veneer tightness on minimizing face-checking of plywood.

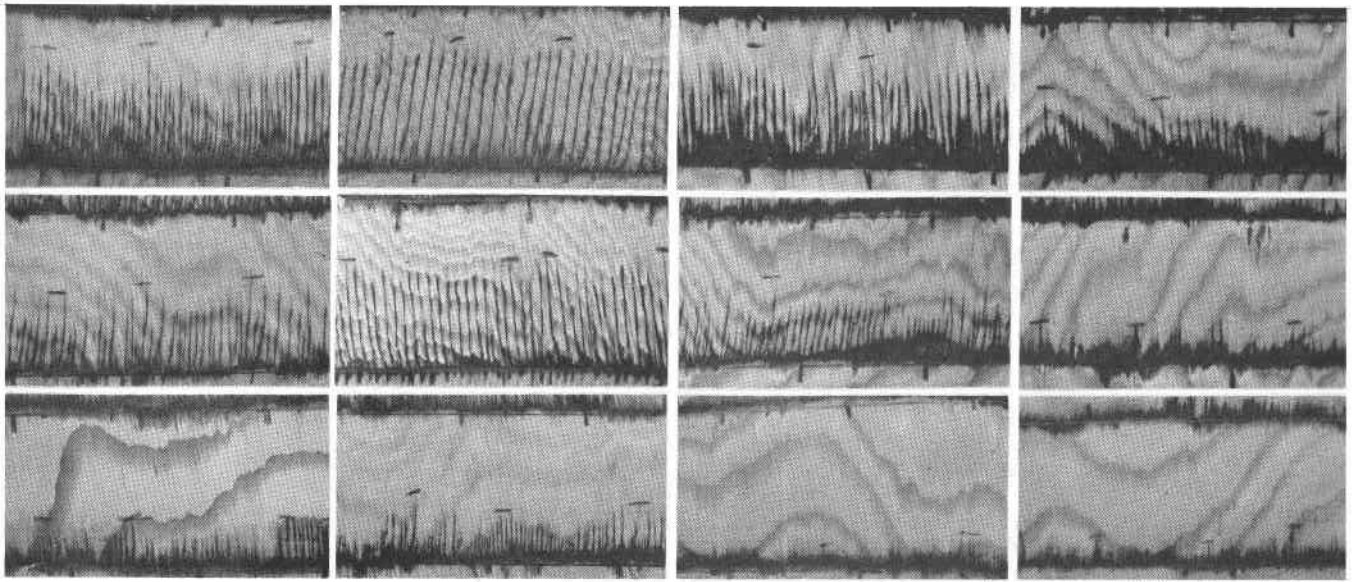
Tensile strength across grain

At plant I, heartwood veneer had tensile strength across the grain greater than that of sapwood veneer, and maximum strength occurred with veneer peeled at 160 F (Figure 28).

For veneer peeled at plant II, veneer from coarse-grained logs resulted in highest tensile strength across the grain when peeled at 142 F (Figure 29). Veneer from fine-grained logs was consistently stronger in cross-grain tensile strength than was veneer from coarse-grained logs (Figure 30).

Tensile strength of veneer perpendicular to the grain could be expected to be related inversely to depth of lathe checks, since checks reduce the area of unfailed wood in sections parallel to the grain. A comparison of Figures 28, 29, and 30 with Figures 22, 24, and 26 shows that, indeed, there is a close inverse relationship between tensile strength and depth of lathe checks. Deep lathe checks are, in general, associated with low tensile strength perpendicular to the grain. Maximum tensile strength perpendicular to grain had, in general, been reached at a peeling temperature of about 140 F.

Heartwood veneer peeled with light pressure on the nosebar was from a different zone in the log than heartwood veneer peeled at heavy pressure. Difference in veneer might, therefore, be a result of origin



70 F 115 F 142 F 178 F

Figure 25. Lathe checks in typical scarfed veneer peeled at indicated temperatures from fine-grained log D at plant II. Pieces in top row were from sapwood zone peeled with low pressure on the nosebar; middle row, heartwood with low pressure; and bottom row, heartwood with high pressure on the nosebar.

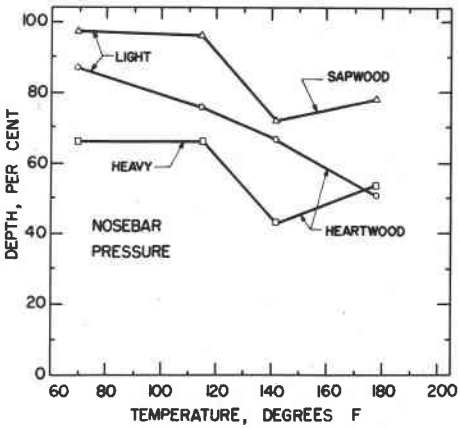


Figure 26. Averages of maximum depths of lathe checks, based on thickness of veneer, at various peeling temperatures for veneer from coarse-grained logs at plant II.

in the log, as well as pressure on the nosebar. Tensile strength perpendicular to grain was higher for veneer peeled at light pressure and 140 F than for veneer peeled at room temperature with heavy pressure on the nosebar, although the lathe-check depth was greater with light pressure. The above condition suggests that perhaps veneer was weakened when peeled at heavy pressure. Kivimaa (15) also reported that pressure on the nosebar above a certain optimum caused a decrease in tensile strength perpendicular to the grain. He attributed the decrease to permanent deformation in the fine structure of the wood caused by excessive pressure on the nosebar.

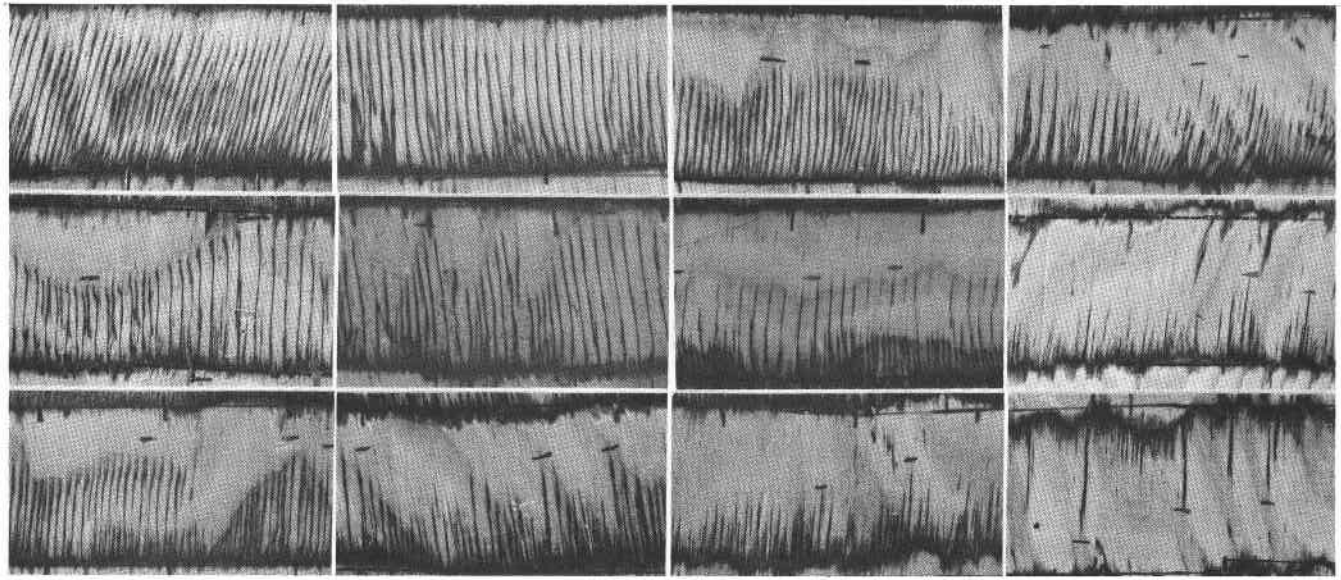
Bending strength

At plant I, elevated peeling temperatures increased the strength of heartwood veneer in bending parallel to the grain, an effect that was not evident in sapwood veneer (Figure 31). The average modulus of rupture of all heated veneer was 16,720 psi, or about 16 per cent more than the average of 14,410 psi for all unheated veneer peeled at plant I.

Bending strength of veneer from logs peeled at plant II was, in general, higher for veneer peeled at elevated temperatures (Figures 32, 33). Bending strength was not a maximum, however, at the highest peeling temperature of 178 F, but rather at 115 F. The average modulus of rupture was 10,730 psi for all veneer peeled at room temperature, or about 14 per cent higher than the average of 12,230 psi for all veneer peeled from heated blocks.

Depth of lathe checks did not seem to affect strength in bending parallel to grain (compare Figures 32 and 33 with 22 and 24).

Heartwood veneer peeled with heavy pressure on the nosebar was generally weaker in bending strength than when peeled with light pressure. As suggested previously, the low strength at heavy pressure indicates that overcompression weakened the wood.



70 F 115 F 142 F 178 F

Figure 27. Lathe checks in typical scarfed veneer peeled at indicated temperatures from coarse-grained log "C" at plant II. Pieces in top row were from sapwood zone with low pressure on the nosebar; middle row, heartwood with low pressure; and bottom row, heartwood with high pressure on the nosebar.

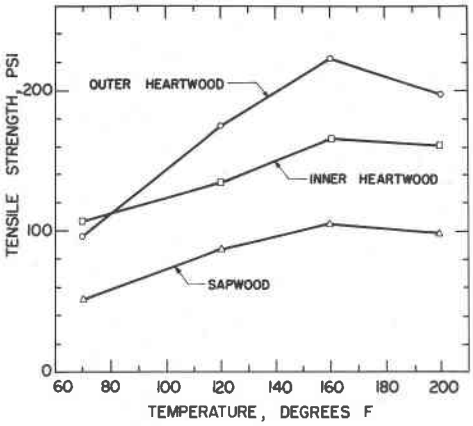


Figure 28. Average tensile strength perpendicular to the grain of veneer from plant I peeled at various temperatures.

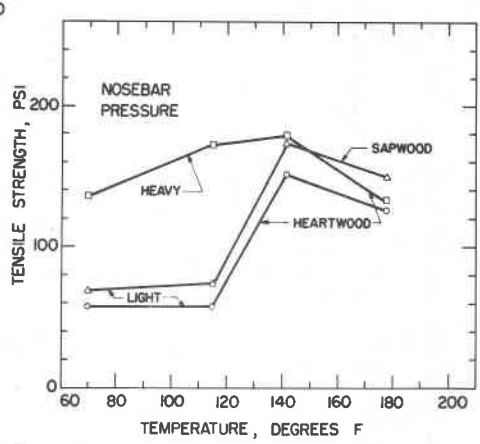


Figure 29. Average tensile strength perpendicular to the grain of veneer from coarse-grained logs at plant II peeled at various temperatures.

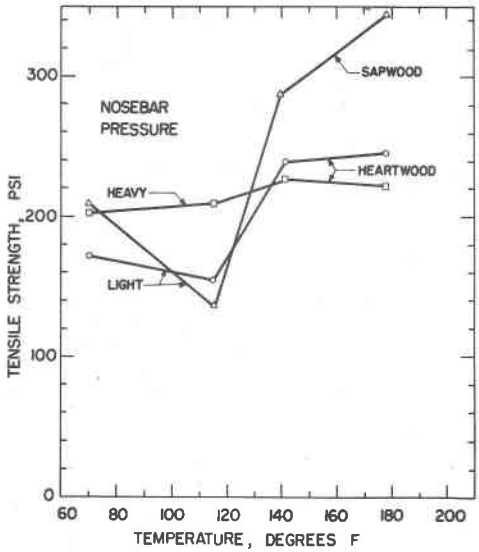


Figure 30. Average tensile strength perpendicular to the grain of veneer from fine-grained logs at plant II peeled at various temperatures.

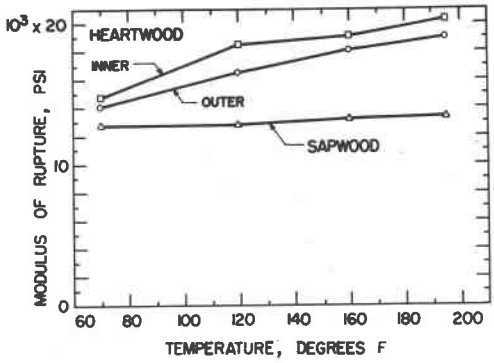


Figure 31. Average bending strength parallel to grain of veneer from plant I peeled at various temperatures.

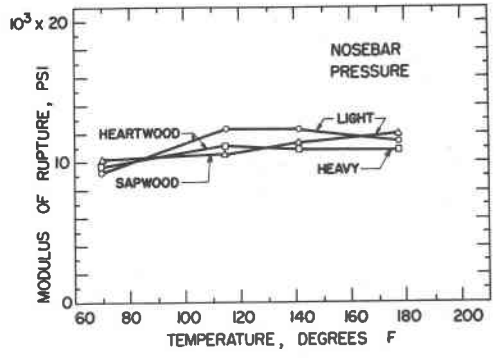


Figure 32. Average bending strength parallel to grain of veneer from coarse-grained logs at plant II peeled at various temperatures.

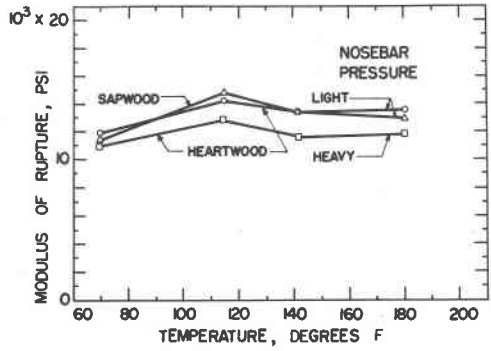


Figure 33. Average bending strength parallel to grain of veneer from fine-grained logs at plant II peeled at various temperatures.

Location of the peeling blocks along the length of the log may affect strength. Wangaard (25) found that density and strength of Douglas fir decreased with increase in height above the ground. Maximum differences in strength with position were found near the base of the tree. Wangaard (25) reported a difference in modulus of rupture of 7.4 per cent between 10 feet and 22 feet above ground, or a distance of 12 feet along the log. Since the blocks peeled at room temperature were from

the small diameter of the log, inherent strength of the wood at the large end might be 7-8 per cent greater.

Since strength in bending parallel to the grain for veneer from heated blocks averaged about 15 per cent greater than for the veneer from unheated blocks at the small end of the log, about half of this increase may be assumed due to position in the log and half due to heating. Although results from the study are not conclusive, they indicate some increase in strength may result when veneer is peeled from heated blocks.

Plath (23) reported an increase in strength of veneer when logs were steamed before peeling. He suggested that the increase was caused by reserve starch in the tree coalescing into a homogenous mass under the influence of water and heat. Plath also pointed out the importance of time as well as temperature during steaming. If steaming were continued for an excessive time, water-soluble components of the starch were said to dissolve, and "shelling" or separation of springwood and summerwood would become evident. There was evidence of this phenomenon with veneer from the block heated to 200 F for 103 hours at plant I.

Additional observations

Veneer peeled at 200 F at plant I exhibited pronounced shelling--characterized by darkening, especially of the summerwood--and separation of the wood at the springwood-summerwood boundaries. Shelling was especially pronounced in sapwood veneer, but also was noticeable in heartwood veneer (Figure 34).

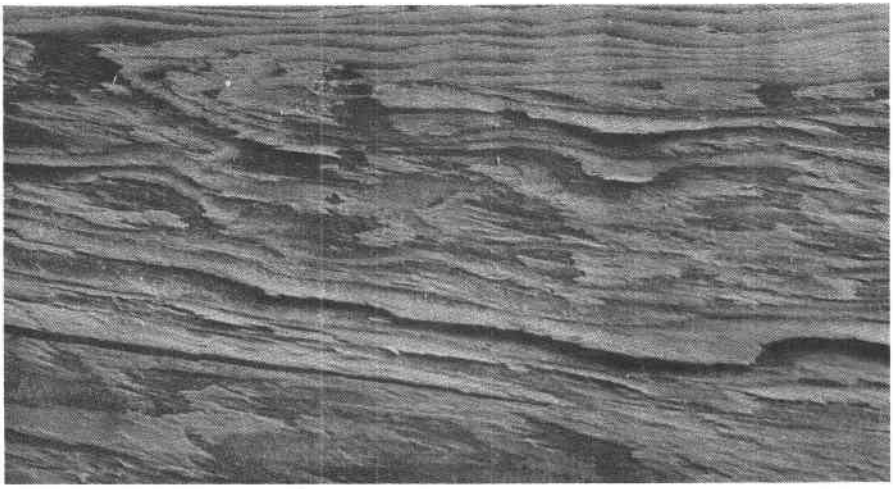


Figure 34. Shelling, or separation of wood at boundaries between springwood and summerwood, in sapwood veneer peeled at 200 F.

At plant II, the block peeled at 180 F from log B developed small, localized projections or bumps of wood directly behind the knots when near the core (Figure 35). These projections occurred immediately after the knife had passed through the knot. The projections may have been caused by excessive pressure on the nosebar.

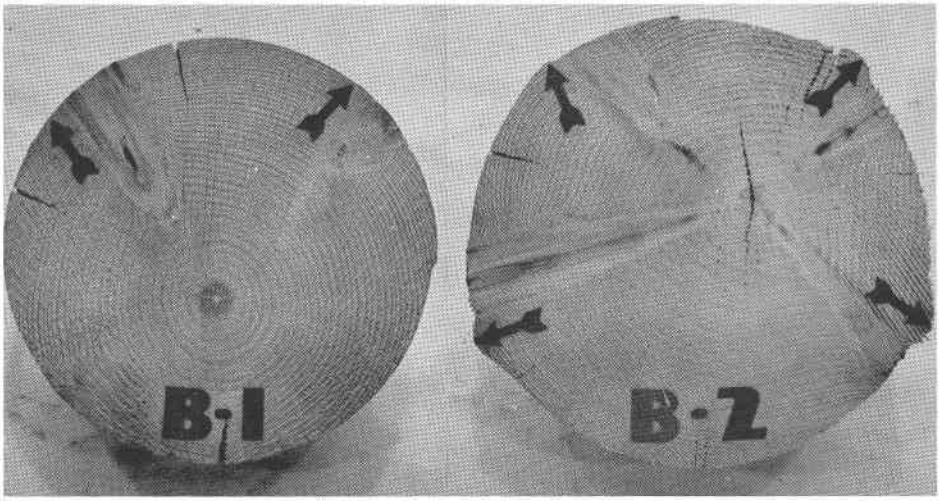


Figure 35. Cross sections of cores from log B after peeling, illustrating projections of wood directly behind knots on the block peeled at 180 F (B-2) and absence of projections on the block peeled at room temperature (B-1).

CONCLUSIONS

The most important measure of quality of veneer probably is tightness, or depth of lathe checks that result from peeling. Tensile strength perpendicular to the grain and splitting of veneer during processing are related closely to tightness.

Heated blocks produced veneer that was tighter than veneer from unheated blocks. Depth of lathe checks was less, and tensile strength perpendicular to the grain was greater, for veneer peeled from heated blocks. Other investigators have noted similar results.

Pressure on the nosebar had marked influence on quality of the veneer. Depth of lathe checks was reduced greatly at heavy pressure on the nosebar, especially at room temperature. There was evidence, however, that heavy pressure caused excessive compression that weakened the wood.

Roughness of veneer and variation in thickness were not improved by heating the blocks before peeling. Measurements by an airflow system indicated increased roughness at high peeling temperatures. This finding was contrary to reports of other investigators, who used optical methods for measuring roughness of veneer.

There appeared to be a slight increase in strength of veneer parallel to grain when blocks were heated before peeling. This increase in strength may have been caused by the reaction of moist heat on the wood during steaming. The same reaction, when continued too long, or at too high a temperature, also may explain the shelling, or separation of wood at the springwood-summerwood boundaries, that was noted in veneer from the block steamed at 200 F for 103 hours. Further tests are suggested to confirm the increase in strength parallel to grain found for veneer from heated blocks and also to explore temperature-time relationships.

From results obtained in the study, the optimum temperature for peeling Douglas fir appears to be about 140 F.

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