EFFECT OF WOOD GRAIN AND VENEER SIDE ON LOBLOLLY PINE VENEER WETTABILITY

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ABSTRACT

Research was initiated to determine the effect of veneer side (tight or loose), and wood grain (earlywood or latewood) on the wettabiiity of loblolly pine veneer. Contact angle measurements were performed with phenol-formaldehyde resin and distilled water. The resin and distilled water showed slightly higher contact angle mean values on the latewood portion for both the tight side and loose side. The distilled water showed lower contact angle mean values on the loose side compared to the corresponding resin values on the loose side. This difference is largely attributable to the differences in the surface tension of these two wetting materials, and the ability of the distilled water to more easily penetrate on the loose side of veneer.

Numerous previous researchers have shown that the wcttability of wood as determined through contact angle assessment is intimately associated with glueline integrity (2,4,9,14). The principle of equilibrium contact angle and its methods of determination on wood surfaces was detailed by Gray (5). Herczeg (7) discovered that bond strength is dependent on wetting, spreading, and surface tension. Bryant (3) found that bond quality is influenced by the wettability of wood, resin, and chemical interactions between the resin and the wood surface.

Wellons (15) found that Douglas-fir veneer becomes less wettable as the moisture content (MC) decreases at ambient temperature. Also, at hot-press conditions, the gluability is not inhibited by low wettability; instead, the adhesive film is likely to dry out. Suchsland and Stevens (14) studied the gluability of southern pine veneer dried at high temperatures and found it feasible to dry veneer at temperatures in excess of 500°F. The importance of phenol-formaldehyde resin formulation on wettability of southern pine veneer was investigated by Hse (9). Hse's research showed the contact angle decreased as molar ratios of sodium hydroxide to phenol increased and ratios of formaldehyde to phenol decreased. Contact angle was not correlated with solids content. The Hse study is one of the few studies that addressed wettability differences between southern pine earlywood and latewood. Hse found the contact angle on earlywood was less than that on latewood.

The objective of this study was to determine the differences in the wettability, using both phenol-formaldehyde resin and distilled water, of loblolly pine veneer by contact angle measurement due to veneer side (tight and loose sides) and wood grain (earlywood and latewood).

MATERIALS AND METHODS

A detailed description of the veneer processing methods is given by Shupe et al. (12) and of the forest stands by Baker and Bishop (1). In summary, five representative trees each from five silviculturally different loblolly pine (*Pinus taeda* L.) stands growing near Crossett, Ark., were harvested and bucked into peeler bolts (Table 1). Three of the silvicuhural regimes were even-aged and consisted of stand 1 (sudden sawlog), stand 2 (conventional), and stand 3 (natural regeneration). The term sudden sawlog originated

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TABLE 1. — Basic stand information mean values of the five harvested loblolly pine trees from the five stands growing near Crossett, Ark. (12).

Stand	Age	Height	DBH[a]	Basal area	Site index	Live crown ratio[b]
	(yr.)	(ft.)	(in.)	($ft.^2$/acre)		(%)
1 - Sudden sawlog	48	94 2	21.1	90	95	56
2 -Conventional	48	93.8	15.3	118	95	39
3 - Natural	48	98.6	16.4	76	100	39
4 - Single tree	49	88.6	16.4	72	89	55
5 - Crop tree	79	110.2	24.7	42	97	56

[a] Diameter at breast height.
[b] Live crown ratio = (length of live crown/total length of tree) x 100.

TABLE 2. — Mean contact angle values, measured in degrees, obtained using commercial phenol-formaldehyde resin and distilled water. Each mean value represents 60 observations.

Stand	Tight side		Loose side		Mean
	Earlywood	Latewood	Earlywood	Latewood	
			Phenol-formaldehyde resin		
1	53.18 (0.12)[a]	54.07 (0.18)	52.67 (0.16)	55.15 (0.10)	53.77
2	52.85 (0.18)	54.27 (0.18)	52.10 (0.21)	54.47 (0.15)	53.42
3	51.67 (0.16)	52.12 (0.14)	48.02 (0.24)	54.17 (0.14)	51.50
4	49.43 (0.13)	51.30 (0.11)	48.85 (0.25)	52.73 (0.16)	50 58
5	49.18 (0.14)	50.85 (0.12)	46.35 (0.25)	53.92 (0.12)	50.08
			Distilled water		
1	53.53 (0.14)	55.23 (0.08)	38.60 (0.15)	42.20 (0.17)	47.39
2	52.50 (0.13)	54.43 (0. IO)	37.97 (0.14)	45.43 (0.21)	47.58
3	53.85 (0.14)	55.00 (0.11)	38.30 (0.14)	45.45 (0.23)	48.15
4	53.87 (0.13)	55.05 (0.11)	37.32 (0.15)	44.55 (0.19)	47.70
5	53.88 (0.14)	55.07 (0.12)	38.83 (0.18)	44.33 (0.22)	48.03

[a] Numbers in parentheses are coefficients of variation (%).

at the USDA Forest Service, Crossett Experimental and Demonstration Forest at Crossett, Ark. This term was developed because the goal of a sudden sawlog silvicultural stategy is to produce trees of sawlog dimension as rapidly as possible. The uneven-aged stand investigated was subdivided into two tree-age classes: stand 4 (single tree selection) and stand 5 (crop trees).

Veneer was rotary-peeled by Hunt Plywood at Pollock, La., to approximately 54 by 98 inches. The 1/8-inch-thick veneer was coded according to stand, tree within stand, log within tree, and veneer location within log as it was peeled. All veneer was graded by a certified grader from APA – The Engineered Wood Association. The veneer was dried for approximately 10 minutes at 380°F to a final MC of 4 percent.

Contact angle determination, measured in degrees, was accomplished with a microscope equipped with a goniometer eyepiece. The microscope tube was arranged horizontally. The veneer specimens were placed on a stage, and a 0.05-mL droplet of resin or water was applied with a pipette to the surface of each specimen. The contact angle was measured in the direction parallel to the grain and accomplished by rotating the goniometer eyepiece so that the hairline passed through the point of contact between droplet and veneer and was tangent to the droplet at that point. All measurements were made 5 seconds after the resin or water had been dropped. Twenty samples measuring 1 by 1 by 1/8 inch were cut for each stand from full-sized veneer sheets. Three observations were made on each sample for a particular combination of stand, veneer side, and wood grain. Therefore, each contact angle mean value is an average of 60 observations. Samples were categorized according to stand for convenience. No significant contact angle differences were anticipated to exist between stands due to the large variability of veneers sampled within a stand.

RESULTS AND DISCUSSION

The mean contact angle measurements determined with commercial phenol-formaldehyde resin (from Borden Adhesive Co.) and distilled water are presented in **Table 2. The** experimental resin contained a pH of 11.2, 51 percent solids content, and the viscosity was 260 cps. The effect of the different stands on the wettability values obtained was minimal. As expected, latewood values were greater than earlywood values determined with phenol-formaldehyde resin and distilled water on both sides of the veneer. Hse **(9)** also found that contact angles on latewood were significantly greater (mean = 82.43) than those on earlywood (mean = 78.20).

This difference is because earlywood fractures across the cell wall when cut with a veneer lathe, thus exposing its larger lumens. Conversely, latewood fractures within and between cell walls to expose a relatively smooth, tight surface with fewer lumen openings (10,11). Hse (9) concluded that the surface roughness and possibly the surface chemical properties of earlywood differed from those of latewood and that these differences may affect the contact angle. Haupt and Sellers (6) found that contact angles measured on southern pine springwood were dependent on resin viscosity.

Earlywood and latewood differences are critical in determining the gluability of southern pine plywood. Hse (8) found that earlywood cells near the glueline were compressed and impregnated with resin. However, the thick-wailed latewood showed no deformation and resin impregnation was confined to the cells immediately adjacent to the glueline. Consequently, the best gluebond quality, as tested wet and dry in tension, was with earlywood-to-earlywood specimens. Shupe et al. (13) produced plywood from the same veneer sources used in this study. That study found minimal differences in the latewood percentage of shear samples from the five different stands. Consequently, differences in shear strength and wood failure were minimal when tested after three different accelerated-aging treatments.

The effect of veneer side was small when using resin **(Table 2).** However, when using distilled water, loose-side values were much smaller than tight-side values for both earlywood and latewood. This difference is largely due to the deeper lathe checks on the loose side of the veneer. As a result, liquids with low surface tension such as water will easily penetrate the wood surface on the loose side and yield lower contact angle measurements. The phenolic resin apparently possessed sufficient surface tension to prevent appreciable differences in contact angles between veneer sides.

A higher contact angle is indicative of a fairly impermeable surface, and thus poor flow and wetting of the resin. Conversely, a resin with a comparatively lower contact angle indicates a surface with higher permeability, and the opportunity exists for overpenetration and consequential starvation of the glueline. Hse (9) believed that a resin with a high contact angle may give the best compromise of the conditions necessary for wetting, spreading, and penetration.

Conclusions

This research was initiated in order to determine the effect of veneer side (tight and loose) and wood grain (earlywood and latewood) on the wettability of loblolly pine veneer. Based upon this research, the following conclusions are offered. Contact angles are slightly greater on latewood than earlywood for both the phenol-formaldehyde resin and distilled water used in this study. The effect of veneer side was not critical when using the phenol-formaldehyde resin in this study but is critical for distilled water. Other phenol-formaldehyde resins will act differently, and therefore, the conclusions of this study should not be applied to all formulations of phenol-formaldehyde resins or wood species.

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