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OPTICAL EVALUATION OF RESIN COVERAGE ON FIBER FURNISH

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ABSTRACT

This study describes an inexpensive and simple method of evaluating the percent of surface area of fiberized wood furnish that is covered with adhesive. The method uses an integrating microscope eyepiece and a random-field sampling technique to observe dyed (*rhodamine* B) resin. Blended furnishes of known surface coverages were evaluated to illustrate the accuracy of the sampling technique. The technique is particularly adaptable to in-plant use. The relationship between resin coverage, resin level, and blender loading rate is presented. Results indicate that, on a surface area basis, smaller size fiber does not receive a disproportionate share of resin when blended in a pilot-plant-size, short-retention-time blender.

Keywords: Medium-density fiberboard, fiberboard, hardboard, resin coverage, resin level, blender loading rate, short-retention-time blender, rhodamine B.

INTRODUCTION

The attainment of maximum resin efficiency in the medium-density fiberboard (MDF) industry requires a rapid means of evaluating the amount of resin coverage on the fiberized furnish. Achieving maximum resin efficiency is critical to minimize MDF production costs. Production personnel are hampered in evaluating their particular means of achieving maximum resin efficiency because of lack of a technique to quantitatively measure resin coverage. The terms "resin coverage" and "resin distribution" have often been used interchangeably. For this study, "resin coverage" is defined as the amount of surface area covered with resin, expressed as a percentage of the total surface area. "Resin distribution" is defined as the variation in resin content over a range of particle-size classes, expressed as a percentage of the total resin content.

Quantitative measurement of resin coverage on a fiber furnish in a production situation could be used both in the evaluation of production variables and in process control. Evaluation of resin coverage on particles has usually been aided by the addition of dyes that color either the resin or the wood. The dyed-resin coverage has been evaluated by light microscopy (Lehmann 1965), reflection photometry (Lehmann 1968), or ultraviolet light photography (Lehmann 1970). Ginzel and Stegmann (1970) evaluated 75 coloring agents and found 12 that were suitable for detecting uncoated flake surfaces. These methods either did not give quantitative estimates of resin coverage or the equipment required was cost-prohibitive for the typical in-plant laboratory.

A method of measurement using a dot-grid, integrating eyepiece in a microscope has been used effectively in several anatomical and mensurational studies of wood.

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Harris (1969) used the dot-grid integrating eyepiece for estimating cell-wall thickness in wood specimens. Quirk (1975) and Quirk and Smith (1975) used the integrating eyepiece for estimating cell-wall areas and specific gravities of wood samples. Taylor (1973) used this method to estimate the proportion of tissue types in various woods.

The objective of this study was to evaluate the feasibility of using a dot-grid integrating eyepiece as a random-field sampling technique to quantitatively measure resin coverage of a fiber furnish. The integrating eyepiece was used as a dot-grid sampling technique in that dots are asymmetrically arranged within a circular field on a graticule inside the eyepiece of the microscope and are superimposed on the specimen to be evaluated.

PROCEDURE

Fiber blending

The fiber furnish used in this study was a mixture of commercially pressure-refined southern hardwoods. Rhodamine B, an ultra-violet-fluorescent dye, was added to a commercial urea-formaldehyde resin at 0.5% based on resin solids. Blending was accomplished in a pilot-plant-size, short-retention-time blender with through-the-shaft resin application. Three resin levels (6%, 9%, and 12%) and two blender loading rates (1.1 kg/min and 3.3 kg/min of wood fiber) were used. For each set of blending conditions, the blended fiber was pneumatically conveyed to a vacuum former where a 51-cm by 61-cm mat was formed. The mat was mechanically scalped to a uniform thickness of approximately 12 cm.

Fiber sampling

A randomly selected cross section of a scalped mat for each set of variables was removed and oven-heated for 5 minutes at 105 C, thus curing the resin to avoid disturbing the resin coverage during further processing. A 25-g sample was randomly selected and screen classified in a Tyler Ro-Tap. Screen sizes were 18-, 30-, 45-, 60- and 80-mesh (Tyler).

A random sample of the blended fiber from each screen fraction was uniformly distributed on a microscope slide. The slide was examined with a light microscope equipped with ultra-violet incident lighting and a Carl Zeiss Integrating Eyepiece 1. The following Zeiss ultra-violet excitation and suppression filters were used to avoid the "halo effect" from around the rhodamine B dye on the furnish: 3mm BG12, 4mm BG36, 1mm UG1, and a K530.

Three counting fields on each slide were randomly selected, and three counts were made at each field by random rotation of the eyepiece. Points falling coincident with both uncoated and dyed-resin-coated fiber surface were recorded. The extent of dye migration and/or leaching was negligible with this technique. Therefore, it was assumed that the observed location of the dye on the fiber was coincident with the location of the resin. Care was taken to focus on the resin points, which were counted, insuring that the resin observed was on the top surface of the fibers. The microscope magnification used was such that the average diameter of the fibers being measured was about equal to the distance between two grid points of the integrating eyepiece, as suggested by Neuer (1967).

Accuracy of sampling technique

To determine accuracy of the random-field sampling technique, control samples of known dyed surface area were prepared and evaluated. A random sample of unblended fiber was immersed in a dye-water solution, and another random sample was immersed only in water. Both samples were oven-dried and then screen classified as described in the previous section on fiber sampling. Fiber retained on the 18-mesh screen was selected as the control fiber sample, since this screen fraction constituted approximately 45% of the total weight of the fiber furnish used in this study. Control samples of 0%, 25%, 40%, 50%, 60%, 75%, and 100% coverage were prepared by mixing, on a weight basis, fibers that were immersed in the dye-water solution (100% dye coverage) with fibers that were immersed only in water (0% dye coverage). Fibers were randomly selected from each set of control samples, uniformly distributed on microscope slides, and evaluated for dye coverage as previously described.

It must be emphasized that the accuracy of the sampling procedure was evaluated with the above approach and not the accuracy of the total technique of sampling and resin coverage determination. Several problems of evaluating resin coverage on blended fiber furnish do exist. The major problem is avoiding "show-through" of resin from surface to surface on the smaller-size fiber fractions (80-mesh or smaller). Very careful focus adjustment is required to minimize this effect. Errors related to "show-through" would result in an abnormally high resin coverage. Another problem occurs when the fibers are covered with small resin spots. The operator must make a subjective evaluation to determine if a dot is to be counted as coincident with a resin spot. These borderline cases require subjective evaluation, and, with the fiber and resin types used in this study, this particular problem occurred with approximately 5% of the fiber evaluated.

RESULTS AND DISCUSSION

Accuracy evaluation

The relationship between actual dye coverage of the control samples and dye coverage observed with the integrating eyepiece using the random-field sampling technique is shown in Fig. 1. The equation that relates the observed coverage to the actual coverage is also indicated in Fig. 1. The greatest difference between the observed and actual coverage, 5.4%, occurred for the mixture having 50% resin coverage, with an average difference of 2.4%. The coefficient of determination, R^2, was 0.99.

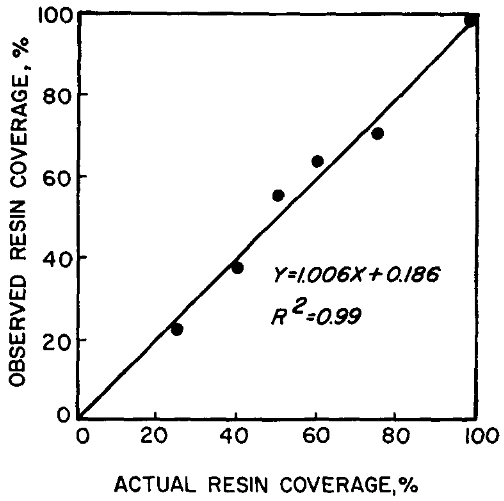

FIG. 1. Relationship between observed and actual surface area of 18-mesh fiber covered with dye.

The accuracy of the technique when applied to determination of resin coverage on blended fiber was not determined. The problems mentioned in the previous section made these measurements somewhat subjective. However, errors caused by the subjective nature of the measurements were assumed not to significantly affect the usefulness of this technique as a production-control tool.

Resin coverage

The resin coverage for each screen fraction of blended fiber, for each combination of resin level and loading rate, is shown in Table 1. The average resin coverage, combining all resin levels and loading rates for each screen fraction, is shown in Fig. 2. An average of 35% of the surface area of the blended fiber retained on the 18-mesh screen was covered with adhesive. The average covered surface area for 80-mesh blended fiber was 34%. This represents less than a 1% variation in resin coverage from the largest to the smallest fiber size. There was no significant difference between these means. It is known that the total surface area for a given amount of fiber increases with decreasing fiber size. Con-

TABLE 1. *Resin coverage for six screen fractions of fiber at various resin levels and blender loading rates*

Loading rate kg/min	Resin %	Resin Coverage by Screen Fraction, % +18	+30	+45	+60	+80	−80	Average coverage %
1.1	6	26	16	26	16	21	21	21
3.3	6	25	32	28	30	33	35	31
1.1	9	34	32	35	32	34	38	34
3.3	9	39	41	33	31	35	30	35
1.1	12	35	46	46	47	36	44	42
3.3	12	50	44	35	40	47	47	44
Average coverage, %		35	35	34	33	34	36	

sequently, on the basis of surface area, the smaller-size fibers did not receive a disproportionate amount of resin, even though Haigh and Zahrnt (1967), and Maloney (1975) show that they do on a weight basis. A second consequence of this finding is that, in a quality control application, it would not be necessary to evaluate six screen fractions to determine resin coverage. The geometry of the blended fiber used in this study permitted the use of two magnifications (110× and 75×) to meet the requirement discussed earlier that the average diameter of the particles measured be equal to the distance between two grid points of the integrating eyepiece. Fibers larger than 45 mesh were evaluated using optics with a 75× magnification, and fibers smaller than 45 mesh were evaluated at 110×. Therefore, only two screen fractions need to be evaluated for fibers of the type used in this study.

As expected, resin coverage increased with increasing resin level, as shown in Fig. 3. An analysis of variance (Table 2) revealed that the relationship was significant. The difference in resin coverage between fiber blended with 12% resin and fiber blended with 6% resin was 100% at the 1.1 kg/min loading rate and 42% at the 3.3 kg/min loading rate. All resin coverages were lower than expected. The low resin coverage obtained in the short-retention-time blender investigated indicates

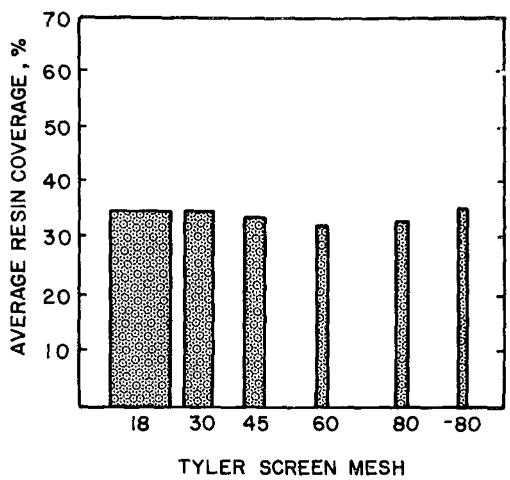

FIG. 2. Average resin coverage versus fiber size. The area enclosed is indicative of the percent of material retained on a particular screen.

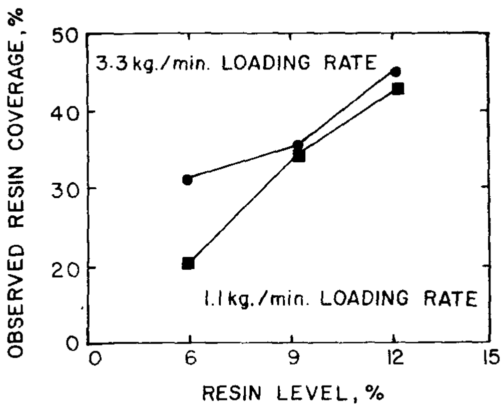

FIG. 3. Resin coverage as a function of resin level and blender loading rate. Each value represents an average of 54 observations.

TABLE 2. *Analysis of variance of resin coverage as affected by resin level and blender loading rate*

Source	df	Sum of squares	Mean squares	F
(A) Resin level	2	16736.2249	8368.1124	3.455*
(B) Blender loading rate	1	1429.68	1429.68	ns
(A × B) Interaction	2	1542.595	771.2975	ns
Error	318	770301.7448	2422.3325	
Total	323	790010.2447		

* Significant at the 95% level of probability.

that there is considerable room for improvement in blender design and/or manipulation of blending variables.

Average resin coverage at all resin levels was higher with the higher blender loading rate, although the difference was not statistically significant (Fig. 3 and Table 2). The higher resin coverages observed with the higher loading rate in general are due to the design of the blender, which permits it to function more efficiently under load because of the greater scrubbing action of the particles on each other (Campbell 1974).

Application of the technique

A technique for accurately evaluating resin coverage that is adaptable to in-plant evaluations of production and blender variables has been described. In a production situation, this type of evaluation may be tailored to fit the particular plant. If board production is to be overlayed with thin veneers or the edge exposed, a dye that fluoresces under ultra-violet light but that is invisible under normal incident light may be used. If the end use of the board does not demand a natural color, other dyes that are readily detectable under normal incident light can be used to adapt the procedure to the lighting equipment normally available in plant situations. Generally, the evaluation of resin coverage would be done periodically requiring only a small amount of dyed furnish.

CONCLUSIONS

The optical evaluation of resin coverage on fiber furnish using a dot-grid integrating eyepiece as a random-field sampling technique was shown to be technically feasible. This relatively simple technique is readily adaptable to in-plant evaluation of production and blending variables.

Using a pilot-plant-size, short-retention-time blender with through-the-shaft resin application, resin coverage on the fiber furnish was found to be independent of fiber size for a particular set of blender variables. The resin coverage increased with increasing resin level.

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