

# IMPROVING STRAND QUALITY OF UPLAND OAKS FOR USE IN ORIENTED STRAND BOARD

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**Abstract.**—Past research estimates that more than 1 million tons of oak logging residues go unused in West Virginia each year. Much research has been done investigating potential products and markets for this underutilized resource. West Virginia is home to an oriented strand board (OSB) producer that consumes large volumes of small diameter, low quality round wood. However, the use of oak species is limited because of their undesirable physical properties. Much of this rejection is due to the poor strandability of oak and the production of significant volumes of fines during the stranding process. New stranding technology for improving the quality of oak strands produced for the OSB manufacturing process was investigated. The process of making OSB strands was examined to see if changes could be made to improve the quality of oak strands. Changes in cutting speed, knife angle, pocket angle, and rotations per minute improved the strand geometry and reduced the percentage of fines produced during the oak stranding process.

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## INTRODUCTION

More than 10 tons of logging residues per acre are left in the woods annually after harvest in southern West Virginia (Grushecky et al. 2006). An estimated 50 percent of that residue is low quality oak. If this trend is extrapolated to the whole state, approximately 1,125,000 tons of low quality oak is available each year in West Virginia. This residue represents a potential resource, but at present, no lasting market has developed for its use. Makers of engineered wood products consume large amounts of low quality logs, tree tops, and large branches. In particular, oriented strand board (OSB) is produced using lower density and underutilized hardwoods and smaller diameter softwoods that in many cases can be in the form of irregular logs (Maloney 1996, McKeever 1997).

A moderate size OSB mill can use as much as 730,000 tons of low quality logs and tree parts annually. It can be extremely difficult to procure enough timber for consumption on such a large scale. OSB mills in West Virginia use 52 or more species for their furnish. With these species, they are capable of using the same stranding setup and techniques to achieve the desired strands. However, the use of oak species is limited by the poor stranding quality of ring-porous hardwoods and the large area of the ray crossings. The impact force of the knives of a strander causes the wood to break the earlywood into very narrow strands. Narrow strands are geometrically undesirable because they lower the mechanical properties of the finished panels. Another drawback of stranding oak is the resulting higher percentage of fine wood particles produced. Fines are prone to overdrying, consume disproportionately large amounts of resin, and reduce product strength (Stiglbauer et al. 2006). These fines must be screened out of the process, hence lowering the yield from the log and driving up the cost of the finished product.

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Mechanical properties of OSB can be improved by using longer strands (Zhang et al. 1998). Suzuki and Takeda (2000) reported decreasing strand alignment with decreasing strand length. It is also known that modulus of elasticity (MOE) and modulus of rupture (MOR) increase with strand orientation parallel to the primary panel axis.

The geometry and quality of oak strands may be improved by altering processing variables such as moisture content and knife angle. In veneer production, knife angle is a critical factor in peeling a veneer block with a good surface (Spelter 1991). The stranding operation used by some OSB producing mills is similar to “peeling” veneer; therefore, knife angle is potentially a significant variable in improving the stranding of oak species. Moisture content and temperature have a plasticizing influence on wood, making it easier to peel or strand. Woodson (1979) noted an inverse relationship between tool force and moisture content.

In 2004, attempts were made at Weyerhaeuser’s OSB mill in Sutton, WV, to use oak in the production process. Although the final product was able to meet commodity structural panel strength and stiffness requirements (as per Voluntary Product Standard PS2), the quality of strands was poor. The strands were typically very narrow and there was a high percentage of fines ( $<3/16$  inch). The knife life (i.e., durability) was also poor with multiple knife changes needed per shift. The resulting poor knife durability, when stranding oak, would likely lead to reduced production and an increase in costs. In addition to the reduced knife durability, when using oak strands, panel density had to be increased, as compared to normal production to meet industry standards. It was not known if the necessary increase in panel density was due to the poor strand quality or the higher density of the oak species. Past research has indicated that higher compaction ratios resulted in panels with higher mechanical properties (Beck et al. 2009, Rice 1984). Higher density wood species will reduce the compaction ratio of the entire panel. Compaction ratio may be expressed as the density of the panel to the density of the wood species used. Hence the use of a higher density wood species may require a higher overall panel density to achieve the necessary pressure for bonding and compaction ratio. If oak species could be successfully used to produce OSB strands and panels, then industry in the regions where oak is abundant may benefit from the availability of a low cost resource in the form of oak logging residues. Conversely, the creation of a market for oak logging residues for use in OSB production will allow for increased consumption of an underutilized resource.

Because there is significant potential to increase the utilization rate of oak logging residues through the modification of stranding techniques, the Appalachian Hardwood Center (AHC) at West Virginia University, Weyerhaeuser Company, and Pallmann Machine Manufacturing Company in Germany undertook a study to answer the following questions:

- 1) Can strand geometry from oak be improved so the panel density does not have to be increased to compensate for the reduction of mechanical properties caused by short, narrow oak strands?
- 2) Can oak strands be produced with a reduction in the percentage of fines?

This paper reports the results of this study to determine if an acceptable strand can be produced with less fines production.

## METHODS

Debarked (and immediately wrapped in plastic) northern red oak (*Quercus rubra*) and chestnut oak (*Quercus prinus*) logs were shipped from West Virginia to Pallmann in Germany to be stranded. Three logs, 6 feet in length and 10 inches in diameter, were selected and shipped for each species of oak. The red and chestnut oak from West Virginia made up the first trial samples. Additionally, a second trial was performed using white oak (*Quercus* spp.) logs that Pallmann selected in Germany. A Pallmann Lab-Ring Flaker PZUL 8–300 was used to produce strands from the oak logs. The laboratory strander used could be adjusted for different processing parameters. Specifically, different combinations of knife angle, cutting speed, and ring (i.e., pocket) angle were varied until the optimum combination was determined based on visual observations of the fines and the strand width.

In determining the best combination of the stranding variables, 40 separate combinations were investigated. Moisture content of the logs at time of stranding was approximately 35 percent dry basis. After the stranding trials in Germany, five bags of strands from each species (i.e., red and white oak) were sent back to West Virginia University. Each bag of strands weighed approximately 15 lbs. Three bags from each species group were first classified using a BM&M screen classifier containing eight size classifications. The size classifications consisted of 1¼ inches, 1 inch, ¾ inch, ½ inch, ¼ inch, ⅜ inch, ⅛ inch, and the pan (no holes). Next, the strand thickness was measured by randomly selecting 50 strands from the 1¼ inch tray. Finally, the average width and length weighted based on mass of sample pans were determined for the sample.

## RESULTS

By reducing the cutting speed and using a very flat knife cutting angle, oak strands were successfully produced. The average strand length from the first trial, combining both the red and chestnut oak species from West Virginia logs, was 3.9 inches, while the average strand length from the second trial, using white oak from Germany, was 3.4 inches. During the stranding setup, a “scoring tip” was inserted into the knife assembly to cut the strands into the desired length. The length targeted may range from 3 to 5 inches. During this study, the scoring tips were set up to target a 4-inch strand length. The results of the two trials revealed that the final lengths of the oak strands were within an acceptable range of the target length.

The knife setup used targeted a strand width of 1 inch. The average strand width found for the West Virginia logs was 0.74 inches. Strand width for the German white oak logs was 0.73 inches. In prior stranding attempts using a typical industry strander and settings, the resulting oak strands were quite narrow, and large amounts of fines were produced (Fig. 1). Strands from this study using slower cutting speeds and flatter knife angle produced strands that were wider and longer than prior attempts at stranding oak using typical hardwood strander settings (Fig. 2). A graphical representation of the distribution of the strand geometry for the first and second trials may be found in Figure 3.

A significant finding from the stranding trial results was that, by using a slower cutting speed and flatter knife angle, a higher percentage of large strands (i.e., >1 inch wide) could be obtained and the percentages of fines could be reduced, as compared to current industrial strander settings. Specifically, in both the first and second studies, the largest concentration of strand width was in the 1-inch

and larger category (Table 1). The first and second studies resulted in 67 percent and 70 percent of strands being classified in the 1-inch and greater width category, respectively. These percentages were considerably higher than the 60 percent of 1 inch and greater strand width for the oak stranded using typical industry settings. Between the two trials, a slight difference was noted in fines content. Both the first (10 percent) and second (4.8 percent) trials resulted in a much lower percentage of fines produced, as compared to the fines content (17.7 percent) of the of strands produced using typical industry settings.

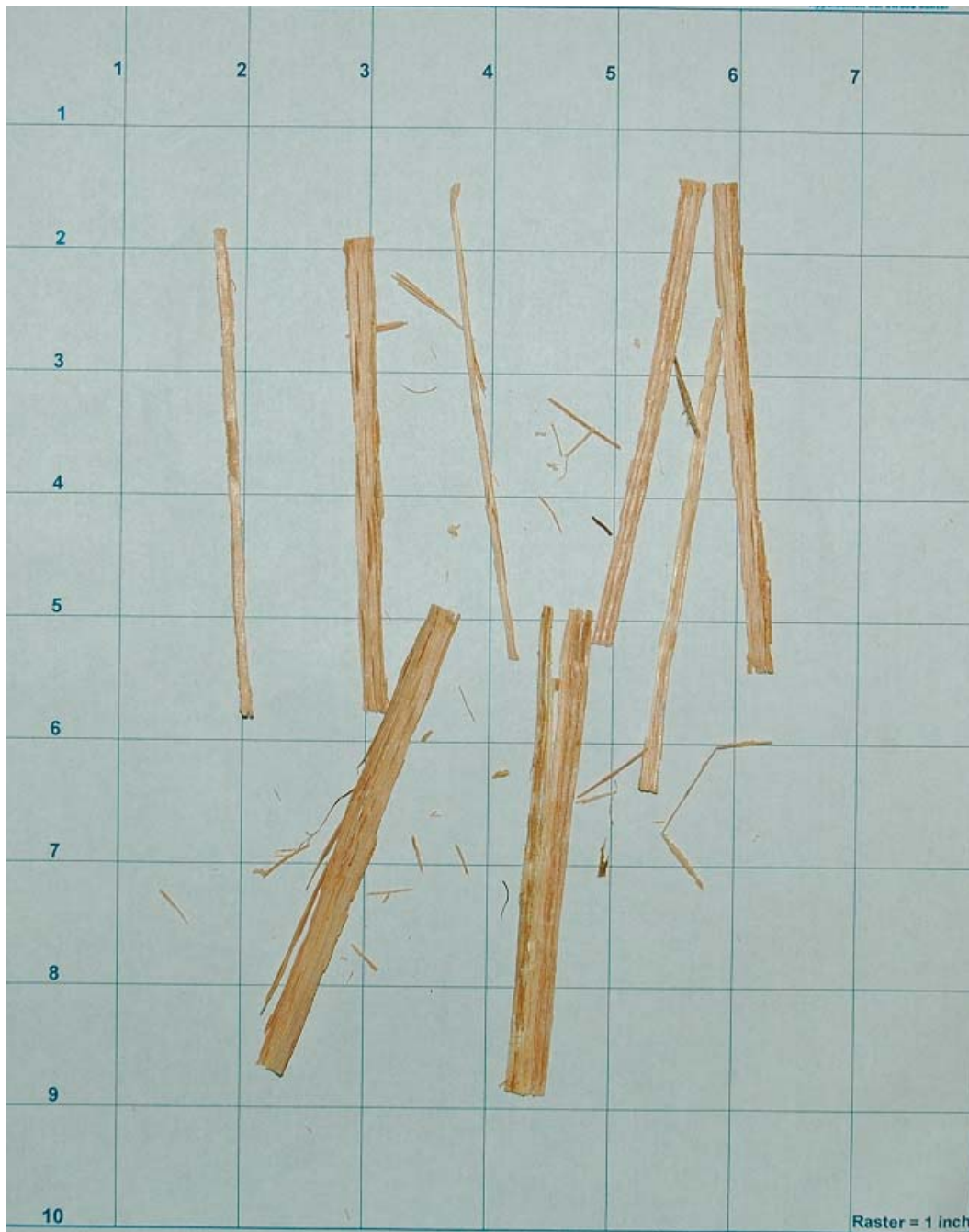


Figure 1.—Typical oak strands resulting from common strander settings.



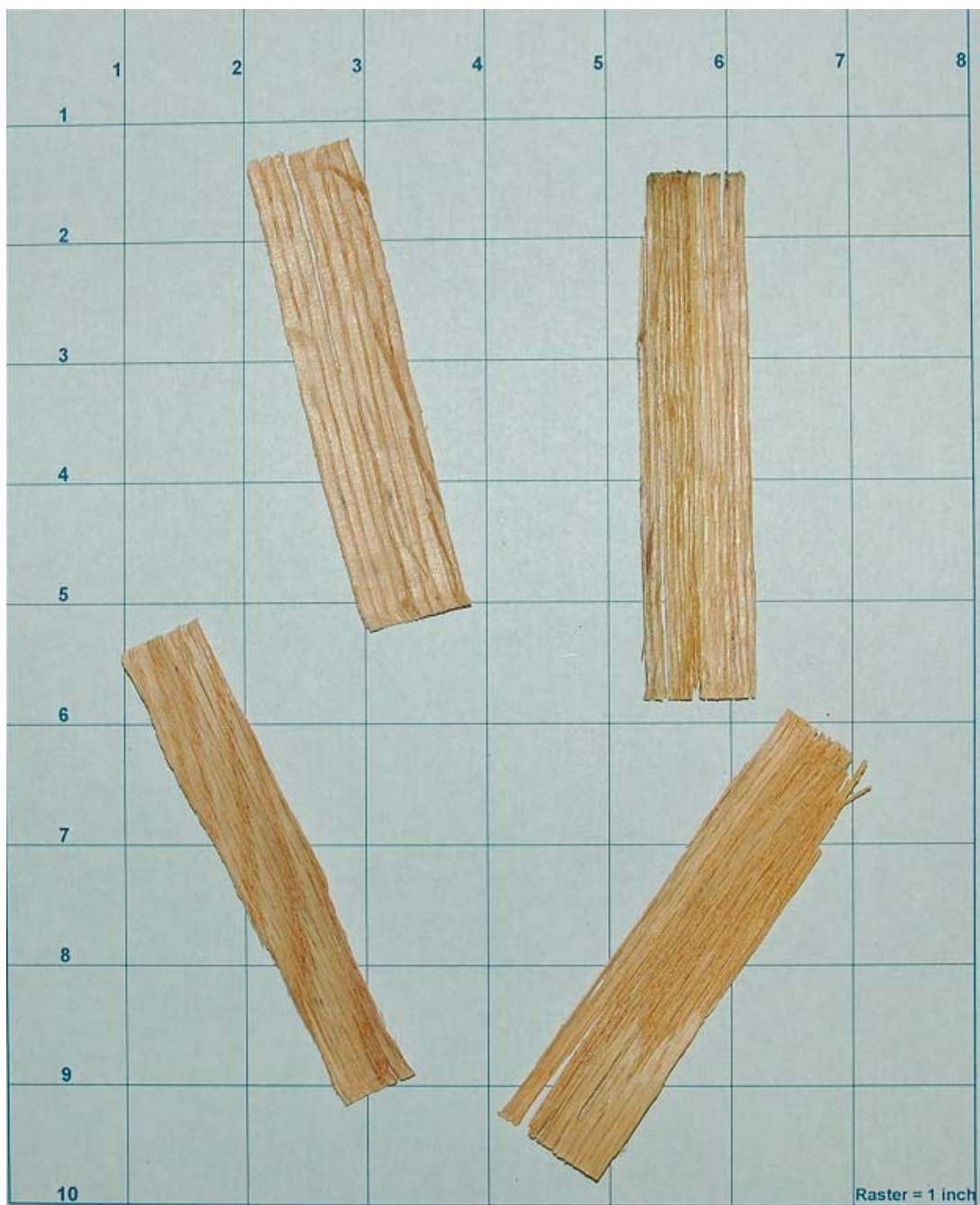


Figure 2.—Oak strands from optimized strander setup.

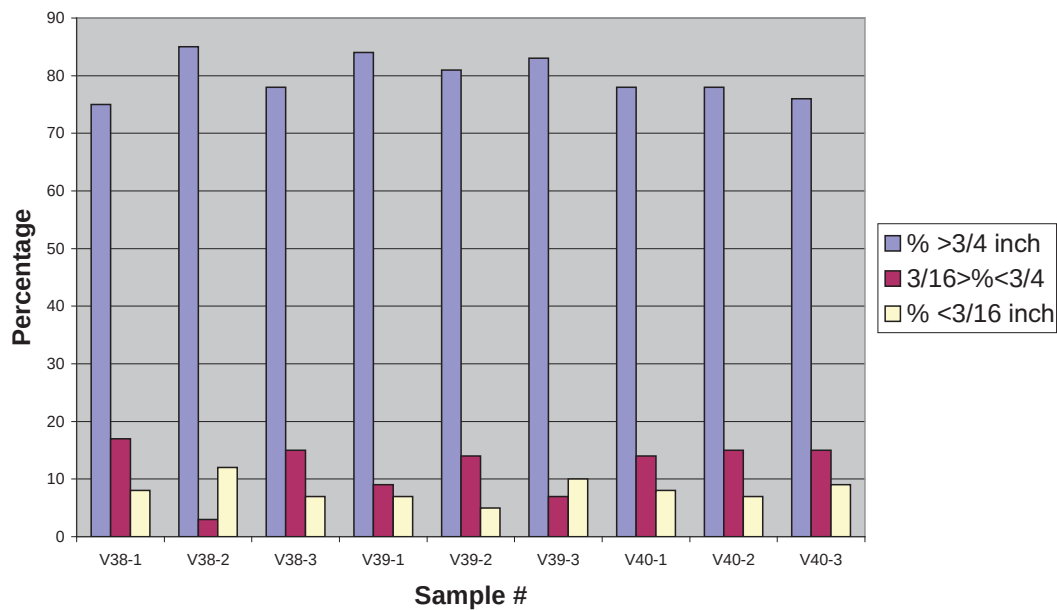


Figure 3.—Average strand width distribution for oak strands from optimal strander setup. V38, W39, and V40 represent red, chestnut, and white oak, respectively, while the -1 through 3 represent the sample log number for each species.

**Table 1.—Descriptive statistics for strand data: “Length” and “Width” variables are weighted average results**

| Variable                           | n | Mean   | StDev  | Minimum | Median | Maximum |
|------------------------------------|---|--------|--------|---------|--------|---------|
| <b>Oak trial 1<sup>a</sup></b>     |   |        |        |         |        |         |
| Length                             | 6 | 3.899  | 0.026  | 3.859   | 3.898  | 3.939   |
| Width                              | 6 | 0.744  | 0.092  | 0.623   | 0.735  | 0.896   |
| % < 3/16 inch                      | 6 | 10.030 | 1.810  | 7.370   | 10.220 | 12.010  |
| % ≥ 1 inch                         | 6 | 66.940 | 5.040  | 59.820  | 67.680 | 72.400  |
| <b>Oak trial 2<sup>a</sup></b>     |   |        |        |         |        |         |
| Length                             | 3 | 3.407  | 0.085  | 3.310   | 3.440  | 3.470   |
| Width                              | 3 | 0.727  | 0.095  | 0.630   | 0.730  | 0.820   |
| % < 3/16 inch                      | 3 | 4.767  | 0.643  | 4.300   | 4.500  | 5.500   |
| % ≥ 1 inch                         | 3 | 70.333 | 1.528  | 69.000  | 70.000 | 72.000  |
| <b>Typical strands<sup>a</sup></b> |   |        |        |         |        |         |
| Length                             | 9 | 2.960  | 0.291  | 2.650   | 2.830  | 3.630   |
| Width                              | 9 | 0.490  | 0.154  | 0.350   | 0.440  | 0.870   |
| % < 3/16 inch                      | 9 | 17.740 | 2.827  | 8.590   | 10.730 | 16.250  |
| % ≥ 1 inch                         | 9 | 59.920 | 10.075 | 40.620  | 62.110 | 70.560  |

<sup>a</sup> Oak trial 1 included red and chestnut oak sourced from West Virginia, Oak trial 2 included white oak sourced from Germany, and Typical strands included red and chestnut oak from West Virginia stranded at an OSB mill using settings for typical mixed hardwoods.

## DISCUSSION

The weighted average length of 3.9 and 3.4 inches and width of 0.74 and 0.73 inches in the first and second trials, respectively, are comparable to the weighted average of the typical mixed hardwoods produced industrially. For example, mixed hardwood strands from Weyerhaeuser's mill in Sutton, WV, were found to have a weighted average length after drying of 3.10 inches and a width of 0.56 inches. The results from the Pallmann trial runs appear to have produced strands better suited for OSB production, as compared to the mill trial results. It should be noted, however, that Pallmann strands were dried in a conveyor system, while the mill strands passed through a rotary drier that could have further reduced the mill's strand dimensions. Specifically, a rotary dryer would tend to break up the strands as they tumble through the two triple-pass dryer drums. However, the oak strands were loaded by hand into bags, boxed, and air freighted from Germany. Any damage that occurred in handling of the Pallman stranded material is unknown.

The fines content from the strands produced by Pallmann was encouraging, when compared to the mill's typical fines content. A typical mixed hardwood mill would normally have 15 percent to 25 percent of fines after the stranding and before drying, with an average of about 19 percent, by weight. The oak fines content of 10 percent and 4.8 percent in the first and second trials, respectively, was found to be a noticeable improvement, as compared to the 17.8 percent fines for the oak stranded at the OSB mill using typical mixed hardwood stranding settings. The fines content results are directly comparable because both were taken after stranding before screening and drying; therefore, no damage would have been incurred on the fines before measurement.

While the strands produced in this study were comparable to typical strands used in mixed hardwood OSB mills, more research is needed to look at adding the oak strands in varying proportions in OSB panels. Specifically, research is needed to determine whether oak can be incorporated into OSB panels and maintaining mechanical and physical properties without increasing the density. Specifically, higher density oak strands will weigh more than most of the other mixed hardwood species typically used in OSB mills, so a lesser number of strands will be needed when using various portions of oak, to achieve the same overall panel density. Additionally, having fewer strands in the panel will likely reduce surface to surface pressure that is required for optimal glue bonding. However, additional research should be able to find an optimal panel density and proportion of oak strands that will produce OSB panels with mechanical and physical properties equal to that of currently produced OSB.

## CONCLUSIONS

The quality of the strands produced by Pallmann, in terms of fines and weighted average length and width, is quite promising when compared to the mill's typical strand data. By slowing the cutting speed and reducing the knife angle (i.e., very flat angle), oak logs were able to be used to make strands comparable to what is typically used in OSB mills that use other mixed hardwoods. The results of the research have provided strands suitable for further investigating the addition of varying proportions of oak strands in OSB panels.

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