

ORIGINAL ARTICLES

Oriented Strand Lumber from Rubberwood Residues

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ABSTRACT

This research investigated the effect of processing parameters on strength properties of Oriented Strand Lumber (OSL) produced from rubberwood (*Hevea brasiliensis* Muell. Arg.) residues and determined the most optimum parameters for a manufacturing process. The experiment proposed three essential manufacturing parameters, i.e., two resin types (pMDI and PF), three levels of resin content (3, 6, 9%) and three levels of strand length (60, 100, 140 mm). The results demonstrated that the strength properties of the produced OSL were higher than those of solid wood. The most optimum parameters found were pMDI resin, 9% resin content and strand length of 140 mm.

Key words: Rubberwood - Oriented strand lumber - Strength properties - Wood strands - Harvesting residues

INTRODUCTION

Rubber trees, native plants of Brazil, are widely planted for latex production in South East Asia, particularly in Indonesia, Malaysia and Thailand (1). The total area of plantations in Thailand is about two million hectares distributed in the south, east and northeast regions (2). Between 25 to 30 years of age in which the latex production is uneconomical, the trees are felled for replanting. In this case, rubberwood logs are harvested for saw mills leaving residues (branches, tops and stumps) in the field for low-cost charcoal production (3).

The value of this left-over residues could be added by converting the residues into a strong oriented strand lumber (OSL). OSL is a wood-strand composite with wood fibers primarily oriented along the length of the member. The smallest dimension of the strand should not exceed 0.635 mm and the average length should be between 75 and 150 times that of the least dimension (4). OSL is a concept utilizing oriented strand board (OSB) technology and process. OSB is primarily used in panel applications, such as sheathing, while OSL is developed for use as structural members including beams and columns (5,6). OSL is the newest product of structural composite lumber (SCL), and markets are still under development. Strength properties make OSL a highly competitive engineered alternative to traditional lumber and will become an important forest product in the future (7).

The objectives of this research was to 1) determine the appropriate characteristic and size of rubberwood residues (branches) for strand preparation and 2) investigate the effect of processing parameters on physical and mechanical properties of OSL.

MATERIALS AND METHODS

Furnish Preparation

Strands were made from rubberwood branch as with a diameter less than 150 mm collected from Thasala district, Nakhon Si Thammarat province. The moisture content (MC) and specific gravity (SG) of the green branches were determined. The experiment was designed with 2 factors, i.e., two levels of wood quality (defect and non-defect) and four levels of branch diameter (60, 80, 100 and 120 mm). Branches were crosscut into 140 mm long segments and subsequently debarked for strand preparation. Stranding was carried out on a CAE 6/36 Laboratory Disc Flaker. Machine conditions were set as follows: counter-knife angle of 60 degrees, knife projection of 0.736 mm and scoring-knife distance of 60, 100 and 140 mm, respectively.

Strands of 200 pieces were manually sampled and individually measured for width and thickness near the middle portion by vernier caliper and micrometer, respectively and then sorted via a Gilson Screen (Model TM-4) for different size groups. The strands retained on each screen were weighed separately for calculating size percentage. Strands that passed through the smallest screen in the classifier and remained in the pan were considered as fine fractions.

Billet Fabrication

An inhouse-made rotary-type blender with a diameter of 1,700 mm and a rotating speed of 8 rpm was used for spreading adhesive onto the strands. To ensure uniform glue distribution, the optimal conditions of rotation rate and the amount of furnish for one-glue application were determined by pretests.

Oriented strand mats were formed using an inhouse-made strand orienting apparatus equipped with fins spaced at 10 mm. The free fall distance, which is the distance between the bottom of the fins and the top of the mat, was kept at 70 mm.

In the study, 54 billets of OSL were produced by employing a pressing temperature of 160°C at 25 MPa for 18 minutes for pMDI-bonded billets and using a pressing temperature of 200°C at 25 MPa for PF-bonded billets (8).

Physical and Mechanical Properties Testing

The fabricated billets were machined into test specimens and placed in a conditioning chamber maintained at 65% RH and 20°C until constant weight was attained. Mechanical tests were conducted using a universal testing machine (LLOYD 150 kN) equipped with a computerized data acquisition system following the procedures of ASTM D 5456-99a and CSA 0437-93. Data analysis according to a designed factorial experiment were carried out by using the statistical analysis system (SAS) software package.

RESULTS AND DISCUSSION

Strand Geometry

The results indicated that the green rubberwood branches for strand preparation had an average initial MC and SG of 68±3% and 0.6±0.05, respectively. The width and thickness of the measured sample strands are shown in **Table 1**. The classification of strand size and fines levels from 140 mm long rubberwood-branch strands is in **Figure 1**. The obtained strand size (**Figure 2**) conformed to the target geometry of 12.7 to 25.4 mm wide and 0.58 to 0.8 mm thick as suggested in other papers (6,11).

Table 1. Width and thickness of strands produced from rubberwood branches.

Appearance	Mean (mm)	SD (mm)	CV (%)
Width	16.01	3.17	19.77
Thickness	0.68	0.14	20.91

Data show that the strand width can be influenced by branch diameter. Small diameter branches produce narrower strands since the knives pass through these branches more frequently. There are many strands that have a width larger than 25 mm because the grain of rubberwood consists of both straight and interlocked portions. The interlocked portion resists a break along the grain of the strand induced by a bending moment from the counter knife. This consequently produces too wide strands.

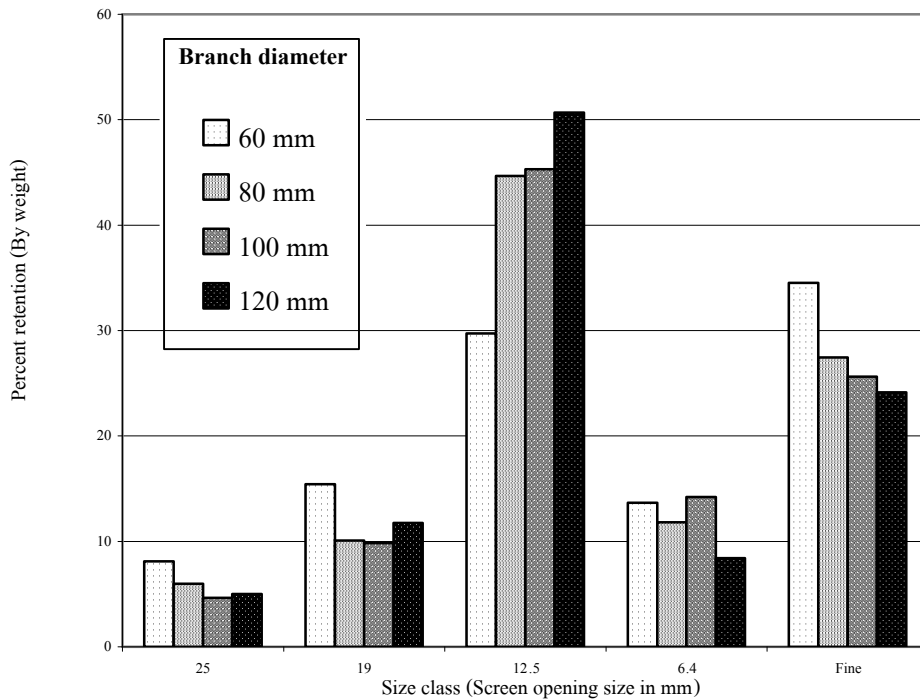


Figure 1. Size classification data from the strand sample screened on a Gilson Screen.

Strand Yield and Fines Level

Fines are the smallest particles present in the strand furnish that pass through the smallest screen, a perforation size of 6.4 mm, and remain in the pan. The level of fines is a function of wood diameter and quality as shown in **Figure 2** and **Figure 3**, respectively.

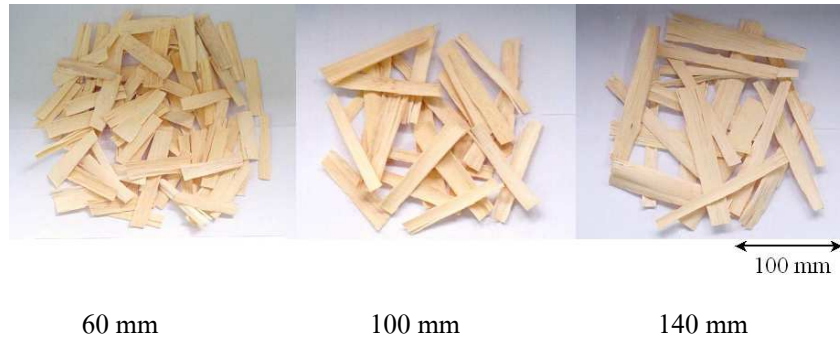


Figure 2. Strands produced from rubberwood branches.

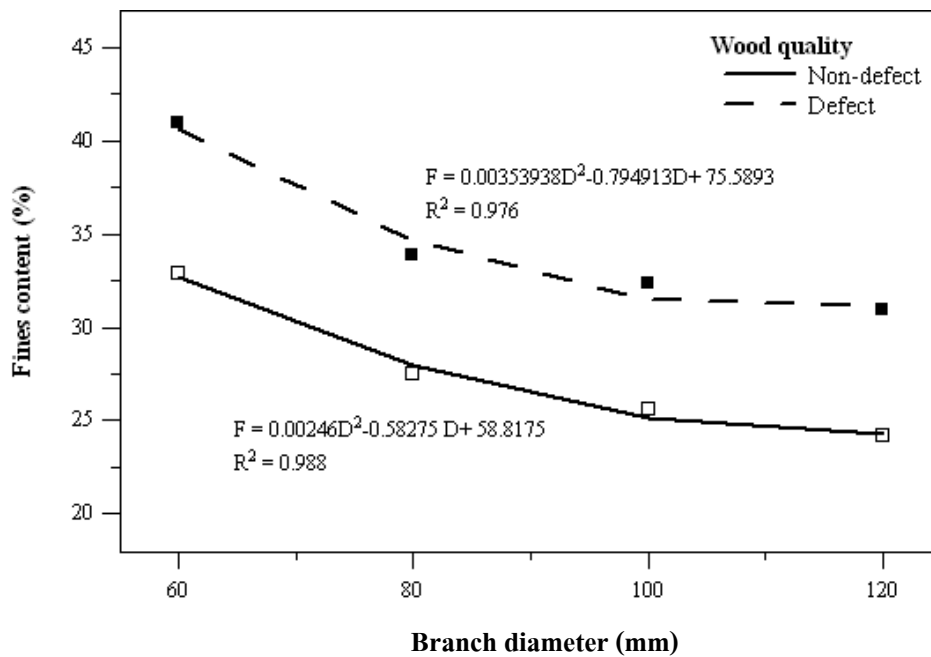


Figure 3. Effect of wood quality and diameter on fines fraction.

Knots or crooked branches reduce the quality of wood being processed and increase the fines level. Grain alignment of these branches are not parallel to the

cutting plane. Wood will therefore be cut across the grain producing strands that are weak in tensile strength and tend to break easily.

The small diameter branches produce higher fines levels than the large diameter ones. The increased amount of fines may result from the cutting knives passing through smaller diameter branches more frequently. In addition, smaller diameter branches are more difficult to hold tightly in the spicked infeeds causing movement during stranding.

Physical and Mechanical Properties

The fabricated OSL billets (**Figure 4**) have equilibrium moisture content (EMC) ranging from 7.85% to 8.15% and SG between 0.69 and 0.75. Average SG values for all billet types seem to have large variation especially the billets that are made from long strands. This might be due to uneven formation of the mats.



Figure 4. Oriented strand lumber made from PF resin (upper) and pMDI resin (lower).

Thickness swelling of the test sample after a 24 hours water-soak significantly decreases with an increasing amount of resin content (**Figure 5**). In addition, pMDI resin appears to have an impressive improvement of dimensional stability over PF resin.

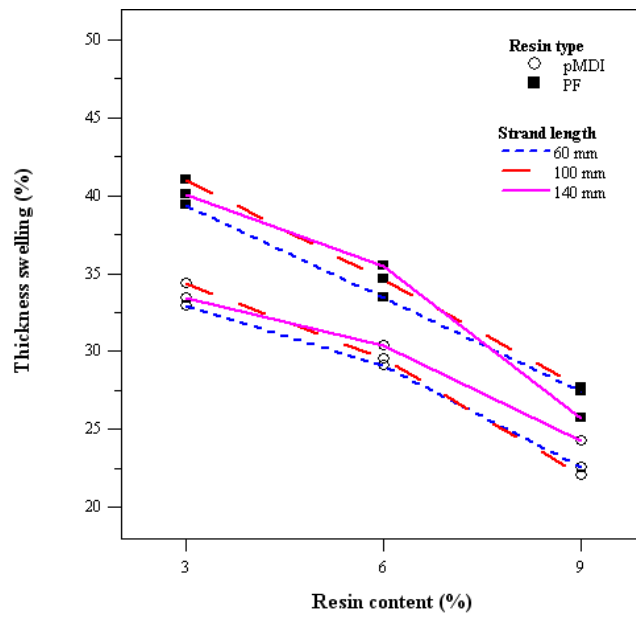


Figure 5. Effect of processing parameters on thickness swelling of rubberwood OSL.

Comparing the mean values of all billets, the modulus of rupture (MOR) of pMDI-bonded OSL is higher than that of PF-bonded OSL (Figure 6). With increasing resin content and strand length, the MOR of OSL increases. For modulus of elasticity (MOE), as shown in Figure 7, resin content is the only parameter that affects the MOE value.

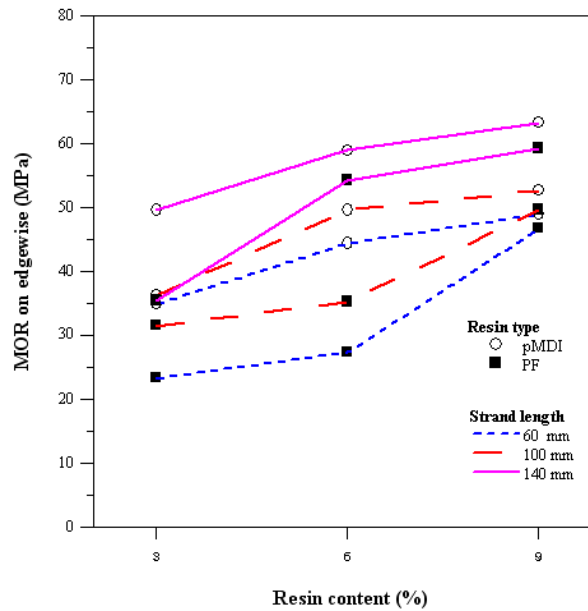


Figure 6. Effect of processing parameters on the MOR value of rubberwood OSL.

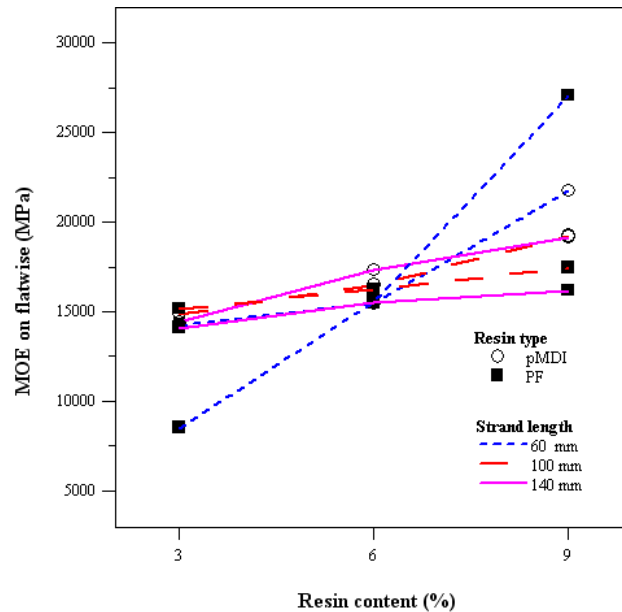


Figure 7. Effect of processing parameters on the MOE value of rubberwood OSL.

Both ultimate stress in tension and compression-parallel-to-grain values depended on all parameters similar to those of the MOR values as presented in **Figures 8 and 9**. Tension parallel-to-grain specimens were generally failed within the gauge length exhibiting a strong influence of resin content. Failures observed during the tests of compression parallel-to-grain specimens were mainly in tension perpendicular to the billet plane (**Figure 10**). This failure mechanism was observed to occur along the strand surface which could be the result of strand buckling during loading.

The quantity of resin was found to be the major parameter contributing to the improvement of strength and dimensional stability of OSL. Increased resin content yields stronger and more dimensionally stable billet. This is in agreement with the result of Post (12) and Barnes (13) who found that increasing the resin content of composite board increases physical and mechanical properties.

The results indicated that longer strands increase mechanical properties because of effective contribution of the longitudinal properties of wood itself to OSL properties. The slenderness ratio (the ratio of strand length to strand thickness) is employed to describe strand configuration. Many researchers have been interested in studying the effect of strand length on composite properties. Barnes (13,14) found that increasing strand length increased the MOR and MOE along the parallel axis of the panel for strands of 7.5 to 30 cm in length. Suzuki and Takeda (15) reported that bending strength of OSBs were markedly affected by the strand length. Post (12) found that the MOR of flakeboard increases with increasing slenderness ratio of the flake.

The results revealed that strand length also has an effect on strand orientation during mat formation. Short strands can produce better alignment distribution than long strands. This result is in good agreement to the findings reported by Suzuki and Takeda (15). They found that strand alignment angle distribution strongly depends on the free fall distance and the formed-strand length.

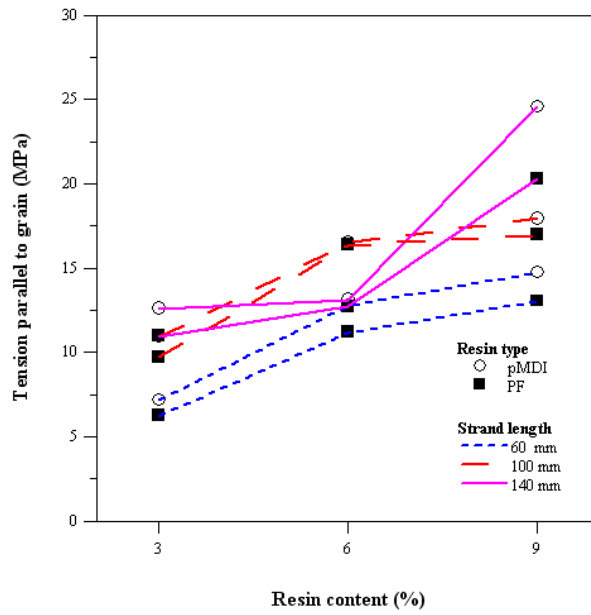


Figure 8. Effect of processing parameters on ultimate stress in tension parallel-to-grain of rubberwood OSL.

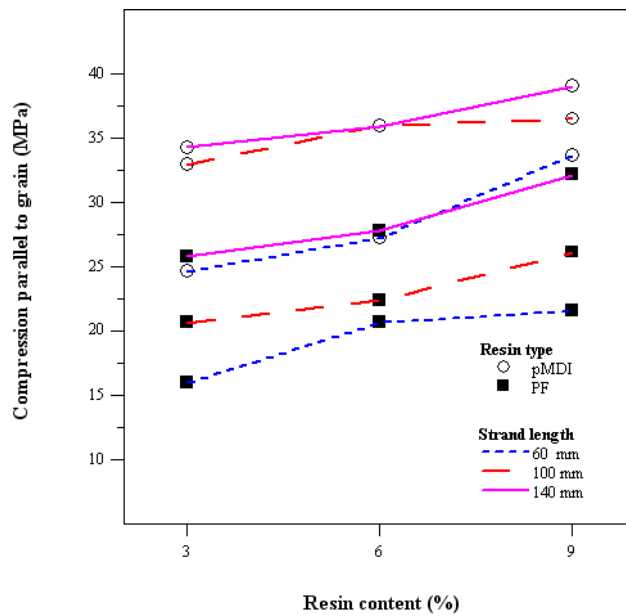


Figure 9. Effect of processing parameters on ultimate stress in compression parallel-to-grain of rubberwood OSL.



Figure 10. Tension perpendicular-to-grain failure in a specimen under compression parallel-to-grain test.

CONCLUSIONS

The following conclusions can be drawn from this work:

1. Appropriate characteristic and size of rubberwood branches were straightness and large diameter.
2. Dominant parameters controlling physical and mechanical properties were resin type, resin content and strand length. Mechanical properties of pMDI-bonded OSL were higher than those of PF-bonded OSL.
3. The optimum parameters were pMDI resin, 9% resin content and strand length of 140 mm.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge The Thailand Research Fund (TRF) for financial support. We would like also to express our thanks to the Wood Science and Engineering Research Unit, Walailak University for providing spaces and facilities for the experimental work.

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บทคัดย่อ

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โอเอสแอลจากเศษเหลือไม้ยางพารา

งานวิจัยนี้ได้ทำการศึกษาอิทธิพลของปัจจัยในการผลิตที่มีผลต่อสมบัติความแข็งแรงของโอเอสแอล (Oriented Strand Lumber; OSL) ที่ผลิตจากเศษเหลือไม้ยางพารา (*Hevea brasiliensis* Muell. Arg.) และค้นหาปัจจัยที่เหมาะสมสำหรับกรรมวิธีการผลิต โดยกำหนดปัจจัยในการผลิตที่สำคัญไว้ 3 ปัจจัย คือ ชนิดกาว 2 ชนิด (กาวไอโซไซยานาต และกาวฟีนอลฟอร์มัลดีไฮด์), ปริมาณกาว 3 ระดับ (ร้อยละ 3 6 และ 9 ต่อน้ำหนักแถบไม้อบแห้ง) และความยาวของแถบไม้ที่ใช้ในการผลิต 3 ระดับ คือ (60, 100 และ 140 มิลลิเมตร)

ผลการทดลองแสดงให้เห็นว่าโอเอสแอลที่ผลิตจากเศษเหลือไม้ยางพารามีความแข็งแรงสูงกว่าไม้จริง (Solid wood) ปัจจัยที่เหมาะสมสำหรับการผลิตที่ได้ คือ กาวไอโซไซยานาตเป็นตัวประสานที่ปริมาณร้อยละ 9 และความยาวของแถบไม้เท่ากับ 140 มิลลิเมตร

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