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THE EFFECTS OF SOME PRODUCTION FACTORS ON THERMAL CONDUCTIVITY OF ORIENTED STRAND BOARD

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Abstract

This study was carried out to determine the effects of some production factor such as adhesive ratio, pressing time and press pressure on thermal conductivity of oriented strand board (OSB). For this purpose, 80mm long strands made of Scots pine (Pinus sylvestris L.) were bonded with phenol-formaldehyde resin at three different ratios (3, 4.5, and 6%) to produce three-layer cross-aligned OSBs. Strands used for the production of OSB panels were produced 40% of core layer and 60% of outer layers. The panels were pressed for three different pressing times, from 3, 5, to 7 minutes, and three different pres pressure, from 35, 40, to 45, aiming for a target density of 0.70 g/cm3. The thermal conductivity test was performed based on ASTM C 1113-99 hotwire method. The lowest thermal conductivity of 0,129 W/mK was obtained from 1 sample. The highest thermal conductivity of 0,170 W/mK was obtained from the number of 26 samples. Consequently, the results of experimental study were showed that as increasing adhesive ratio, and press pressure and pressing time the thermal conductivity of samples were increased.

Key words: Oriented strand board, thermal conductivity, Phenol-for maldehyde, Physical and Mechanical properties

1. Introduction

Wood composites, produced with discontinuous wood elements such as flakes and strands, result from the processing of the wood constituent with resin and other additives. Oriented strand board (OSB) is a structural reconstituted panel that consists of wood strands bonded with an exterior resin type.

OSB panels are made of compressed strands lined up and arranged in three to five layers that are oriented at right angles to each other. And in some cases, the strands used in core layers are randomly oriented [1].OSB is generally similar to three-layered symmetric laminate. The outer layers of strands are orientated with the long dimension, and the inner layers are orientated at right angles to the outer layer [2].Oriented strand boards are a relatively new kind of wood-based panels that are defined in the European Standard. Particle boards are classified depending on the size and orientation of their components [3].

The primary benefits of OSB are its equivalent mechanical properties and substantially lower cost compared to the other structural plywood. They are more commonly used in the building sector as construction panels, both for structural purpose and as ceiling coverings [4].The most distinguishing difference between OSB and waferboard, which is the predecessor of OSB, is the high degree of orientation in the face strands. This orientation serves to improve the mechanical properties of the panel in the direction of alignment. As a result, the panel has greater elastic modulus in the longitudinal direction. It is apparent that the orientation of the principal material directions of the flakes will greatly influence the mechanical and physical properties of the board [5].

Significant opportunities exist for improvement and optimization of the physical and mechanical properties of the composites through controlling raw material input and manufacturing process. The importance of flake

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mat structure and its influence on panel properties is well known.

Suchsland investigated the density variation in the plane of the panel, known as Horizontal Density Distribution (HDD), and determined that flake geometry will affect the relative void volume in a mat [6]. Suchsland and Xu, continued their investigation to develop a model for simulation of the HDD in flakeboard. From this research, it was concluded that both internal bond and thickness swell properties were directly affected by HDD [7].Dai and Steiner, developed a probability-based model to describe randomly packed, short-fiber-type wood composites. The model uses the approach that the structural properties of a randomly formed flake network are random variables, essentially characterized by Poisson and exponential distributions and predicts the distribution of number of flake centers per unit of flake area, flake area coverage, free flake length, and void size [8]. Lang and Wolcott, developed a Monte Carlo simulation procedure that predicts the number of strands in the centroid of imaginary strand columns, the vertical distance between adjacent strands and the position of the column centroid in relation to strand length based on data from laboratory mats [9].

There are so many factors that affect on the physical and mechanical properties of panels, and the determination of the effects of these factors on them properties of panels is very important for manufacturing of OSBs. Unfortunately, there is so little information about thermal conductivity of OSB. The aim of this study is to evaluate the effects of production conditions of OSB panels such as adhesive ratio, pressing time and pressing pressure on thermal conductivity of OSB.

2. Material and Methods

2.1. Production of OSB panels

Scots Pine (Pinus sylvestris L.) wood was used in the production of the OSB. The strands dimension in usage was approximately 80 mm long, 20 mm wide and 0.7mm thick. First, the wood strands were dried to 3% moisture content before adhesive was sprayed on them for three minutes. Then, adhesive material without wax, a solid content of 47% liquid phenol- formaldehyde resin, was applied in 3, 4.5 and 6 percent ratios based on the weight of oven dry wood strands. The press periods and press pressure were 3, 5 and 7 minutes under the 35, 40, 45 kg/cm2 press pressure, respectively. The shelling ratio was 40% for core layer and 60% for face layer, and density of the boards was aimed at 0.70g/cm3density. Totally 27 OSB panels, dimensioned as 56x56x1.2 cm, were made for experiments. Hand formed mats were pressed in a hydraulic press. These panels were labelled from 1 to 27. All mats were pressed under automatically controlled conditions at 182±3ºC. After pressing, the boards were conditioned to constant weight at 65±5% relative humidity and at a temperature of 20±2 ºC until they reached stable weight [10]. Afterwards, the density and moisture content values of OSBs were determined according to the related standards [11, 12].

2.2. Measurement Procedures of Thermal Conductivity

A quick thermal conductivity meter based on the ASTM C 1113-99 hot-wire method was used [13].The thermal conductivities of the samples were measured by using a thermal conductivity meter (Quick Thermal Conductivity Meter-QTM-500) that was based on the unsteady hot-wire method. During the test operation, the temperature of the hot wire rises rapidly and this temperature rise spreads outward in the samples. Dimension of specimens should be large enough so that the temperature on the outer edge of the sample specimen remains constant during the measurement of the thermal conductivity

2.3. Data Analyses

Data for each test were statistically analyzed. The analysis of variance (ANOVA) was used (α: 0.05) to test for significant difference between factors. When the ANOVA indicated a significant difference among factors, the compared values were evaluated with the Duncan test to identify which groups were significantly different from other groups.

3. Results and Discussion

The average density and moisture content of panels were obtained as 0.73 g/cm3 and 7.4%, respectively. It was found out that the aimed and acquired values related to density and moisture were within the ranges specified in the standards. The thermal conductivity values of OSB panels according to experimental design were showed in Table 1.

Table 1. The thermal conductivity values of OSB panels and experimental design

Number of OSB panels	Experimental conditions			Thermal Conductivity (W/mK)	
	Adhesive ratio (%)	Pres time (min.)	Pres pressure (kg/cm^2)	Mean Value	Std. Deviation
1	3	3	35	0.129	0.010
2			40	0.148	0.008
3			45	0.148	0.023
4		5	35	0.142	0.012
5			40	0.153	0.028
6			45	0.144	0.018
7		7	35	0.158	0.031
8			40	0.141	0.025
9			45	0.152	0.025
10	4.5	3	35	0.144	0.019
11			40	0.142	0.023
12			45	0.157	0.017
13		5	35	0.153	0.024
14			40	0.152	0.020
15			45	0.143	0.026
16		7	35	0.146	0.025
17			40	0.160	0.029
18			45	0.155	0.026
19	6	3	35	0.169	0.023
20			40	0.153	0.020
21			45	0.163	0.027
22		5	35	0.154	0.018
23			40	0.156	0.018
24			45	0.161	0.025
25		7	35	0.158	0.027
26			40	0.170	0.019
27			45	0.169	0.024

It was found that the thermal conductivity value varied between 0.129 W/mK and 0.170 W/mK. The highest thermal conductivity of produced panel was found the number of the first as 0.170 W/mK (6% adhesive ratio, 7 minutes press time and 40 kg/cm2 pres pressure) and the lowest thermal conductivity value was obtained in the number of twenty-sixth panel which is produced in 3% adhesive ratio, 3 minutes press time and 35 kg/cm2 pres pressure. It was showed that, as the increased of adhesive ratio, press time and pres pressure, the thermal conductivity value of OSB panels was increased.

Variance analysis was used in order to determine whether or not variables and their interactions with each other were influential on the thermal conductivity according to the values are given in Table 2.

Table 2. Variance results of thermal conductivity

Sources	Sum of Squares	Degrees of freedom	Mean Square	F-Value	Sig.($p \leq 0.05$)
Factor A	0.02	2.00	0.01	23.33	0.00
Factor B	0.00	2.00	0.00	3.80	0.02
Factor C	0.00	2.00	0.00	1.32	0.27
A * B	0.00	4.00	0.00	0.81	0.52
A * C	0.00	4.00	0.00	0.33	0.86
B * C	0.00	4.00	0.00	1.17	0.32
A * B * C	0.02	8.00	0.00	3.96	0.00
Error	0.26	513.00	0.00		
Total	12.89	540.00			
Factor A: Adhesive ratio (3-4.5-6%) Factor B: Pres time (3-5-7 min.) Factor C: Pres pressure (35-40-45 kg/cm^2)					

According to the results of the variance analysis, the adhesive ratio and the period of pres time are influential on the thermal conductivity values were statistically significant, but their interactions aren't on it. Duncan test results conducted to determine the importance of the differences between the groups are given in Table3.

Table 3. Duncan test results of thermal conductivity

Experimental conditions		Mean (W/mK)	HG
Adhesive Ratio (%)	3	0.146	A
	4.5	0.150	A
	6	0.161	B
Pres Time (min.)	3	0.150	A
	5	0.150	A
	7	0.156	B
Pres pressure (kg/cm^2)	35	0.150	A
	40	0.152	A
	45	0.154	A
HG: Homogeneous group			

According to Duncan test results, it can be said that thermal conductivity values were affected by adhesive ratio and pressing time. According to the results of the statistical analysis, the adhesive ratio and pressing time were found to have significant effects on the thermal conductivity value. Increasing of adhesive ratio from 3 to 6% increased the thermal conductivity of panels. In addition, increasing of pressure time from 3 minute to 7 minute got higher thermal properties of OSB panels. The dependencies on the adhesive ratio and pressing time of the thermal conductivity values are given in Figure 1.

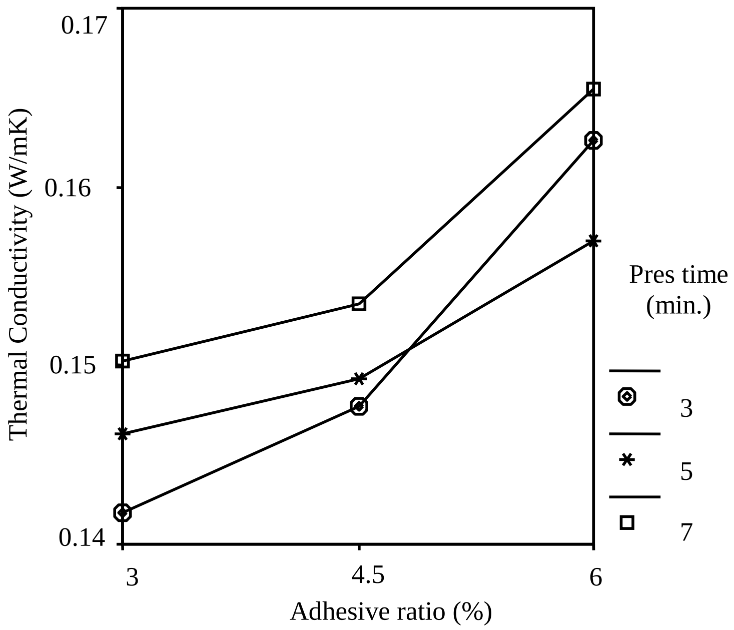

Figure 1. Effects of adhesive ratio and pres time on thermal conductivity.

4. Conclusion

Decreasing suitable forest resources around the world urge the forest product industry to produce new materials from available resources. Oriented strand board is an important light construction material that can be use insulation material in building construction. This is why, thermal conductivity of OSB board and the factors affecting it are very important. The results showed that the values of thermal conductivity changed between 0.129 and 0.170 W/mK. As the adhesive ratio, pres time and pres pressure increased, value of thermal conductivity increased. This case occurred that the effect of the mechanical connection between the strands.

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