Com-Ply Board Properties Made from Oil Palm Trunk Bonded with Isocyanate, Phenol Formaldehyde and Urea Formaldehyde

Apri Heri Iswanto, Irawati Azhar, Tito Sucipto and Fazila Oktaviani Tarigan
Department of Forest Product, Faculty of Forestry, Universitas Sumatera Utara, Padang Bulan, Medan 20155, Indonesia

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Abstract: Problem of Indonesian wood industry is lack of wood as raw material. Need alternative materials to solve that problem. Oil palm trunk is one of non-wood lignocellulosic material that potential to develop for material substitution in the wood industry, especially of biocomposite industry. The objective of this research was to evaluate of physical and mechanical properties of com-ply made from oil palm trunk bonded with UF, PF, and isocyanate resin. The results showed that isocyanate resin produced the best properties of the board. All parameters fulfill the requirement of JIS A5908 (2003). For all resin type, 7% adhesive level resulted in the best properties of the board.

1 INTRODUCTION

The general problem of the Indonesiaan wood industry is the lack of wood as raw material. Many research had been done to find alternative material from non-wood lignocellulosic materials. Oil palm trunk is one of lignocellulose non-wood materials that abundant in Indonesia. Sumatra islands are the biggest plantations of oil palm in Indonesia. In the plantation area, non-productive oil palm plant after cutting process only became waste. This research would try to utilize of oil palm trunk for biocomposite materials, especially of the com-ply board.

Com-ply is biocomposite made from a combination of particleboard for the core layer and veneer for the surface layer (Tsoumis, 1991; Forest Product Laboratory, 1999; Haygreen and Bowyer, 1985). Com-ply had better strength compared to particleboard. Iswanto et al. (2017) reported that utilization of veneer as a surface layer in particleboard can improve the bending strength of non-wood particleboard. In the producing of Com-ply, adhesives have an essential role to result ining the right product. Forest Product Laboratory (1999) classified the adhesive into three types namely exterior type (Phenol Formaldehyde-PF, Resorcinol Formaldehyde-RF, Phenol Resorcinol Formaldehyde, Isocyanate Emulsion, and Melamine Formaldehyde-MF), limited exterior type (Melamine Urea Formaldehyde-MUF, Isosianat, and Epoxy) and interior type (Urea Formaldehyde and Casein). The objective of this research was to evaluate properties of com-ply made from oil palm trunk bonded with Isocyanate, Phenol-Formaldehyde and Urea Formaldehyde.

2 MATERIALS AND METHODS

2.1 Materials

Materials were used in this research consisted of oil palm trunk (Elaeis guineensis Jacq.) was collected from a plantation in North Sumatra, Meranti wood veneer and Isocyanate, Phenol-Formaldehyde (PF) and Urea Formaldehyde (UF) resin.

2.2 Methods

The com-ply board was fabricated in size of 25 by 25 cm with density and thickness target of 0.7 g/cm3 and 1 cm respectively. Resin variation in that determined in this research was 3, 5, and 7%. Com-ply board composition consisted of veneer used as a surface layer (face and back) and particle of oil palm trunk used as a core layer. Detail manufacturing process showed in Fig.1.

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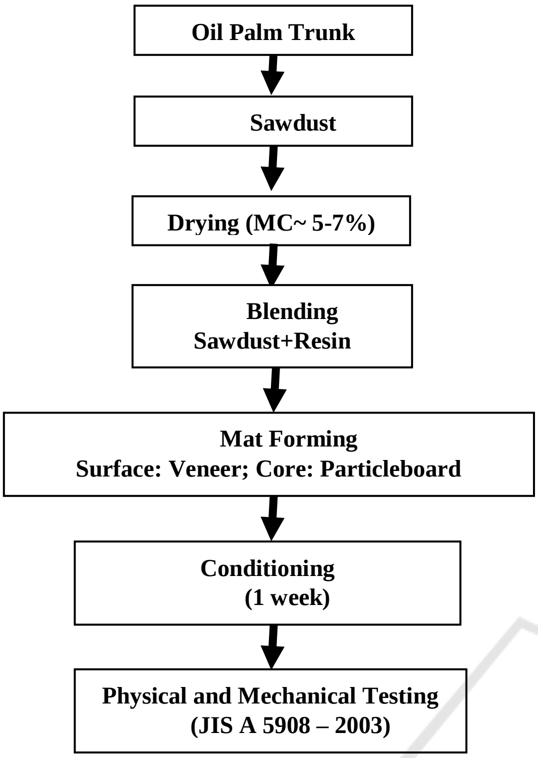

Figure 1: Diagram of com-ply manufacturing.

3 RESULT AND DISCUSSION

The properties of com-ply results of this research shown in Table 1.

Table 1: Data of physical and mechanical properties com-ply board.

Parameters	Resin Level	Resin Type		
		Isocyanate	PF	UF
Thickness Swelling (%)	3	25.17	43.73	61.60
	5	21.94	32.65	60.88
	7	17.80	25.56	59.93
Water Absorbtion (%)	3	50.51	141.03	105.97
	5	57.94	90.86	98.14
	7	51.43	71.67	88.87
Modulus of Elasticity (kg/cm^2)	3	63,644	65,116	26,254
	5	55,291	76,101	38,227
	7	60,653	78,020	40,886
Modulus of Rupture (kg/cm^2)	3	626	475	195
	5	625	505	192
	7	639	548	234
Internal Bond (kg/cm^2)	3	3.38	2.73	0.31
	5	5.05	3.03	0.57
	7	5.76	3.98	0.62
Screw Withdrawl (kg/cm^2)	3	37.9	27.50	20.98
	5	51.6	33.19	25.57
	7	54.8	41.21	35.76

3.1 Physical Properties

3.1.1 Thickness Swelling (TS) and Water Absorption (WA) of Board

Thickness swelling values of the board were varied from 17.80% to 61.60%. Isocyanate resin resulted in the lowest value of TS. Chemical bonding of isocyanate resin resulted in good bonding compared to PF and UF resin. Isocyanate group (–N=C=O) will react with the hydroxyl group (OH) from wood resulted in urethane (Teco, 2005 and Mara, 1992). Combination factors such as a non-polar, aromatic compound of Isocyanate more resistant to hydrolysis. Furthermore, the trend of the data showed that a high level of resin resulted in decreasing of TS value for all resin type. It similar research that conducted by Iswanto et al. (2018a, 2018b, 2019), They reported that effect of increasing adhesive level on decreasing the TS of passion fruit hulls particleboard bonded with UF resin. JIS A 5908 (2003) requiring of maximum TS value is 12%, all adhesive types in this research did not fulfill of standard. UF resin had the highest value of TS. It is worst resin in order to dimensional stability because UF more easy hydrolysed of the hidrogen bond as a result of humidity, strong acid, especially in medium to a high temperature so UF (Pizzi 1994).

Water absorption values of the board were varied from 50.51% to141.03%. Similar trend data with TS value also shown in WA, isocyanate resin resulted in lowest WA value. Even though in the lowest resin level (3%), isocyanate produced better dimensional stability compared to PF. Teco (2005) and Mara (1992) stated that compared to PF and UF, the adhesive bond of isocyanate resin is chemical bond, so that results of stable bond and strong.

3.2 Mechanical Properties

3.2.1 Modulus of Elasticity (MoE) and Modulus of Rupture (MoR)

The MoE values of board were varied from 26,254.42 to 78,020.03 kg/cm^2. PF resin produced by hihgest MoE value. Generally, PF and isocyanate resin had fulfilled JIS A 5908 (2003) that requirement the lengthwise of MoE minimum of 40,000 kg/cm^2. The adhesive level had a linier correlation with MoE value. The increasing of adhesive level produced of higher MoE value. Maloney (1993) stated that MoE affected by amount and adhesives type, adhesive bond, and fiber length of particle. The difference of resin level had a significant effect on mechanical properties.

The MoR values of the board were varied from 192.56 to 639.43 kg/cm^2. JIS A 5908 (2003) that requirement the lengthwise of MoR minimum of 300 kg/cm^2. Similar with MoE value, PF and Isocyanate resin resulted in higher MoR value, and the higher level of adhesive produced of greater MoR value. Bowyer et al. (2003) stated that the increasing of resin up to optimum condition resulted in the rise of MoR value, the excess of resin did not result significant effect on MoR value.

3.2.2 Internal Bond (IB) and Screw Withdrawl (SW)

Internal bond values were varied from 0.31 to 5.76 kg/cm^2. JIS A 5908 (2003) that requirement of IB minimum of 3 kg/cm^2. Board bonded with UF resin did not fulfill standard, meanwhile of PF and isocyanate resin overall meet the standard excepted of 3% level for PF resin. Data trend showed that higher resin level resulted in better IB value for all resin type. Haygreen and Bowyer (1985) stated that the internal bond would be perfect as the adhesive level increases.

Screw withdrawal values were varied from 20.98 to 54.82 kg. JIS A 5908 (2003) that requirement SW minimum of 51 kg. According to the standard, only isocyanate resin at 5 and 7 level that fulfill the requirement of JIS A 5908 (2003). Similar to the previous mechanical properties, the increasing of adhesive level caused of increasing of SW value.

4 CONCLUSIONS

Over all com-ply bonded with isocyanate resin fulfill JIS A 5908 (2003). For UF and PF adhesives, resin level 7% produced the best of physical and mechanical properties of com-ply. While for isocyanate resin, 3% level can be produced of com-ply that fulfill of standard.

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