Relationship of Board Density and Resin Contents Towards the Particleboard Properties from Weathered Oil Palm Trunk

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ABSTRACT

In this study, the relationship of density and resin content (RC) on mechanical and physical properties of particleboard manufactured from weathered oil palm trunk particles were determined. Weathered trunk of Oil palm (Elaeis guineensis Jacq.) was used as alternative raw materials for particleboard manufacturing. During board manufacture, resin content (7, 9 and 11%) and density (500, 600 and 700kg/m^3) were used. The experimental panels were tested for their mechanical strength including modulus of rapture (MOR), modulus of elasticity (MOE), internal bonding (IB) and physical properties thickness swelling (TS) and water absorption (WA) were determine based on British European (BS EN) standard. Mechanical properties and physical properties strength of particleboard increased toward higher board density and resin contents. All of particleboard does not satisfy the minimum MOR, MOE, IB and TS standard requirement of non-load bearing particleboards for general use.

Keywords: oil palm trunk, particleboard, density, resin content

Introduction

The demand for particleboard represents 57% of the total volume of wood-based panels has recently increased dramatically throughout the world. Housing construction and furniture manufacturing are the higher demand for the particleboard. Worldwide demand for particleboard has been steadily growing since then at a rate between 2% and 5% per annum. In recent years, wood-based industries all over the world are facing difficulty in obtaining wood raw material. Deforestation, increasing wood demand and forest degradation for wood-based panels has led to a shortage of raw materials in the wood industrial sector for a long time (Ayrilmis et al., 2012). In other words, the worldwide demand of particleboard is still growing.

Fordaq Furniture (2010) reported that Europe produced 62 per cent of the world's particleboard, North Asia produced fourteen per cent, North America produced nine per cent, South Asia produced eight per cent, South America produced six per cent, and Australasia produced one per cent in the year 2009. In Europe, production of particleboard is forecast to drop slightly to 60 per cent by 2013. Over the same period production in North America and South Asia is expected to increase slightly to nine per cent, and in South America production in forecast to increase to seven per cent. In North Asia and Australasia, production of particleboard will remain unchanged.

In Malaysia, wood based industry comprises of sawn timber, veneer and panel products which include plywood and other reconstituted panel product such as particleboard, fiberboard, chipboard, moldings and builders joinery and carpentry. Traditionally, Rubberwood is the main raw material used for particleboard production. The declining supply of Rubberwood is caused demand of rubberwood logs to be utilized in the manufacture of a variety of products (MDF, plywood, sawn timber etc.) and the rubber plantation area is getting smaller due to unattractive price (Loh et al., 2010). The huge usage of these materials will cause the depletion of the resource in the future thus other material such as oil palm trunks should be investigated as an alternative to those materials.

The oil palm planted area in 2011 in Malaysia reached 5.00 million hectares, an increase of 3.0% against 4.85 million hectares recorded the previous year (MPOB, 2011). In the oil palm plantation, oil palm trees with ages of 25 years and above will be cut down and replanted. The problem face by the plantation sector is how to manage the oil palm trunk after cutting. If they burn all the oil palm trunks, this would increase the air pollution. To reduce the waste of the palm oil trunks, new uses must be found to maximize the utilization of the oil palm trunks. By fulfilling the demand of the raw material requirement in the particleboard industries by using the palm oil trunk, this could solve the raw material supply scarcity and open the opportunity of maximizing the utilization of the palm oil tree. Therefore, the huge amount oil palm plantation wastage especially from weathered oil palm trunk could be a the feasible raw material for particleboard industry in future. It can be major raw materials for panel product industry in future. The objectives of the study are to determine the particleboard properties made from weathered oil palm trunk and to study the effects of board density and resin contents on the properties.

Materials and Methods

Field Procedure and Material Preparation

Weathered Oil palm trunks (Figure 1) were used for making particleboard in this research. These oil palms were left in the open area at the Wood Technology workshop, UiTM Pahang for nearly one year. The oil palm trunk was cut into billet with the length of 8 inch using a Chain saw. The oil palm trunk barks were removed by using cleaver. Disc flaker converted the billet into flakes. The flakes were passed through a dust extractor to reduce the flakes into smaller particles. The particles were airdried for one week before they were screened. The particles were screened into 0.5 mm, 1.0 mm and 2.0 mm particle sizes. In this study only 2.0 mm size was used in particleboard manufacture. The screened particles were then dried in the oven at 80oc for 24 hours to reduce the moisture content to less than 5%.

Figure 1: Raw material for particleboard (weathered Oil Palm Trunk)

Board Manufacture

In the manufacture of homogenous particleboard, phenol formaldehyde resin was used. The resin was made available by a local resin company and was formulated according to commercial use. Particleboards were produced with screened particles of 2.0 mm. Resin content of 7, 9 & 11 % and target board density of 500, 600 and 700 kg m^{-3} were used in the study. In the manufacture of particleboard, a weighted amount of particles was placed in the particle glue mixer and sprayed with the phenolic resin at an air pressure of 1.8 MPa. The sprayed particles were then manually laid in a wooden mould over a caul plate with a dimension of

35 X 35 cm and then pre-pressed at 3.5 MPa for 30 seconds. The wooden frame was removed and two metal stops of 12 mm were placed near the sides of the consolidated mat before another caul plate was laid on top of it. The consolidated mat was then finally pressed to the required thickness of 12 mm at 165 °C for 6 minutes and the maximum pressure at the metal stops was set at 1800Psi. A total of two boards were produced for each variable.

Sample Cutting, Conditioning and Board Evaluation

Board trimming and cutting process for samples testing were done by using Table Saw. The conditioned boards were cut into specific dimensions; for static bending test (50 mm X 50 mm X 340 mm), internal bonding test (50 mm X 50 mm), water absorption and thickness swelling (50 mm X 50 mm). All samples were measured for their thickness, weight, length and width. The properties tested were flexural strength (MOR), internal bonding (IB), water absorption and thickness swelling (T). These properties were tested in accordance to British Standard (BS EN 310:1993 for static bending test, BS EN 319:1993 for internal bonding test and BS EN 317:1993 for water absorption and thickness swelling).

Results and Discussions

Mechanical and Physical Properties

The mechanical and physical properties of particleboard from weathered oil palm trunk particles are presented in Table 1. The MOR values ranged from 4.85 to 13.71 MPa and does not satisfies the minimum standard of 15 MPa. The ranges for MOE of particleboard are in range 830 to 2500 MPa. Particleboard of 600kg/m^3 with resin content 9%, and 700kg/m^3 with resin content 9 and 11% are able to meet the minimum requirement of non-load bearing particleboards for general use in humid conditions (2050MPa).The minimum requirement for internal bonding of particleboard for non-load bearing particleboards for general use in humid conditions is 0.45 MPa, however all particleboards produced do not achieve the minimum requirement based on BS EN 312-4, 2003 except for board at 700kg/m^3 with 11% resin content.

Table 1: Mechanical and physical properties of particleboard from weathered oil palm trunk particles.

DENSITY (Kg/m^3)	RESIN CONTENT (%)	MOR (MPa)	MOE (MPa)	IB (MPa)	TS (%)	WA (%)
500	7	4.85	830	0.16	39.73	168.57
500	9	6.25	1315	0.30	23.99	137.75
500	11	6.62	1088	0.26	18.35	124.09
600	7	7.61	1332	0.23	29.81	124.22
600	9	9.49	2449	0.33	26.92	111.79
600	11	10.58	1807	0.36	14.89	92.34
700	7	12.19	1976	0.28	37.29	103.32
700	9	12.97	2102	0.40	31.47	96.12
700	11	13.71	2500	0.54	19.09	76.82
BS EN 312-4, 2003		> 15	> 2050	> 0.45	< 14	-

Weathered oil palm trunk particleboard showed higher thickness swelling and water absorption values. Range of water absorption of particleboards for 24 hour immersion were between 76 to 169%, while the maximum thickness swelling allowable for 24 hour immersion is 14%. Thicknesses swelling of all particleboards from weathered oil palm trunk particles were between 14.89 to 39.73%. All of particleboard does not satisfy the minimum MOR, MOE, IB and TS standard requirement of non-load bearing particleboards for general use.

Effect of Density on Mechanical Properties of Particleboard

Figure 1 shows the effect of board density on the mechanical properties of OPT weathered particleboard. All the mechanical properties of the boards were significantly affected by increasing board density. The MOR values were improved as the board density increased. Similarly, MOE and IB also showed higher value with higher board density. The compaction of mat to an average density higher than the density of the raw

material will allow better surface contacts among the particles in the mat. The amount of void space in the final board decreases when the board density increases and it resulting in higher strength of particleboard (Barnes, 2000).

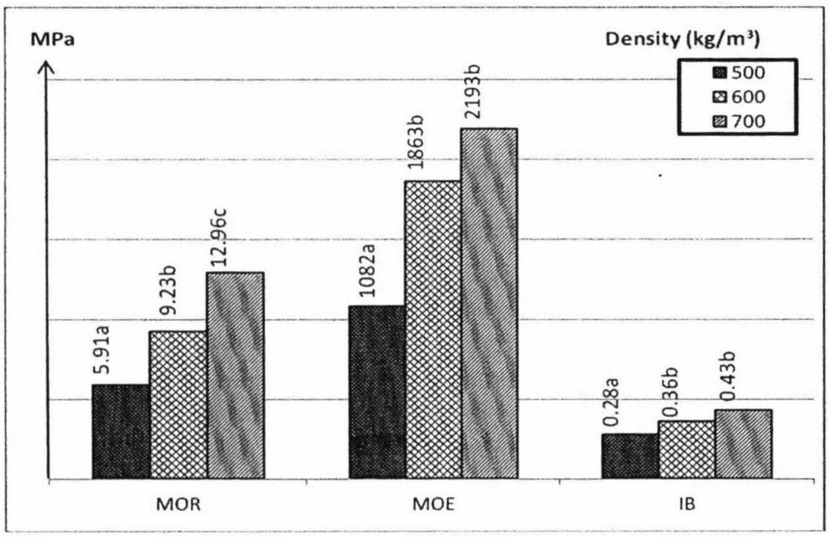

Figure 1: Effect of board density on mechanical properties of particleboard

Effect of Board Density on Physical Properties

Figure 2 show the effect of density particleboard on the thickness swelling and water absorption of particleboard. For thickness swelling, it decreased significantly when the board density was increased from 500 kg/m^3 to 600 kg/m^3 by about 15.46%. Usually, increasing board density will cause the thickness swelling to be improved. Water absorption was shown to decrease significantly when the board density was increased from 500 to 700kgm^{-3}. According to Barnes (2000), the compaction of mat to an average density higher than the density of the raw material will allow better surface contacts amount the particles in the mat. It avoids the water from being absorbed into board thus contributing to lower thickness swelling. Thickness swelling of particleboard improved as the density of board increased was also reported by Wang and Sun (2002).

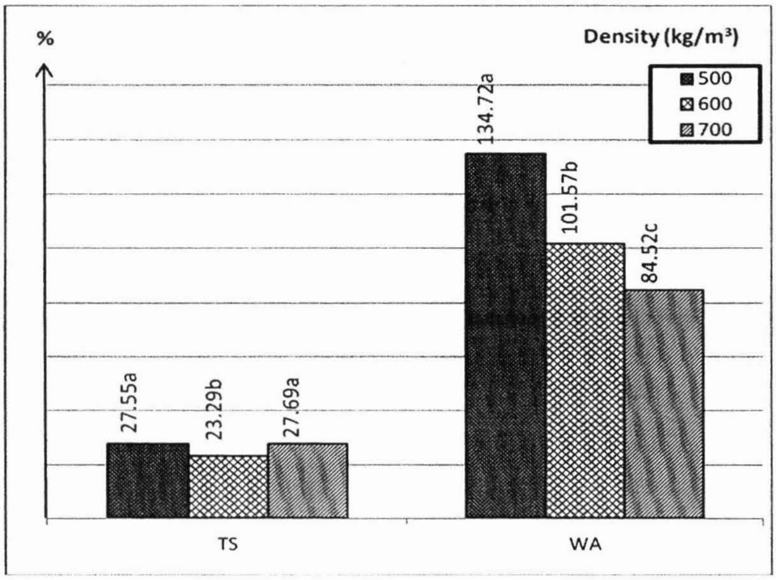

Figure 2: Effect of board density on physical properties

Effect of Resin Content on Mechanical Properties

Figure 3 shows the effects of resin content on MOR, MOE and IB values. All the MOR, MOE and IB values significantly increased when resin content was increased from 7 to 11%. According to Ashori and Nourbakhsh (2008), the mechanical properties of particleboard were improved with higher resin content. This increase in strength is due to the better bonding of the particles in the presence of more resin (Kelly, 1977).

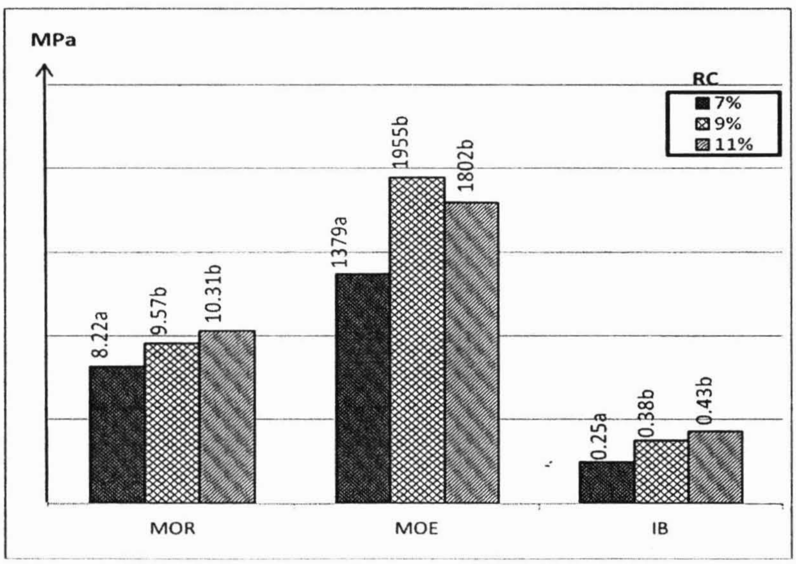

Figure 3: Effect of resin content on mechanical properties of particleboard

Effect of Resin Content on Physical Properties

Figure 4 shows the effects of resin content on thickness swelling and water absorption of board. Increasing the resin content from 7 to 9% showed significant improvement in TS and WA values. For TS when the resin content was increased from 7 to 9% an improvement in TS value of about 51% was exhibited. WA also improved by about 29% when the resin content was increased to 9%. Higher resin content gives good physical properties (Ashori and Nourbakhsh, 2008). The high resin content in weathered oil palm trunk particleboard covered by the parenchyma tissues, reduces the ability of parenchyma to absorb water (Abdúllah et al., 2012)

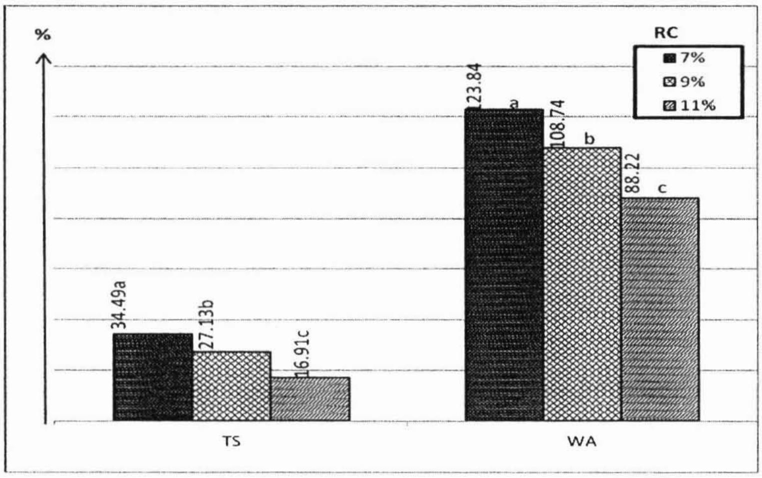

Figure 4: Effect of resin content on physical properties of particleboard

Conclusion and Recommendations

All the mechanical and physical properties of the boards were significantly affected by increasing board density. Mechanical properties of MOR, MOE and IB increase while properties of WA and TS were improved. For the effect of resin contents on boards, it was shown that mechanical properties (MOR, MOE, and IB) increased significantly when the resin content was increased from 7% to 11%. TS and WA was improved significantly when the resin contents were increased from 7% to 11%. It is recommended that, future study of the particleboard using weathered Oil Palm Trunk be continued. It could solve the problem shortage of raw material in the wood industry especially for particleboard industry.

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