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FINISHING SYSTEM FOR OIL PALM EMPTY FRUIT BUNCH (EFB) MEDIUM DENSITY FIBERBOARD

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BY

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DEDICATION TO ……..

Abu Huraira (r.a) reported God's messenger (peace and blessings of Allah be upon him) as saying, " When a man dies, no further reward is recorded for his actions, with three exceptions: Sadaqa (alms) which continues to be supplied, or knowledge from which benefit continues to be reaped, or the prayers of a good son for his dead father." (Muslim)

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ABSTRACT

This study evaluates the surface properties of finished oil palm Empty Fruit Bunch (EFB) Medium Density Fiberboard (MDF) coated with different finishing system. Two types of lacquer i.e., Acid Catalyst (AC) and Nitrocellulose (NC), were used in this work. The 20 mm thick EFB MDFs were cut to 150 x 100 mm size. The boards were coated with five different treatments: (1) a wash coat, a sealer, and a top coat, (2) a sealer and two top coats, (3) two sealers and a top coat, (4) a wash coat, two sealers, and a top coat, and (5) a wash coat, two sealers, and two top coats. The coated boards were assessed for impact, adhesion and gloss (at 20^o, 60^o, and 85^o), according to British Standard BS 3962 Part 6 (1975) and ASTM D523-67 (1967). The result shows that MDF coated with AC lacquer has higher finish uptake (4.31 g/m^2) and good impact rating (3) compare to that of NC lacquer (3.01 g/m^2 and 3 respectively). NC gives better gloss compared to AC lacquer. No significant difference was detected between AC and NC lacquers in terms of adhesion. The results also indicate that all the treatments used in this study have no significant influence on both the amount of finish uptake and impact resistance of the coated MDF. Among the treatments used, that with two sealers and a top coat (treatment 3) gives good adhesion. However, surface gloss was significantly affected by the surface treatment. Highest gloss was obtained by either applying a sealer and two top coats (treatment 2) or by applying a layer of wash coat, two sealers, and two top coats (treatments 5). The best finishing system for EFB MDF is given by NC with a sealer and two top coats (treatment 2).

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LIST OF ABBREVIATIONS

AC	Acid catalyst
EFB	Empty fruit bunch
L	Lacquer
MDF	Medium density fiberboard
NA	Not available
NC	Nitrocellulose
PU	Polyurethane
RH	Relative Humidity
S	Sealer
T	Treatment
TC	Top coat
WC	Wash coat
POME	Palm Oil Mill Effluent
PPM	Parts per million
ATTC	ASEAN Timber Technology Centre
C	Carbon
N	Nitrogen
P O	Phosphorus Oxide
K O	Potassium Oxide
Mg O	Magnesium Oxide
B	Boron
Cu	Copper
Zn	Zinc
Fe	Iron
Mn	Manganese

CHAPTER ONE

INTRODUCTION

1.0 GENERAL OVERVIEW

Oil palm (*Elaeis guineensis*) was abundantly found in tropical Africa under natural condition and its kernel and pericarp oil was widely used by the natives. The oil palm first entered Malaysia through the Botanical Gardens, Singapore in 1870 but the first commercial planting was initiated at 1970 (Tang et al., 1966). The first experimental planting by the department of agriculture was at Batu Tiga, Selangor in 1903 (Husin et al., 1985). The review of The Malaysian Palm Oil Industry in 1996 indicated that the total of oil palm planted area in 1966 increased by 2.96 % to 2,615,269 hectares compared to 2,540,087 hectares in 1995.

According to the 1992 statistics by PORLA, there are over million hectares of plantation areas in Malaysia. There are 292 registered mills in Malaysia, which processes 23.23 million tones fresh fruit bunches yearly. Based on 30 % extraction rate of fiber from EFB alone, there are more than 2 million tones of fibre can be produced (Aziz, 1994). Oil palm trees have a potential as a new source of fiber for panel industry. This is due to its availability (Caesar et al., 1996) and long vascular bundles, which is suitable in producing various wood composite products such as medium density fiberboard (MDF) (Rahim et al., 1993).

MDF was commercially produced in Malaysia 1987 by Takeuchi MDF sdn. Bhd. Currently, all MDF plants, except Daiken and Samling in Sarawak, use rubberwood as raw material since it is cheaper, readily available and gives good quality MDF with acceptable physical properties. Daiken is the first MDF plant in the world to use heterogeneous tropical hardwood for MDF production. To produce an MDF with output of 100,000 m^3, about 300 tones of dry fibre are requires daily (Caesar et al., 1996).

The value and quality of MDF can be increased if it is finished whether by varnishing, lacquering, painting or by overlaying. Finishing is the final process of manufacturing and normally includes processes such as varnishing, lacquering, painting, plating, anodizing, phosphatizing, galvanizing and bluing. Finishing on furniture is of great importance. Superior finished means it will not fade, peel or check. Besides, that, good quality finishing must also include durability and protection and characteristics related to production (Arturo, 1980).

Because of its flat, smooth, uniform, dense and free of knots surface MDF is easier for finishing compared to solid wood. However, since MDF is made up of wood fibres it tends to absorb more coating materials (Jaili, 1993) than does solid wood. This problem becomes more crucial with MDF made from oil palm fibres. This study is carried out to determine the capability of finishing system apply to oil palm MDF make from empty fruit bunch (EFB).

1.1 JUSTIFICATION

One of the important character of MDF is it produces good finishing characteristics such as excellent paint ability, degree of finish absorption, smoothness, and etc. Since oil palm particles had been reported to have lower wet ability compared of the wood (Ding, 1977 and Wong, 1999), finishing of MDF made from this material may pose some difficulties. To date even though extensive research has been conducted in enhancing the properties MDF manufactured using oil palm fibres, very little was done concerning finishing system for this panel.

1.2 OBJECTIVE

The objectives of this study were:

1. To assess the suitability of selected lacquer to be used on MDF made from oil palm empty fruit bunch (EFB).
2. To evaluate the effect of different types of surface treatment on the quality of finished MDF made from empty fruit bunch (EFB).

CHAPTER TWO

LITERATURE REVIEW

2.1 HISTORY OF OIL PALM

Today, there has been an increasing shortage in the supply of timber for certain species. Furthermore, the Sustainable Forest Management, Certification and the global environmental also reduce the use of tropical hardwood. These reasons prompted Malaysia wood industry to seek for other alternative raw materials for the manufacturing of wood and fiber base products. The demand for composite panel trend to increase due to good properties and characteristics. Oil palm residues have potential to be used as new source of fibre for panel product manufacture. Three sources of fiber from the oil palm are empty fruit bunches (EFB), trunks and fronds. For the past few years, EFB is either use as mulching in the fields or burnt as fuel for the boiler. This open burning can cause environmental problems and disposing EFB and frond cost RM 15 per metric tone. Some researches have been conducted in order to diversify the usage of oil palm tree. Khoo (1991) and Khozirah (1991) reported that oil palm is a potential raw material in manufacture of panel products such as particleboard. MDF admixtures made from the fronds and minimum of 50 % rubber wood fibers can give an acceptable strength properties (Mohd Nor et al., 1993). However, MDF from EFB fiber have low strength properties and fails to meet the JIS standard for Type 300, which is used by the MDF industry.

From the aspect of availability, Norini et al. (2000) estimated that Malaysia has the potential of producing from 0.88 million m3 to 8.0 million m3 of oil palm trunks/stems volume, between the years 2001 and 2010 (Table 1). These volumes are based on the target area due for replanting, multiplied by an average of 134 palms per ha (Norini et al. 1999) and volume of 1.638 m3 per trunk (khali Aziz & Wan Razali 1991). It has also been estimated that the amount of EFB will range from 9.36 million ton to 14.33 million ton between the years 2000 and 2020 (Norini et al. 2000). This directly indicates that oil palm residues, especially those that come in the form of oil palm trunk/stem and EFB, are expected to play a major role as a source of raw materials for development of pulp and paper sector, and other products, such as medium density fiberboard (MDF), particleboard, mineral-bonded particle board, and other types pf products, that will use oil palm residues as raw materials.

Table 1: Projection of oil palm trunks/stems, Malaysia (2001 to 2010)

Year	Replanting Area (ha)	Volume of Oil Palm (m^3)
2001	29,000	6,365,268
2002	24,000	5,267,808
2003	14,000	3,072,888
2004	4,000	877,968
2005	12,000	2,633,904
2006	14,000	3,072,888
2007	25,000	5,487,300
2008	33,000	7,243,236
2009	36,000	7,901,712
2010	29,000	6,365,268

Source: Norini et al. (2000)

Oil palm fibers can be obtained from the trunk, frond and the empty fruit bunch (EFB). Due to the (Table 2), the availability of EFB was estimated at 10.851 million tones per year and 12.434 million tones in 1997 and year 2000 respectively. 6.653 million tones per year and 7.623 million tones for fibre in 1997 and year 2000 respectively. Shell and POME gave 2.701 million tones per year and 33.019 million tones per year in 1997 respectively, in the year 2000 Shell and POME gave 3.094 million tones per year and 37.835 million tones per year respectively.

Table 2. The amount of by product from palm oil mill

Year	Location	By-products in million ton/year			
		EFB	Fibre	Shell	POME
1997	Peninsular Sabah & Sarawak	7.823 3.028	4.797 1.856	1.947 0.754	23.806 9.213
		10.851	6.653	2.701	33.019
2000	Peninsular Sabah & Sarawak	8.288 4.146	5.081 2.542	2.061 1.032	25.219 12.616
		12.434	7.632	3.094	37.835

Source: Chan, 2000

2.1.1 EMPTY FRUIT BUNCH (EFB)

The length of the fruit bunch can reach 50 cm in length and 35 cm in breadth. The bunch weight ranges from a few kilograms about 100 kilogram. For mature plantations, the mean weights are 10-30 kg. One bunches can carry 500 to 4000 fruit, but normally are 1500 fruit (Hartley, 1997). The bunch with fruits is called as fresh fruit bunch (FFB) and empty fruit bunch (EFB) is the spike let of fresh fruit bunch was separated from the bunch stalks after removing the fruits. The fresh fruit bunches harvested from the field were brought to palm oil mill and sterilized under pressure at 3 atmospheres for about one hour. After sterilized, the bunches are then sent for threshing to separate the fruits from the bunches. That is about 20 % to 22 % of the weight of fresh fruit bunches contain 30.5% dry matter, 2.5% oil and 63.0% water (Husin, 1985). For every 100 ton fresh fruit bunch (FFB which has been processed, approximately 20-25 ton of EFB can be obtain (Gurmit et al., 1989). EFB is good for organic matter and plant nutrients. Gurmit, (1994) have reported that 1 tone of EFB are equivalent of 7 kg urea, 2.8 kg rock phosphate, 19.3 kg mutiate of potash and 4.4 kg kiescrite, all of these are fertilizer.

Table 3. Major chemical constituents of oil palm trunk, frond and empty fruit bunch (EFB)

Oil Palm Material	Trunk	Frond	EFB	Trunk	Frond	EFB
Major Chemical Composition	(%)	(%)	(%)	(%)	(%)	(%)
	(1)	(1)	(1)	(2)	(3)	(4)
Holocellulose	70.7	75.5	71.8	71.8	68.2	70.0
Lignin	27.9	16.4	18.6	22.6	19.2	17.2
∝-Cellulose	43.4	56.2	57.2	45.8	52.2	42.7
Extractive						
a) Acetone: Ethanol Toluene	1.3	5.4	5.4	NA	NA	NA
b) Ethanol: benzene	NA	NA	NA	1.2	5.2	0.9
Ash	3.8	4.2	5.0	1.6	4.9	0.7
Summative analysis (%)	103.6	97.3	100.8			

Source: (1) Jalaluddin Harun, 1993
(2) Khoo & Lee, 1987
(3) Ashari et al., 1991
(4) Peh, Khoo and Lee, 1976
NA= Not available

It has also been estimated that the amount of EFB will range from 9.36 million tan to 14.33 million tan between the years 2000 and 2020 (Norini et al. 2000). EFB fiber is wider (25 microns) than that of rubberwood (22.59 microns), however its length (0.89 mm vs. 1.44 mm) is shorter than it (1.44 mm). The thickness of EFB fiber is 2.6 micron. EFB fibers contain about 71.5 % holocellulose, 42.6 % ∝-cellulose and 17.19 % lignin (Mohammad, 1995).

Table 4. Composition of Empty Fruit Bunch

Parameter	Dry matter basis		Fresh wt. Basis* (mean)
	Range	Mean	
Ash (%)	4.8 –8.7	6.3	2.52
Oil (%)	8.1-9.4	8.9	3.56
C (%)	42.0-43.0	42.8	17.12
N (%)	0.65-0.94	0.8	0.32
P O (%)	0.18-0.27	0.22	0.09
K O (%)	2.0-3.9	2.9	1.16
Mg O (%)	0.25-0.40	0.3	0.12
Ca O (%)	0.15-0.48	0.25	0.1
B (ppm)	9.0-11	10	4
Cu (ppm)	22-25	23	9
Zn (ppm)	49-55	51	20
Fe (ppm)	310-595	473	189
Mn (ppm)	26-71	48	19
C/N ratio		54	54

*Moisture content 60 – 65 %
Source: Gurmit Singh et al., 1989

Table 5. Fiber dimension of oil palm trunk, frond and empty fruit bunch and rubber wood

Fiber	Trunk		Frond		Empty Fruit Bunch		Rubber Wood
Characteristics	(1)	(2)	(1)	(3)	(1)	(4)	(5)
Length (mm)	1.22	1.23	1.52	1.96	0.89	0.82	1.44
Width (microns)	35.30	36.60	NA	NA	25.0	27.00	22.50
Cell wall thickness (microns)	4.50	3.40	NA	NA	2.80	3.25	NA

Source: (1) Mohammad Husin et al., 1985
(2) Mohd Nor, 1985
(3) Ashari et al., 1976
(4) Peh et al., 1976
(5) Peel and Peh, 1960
NA= Not available

A number of researches had been carried out to determine the suitability of EFB fiber for making MDF. R. Maylor (1994) found that EFB MDFs have lower strength properties (MOR 153 $kgcm^{-2}$) compare to that of rubberwood (MOR 338 $kgcm^{-2}$) and failed to meet Type 300 specification in JIS standard (MOR min 300 $kgcm^{-2}$). However, Caesar (1996) reported that MDF made from admixture of wood-EFB gave relatively good strength properties, however they are inferior to those made from trunk fibers. One of the contributing factors for the inferior performance by the EFB panels is the presence of oil remnants that affect the particle bonding.

2.2 MEDIUM DENSITY FIBERBOARD (MDF)

MDF was first developed in the United State in 1960s. This panel product is made from wood or non-wood lignocelluloses materials that have been reduced to individual fibers, which are bonded together through the use of synthetic resin as a binder. Wood lignocelluloses materials are such as round wood and lesser known species or obtainable from forest thinning, logging residues and urban areas (Anon, 1985). For non-wood lignocelluloses materials, it can be of agricultural residues such as bagasse, flax shives, jute sticks, straw and hemp in the form of fibers (Maloney, 1977).

MDF boards have density ranging from 660 to 860 kg/m3 (Maloney, 1977). MDF has a good property and can be substitute for particleboard, plywood or solid timber and can be used to produce high quality furniture. It has becoming more popular because of its physical properties and characteristics, which made the product unique. By the end of 1999, the total number of MDF plants in Malaysia is 10, with production capacity were estimated at 2,999,000 m3 per annum (Rahim Sudin, 2000)

Table 6. MDF Industries in Malaysia

Plant	Location	Capacity m3/day	Raw metarial
Takauchi Sdn. Bhd	Pasir Gudang	265	Rubberwood
Golden Hope Fiberboard	Nilai	300	Rubberwood
Hume Fiberboard	Nilai	300	Rubberwood
Merbok MDF Sdn. Bhd.	Sg. Petani	700	Rubberwood
Kumpulan Guthrie Bhd.	Kulim	850	Rubberwood
Evergreen MDF	Batu Pahat	440	Rubberwood
Robin Resources (M)	Mentakab	375	Rubberwood
Daiken Sarawak	Bintulu	350	Tropical wood
Samling Fiberboard	Miri	350	Tropical wood
Soon Seng Sdn. Bhd.	Gemas	50	Oil Palm EFB

Source: Rahim sudin, 2000

The total consumption of MDF worldwide has increased from 5,776,000 m3 in 1992 to 9,910,000 m3 in 1996 (Anon, 1997). Malaysia has an export MDF value of RM253.55 million (384,149 m3) in 1997, an increase of 68% and 45% in volume and value (Anon, 1998).

Table 7. Regional consumption of MDF 1992 and 1996 (000 m3)

Regional	1992	1996	P.a. Change
North America	1,760	2,495	+9.1%
Europe	2,300	3,925	+14.3%
South America	>40	250	+58.1%
Africa	>50	60	+4.7%
Asia	1,196	2,700	+22.6%
Oceania	430	480	+2.8%
Total	5,776	9,910	+14.4%

Source: Anon. 1997

2.2.1 ADVANTAGES OF MDF

Merchantable edges for this panel product are similar to solid wood and superior to particleboard and plywood. This made the MDF not only suitable for decorative effect but also can be used in functional aspect for tongue and grooved, wall paneling or dovetail joints for furniture car casing. Beside that, it is also can be moulded, shaped, routed as solid wood, and carved by hand. The fine fibers used in this product enable MDF to have higher strength and more solid edge compare with particleboard (Parkins, 1998).

MDF is a preferred material for making the pianos and stereo equipment due to its good tonal quality (Anon, 1997). Because of its fine and smooth surface, this panel product was easy to finish and allows for a variety of finishes. It also can be laminated from thin paper overlays to sophisticated lacquering techniques (Anon, 1997).

2.2.2 FINISHING OF MDF BOARD

The advantages of MDF in finishing are given by the smoothness and stability of the surface. Compare to other wood-base panels, MDF can be easily finished on perpendicular and moulded edges without any adhesive bonded edging materials. Also, it is important in assuring that there is its uniform surface contributes to the actual (right) colour, reflection and gives good flow characteristics during finishing (Anon, 1980).

There are two main methods usually used in industrial are use in industrial finishing of MDF. First is staining and a clear lacquer on top, and the other is with pigmented paint. The required appearance and its application will determine the selection of finish materials. Sandpaper with grits 80 to 360 can be used to give better surface of MDF board for finishing. An 80-100 grits sandpaper will take away cutter marks and 100-120 grits are use to remove the dust. For 120-150 grit, it is use finish sanding. Apart for adhesion, smoothness and finish, 150 or 180 grits sandpaper is also used to minimize fiber rising when the first finish coat is applied. After applied with sealer, the surface should be sanded with 240-320 grit sandpaper.