UNIVERSITI PUTRA MALAYSIA

EFFECTS OF STEAMING PRE-TREATMENT AND COMPRESSION LEVEL ON PROPERTIES OF OIL PALM WOOD

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By

ALHASSAN YAKUBU ABARE

Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science.

June 2015

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DEDICATIONS

I would like to dedicate this work to my parents
Alh. YakubuAbare and **HajiyaHadizaAbare**
Who are my inspiration and for their affection, love, continuous support and prayers
My loving Wife **AishatuSalihu Baba**
And my son **Yaqub A. Abare**
For the sacrificed they made and their continuous support and prayers

Abstract of thesis presented to the Senate Universiti Putra Malaysia in the fulfillment of the requirement for the degree of Master of Science

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June 2014

Chairman: Assoc. Prof. Edi SuhaimiBakar, PhD
Faculty: Forestry

There are various technical problems in the current processing technology to convert oil palm trunks to lumber and other useful products. Sawing of oil palm wood andtime in drying and heating are generally considered difficult by industry. The main objective of this study was to evaluate the effect of steaming pre-treatment and compression level during hot press on the properties of oil palm wood produced using integrated processing and approach method.The research was divided into two phase viz; Comparison of sawing patterns and treatment Processes of oil palm wood (OPW). In the comparison of sawing patterns, two of sawing patterns were adopted from cant sawing and named as modified cant sawing (MCS) and reverse cant sawing (RCS).The process of each sawing pattern was divided into 5 work elements: (a) sawing pattern mapping (b) transporting log from log-yard to log-deck (c) loading log to carriage (d) sawing (Head rig) and (e) re-sawing. The total sawing time for each sawing pattern was calculated. The total sawing time comprises both the effective and ineffective time. This was used in the comparison of the two sawing methods. For the treatment processes,three palm trees (≥ 28-year) were harvested and debarked using the Spindle-less peeler and thereafter sawn with a reverse cant sawing pattern (RCS) to get slabs which were edged to form samples with measurements of 30cm long, 6 cm thickness and 15cm width. The samples were then steamed and cold compressed at various compression percent (0%, 20%, 30%, and 40%),drying was carried outat a targeted moisture content of 15 percent. Then it was treated with low molecular weight phenol formaldehyde (LMW-PF) in an impregnation cylinder. Subsequently, the samples were further dried to moisture target of 70 percent in an oven, and finally hot densification to 50% of the original thickness for 45 minutes. The results obtained from comparison of the two sawing patterns were further compared with secondary data of polygon sawing (PS). The total sawing time of reverse cant sawing, modified cant sawing, and polygon sawing was 842 seconds, 919 seconds and 2760 respectively. The total sawing time of PS was more than three times (2760 second) any of these two types of sawing pattern. The result from the treated test samples showed that the physical properties showed that, steamed samples with 40% compression level has the highest density (1065.23 kg/m^3) while the lowest density was recorded at un-steamedsamples with 0% compression level (766.13 kg/m^3). The density showed an increasing trend from 0%

to 40% level for both the steamed and un-steamed samples. Similarly, the density gain and weight percent gain showed almost the same trend. The analysis of variance showed that steaming was not significant on most of the physical properties while the compression level was significant in most of the physical properties.The mean values of the Modulus of Elasticity (MOE) and Modulus of rapture (MOR)ranges from 5687.34 MPa -15046.53 MPa and 42.57 MPa to 114.57MPa respectively. Steaming does not have significant effect on both MOE and MOR while compression level showed significant for both MOE and MOR.From the result, it was found that RCS is the most suitable sawing pattern to produce OPW, because it consumed the shortest total sawing time and it is easy to carry out.In the treatment processes, steaming of the wood samples for this research did not give much effect on variables measured for this study, this implies that it is not necessary for this study. The compression level (%) has great role in this research because it helps in improving the properties of the treated compreg OPW. The compression levels that can be consider most suitable is either 30% or 40%. A patent has already been applied for this research work.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

KESAN PRA- RAWATAN KUKUSAN DAN TINGKAT PEMAMPATAN BAGI SIFAT KAYU KELAPA SAWIT

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Terdapat beberapa masalah teknikal didalam teknologi pemprosesan semasa untuk menukarkan batang kepala sawit kepada papan kayu dan produk penting lain. Menggergaji kayu kelapa sawit dan masa pengeringan dan pemanasan umumnya dianggap sukar oleh industri. Objektif utama penyelidikan ini adalah untuk mengkaji kesan pra-rawatan kukusan dan tahap mampatan semasa proses mampatan panas terhadap sifat kayu kelapa sawit yang dihasilkan melalui proses bersepadu dan pendekatan kaedah. Penyelidikan ini dibahagikan kepada dua fasa iaitu; Membandingkan corak penggergajiandan proses rawatan kayu kelapa sawit (OPW). Didalam membandingkan corak penggergajian, dua corak penggergajian telah diterima pakai daripada penggergajian cant dan dinamakan sebagai penggergajian cant yang diubahsuai (MCS) dan penggergajian cant berbalik Proses bagi setiap corak penggergajian telah dibahagikan kepada 5 unsurkerja: (a) pemetaan corak penggergajian (b) mengangkut balak daripada kawasan pembalakan ke dek pembalakan (c) memindahkan balak kepengangkut (d) penggergaji (Kepalapelantar) dan (e) penggergajian semula. Jumlah masa penggergajian untuk setiap corak penggergajian telah dikira. Jumlah masa menggergaji terdiri daripada kedua-duamasaberkesandantidakberkesan. Initelahdigunakandalammembandingankedua-duakaedahpenggergajian. Bagi proses rawatan, tigakayukelapasawit (≥ 28 tahun) telah ditebang dan dibuang kulit menggunakan alat mengupasan Spindle-kurang dan selepas itu dipotong dengan corak penggergajian cant berbalik (RSC) untuk mendapatkan papankayu yang mempunyaiukuran 30cm panjang, 6 cm tebaldan 15cm lebar. Sampel telah dikukus dan dimampat sejuk kepada pelbagai peratus mampatan (0%, 20%, 30%, and 40%),pengeringan kayu telah dilakukan bagi mencapai tahap 15% kelembapan kayu. Setelah itu, ianya telah dirawat dengan fenol formaldehid berat molekul rendah (LMW-PF) didalam silinder penghamilan. Setelah itu, sampel dikeringkan lagi sehingga mencapai 70 % tahap kelembapan didalam ketuhar, dan akhir sekali dimampat panas sehingga 50% daripada ketebalan asal untuk 45 minit. Keputusan diperolehi daripada perbandingan dua corak penggergajian telah disbanding dengan lebih lanjut dengan data sekunder oleh penggergajian polygon (PS). Jumlah masa penggergajian cant berbalik, penggergajian cant yang diubahsuai, dan penggergajian polygon ialah 842 saat, 919 saat dan 2760 saat. Jumlah masa penggergajian PS adalahtiga kali lebih (2760 saat)

diantara mana-mana dua jenis corak penggergajian. Keputusan daripada sampel yang telah dirawat menunjukkan sifatfizikal, sampel kukusan dengan 40% tahap mampatan mempunyai ketumpatan paling tinggiiaitu (1065.23 kg/m³) sementaraitu, ketumpatan paling rendah direkodkan adalah sampel yang tidak dikukus dengan 0% tahap mampatan (766.13 kg/m³). Ketumpatan menunjukan trend meningkatan daripada tahap 0% kepada 40% untuk kedua-dua sampel yang dikukus atau tidak dikukus. Begitu juaga, ketumpatan kepadatan dan berat ketumpatan kepadatan menunjukan trend yang sama. Analisis kepelbagaian menunjukan tahap kemampatan yang tidak signifikan untuk hamper semua sifat fizikal manakala tahap kemampatan adalah signifikan didalam hamper semua sifat fizikal. Nilai min Modulus Keanjalan (MOE) dan Modulus Keampuhan (MOR) berjulat daripada 5687.34 MPa -15046.53 MPadan 42.57 MPa kepada 114.57 MPa. Kukusan tidak signifikan untuk kedua-dua MOE dan MOR. Keputusan diperolehi, menunjukkan RCS ialah merupakan corak penggergajian paling sesuai untuk menghasilkan OPW, kerana ia mengambil masa paling singkat dan ianya mudah untuk dijalankan. Didalam proses rawatan, sampel kukusan kayu bagi penyelidikan ini tidak begitu memberikan kesan terhadap pemboleh ubah yang diukur dalam kajian ini, ini menunjukan bahawa ianya tidak perlu untuk kajianini. Tahap kemampatan (%) mempunyai peranan yang besar didalam penyelidikan ini kerana ia membantu dalam meningkatkan sifat-sifat compreg OPW dirawat. Tahap mampatan yang paling sesuai dipertimbangkan ialah samaada 30% atau 40%. Patent telah diterima pakai didalam kajian ini.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science.The members of the Supervisory committee were as follows:

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LIST OF ABBREVIAITONS

ANOVA	Analysis of Variance
CS	Compression Strength
DG	Density Gain
EFB	Empty Fruit Bunch
FRIM	Forest Reserve Institute of Malaysia
H	Hardness
LMW-PF	Low Molecular Weight Phenol Formaldehyde
MC	Moisture Content
MCS	Modified Cant Sawing
MMW	Medium Molecular Weight
MOE	Modulus of Elasticity
MOR	Modulus of Rapture
MW	Molecular Weight
OPF	Oil palm Frond
OPT	Oil palm Trunk
OPW	Oil palm Wood
PF	Phenol Formaldehyde
PS	Polygon Sawing
RCS	Reverse Cant Sawing
SS	Shear Strength
TS	Thickness Swelling
WA	Water Absorption
WPG	Weight Percent Gain

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Wood demand is increasing day inand day out and the supply is decreasing as a result of declining forest productivity (Giz, 2012).This happen because of over exploitation of the forest resulting from activities such as indiscriminate cutting of trees, forest fire, urban expansion, lack of tree planting campaign etc. (Hosonuma *et al*., 2012). The production capacity of our forest cannot fulfil the high demand of wood industries. This problem necessitates providing alternative to compliment the supply of wood to the wood based industries.

All over the world, researches are ongoing on non-wood resources from agricultural waste as an alternative for raw materials to wood based industries(Suhaily *et al.*, 2012). One of such alternatives is oil palm tree which can serve as a substitute for wood due to its abundance in Indonesia andMalaysia. Oil palm (*Elaeisguinensis*) is known to be originated from West Africa, which is now cultivated in larger hectares in Indonesiaand Malaysia, making them the largest and the second largest producers of oil palm in the world (UNEP, 2012). It is believed that,these countries obtained their palm oil from the West African countries. Indonesia is the highest oil palm producing country in the world with the total planted land mass of 10.13 million hectares(Statistics Indonesia, 2013). The second largest oil palm producing country is Malaysia, having a total planted land mass of 5.4 million hectare (MPOB, 2014). Nigeria is the fourth largest oil palm producing country, after Thailand.

Oil palm is a monocotyledonous plant with a life span of economic production between 25-30 year (Ismail and Mamat, 2001). This means that, at this age, the productivity of the oil palm has been reduced drastically and it is ready for replanting exercise.Generally, huge amount of oil palm trunk (OPT) are generated each year, and these can be used as an alternative for other woody materials especially the outer part of the trunk. The best part to be utilised is the outer part of the OPT.

Oil palm wood is gotten from oil palm trunk. It is a by-product of oil palm tree after replanting. Oil palm wood is a woody material that can serve as a substitute for other wood. The Oil palm wood from the outer part has some imperfections such as being very low in strength and dimensionallyunstable - having low durability and very poor machining characteristics (Way et al., 2006). Ibach and Dale (2005), suggested that, the many properties of wood such as strength, dimensional stability and durability can be improve through treatment with phenolic resin. This imperfection of oil palm wood was practically solved through the modified compreg method. The method include four step processes such as drying, resin impregnation, re-drying and hot densification (Bakar *et al*., 2005). This method consist of drying in two cycles, which is considered to be time consuming and delicate to be practiced by practitioners. This research will try to find an alternative to address this problem by adjusting and improving upon previous studies. Therefore, there are lots unknown parameters and variables in every step in the process that need to be optimized. In compression alone, there are various compression variables needed to be optimized, that gives maximum advantage (fast drying) but not negatively affecting or reducing the physical or mechanical properties of compreg OPW. Therefore, there are many further studies on this new method needed to be carried out. In addition, the optimum compression level to produce high performance compreg OPW has not been know yet. If the whole study on this research is concluded, it will help save time, money and energy and thereby producing high grade compreg OPW with integrated process approach. This study therefore incorporates the integrated sawing and treatment process of oil palm wood.

1.2 Problem Statement

Oil palm plantation in Malaysia is about 5.4 million hectares (MPOB, 2014), making it the highest palm oil producer in the world. This higher number of planted hectares calls for concern in many sectors of the country, because this will generate a lot of waste to the environment. More importantly, looking at the age of optimum productivity gives an issue to worry a lot about, i.e. the 25-30 years age limit of effective productivity.

Presently, Malaysia's total oil palm area has 65% between the ages of 9-28+ and 26% are between 20-28+ years old (USDA, 2012). This indicates that majority of the plants have reached their replanting age, and it is expected that their annual yield will drastically reduce. Malaysian government has put in placemeasures to replace the old plants with new ones. It was reported that 365,000 hectares, which is about 8% of the planted areas is between the ages of 27-30 years, it further forecasted that in the next ten years, each year will have an additional 126,000 hectares that will fall into this category (USDA, 2012). The government has made plans to address this problem by replacing old plants with new ones. This means that if such replanting campaign will go on as indicated by government, more waste will be generated. These waste are in a form of oil palm trunk, empty fruit bunch (EFB) and Oil palm frond (OPF).These waste caused a lot of problem to the environment and they need to be addressed. In line with Malaysian government's policy of turning waste into wealth, various works have been done to convert under-utilized oil palm trunk (OPT) (Anwar *et al*., 2009; Way *et al.*, 2006). Oil palm wood (OPW) is gotten from oil palm trunk after it has been sawn using the head rig sawing machine.

Oil palm wood has high moisture content, bad dimensional stability, low in strength, poor durability and poor in machining behaviour. These imperfections were practically solved by four-step modified compreg method (Drying- resin impregnation-re-drying or heating-hot pressing densification) thereby producing high grade wood composite in which properties can be compared to that of wood (Faizatul *et al*., 2011).

This method was also considered not suitable because of the polygon sawing which is used in converting OPT into OPW which has been considered very difficult and needs professionals to handle it, because of its advanced carriage system. Another problem that is associated with this method is the drying which takes place in two cycles which is longer and consumes time. These problems necessitate a new method that can solve this pending problems. The integrated sawing and treatment process on improving the properties of oil palm wood is expected to practically solve these problems. It is comprehensive method that consists of 7-step processes used in producing high grade compreg OPW. The stepsor processes involves sawing, steaming, cold press, drying, resin impregnation, re-drying, and hot densification. Amongst these processes, sawing and cold press are the most important variables in this study. A new modified type of sawing pattern, known as a reverse cant sawing, that can fasten the sawing process will be introduced. It is easy to carry out and saves a lot of energy. The cold press (compression level) will also be introduced to reduce the amount of moisture content in the green wood, to facilitate fast drying without having any negative effect or reducing the physical and mechanical properties. This research will produce high grade compreg OPW with a process that is easier and saves time.

1.3 Research Objectives

The main objective of this study is to determine the effect of steaming, pre-treatment and compression level during cold press on the properties of oil palm wood produced using integrated processing and approach method. Other specific objectives are as follows;

1. To compares reverse cant sawing with other sawing patterns such as modified cant sawing and polygon sawing in terms of sawing time.
2. To determine the effects of steaming on the physical properties and mechanical properties of OPW composite
3. To evaluate the effects of compression on the physical and mechanical properties of OPW composite

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