UNIVERSITI PUTRA MALAYSIA

PERMEABILITY AND MOISTURE DISTRIBUTION IN OIL PALM WOOD AND INFLUENCE ON DEVELOPMENT OF EFFECTIVE METHOD FOR VENEER MOISTURE REDUCTION

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IPTPH 2012 2

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DOCTOR OF PHILOSOPHY

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2012

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By

ADRIAN CHOO CHENG YONG

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Doctor of Philosophy

February 2012

To my beloved wife

Rachel Tan Choon Hui

My beloved parents

Choo Geok San & Maureen Tan Juat Khing

My beloved sister

Patrina Choo Mei Yin

Thank you for being the people I love the most

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

PERMEABILITY AND MOISTURE CONTENT IN OIL PALM WOOD AND INFLUENCE ON DEVELOPMENT OF EFFECTIVE METHOD FOR VENEER MOISTURE REDUCTION

By

ADRIAN CHOO CHENG YONG

FEBRUARY 2012

Chairman: Professor Paridah Md Tahir, PhD

Faculty: Institute of Tropical Forestry and Forest Science (INTROP)

In Malaysia, it is estimated that there is an excess of 14 million cubic meters of oil palm stem available every year due to replanting. However, the large variation in density and moisture content (MC) hinders a full utilization of the oil palm wood. In this study, an investigation was conducted to determine the basic properties of the oil palm wood and also the veneers that are derived from it. Permeability studies were also conducted on the palm wood and its influence on moisture was examined. A method was also developed to reduce the moisture content of oil palm veneers before they were subjected to drying.

Oil palm trees were selected randomly from the species *Elaeies guineensis* Jacq from Taman Pertanian Universiti located in Universiti Putra Malaysia, Serdang, Malaysia. The water and gas permeability values were measured using two specific apparatus that was set-up for the purpose of this study. The oil palm wood was segregated to outer,

middle and inner sections and samples of different lengths were tested. Anatomical studies were then carried out using an image analyzer to determine the maximum or theoretical permeability. Veneers obtained from a plywood factory in Kedah were examined for density and moisture content variations and its distribution throughout the length of the stem. A specially designed and built machine (Malaysian Patent No: MY-143318-A) was used to conduct a pre-drying process on green veneers and optimization of pressing conditions on reducing the moisture content was carried out using the Response Surface Method (RSM).

The permeability results showed that the oil palm wood is more permeable when it is green compared to after it is dried. Shorter samples had a higher permeability value compared to longer samples. Results showed that the different sections influenced both the water and gas permeability values of the oil palm wood with the middle section giving the highest values followed by the inner and outer sections respectively. The maximum or theoretical permeability was consistently higher than the water and gas permeability for all samples. The average permeability values for 5 cm samples were 23.29 darcies, 5.91 darcies and 0.96 darcies for the maximum or theoretical, water and gas respectively.

The density of the oil palm veneers decreases as the veneers were peeled towards the inner section of the stem while the inverse was true for MC. The outer veneers had an average density of 0.337 g/cm^3 compared to 0.272 g/cm^3 for the inner veneers. The

veneers obtained from the top part of the stem had higher density values (0.318 g/cm^3) compared to veneers obtained from the bottom part of the stem (0.290 g/cm^3). The inner veneers had an average MC of 313.4 % while the outer veneers had an average MC of 229.0 %. There was not a significant difference in MC between veneers taken from the bottom and top part of the stems.

Optimum conditions were obtained in the pre-drying process. They were feeding for two passes, 82 kgf/cm^2 pressure and 41.49 Hz roller speed for outer veneers and two passes, 77 kgf/cm^2 pressure and 41.49 Hz roller speed for inner veneers. The expected response was 17.62 % and 22.01 % MC reduction for outer and inner veneers respectively.

This study found that the different sections of the oil palm stem showed different physical properties. The study suggests that the oil palm wood or veneers should be segregated to outer and inner sections to maximize efficiency and to improve homogeneity in various processes concerning it. The method of reducing moisture content was proven to be successful and it can be utilized before the drying process to lower drying time and cost.

Abstrak thesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KETELAPAN DAN TABURAN LEMBAPAN DI DALAM KAYU KELAPA SAWIT DAN PENGARUHNYA TERHADAP PEMBANGUNAN SUATU KAEDAH PENGURANGAN AIR DALAM VENIR

Oleh

ADRIAN CHOO CHENG YONG

FEBRUARI 2012

Pengerusi: **Profesor Paridah Md Tahir, PhD**

Faulti: **Institut Perhutanan Tropika dan Produk Hutan (INTROP)**

Terdapat anggaran 14 juta meter padu batang kelapa sawit yang boleh didapati setiap tahun di Malaysia hasil daripada penanaman semula. Namun begitu, variasi yang tinggi dalam ketumpatan dan kandungan air di dalam kelapa sawit menyebabkannya sukar dimanfaatkan. Dalam kajian ini, siasatan dilakukan ke atas sifat-sifat asas kayu dan venir kelapa sawit. Kajian ketelapan juga dilakukan ke atas kayu kelapa sawit dan kesannya terhadap kandungan air turut dikaji. Suatu kaedah mengurangkan kandungan air venir kelapa sawit sebelum ianya dikeringkan juga dibangunkan.

Beberapa batang kelapa sawit dari spesis *Elaeies guineensis* Jacq telah dipilih secara rawak dari Taman Pertanian Universiti, Universiti Putra Malaysia yang terletak di Serdang, Malaysia. Ketelapan air dan gas telah diukur menggunakan dua radas yang dicipta khas untuk tujuan itu. Kayu kelapa sawit telah diasingkan kepada bahagian luar, tengah dan dalam dan sampel dengan kepanjangan yang berbeza telah diuji. Penelitian anatomi telah dilakukan dengan menggunakan penganalisis imej. Kajian ke ketumpatan

dan kandungan air telah dilakukan ke atas venir yang diperolehi daripada sebuah kilang papan lapis di Kedah. Satu mesin khas telah dicipta dan dibina untuk tujuan menjalankan proses mengurangkan kandungan air di dalam venir basah sebelum venir itu dikeringkan dan pengoptimaan telah dilakukan dengan menggunakan kaedah permukaan gerak balas.

Kajian ketelapan air menujukkan bahawa sampel basah adalah lebih telap berbanding dengan sampel kering. Sampel pendek juga memberikan nilai ketelapan yang lebih tinggi berbanding dengan sampel panjang. Keputusan juga menunjukkan bahawa bahagian yang berbeza di dalam kelapa sawit mempengaruhi nilai ketelapannya. Bahagian tengah kelapa sawit memberikan nilai ketelapan yang tertinggi diikuti dengan bahagian dalam dan bahagian luar. Purata nilai ketelapan untuk sampel yang berukuran 5 cm adalah 23.29 darcies untuk ketelapan maksima, 5.91 darcies untuk air dan 0.96 darcies untuk gas.

Ketumpatan venir kelapa sawit berkurangan apabila batang kelapa sawit itu dikupas ke arah bahagian dalam. Sebaliknya, kandungan air meningkat apabila batang kelapa sawit itu dikupas ke arah bahagian dalam. Venir dari bahagian luar mempunyai ketumpatan purata sebanyak 0.337 g/cm^3 berbanding dengan 0.272 g/cm^3 untuk venir dari bahagian dalam. Venir yang didapati dari bahagian atas betang kelapa sawit mempunyai nilai ketumpatan yang lebih tinggi (0.318 g/cm^3) berbanding dengan venir yang didapati dari bahagian bawah batang kelapa sawit (0.290 g/cm^3). Purata kandungan air di dalam venir

kelapa sawit didapati bertambah apabila venir dikupas k arah bahagian dalam batang kelapa sawit. Venir dari bahagian dalam mempunyai kandungan air purata sebanyak 313.4% manakala venir dari bahagian luar pula mempunyai kandungan air purata sebanyak 229.0%. Tiada perbezaan nyata di antara kandungan air purata venir dari bahagian bawah dan venir dari bahagian atas batang kelapa sawit.

Keadaan optima juga telah didapati untuk proses pra-pengeringan. Untuk venir dari bahagian luar kelapa sawit, keadaannya adalah seperti berikut; 2 kali laluan, tekanan sebanyak 82kgf/cm^2 dan kelajuan penggelek 38.55Hz. Untuk venir dari bahagian dalam pula, keadaannya adalah seperti berikut; 2 kali laluan, tekanan sebanyak 73kgf/cm^2 dan kelajuan penggelek 41.49Hz. Hasil yang dijangkakan adalah pengurangan kandungan ait sebanyak 16.2% untuk venir dari bahagian luar dan 20.14% untuk venir dari bahagian dalam.

Kajian ini menunjukkan bahawa bahagian berbeza dalam batang kelapa sawit menunjukkan sifat-sifat fizikal yang berbeza. Dicadangkan bahawa kayu atau venir dari batang kelapa sawit harus diasingkan kepada bahagian yang berbeza untuk memaksimumkan kecekapan dan meningkatkan kehomogenan di dalam proses-proses yang melibatkan penggunaannya. Kaedah untuk mengurangkan kandungan air juga boleh digunakan sebelum proses pengeringan untuk mengurangkan kos dan masa produksi.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank my Lord and Saviour Jesus Christ for his love for us all.

I would like to express my sincere gratitude to the Ministry of Science, Technology and Innovation for granting me the National Science Fellowship scholarship to conduct my research.

I would like to say a big thank you to Professor Dr Paridah Md Tahir, my supervisor for this thesis, without whom my research would not have been possible. I would also like to thank her for all the guidance and encouragement that she has shown me throughout the period of this research as a supervisor, a teacher and I hope as a friend. To my co-supervisors, Professor Alinaghi Karimi, Associate Professor Dr Azmi Ibrahim, Associate Professor Dr Edi Suhaimi Bakar and Associate Professor Dr Khalina Abdan, I extend to you my warmest thanks for being patient and understanding and for providing me invaluable guidance. I would like to also say thank you to Associate Professor Dr Zaidon Ashaari for your willingness to spend some time to impart knowledge to me.

I would also like to extend my appreciation to all the staff of the Faculty of Forestry and the Institute of Tropical Forestry and Forest Products, especially Mr Azam, Mr Rizal, Puan Halimah and Kak Lin for all their help during my study.

To my fellow researchers, Dr Loh Yueh Feng, Beng Hoong, Juliana and Balkis, I sincerely appreciate all the help that you guys have given to me and I truly cherish our friendship.

I am deeply indebted to my parents and my sister for being understanding and supportive through the years. Last but not least, my deepest appreciation to my lovely wife, Rachel Tan Choon Hui for always being there for me and encouraging me through the trials I faced in completing this thesis. I dedicate this thesis to all of you.

Adrian

I certify that an Examination Committee has met on **10 February 2012** to conduct the final examination of **ADRIAN CHOO CHENG YONG** on his **DOCTOR OF PHILOSOPHY** thesis entitled "**PERMEABILITY AND MOISTURE CONTENT IN OIL PALM WOOD AND ITS INFLUENCE ON THE DEVELOPMENT OF AN EFFECTIVE METHOD FOR VENEER MOISTURE REDUCTION**" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the student be awarded the relevant degree.

Members of the Examination Committee were as follows:

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

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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ADRIAN CHOO CHENG YONG

Date: 10 Februari 2012

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