



**UNIVERSITI PUTRA MALAYSIA**

**COMPARING DRYING CHARACTERISTICS OF MELANTAI, KELEDANG,  
KEKATONG AND KHAYA TIMBERS USING THREE DIFFERENT DRYING  
METHODS**

**ZAIRUL AMIN RABIDIN**

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**MASTER OF SCIENCE  
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**By**

**ZAIRUL AMIN RABIDIN**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,  
in Fulfilment of the Requirements for the Degree of Master of Science**

**December 2012**

## DEDICATIONS

*Dedicated to my parents, Rabidin and Zainab  
for caring and never ending love*

*my beloved wife, Siti Melor  
for supporting me enormously, all the time and all the way*

*my son, Hamizan and my daughter, Nurhamizah  
for his/her much joy*

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

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KELEDANG, KEKATONG AND KHAYA TIMBERS USING THREE  
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**ZAIRUL AMIN RABIDIN**

**December 2012**

**Chairman: Professor Mohd Hamami Sahri, PhD**

**Faculty: Forestry**

A study was undertaken to determine and compare drying characteristics of melantai (*Shorea* spp.), keledang (*Artocarpus* spp.), kekatong (*Cynometra* spp.) and khaya (*khaya grandifoliola*) representing light hardwood, medium hardwood, heavy hardwood, and plantation timbers dried using air drying, kiln drying and radio frequency/vacuum drying systems. The specific objectives of these studies were; firstly, to determine physical properties of timbers related to drying, i.e. moisture content, density, and shrinkage; secondly, to compare characteristics of 30 mm thick, end-matched lumbers dried by these three different drying methods; and thirdly, to evaluate effect of thickness (30 and 55 mm thick), degree of vacuum and temperature settings, mode of heating (continuous and intermittent) and surface quality (planed/unplaned) on drying time and quality of RFV dried timber. Drying characteristics of the timbers were compared at final moisture content (MC), i.e. 15-18% MC for air drying and 12% MC for kiln- and RFV-drying, in terms of drying

time, drying rate, formation of defects, shrinkage, moisture distribution between and within the lumbers, and drying stresses.

Moisture content of keledang in green condition was relatively higher than khaya, followed by melantai and kekatong. The highest density and shrinkage in all directions were observed in kekatong. Density of keledang was higher than melantai and khaya but the shrinkage values for these three timber species were not too different.

RFV drying reduces the drying time compared with kiln drying. The percentage of reduction in drying time for 30 mm thick lumbers were about 56.3% for melantai, 19.4% for keledang, and 47.4% for kekatong. Generally, air dried timber for 30 mm thick lumbers possess more uniform moisture content between lumbers than those RFV- and kiln-dried. However, moisture gradient in 55 mm thick lumbers was relatively higher than 30 mm thick. The variation of moisture content between and within lumbers for RFV dried timber was lower than that of kiln dried. Within lumbers, RFV dried timber had lower inner-outer moisture content difference than that of kiln dried lumbers. A number of lumbers dried by RFV had a drier inner compared to the outer layer. In RFV drying, the moisture content of the lumbers increased from the centre towards the bottom and top of the stack. The quality of melantai, keledang and khaya dried by air drying, kiln drying and RFV drying were comparable. The quality of kekatong lumbers dried by RFV was comparable to air dried and relatively better than kiln dried. Shrinkage of the timber dried by RFV was almost similar to air drying, but lower than kiln drying. Ratio of tangential to radial shrinkage and volumetric shrinkage for RFV dried was relatively lower than kiln

dried lumbers. No casehardening was observed on all species dried by air drying. Casehardening is lower in RFV dried timber as compared to kiln drying.

RFV drying times increased with increasing thickness. The percentage of increment in drying time for dense timber was relatively higher than less dense timber. Moisture content variation within lumber for 30 mm and 55 thick lumbers were within the acceptable limit of  $\pm 2\%$ . Planing timber before RFV drying not only facilitate timber stacking but also reduced the drying time and moisture content variation between and within lumbers. Drying time for lumbers dried under intermittent mode of heating was higher than continuous mode. In general, melantai, keledang and khaya can be dried successfully under continuous mode of heating with temperature and pressure set at 40°C and 40 torr respectively. Slower drying settings, i.e. drying under intermittent mode of heating and at 50 torr vacuum pressure should be used when drying kekatong.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia  
sebagai memenuhi keperluan untuk ijazah Sarjana Sains

**PERBANDINGAN CIRI-CIRI PENGERINGAN KAYU MELANTAI,  
KELEDANG, KEKATONG DAN KHAYA DIKERING MENGGUNAKAN  
TIGA KAEDAH PENGERINGAN BERBEZA**

Oleh

**ZAIRUL AMIN RABIDIN**

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Kajian telah dijalankan untuk menentukan dan membandingkan ciri-ciri pengeringan kayu melantai (*Shorea* spp.), keledang (*Artocarpus* spp.), kekatong (*Cynometra* spp.) dan khaya (*khaya grandifoliola*) mewakili kelas kayu keras ringan, kayu keras sederhana, kayu keras berat serta kayu ladang yang dikeringkan dengan sistem pengeringan udara (AD), pengeringan tanur (KD) dan pengeringan frekuensi radio/hampagas (RFV). Objektif spesifik kajian ini adalah; pertama, untuk menentukan sifat-sifat fizikal kayu berkaitan pengeringan iaitu kandungan lembapan, ketumpatan dan kecutan; kedua, untuk membandingkan ciri-ciri pengeringan kayu berketebalan 30 mm, dipotong secara berturutan dari papan asal yang sama, yang dikering menggunakan kaedah yang berbeza; dan ketiga, untuk menilai kesan ketebalan (30 dan 55 mm tebal), darjah hampagas dan ketetapan suhu, mod pemanasan (berterusan dan ulangan) dan kualiti permukaan kayu (diketam/tidak diketam) terhadap masa pengeringan dan kualiti kayu. Ciri-ciri pengeringan kayu dibandingkan pada kandungan lembapan akhir, iaitu 15-18% MC untuk pengeringan



udara dan 12% untuk pengeringan tanur dan RFV, dilihat dari segi masa pengeringan, kadar pengeringan, pembentukan kecacatan, kecutan, taburan kandungan lembapan antara keping papan dan dalam papan itu sendiri serta tegasan pengeringan.

Kandungan lembapan kayu keledang didapati lebih tinggi dari khaya, diikuti oleh melantai dan kekatong. kekatong mempunyai ketumpatan dan kecutan pada semua arah yang paling tinggi berbanding kayu lain. Ketumpatan keledang didapati lebih tinggi dari melantai dan khaya tetapi nilai kecutan untuk ketiga-tiga spesis kayu tidak terlalu berbeza.

Pengeringan menggunakan RFV dapat mengurangkan masa pengeringan berbanding pengeringan tanur. Peratus pengurangan masa pengeringan untuk papan melantai berketebalan 30 mm sekitar 56.3%, 19.4% untuk keledang dan 47.4% untuk kekatong. Secara umumnya, kayu dikering udara mempunyai kandungan lembapan antara papan yang lebih seragam berbanding keringan RFV dan KD. Walaubagaimanapun, cerun kandungan lembapan bagi papan berketebalan 55 mm adalah lebih tinggi dari papan 30 mm. Taburan kandungan lembapan antara papan yang dikering RFV lebih rendah dari keringan KD. Perbezaan kandungan lembapan antara bahagian dalam dan bahagian luar kayu dikering menggunakan sistem RFV juga didapati lebih rendah dari keringan KD. Beberapa keping papan dikering menggunakan RFV didapati mempunyai kandungan lembapan lebih rendah di bahagian dalam berbanding bahagian luar. Dalam pengeringan RFV, kandungan lembapan kepingan papan meningkat dari bahagian tengah ke bahagian atas dan bawah susunan kayu. Kualiti kayu melantai, keledang and khaya yang dikering AD,

KD dan RFV adalah setanding. Kualiti kayu kekatong dikering menggunakan kaedah RFV adalah setanding dengan yang dikering udara dan lebih baik dari yang dikering menggunakan tanur. Kecutan kayu yang dikering menggunakan RFV hampir sama dengan kayu dikering udara tetapi lebih rendah dari keringan tanur. Nisbah kecutan tangen/jejari serta kecutan isipadu kayu dikering menggunakan RFV lebih rendah dari keringan tanur. Tiada tegasan pengeringan diperhatikan pada semua kayu yang dikering udara. Tegasan pengeringan bagi kayu yang dikering menggunakan RFV adalah lebih rendah berbanding keringan tanur.

Masa pengeringan menggunakan sistem RFV meningkat dengan ketebalan kayu. Dengan pertambahan ketebalan, peratus peningkatan masa pengeringan bagi kayu berketumpatan tinggi adalah lebih tinggi berbanding kayu berketumpatan rendah. Taburan kandungan lembapan dalam kayu bagi papan berketebalan 30 dan 55 mm adalah dalam lingkungan  $\pm 2\%$ . Kayu yang telah diketam bukan sahaja mudah disusun malah dapat mengurangkan masa pengeringan dan taburan kandungan lembapan antara dan dalam papan. Masa pengeringan menggunakan mod pemanasan ulangan secara relatifnya lebih tinggi berbanding mod pemanasan berterusan. Secara umum, masa pengeringan yang pantas untuk melantai, keledang, dan khaya dapat dicapai apabila dikering pada mod berterusan dengan suhu dan tekanan masing-masing ditetapkan pada  $40^{\circ}\text{C}$  and 40 torr. Ketetapan pengeringan lebih perlahan diperlukan apabila mengeringkan kekatong iaitu pada mod ulangan dan tekanan lebih tinggi (50 torr).

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I certify that a Thesis Examination Committee has met on 6 December 2012 to conduct the final examination of Zairul Amin bin Rabidin on his thesis entitled "Comparing Drying Characteristics of Melantai, Keledang, Kekatong and Khaya Timbers Using Three Different Drying Methods" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The committee recommends that the student be awarded the Master of Science.

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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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**ZAIRUL AMIN BIN RABIDIN**

Date: 6 December 2012

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