28004

# An Investigation into the Drying of Malaysian Timbers


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28004

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## Absract

*This paper describes the experimental facility developed and drying tests conducted on two species of Malaysian hardwood, Balau and Dark Red Meranti. The project aimed at developing a cost effective timber dryer by using condenser heat of a heat pump cycle to dry timbe samples. In identical five and a half hour test sessions, moisture content of Balau was reduced from 39.1% to 28.2% and thatof Dark Red Meranti from 37.9% to 24.4%.. For identical sized samples, the hourly drying rate per unit mass of timber was 0.0129 for Balau and that for Dark Red Meranti was 0.0178. The drying rate was observed to be slower for thicker sample of the same wood and it was faster for dark Red Meranti.*



Keywords: Drying; Timber; Heat Pump


## Introduction

Timber was and still one of the major sources of revenue of Malaysia. Exports of timber products in 2002 alone were 10.5 million cubic meters valued at 12.6 billion Ringgit Malaysia. Most of these exported timbers are dried prior to shipment to have more value added properties and to reduce the transportation cost. However, like most of timber exporting countries, energy usage in drying accounts for up to 70% of total energy consumption in manufacturing wood products [1].

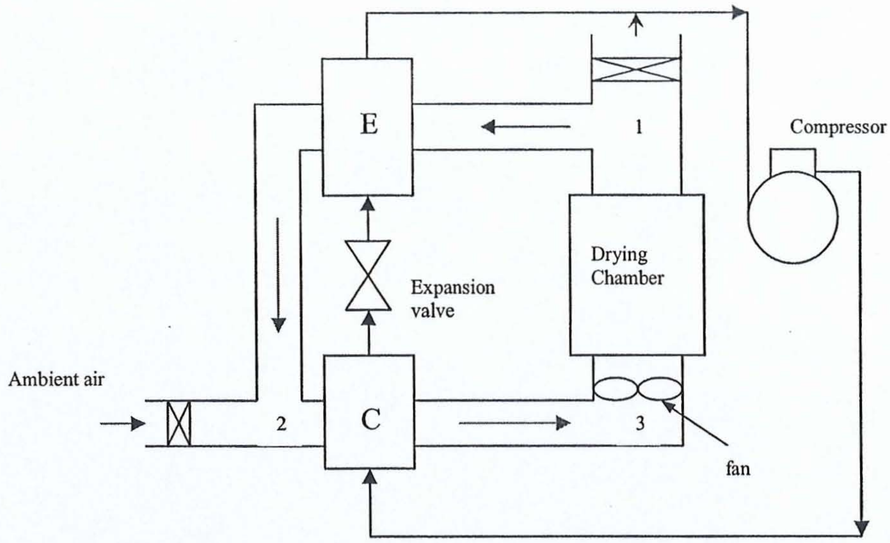
Wood, in its natural state, always contains large amount of water. The presence of water influences the properties of wood and makes it prone to infestation by insects to such extent that for many purposes the moisture must be removed before the wood can be used to manufacture anything. Drying of wood in humid tropical country like Malaysia normally takes a long period that can extend to 3 months to 7 months for Balau. Hence, kiln drying is proving to be useful especially during rainy season to ensure uninterrupted supplies of timber woods. However, drying of timbers is not without disadvantages and costs. Some of the defect of drying includes staining, case hardening, cracks, checks and warpage [2]. One method to minimize such defects is through proper regulation of the drying condition to control drying rates and ensure uniform drying.

Drying with heat pump has gained much popularity in some major timber producer countries in Europe and Down Under, but not much study has been done on local timber woods in Malaysia. Heat pump-assisted drying provides a controllable drying environment (temperature and humidity) for better product quality at low energy consumption i.e. cost [3]. The advantage of heat pump drying for timber include efficient utilization of recovered heat, slow and controlled drying rates resulting in reduction of physical defects. The heat recovery and dehumidifying ability of heat pump dryer reduces the energy cost and enables extraction of the volatile substances evaporated from timber if there is any. Furthermore, electrically driven dryers are preferred by many users due to environmental consideration.

The heat pump is basically a refrigeration cycle but the heat rejected at condenser is used instead of simply allowing dissipating to the atmosphere. The main components of a heat pump are evaporator, compressor, condenser and expansion valve. During operation, heat is drawn from atmosphere or from the humid air leaving the drying chamber, depending on the design of the system. This heat would vaporize the working fluid i.e. the refrigerant in the evaporator, which is then compressed by the compressor to a high-pressure vapour. In the condenser, heat would be rejected from the refrigerant, and it is this heat that is used to dry products. Refrigerant is then throttled to a low pressure through the expansion valve and enter the evaporator to complete the cycle. Figure 1 shows a simplified heat pump dryer cycle.

Timber woods used in the experiment are Balau (*Shorea laevis*) and Dark Red Meranti (*Shorea curtisii*). Balau is one of the heavy hard woods available in Malaysia. It is very durable and usually used in heavy construction, railway sleepers, doors and marine structures. It is known to dry slowly and prone to degrading during drying. Balau has density ranging from 880 to 1040 $kg/m^3$ at 19% moisture content with an average of 960 $kg/m^3$ [4]. Dark Red Meranti, on the other hand is a light hardwood which is available abundantly in Malaysia. This species of wood is well known to wood industries in some European countries such as The Netherlands, Germany, Belgium and the UK due to its mechanical properties and excellence in wood finish. It is known to dry fast without much degradation and it is mainly used in producing high-class joinery products especially door and window frames, facades and doors. Dark Red Meranti has a density ranging from 580 to 770 $kg/m^3$ at 12% moisture content with an average of 670 $kg/m^3$ [5].

In this study, an experimental heat pump-assisted dehumidifying dryer was designed and developed to investigate the feasibility of heat pump to be used in drying of two specific types of Malaysian wood mentioned earlier.




**Legend**
E = evaporator
C = condenser
1 = saturated moist air
2 = dehumidified air
3 = dehumidified hot air

Figure 1: Schematic diagram of the Simplified Heat Pump-assisted Dryer

## Experimental set-up

A schematic diagram of the experimental set-up is shown in Figure 2. The system consists of three sections, which are (i) the drying chamber, (ii) reconfigured heat pump and (iii) the air-recirculation system. The top and one side of the drying chamber measuring 1.3m x 0.75m x 0.75 m, is made from 1 cm thick Perspex for monitoring purposes, while the remaining sides are made from 1 cm thick plywood. Hot air passing through condenser enters the drying chamber. Moisture would be picked up from specimens by the air and then it would be forced through the evaporator installed in the air recirculation system. Moisture in the air was condensed at the evaporator and drained away. The latent heat from the condensate was absorbed by the refrigerant to be reused at the condenser. Temperature of the dehumidified air is low after passing through the evaporator, hence, air from ambient, which is higher in temperature are let into the system to elevate its temperature prior to flowing. Reheated air is a bit moist because of the mixing with the ambient air, but this semi-open system has been proven to be more efficient in a study done by Prasertsan [3].

Dry and wet bulb thermocouples were installed inside the drying chamber and re-circulation system to monitor the temperature and relative humidity of the air before and after drying. Thermocouple was also installed outside the drying chamber to monitor the ambient condition of the air. A weighing scale with a sensitivity of 1g was fitted inside the drying chamber to measure and monitor the weight of the timber wood during drying. An anemometer was also fitted inside the drying chamber to monitor the air velocities. Power consumption of the heat pump was measured by using ammeter and voltmeter while pressure gauges were installed in the heat pump cycle to monitor cycle pressures. The capacity of the R22 compressor is 1 horsepower (745.7 kW).

### Experimental Procedure

Four tests of batch drying were conducted using the heat-pump apparatus. In the experiments, Balau and Dark Red Meranti woods of following dimension were used:

(a) 1″x 3″ x 18″
(b) 3″ x 3″ x 18″

These specimens were all having moisture content at 35% to 40% prior to testing [6]. These wood pieces obtained from saw mill were stacked horizontally inside the drying chamber. Using an electronic balance, initial weight of the wood pieces was taken prior to testing. Each experiment was done using only one species of wood pieces of the same dimension and same quantity. During the experiment, weight of the wood pieces was monitored every 10 minutes, because drying rate was high when the specimen surfaces were still wet. This was done rapidly by switching off the fan to prevent weight fluctuation caused by wind motion. During recording of each set of data, dry and wet bulb temperature of the recirculated air in the drying chamber as well as pressures, temperatures at various points and the power of the refrigeration cycle were recorded. After 3 hours, data were

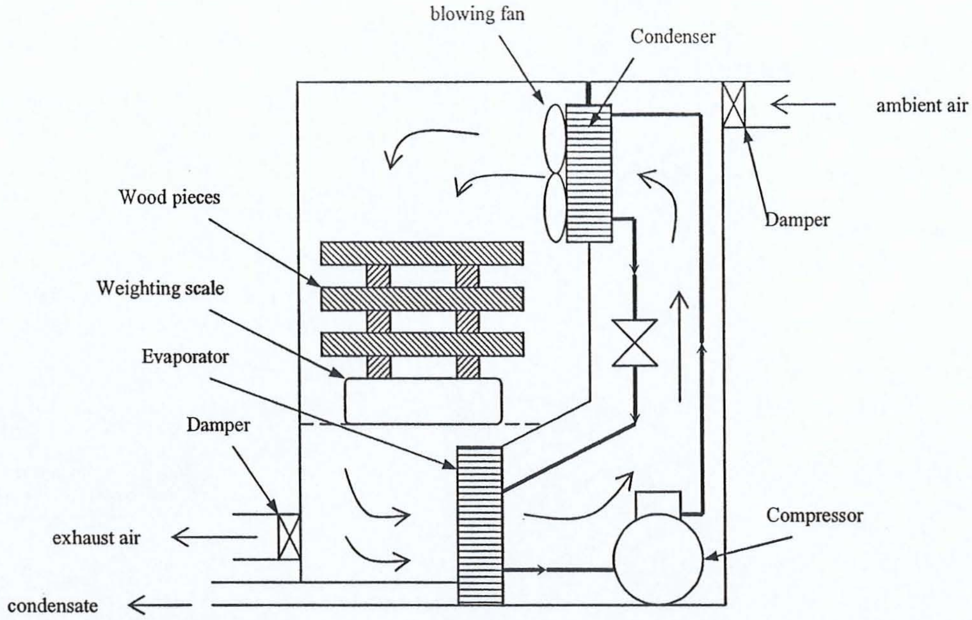



Figure 2: Experimental set-up diagram

recorded at half hourly intervals, as the drying rates of the wood pieces were much lower than the initial stage.

## Result and Discussion

Four tests on wood drying were conducted using the heat pump-assisted timber dryer, working at an average Coefficient of Performance between 2.69 to 3.11. The dryer effectively dries both timber species from around 36%-40% to around 25%-31% in 5 hours time. The test results are tabulated in Table 1.

Both Tests 1 and 2 were conducted using specimens of Balau wood of two different thicknesses. The reduction of moisture in Test 1 was 9.87% whereas the reduction of moisture of Test 2 was 4.33%, demonstrating that thicker wood tend to dry at a slower rate. Similar result was observed from experiments conducted on Dark Red Meranti as well, where the 1″ x 3″ x 18″ wood pieces have a moisture reduction of 8.5% compared to 6.61% for 3″ x 3″ x 18″ wood pieces. This can be explained by the reasoning that the thinner wood pieces have a higher surface per volume compared to the thicker ones. Hence, moisture movement from inside the wood to its surface is faster, promoting higher evaporation rates. Figure 3 and 4 show the comparison of moisture reduction of two different thicknesses versus time for both species of wood. Forest Research Department of Malaysia [6] reported similar trend of slower drying rate for Balau compared to Dark Red Meranti.

Figure 5 shows the comparison of moisture reduction rate for both species of wood of identical dimension (1″ x 3″ x 18″). The Dark Red Meranti has a higher drying rate than Balau. More specifically, Dark Red Meranti dries 37.7% faster than Balau. Figure 6 show the variation of relative humidity during Test 1, the changes of air temperatures inside the drying chamber.

From Table 1 the drying rate for Balau for specimens of two different thicknesses are 0.0129 $kg_w/kg_t$ per hour and 0.00574 $kg_w/kg_t$ per hour, while the same for Dark Red Meranti, are 0.0178 $kg_w/kg_t$ per hour and 0.00953 $kg_w/kg_t$ per hour repectively. In the final phase of testing the heat pump-assisted dryer achieved a constant temperature of 48 °C with relative humidity of around 40%.

## Concluding Remarks

Natural drying is a very time-consuming process in the humid tropical countries like Malaysia, and hence, an economical, fast and environmentally friendly drying process that ensures quality of timber is desirable. Two species of local wood, Balau and Dark Red Meranti were dried under controlled environment in a heat-pump-assisted dryer. Reduction of moisture content from 39.1% to 28.2% for Balau, and from 37.9% to 24.4% was achieved in merely five and a half hours using the experimental set up. Drying rate is faster for Dark Red Meranti and it is slower for thicker wood sample. Heat pump assisted drying is effective in timber drying and is environmental friendly.

## Acknowledgements

The authors would like to express their appreciation to Universiti Sains Malaysia for providing the university facilities to conduct the research.

Table 1: Test results on Wood drying

| | Test 1 | Test 2 | Test 3 | Test 4 |
|---|---|---|---|---|
| Type of wood | Balau | Balau | D.R. Meranti | D.R. Meranti |
| Sample size (cm) | 2.54x7.62x45.72 | 7.62x7.62x45.72 | 2.54x7.62x45.72 | 7.62x7.62x45.72 |
| Initial moisture content (%) | 38.09 | 35.84 | 37.89 | 36.11 |
| Final Moisture content (%) | 28.22 | 31.51 | 24.39 | 29.50 |
| Drying time (hour) | 5.5 | 5.5 | 5.5 | 5.5 |
| $COP_{avg}$ | 2.97 | 2.89 | 3.11 | 2.69 |
| Hourly drying rate per unit mass of timber ($kg_w/kg_t$ per hour) | 0.0129 | 0.00574 | 0.0178 | 0.00953 |

Where $kg_w$= mass of moisture removed and $kg_t$= initial mass of timber

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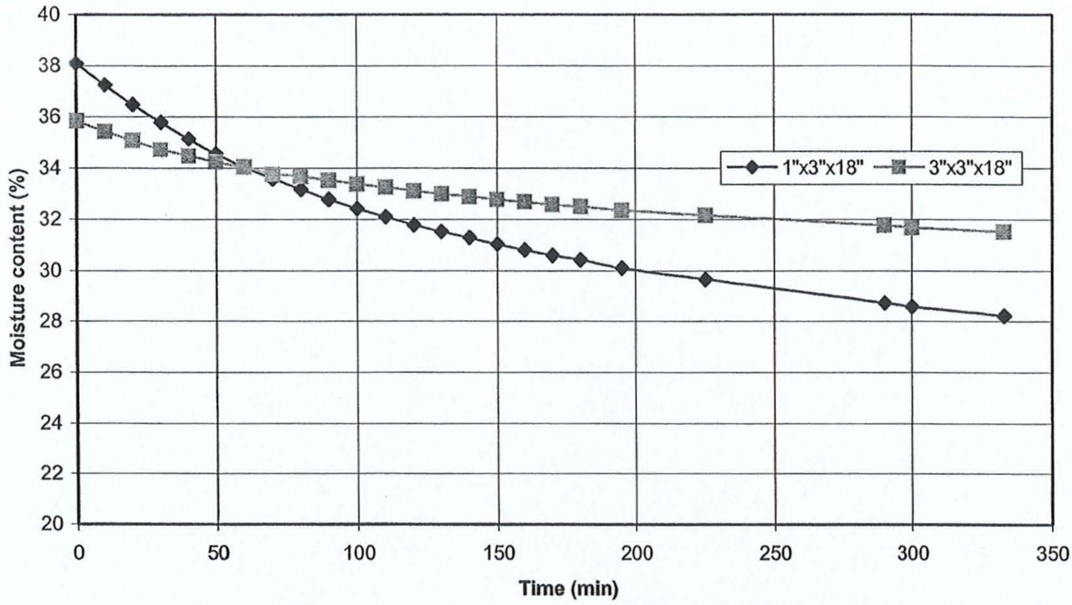


**Figure 3: Comparison of Moisture Content of Balau**

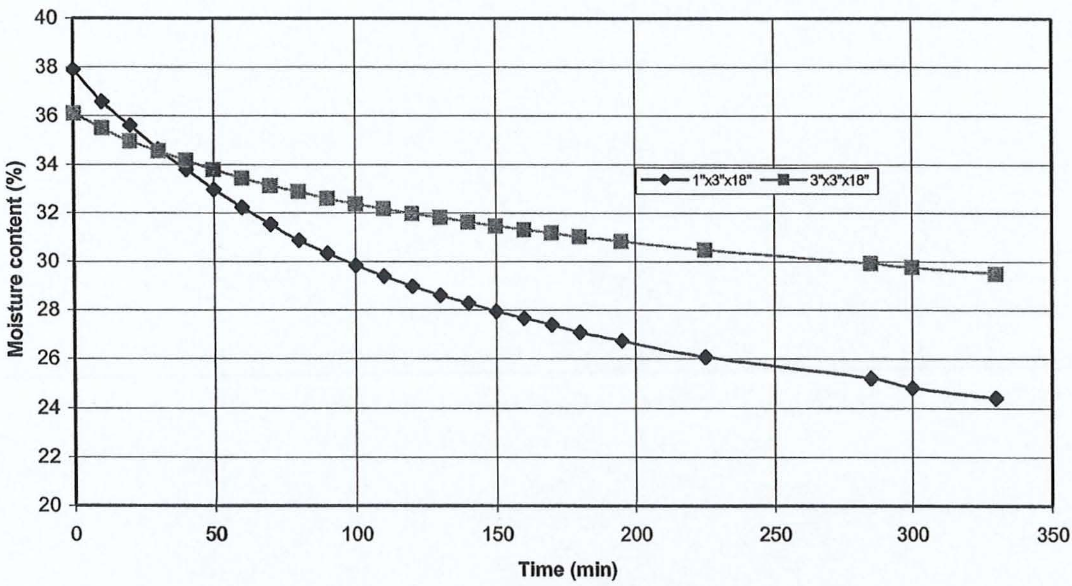


**Figure 4: Comparison of moisture content of Dark Red Meranti**

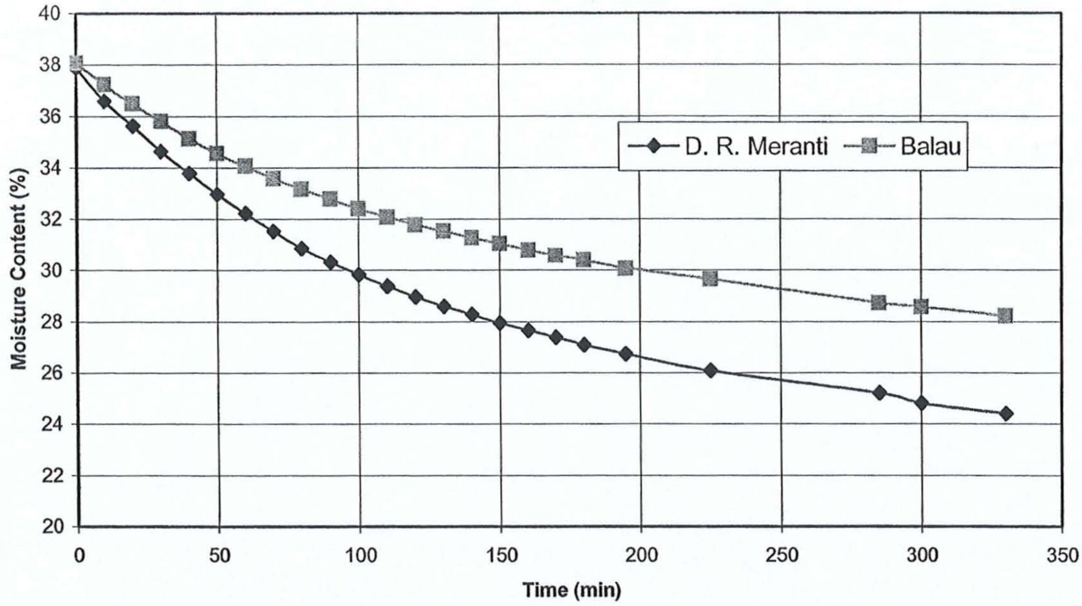


**Figure 5: Comparison of moisture reduction of different species**

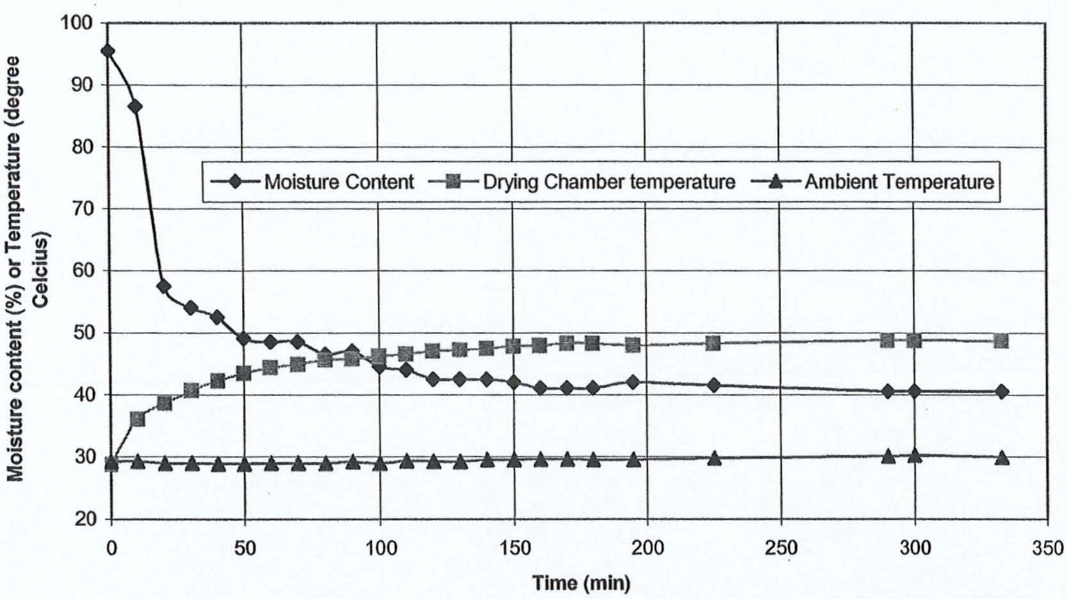


**Figure 6: Drying chamber temperature, ambient temperature and moisture content of air in drying chamber variation during Test 1**