QUALITY THROUGHPUT OF *ACACIA MANGIUM* LUMBER FROM INDUSTRIAL KILN

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ABSTRACT

Currently, the acacia lumber producer is facing various challenges to consistently produce quality acacia sawn lumber, mainly due to the inherent characteristics of the lumber. This study aims to enhance the quality of the kiln dried acacia lumber produced which can be subsequently used in the production of the laminated truck flooring and related components. The optimisation of the drying regime for 30mm-thick acacia lumber using a commercial kiln was conducted in a timber processing mill in Sabah, Malaysia. The optimised drying schedule established is a moisture content based recipe with the initial dry bulb temperature (DBT) limited to 50°C or lower and final DBT to be maintained below 70°C. After drying, the moisture content dispersion of acacia lumber was determined and both the volume and grade recovery for the kiln-dried lumber was carried out based on standard mill practice according to the final dressed-size intended for export market. Overall, recovery study of the kiln-dried lumber recorded low rejection value of 8%, with 76% of the acacia lumber after blanking process classified as grade A of standard mill assessment criteria. Post drying assessment was carried out and the final moisture content (MC) of timber was determined. Results showed that both the MC variation between different sawn lumber in the same kiln charge and within an individual sawn was within permissible range. When MC is uniform, the lumber is less stress and more dimensionally stable when in service.

Keywords: Kiln drying, sawn lumber, recovery, moisture content.

INTRODUCTION

Generally, *Acacia mangium* trees are renowned for their robustness and adaptability, which makes them good plantation species (Lim et al. 2003). The density of *A. mangium* ranges from 290 kg m^{-3} to 675 kg m^{-3}. *Acacia spp* is fast emerging as an important timber resource in the South East Asia region. It is a fast growing plantation species and is one of the major species in timber plantation sector in Sarawak and Sabah, Malaysia, covering more than 300,000 ha of planted acacia trees in both states.

Wood defects such as checks, cup and crook (warp along the length of the edge of lumber) in Acacia board increases after drying, and it is higher than other plantation species (Moya et al. 2008). Besides, acacia lumber had high incidence of collapse and splits, further compounded by the occurrence of moisture/ wet-pockets in the lumber. According to Tenorio and Moya (2011), one of the main factors influencing variability in final moisture content of *A. mangium* is the formation of wet pockets during drying, which tend to form in lumber from trees growing in very humid, tropical climates.

Piao et al. (2000) also reported the drying related problems found in *Acacia mangium*. Whereas, Haslett (1983) had identified the extreme variability of drying rate between the heartwood of a quartersawn compared to flat-sawn as the major problem encountered in the drying of *Acacia melanoxylon* R. Br. In another study, high moisture content variation was detected after drying of 7-year, 10-year and 13-year old *A. mangium* planted in Sarawak, whereby moisture gradient of more than 6% between the shell and core layers of *A. mangium* was found in 60%, 40% and 27% respectively in the order of the aforementioned age-group (Tan, 2014).

In view of the various drying issues faced by the local acacia producer, Sabah Timber Industries Association (STIA) had initiated a Research and Development project by appointing Forest Research Insitute Malaysia (FRIM) to be the technical consultant to assist Sabah acacia producer member to improve the quality of the kiln dried *Acacia mangium* plantation lumber throughput (Anon 2017). The specific objective of the study was to enhance the quality of the kiln dried acacia lumber produced which can be subsequently used in the production of the laminated truck flooring and related components.

MATERIALS AND METHODS

The drying and recovery studies were carried out in a timber processing and manufacturing factory in Sabah, Malaysia. The factory is integrated with sawmilling, kiln drying and finger-jointing activities. The industrial drying kiln used for the study was of 30-ton capacity.

Prior to drying, initial moisture content (MC) values of 40 pieces of randomly selected sample boards were determined in order to monitor the real-time MC reduction of the sample boards at set time interval during drying. To obtain predetermined MC values, 25mm-broad strips were obtained 50mm from the end of the each sample boards. The sample boards were weighed before commencement of drying, during drying at set time interval to record the weight loss of the sample boards and at the end of drying. After completion of the drying run, average MC of the dried sample boards were again determined. In addition, MC variation within each sample board was determined by slicing another 25-mm-wide strip from each of the boards into shell and core sections. The moisture content of the timber was determined based on standard oven drying method and calculated based on the formula below:

$$\text{Moisture content (\%)} = \frac{\text{Initial weight (g)} - \text{Oven-dry weight (g)}}{\text{Oven-dry weight (g)}} \times 100\%$$

The optimised drying schedule used was a moisture content based recipe with the initial dry bulb temperature (DBT) limited to 50°C or lower and final DBT to be maintained below 70°C. Ten sample boards with an extended sticker were placed beside the timber stacks at different height, and also in various locations in the kiln. Moisture content (MC) data during drying were estimated by periodically weighing the selected sample boards. The kiln charge was dried to approximately 10-12% MC based on estimated oven-dried weight.

After drying, the MC dispersion of acacia lumber was determined and both the volume and grade recovery for the kiln-dried lumber was carried out based on standard mill practice according to the final dressed-size intended for product manufacturing.

RESULTS AND DISCUSSION

DRYING SCHEDULE

The optimised drying schedule established in the study was a moisture content based recipe with the *initial dry bulb temperature (DBT)* limited to 50°C or lower and *final DBT* to be maintained below 70°C. The recommended kiln schedule after optimisation is shown in Table 1, for the 30mm thick *Acacia mangium* sawn lumber with mixed lengths of 1.5', 2', 3' 4', 5' and 6' respectively.

It is recommended that 8 to 10 hours of intermediate/intermittent equalising treatment is applied at the on-set of prevalent setting at 60%, 55%, 40% and 30% MC levels. The Wet bulb depression (WBD), i.e. the temperature difference between DBT and wet bulb temperature (WBT) should be kept within 1-2°C. This is to prevent abnormally high moisture dispersion within the lumber during the drying stage (Sik et al. 2015).

It is highly recommended that when the MC of the controls attained estimated values of 10 – 12 % (based on initial MC strips calculation) the whole kiln charge is then set to undergo Final Equalisation Treatment of DBT 60°C/WBT 51°C at a targeted EMC of 10%. This treatment condition is set to last for 48 hours, after which steam supply to the kiln is shut off but with the fans continue running. The kiln load is discharged when the kiln temperature has dropped below 40°C close to the ambient temperature.

Table 1: Moisture content based drying schedule for 30mm-thick *Acacia mangium* sawn lumber

Average MC (%)	DBT (°C)	WBT (°C)	RH (%)
Pre kiln drying conditioning treatment –	50	50	95~
Commencement of kiln drying process :			
60	53	50	84
55	57	52	76
50	59	50	61
40	61	48	48
30	65	47	38
~ 18% Case Hardening Relief Treatment	60	58	90~
10-12% MC Equalisation Treatment	60	51	61

MOISTURE CONTENT

The moisture content (MC) of *Acacia mangium* determined at green condition and after drying. The MC of *A. mangium* ranged from 48.89 to 138.22%, with a mean of 83.71%. The MC of *A. mangium* after drying ranged from 8.50 to 11.40%, with a mean of 9.95%. In addition, the variation of MC within individual dried *A. mangium* sample was determined separately in order to check for presence of wet pockets.

Based on the total number of sample boards randomly selected for monitoring during drying, about 90% of *A. mangium* samples were able to dry uniformly throughout the timber and the variation of MC between the inner and outer layers was within 2.0% after conditioning treatment, which was carried out before the end of drying. Whereas, the remaining samples, albeit higher variation between the inner and outer layers, the MC difference between these samples recorded were under 3%. This is important as effective moisture movement from the core toward the surface during drying is crucial to minimise or prevent the occurrence of severe casehardening. Cai and Hayashi (2007) mentioned that lack of MC uniformity has a significant impact on the manufacturing process and will affect the quality of products manufactured.

RECOVERY OF KILN DRIED ACACIA MANGIUM SAWN

On site recovery studies on kiln dried acacia sawn lumber was carried out based on mill assessment criteria. Table 2 shows the recovery of acacia sawn lumber after drying. After drying, the acacia sawn lumber were dressed down to 22mm-thick, which is the specific mill production requirement.

Overall, recovery study of the kiln-dried lumber was very high, with approximately 83.90% of the sawn lumber which was classified as Grade A and B. Whereas, dried sawn lumber which was undersized, are being further processed and recovered into smaller yet usable dimensional stocks, which classified as ‘fall down’ grade. The reject output from production was relatively low according to industry norms. In general, the rejection of kiln dried sawn lumber pieces is mainly due to off cuts which consist of natural defect such as knots, and defects caused by drying in the form of various warpings, cracks and splits. With proper drying technique, the rejection due to drying can be minised, whilst improving the both the grade and volume recovery of kiln throughput.

Table 2: Recovery of *Acacia mangium* sawn lumber after drying

Category	Volume (m^3)	Recovery (%)
Good Output-		
Grade A	20.1698	76.01
Grade B	2.0950	7.89
Fall Down	2.2525	8.49
Reject Output	2.0183	7.61
Total	26.5356	100.00

CONCLUSION

The findings from this study showed that moisture content based recipe drying schedule with application of intermittent steam treatments optimised for an industrial kiln, and with effective kin drying moinitoring, was efficient at producing quality kiln dried *Acacia mangium* sawn lumber suitable for downstream processing. Overall, recovery of the kiln-dried lumber was comparatively high based on previous kiln drying activities at the mill, whereby 76% of the acacia lumber after blanking process was classified as grade A based on standard mill assessment criteria.

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