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RAPID AND ENVIRONMENTALLY FRIENDLY TREATMENT OF RUBBERWOOD USING HIGH TEMPERATURE DRYING (HTD)

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INTRODUCTION

Hevea brasiliensis, or commonly known as rubberwood, was introduced into Malaya in 1876 using seeds obtained from the Amazon forest (Hong & Sim 1999). Rubberwood was traditionally used as firewood in the rubber and brick making industries (Jegatheswaran et al. 2011). It is known as a non-durable timber, prone to various drying defects and have low recovery for sawn timber. Relentless R&D efforts had been carried out over the last few decades on improving the rubberwood properties through new processing techniques. The development of various processing technologies in the sawing, drying and preservation has led to the commercial utilization of rubberwood for the production of timber products such as fibreboard, flooring component and furniture. Today, rubberwood plays an important role in the wood-based industries as furniture made up from rubberwood has contributed to about 80% of the export of wooden furniture (Ooi 2018).

The production of high quality timber products depends on the properties and performance of timber after treatment. Timber quality can be enhanced through chemical preservation or drying by heat treatment. Drying can increase the stability of timber and at the same time improves its resistance against fungal and insects attack. An improper drying technique causes uneven moisture distribution within the timber, and problems such as split, crack, warp, and check may arise. Hence, a good drying practice is crucial for the production of high quality wooden products with minimum problem (Sik et al. 2009).

In general, there are two types of wood drying practices. Natural drying is carried out by exposing the timbers to the air while artificial drying is conducted in a controlled environment in which the temperature and humidity can be regulated to provide optimum drying results. About 90% of local rubberwood entrepreneurs are still using standard conventional kiln-drying method which involves two (2) step process, i.e., chemical treatment with borates and followed by kiln drying at conventional temperature of less than 80°C which requires a processing cycle time of about 10 days.

Prompted by enquiries from various stakeholders on specific rules and regulations as well as debating on issues of the existing processing and preservatives treatment for rubberwood, FRIM has taken an initiative to develop a green technology for treating rubberwood by adopting the principle of high temperature drying-cum-heat treatment approach. The high temperature drying (HTD) system was developed at FRIM campus via retrofitting of an existing conventional steam-heated kiln (Figure 1).

This HTD system has been successfully used to establish an optimised protocol suitable for producing quality dimension stocks and finger-jointed components by eliminating the use of standard chemical treatment using boric acid. The overall operation involves only a single stage procedure with the processing cycle time reduced by approximately 70% of existing process. In addition, a shorter kiln resident time implies faster turn-around enabling just-in-time (JIT) concept to be incorporated in the operations that leads to lower stock holding cost.

Figure 1 The prototype of high temperature drying system in FRIM campus

Generally, HTD process utilises high operating temperatures in a saturated humidity condition for effective rubberwood treatment. The overall production cost can be maintained for the HTD operator to achieve a relatively attractive and profitable margin as the system uses wood waste produced directly from the plant's daily processing activities for biomass boiler consumption. Besides the significant reduction in processing time using the HTD process, the self-sustenance way of recycling wood waste from integrated mill activities would lead to a more efficient and cost-saving operation that further enhance the competitiveness of the industries involved. The advantages of the high temperature drying system over conventional kiln-drying method in rubberwood processing are summarised in Table 1.

Table 1 The advantages of high temperature drying system over conventional drying method for rubberwood

Key Parameter	High Temperature Drying	Conventional Temperature Drying
Methodology	Single step process: drying-cum-heat treatment	2-step process (chemical treatment followed by drying)
Chemical treatment	No	Borates
Environmental impact	Minimal	Negative
Drying time (days)	3	10
Stock holding /inventory	Minimum (Just in time)	1–2 month
Timber quality	Enhanced	Normal
Production capacity/ kiln/ month (ton)	300 (10 cycles /kiln)	90 (3 cycles /kiln)

Note: Production capacity based on 30 ton-timber capacity per cycle

FRIM HTD technology has been patented in Malaysia and 5 other countries namely: United States, Singapore, Thailand, China and Vietnam, while pending for patent examination in Indonesia and India. The FRIM HTD® trademark was also granted in Malaysia and Thailand (Figure 2). In 2014, the HTD technology won first place at the National Intellectual Property Award and also became a proud finalist at the International Innovation Award (IIA 2014) by the Commonwealth Association of Public Administration Management (CAPAM). The technology also won the prestigious National Innovation Award in 2013 and received a certified-entry into Malaysia Book of Records in 2015 for the "First High Temperature Drying System using Local Innovation".

Currently, the HTD system is being utilised to dry and heat-treat other lower to medium density timber species besides rubberwood, and specific protocols are being developed for these species for optimised timber throughput in terms of grade and volume recovery, as well as the overall drying efficiency.

Figure 2 HTD registered trademark

GENERAL CHARACTERISTICS, PROPERTIES AND USES OF HIGH TEMPERATURE TREATED (HTD®) RUBBERWOOD

HTD® rubberwood has improved dimensional stability when compared to conventional treated rubberwood (Sik et al. 2010). The internal stresses within the structure of timber are reduced when it is treated at high temperatures of the HTD® process and its treatment protocol. The timber quality is also enhanced through the reduction in warping and no incidence of serious collapse or honeycombing due to excessive shrinkage. Furthermore, HTD® Rubberwood has no toxic emission as it is not treated with any preservative, unlike normal rubberwood that is treated with toxic chemicals. General characteristics, bonding, mechanical, shrinkage and wood working properties of HTD® rubberwood are presented in Table 2,3,4,5, & 6. Some of the selected properties of HTD® rubberwood are compared to the timber that was treated by conventional temperature drying (CTD) method.

Table 2 General characteristics

Parameter	Description
Wood colour	The HTD process produces slightly darker colour timber and has minimal discoloration.
Grain	The timber has enhanced wood grain features and aesthetic appearance (Figure 3)

Source: FRIM Material Datasheet for HTD Rubberwood 1/2019

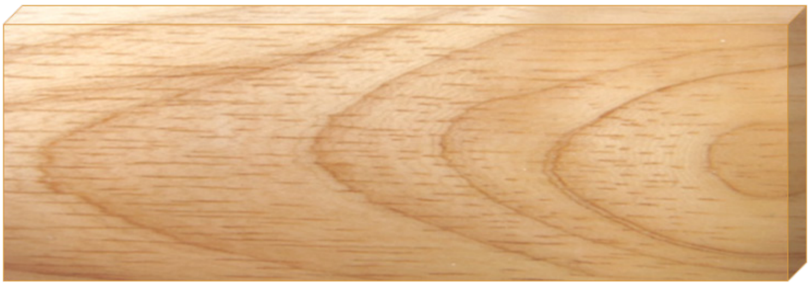

Figure 3 High temperature treated Rubberwood

Table 3 Bonding properties

Type of test	Testing procedure	Results	Remarks
Bonding test (laminated board)	6-hour cold water soaking, followed by oven dry at 40°C	All samples passed the test at which 75% are without any occurrence of delamination whereas another 25% having ratio of delamination of less than 20%.	If ratio of delamination is more than 30%, the sample is considered failed. Notes: Calculation on Ratio of delamination = (Total length of delamination on both ends/ Total length of glue lines on both ends)*100%

Source: FRIM Material Datasheet for HTD Rubberwood 1/2019

Table 4 Mechanical properties

Parameter	Green[a]	Air dry[a]	CTD[b]	HTD[b]
Density (kg/m^3)	800	640	580–660	650–750
Moisture content (%)	52.0	17.2	7.6	6.8
Modulus of elasticity (MOE) (MPa)	8,800	9,240	12,187	12,333
Modulus of rupture (MOR) (MPa)	58.0	66.0	117.0	120.3
Hardness (kN)	3.0	4.3	4.2	5.2
Compression parallel to the grain (MPa)	25.9	32.3	44.5	57.8
Specific gravity	0.5	0.6	0.6	0.7
Shearing strength parallel to the grain (MPa)	9.0	11.9	15.1	17.6

Note: HTD- high temperature drying up to 130°C
CTD- conventional temperature drying up to 60°C
Source : a = Lee et al.1979
b = Sik et al. 2009

Table 5 Shrinkage properties

Shrinkage (%) from green to kiln dried condition	CTD	HTD
Thickness	2.80–3.65%	3.22–4.10%
Width	2.22–4.12%	3.33–5.40%

Notes: Additional shrinkage is not significant in HTD rubberwood compared to CTD rubberwood, thus additional increase of sawn size allowance is not required.
Δ 1% (thickness) = 0.3mm
Δ 1% (width) = 1.0 mm
Source: FRIM Material Datasheet for HTD Rubberwood 1/2019

Table 6 Wood working properties

Working Properties	Better/ Comparable/ Acceptable as compared to conventional kiln dried rubberwood
Machineability	Better
Hardness	Better
Nail and Screw Holding Strength	Comparable
Mechanical properties	Better
Other Assessments	**Rate**
During application of finishes (coating) on HTD rubberwood products, any improvement to the ease of application and coating quality compared to conventional kiln dried rubberwood?	Less coating required with better finishing
During sawing, cutting and profiling of the HTD rubberwood, any noticeable increase in wear-and-tear to saw and cutter knife?	Acceptable The planed surface of the HTD rubberwood exhibits minimal raised grain.
Are major changes to machines or other set-up required before processing the HTD processed rubberwood?	Not required

Note: Data shown are based on the feedback from industry on the trial production of furniture components from HTD rubberwood.
Source: FRIM Material Datasheet for HTD Rubberwood 1/2019

USES

The HTD treated rubberwood is suitable for the production of finger jointed stocks for making laminated bench tops and other range of solid furniture and components. In addition, HTD treated rubberwood is also suitable for the production of value-added products such as solid wooden flooring board (Figure 4).

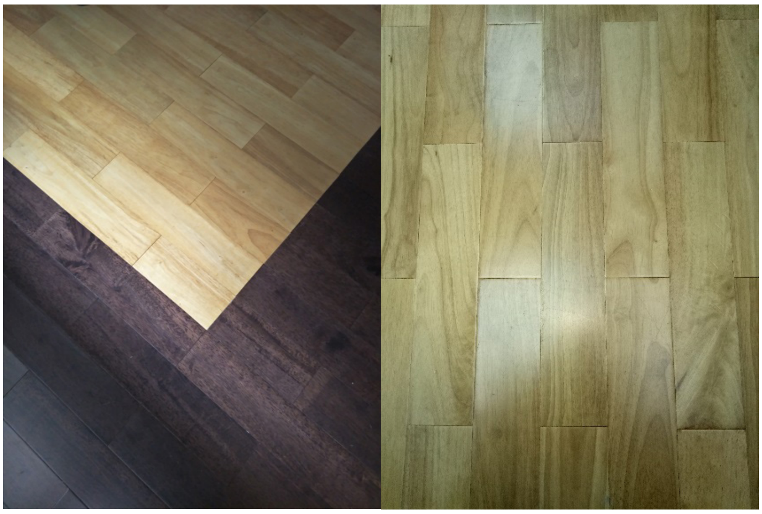

Figure 4 Solid wooden flooring made from high temperature treated rubberwood

CONCLUSION

The environmentally-friendly high temperature drying (HTD) system has been successfully developed for the treatment of rubberwood by eliminating the use of chemical preservatives. The processing cycle time is reduced by approximately 70% of existing conventional rubberwood processing method. The quality of the HTD treated rubberwood sawn timber is improved and has better dimensional stability as compared to lumber produced by conventional methods. Subsequently, these enhanced features will contribute to production of more high value-added products and continue to give a competitive edge to the country as one of the world leaders in producing quality rubberwood-based products.

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REFERENCES

FRIM Material Datasheet for HTD Rubberwood, Forest Research Institute Malaysia, Kepong, 1/2019, page 1–6.

Hong LT & Sim HC. 1999. Rubberwood Processing and Utilisation. *Malayan Forest Record*. No. 39.

Jegatheswaran R, Florin I & Lu W. 2011. Sustainability of the Rubberwood Sector in Malaysia. *Academic Press*. 39 (2):305–311.

Lee YH, Engku Abdul Rahman Cik & Chu YP. 1979. The Strength Properties of Some Malaysian Timbers. *Malaysian Forest Service Trade Leaflet* No. 34. (Malaysian Timber Industry Board & Forest Research Institute Malaysia)

Ooi Tee Ching. 2018. Malaysia's 2017 timber exports to surpass RM23b. *New Straits Times*. 21 January 2018.

Sik HS, Choo KT, Sarani Z, Sahrim A, How SS & Mohamad Omar MK. 2009. Influence of drying temperature on the physical and mechanical properties of Rubberwood. *Journal of Tropical Forest Science*. 21(3):181–189.

Sik HS, Choo KT, Sarani Z, Sahrim A, Maisarah Y & Chin Hua C. 2010. The influence of drying temperature on the hygroscopicity of Rubberwood (*Hevea brasiliensis*). *Journal of Agricultural Science*. Vol. 2, No.1. Pp. 48–58.

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FRIM has successfully developed a rapid and environmentally-friendly High Temperature Drying (HTD®) system for the treatment of rubberwood. This technology eliminated the use of standard chemical treatment and the processing cycle time is reduced by approximately 70% of existing process. In addition, the quality of HTD® treated lumber is overall enhanced and has better dimensional stability compared to lumber produced by conventional methods. HTD® treated rubberwood is suitable for the production of finger jointed stocks and value-added products such as solid wooden flooring. Currently, the HTD® system is being utilised to dry and heat-treat other low to medium density timber species, and specific protocols are being developed for these species for optimised timber throughput as well as the overall drying efficiency.

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