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An Evaluation of the Saw, Dry and Rip Process for the Conversion of Rubberwood

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Abstract: A study was carried out to compare the volume recovery and product quality of two different sawing techniques in the conversion of rubberwood which is plagued with low yield. The study was undertaken in a sawmill in Peninsular Malaysia, using the conventional live sawing process and the Saw Dry and Rip (SDR) process. The results showed that the SDR process resulted in higher volume recovery as well as higher product quality, compared to the conventional live sawing process. Further, the application of high temperature drying for rubberwood sawn material resulted in lower drying defects and together with the SDR process, resulted in a more economical solution for the conversion of rubberwood. Accordingly, a survey of the current industrial practices as rubberwood 125 saw mills revealed that rubberwood sawmilling is plagued with a low yield of 27% and the SDR process, if applied offers a significant improvement both in terms of volume recovery as well as product quality. Therefore, the results of this study have far reaching industrial implications on the sawing and machining of rubberwood in the South East Asian region.

Key words: Sawmilling industry, recovery, process cost, conventional sawing

INTRODUCTION

As of 2010, almost 7.6 million hectares of land was under rubber (*Hevea brasiliensis*) cultivation in the South East Asian region and it is envisaged that the cultivation acreage will increase substantially in years to come as demand for latex or natural rubber continue to increase in worldwide (Ratnasingam and Scholz, 2009). Although cultivated primarily for latex or natural rubber production, the rubber trees also produce a large amount of woody biomass, of up to 180 m^3 per hectare upon harvesting for replanting activities (Hong and Sim, 1994). However, only about 50 m^3 from this amount of the woody biomass is converted into sawn lumber, commercially known as rubberwood *(Hevea brasiliensis*). Despite its inherent harvesting and production shortcomings, rubberwood has emerged as the most important wood raw material for the wood products manufacturing sector. It is used extensively for particleboard, medium density fibreboard, parquet flooring, joinery and furniture productions throughout the South East Asian region, particularly in Malaysia, Thailand and Indonesia (Ratnasingam and Scholz, 2009). The fact that the material is derived from man-made forest plantations makes rubberwood an environment-friendly material, which further boosts its status as a premier wood raw material. Despite, its success in the wood raw materials market, rubberwood is plagued with low processing yield, both in the sawmilling and other machining operations due to the presence of tension wood and other processing defects (Ratnasingam and Scholz, 2007, 2009; Ratnasingam and Ma, 2010). Tension wood is the abnormal wood found commonly in leaning hardwood trees and its branches (Archer, 1986; Lim and Nadzri, 1995) and its presence generally impairs the overall wood yield and quality (Wardrop and Dadswell, 1955; Ratnasingam *et al*., 2010). Although the formation and properties of tension wood has been well documented (Lim and Nadzri, 1995; Plomion *et al*., 2001), information on minimizing its effect on wood yield and quality is limited (Ratnasingam and Scholz, 2009). The use of mobile sawmills in rubberwood processing is predominant throughout South East Asia, as it is suitable for on-site conversion of rubber trees in plantations that are dispersed and remotely located. Consequently, the resultant processing yield is low as the technology is a better choice for re-sawing operations, rather than primary

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sawing. Inevitably, wood yield and quality is impaired to an extent that affects the competitiveness of the material as a primary wood resource for the value-added wood products industry (Ratnasingam and Scholz, 2007, 2009).

One possible technique available to improve wood yield and quality is the Saw-Dry-Rip (SDR) process which has been used for the sawing of hardwoods in other parts of the world (Maeglin and Boone, 1983). The SDR process is a simple process based on well-known manufacturing techniques combined, in a different order, to account for wood structure and stresses. In this process, the logs are first live sawn into flitches and subsequently dried, before being ripped to dimension. The difference in the processing order is that, the conventional sawing cuts the lumber to dimension, with an allowance for shrinkage and planning, before drying. Research has shown that the SDR process show significant improvements in yield when sawing hardwoods (Maeglin and Boone, 1983).

Generally, the green logs are live sawn into thick flitches in the SDR process which allows the inherent stresses to be balanced and restrained. Additionally, the drying stresses induced during the drying process offset, to some degree, the growth stresses in the flitches. After drying, the flitches are straight-line ripped to desired dimensions which results in higher sawing yield. In essence, the SDR process may be useful for converting rubberwood, which has a significant proportion of tension wood and growth stress, which reduces its yield during sawing and drying (Ratnasingam *et al*., 2010).

Therefore, a study was undertaken to compare the conventional and SDR sawing processes for rubberwood in terms of product yield and quality. Further, the study also evaluated the economics of the two sawing processes, to provide the necessary industrial guidelines for improvements in the sawing of rubberwood.

MATERIALS AND METHODS

As most of the rubber plantations were located in the southern states of Peninsular Malaysia, the study conducted in three parts, was carried out in the state of Johor between the months of January to October of 2010. Part I evaluated the processing yield and quality during the sawing of rubberwood in one of the largest sawmills, with a sawing capacity of 50 m^3 of saw logs per day. The saw logs, aged more than 25 years, were in the 28-32 cm diameter class, with an average length of 1.9 m. The sawing process was carried out using mobile sawmills, with vertical saw blades of 100 mm in width to reflect current industrial practices. The saw blade characteristics used in this study, are as shown in Table 1. Sawn rubberwood of 25, 38 and 50 mm in thickness and 50 and 75 mm in width were produced to reflect the most common cutting sizes within the industry (Ratnasingam and Scholz, 2009). The study was conducted over a period of a week, which ensured sufficient sawn material to fill-up the kiln-drying chamber on-site.

Table 1: Saw blade characteristics

Characteristics	Values
Tooth pitch (mm)	40
Gullet depth (mm)	15
Rake angle (α)°	30
Clearance angle (β)°	15
Side clearance (mm)	0.7
Profile	Parrot
Setting	Stellite-Tipped
Blade thickness	1.1 mm

Table 2: Kiln drying schedule for rubberwood

Moisture content (%)	Dry-bulb temperature (°C)	Wet-bulb temperature (°C)
Green	45 (75)	44 (60)
60	48 (90)	45 (69)
40	48 (118)	45 (74)
35	52 (118)	46 (89)
30	55 (118)	47 (81)
25	60 (118)	48 (83)
20	67 (118)	53 (85)
15	75 (118)	60 (87)

Values in parentheses reflected the dry-bulb and wet-bulb temperatures used in high temperature drying

The sawn materials were then dried in two steam-heated kilns, using two different drying schedules (Table 2). The air speed in the drying chamber was maintained at 3.0 m sec^{-1} while a restraining pressure of 100 kg m^{-2} was applied on each bundle as the weight down to minimize warping during both drying schedule. The equal amounts of the different sawn materials were subjected to the two different drying regimes. Kiln samples were used to determine the moisture content of the materials. An equalizing treatment was applied to ensure uniformity in the final moisture content of 10±2%, before discharge.

Part II of the study focused on the use of the SDR process in the conversion of rubber logs. The sawing was carried out to produce flitches of 55 mm in thickness. The sawn materials were then dried in two steam-heated kilns, using the two different drying schedules (Table 2). The drying charge were of similar quantity and quality and at the end of the drying cycle, an equalizing treatment was applied to ensure uniformity in the final moisture content of 10±2%, before discharge. The dried sawn materials were sent to the sawmill for straight-line ripping to the final desired dimensions.

The processing yield measurements, under the two sawing processes were compiled and evaluated on a volumetric basis. In terms of quality, the degree of warp (specifically crook, bow and twist) was measured by placing the piece on a flat surface to determine the

Table 3: Comparison of yield and quality of the two different sawing processes

	Conventional		SDR	
Parameters (%)	Conventional drying	High temperature drying	Conventional drying	High temperature drying
Sawing yield	27 (3.7)		46 (2.4)	
Drying defects-warp	6.4	5.4	4.8	4.3
Drying defects-non-warp	11.4	9.1	8.6	6.9
Quality of sawn material	58-Grade A	64-Grade A	73-Gade A	81-Grade A
	21-Grade B	17-Grade B	10-Grade B	9-Grade B
	21-Grade C	19-Grade C	17-Grade A	10-Grade B

Values in parentheses indicate Standard deviation

maximum deviation from the straight line for each type of warp. This deviation was measured using a calibrated depth gauge recording to the nearest 1 mm. The maximum acceptable warp limits for the material was set as per recommended in the Grading guideline for rubberwood issued by the Malaysian Timber Industry Board (MTIB). The results obtained were statistically analysed using the Analysis of Variance (ANOVA) technique, which ascertained the statistical differences due to the different experimental parameters. The degree of confidence of p = 0.05 reflected the reliability of the results obtained, in comparison to other studies.

Part III of the study involved a survey of current industrial yield at 125 rubberwood saw mills, located mostly in the states of Johor, Melaka and Negeri Sembilan in Peninsular Malaysia. The selected mills were based on the listing provided by the Malaysian Wood Industries Association (MWIA).

RESULTS AND DISCUSSION

Part I: Comparative sawing yield: The sawing yield from the two different processes was derived by calculating the nominal volumes of sawn timber and multiplying it by the number of sawn timber produced. Percent yield is the total volume recovered as a percentage of the total log scale for each sawing process. Although, differences in log diameters were unavoidable, all efforts were taken to ensure equal distribution between the two sawing processes.

The percent volume recovery for the two sawing methods showed significant difference (p = 0.05), since the SDR process resulted in higher nominal yield as it allowed greater versatility during the ripping operation for different dimensions. A similar finding was also reported by Layton *et al*. (1986) who found that the SDR process allows greater recovery due to the possibility of a better cutting plan for increased recovery and the avoidance of shrinkage allowances provided in the conventional sawing process (Table 3).

Based on the rejects for warp only, the SDR process had a significantly lower percentage of rejects (p = 0.05) compared to the conventionally sawn material (Table 3). The study showed that 81% of the SDR produced material was a grade material (no defective pieces beyond the acceptable limit). While only 9% were B grade (less than 15 defective pieces per 100 pieces) and the balance were grade C material (more than 15 but less than 30 defective pieces per 100 pieces) (Table 3). Hence, it is apparent that the SDR process outperforms the conventional sawing process, in terms of both volume recovery and product quality. This is particularly true when the sawn materials were subjected to high temperature drying regimes. Studies by Mårtensson and Svensson (1997) and Lazarescu and Avramidis (2008) have shown that drying wood at high temperatures tends to counter the inherent growth stresses in the wood. On the other hand, the study by Sik *et al*. (2009) and Ratnasingam and Scholz (2009) have shown that drying rubberwood at high temperatures will counter balance the inherent growth stresses in the wood but also minimize the imbalance due to the tension wood by plasticising the lignin in wood. In essence, it is apparent that high temperature drying of rubberwood is advantageous to increase both wood yield and quality.

Part II: Treatment effects on warp development: The effects of the SDR process on the development of warp and other degrades were also studied. The SDR process has been reported to have a strong influence on warp (Layton *et al*., 1986) but the interaction of the various factors on the type and degree of warp in sawn Rubberwood remain inconclusive. Table 4 shows the comparison of the effects of sawing and drying treatments on the type of warp in sawn material from this study. As shown, the effectiveness of the SDR process in controlling crook was substantial (p = 0.05), with more than 50% reduction in crook, both using the conventional and high-temperature drying techniques. Similarly, the defect, twist was reduced by more than 50% (p = 0.05) through the SDR process, under both the conventional and high-temperature drying techniques. In terms of the defect bow, almost 45% of the conventionally sawn material exceeded the allowable bow limits, while only 8% of the SDR sawn material manifested the defect. Previous reports by Sik *et al*. (2009) and Ratnasingam and Scholz

Table 4: Effects of treatments on drying defects

	Conventional (%)		SDR (%)	
Drying defects	Conventional	High temperature drying	Conventional	High temperature drying
Crook	39	35	16	14
Bow	47	44	9	7
Twist	29	25	15	11
Cup	10	9	7	5
Split	21	23	18	19
End-Check	20	22	20	19
Collapse	Nil	Nil	Nil	Nil

Statistical significance was tested at $p = 0.05$

Table 5: Comparative cost of the two sawing processes

	Conventional	SDR
Throughput at sawmill m^{-3} day^{-1}	7-10	5-6
Volume recovery/Yield (%)	27	46
Cost of production (US\$ m^{-3})	100-155	125-190
Selling price (US\$ m^{-3}) based on quality of sawn timber	300-400	500-730

Based on the average log cost of US 25 m^{-3}, labour cost in sawn timber production of US 35 m^{-3}, saw-doctoring cost of US 10 m^{-3}, energy cost of US 15 m^{-3}, drying cost of US 48 m^{-3} and high temperature drying cost of US 115 m^{-3}

(2009) have shown that by turning around the logs during the sawing process as practiced in the SDR process, significantly reduced the defects, twist and crook, in the sawn wood material. Turning around the logs minimized the effect of grain deviation in the wood due to the radial-tangential surfaces counterbalance (Huber *et al*., 1984; Simpson, 1991). Further, the high temperature drying also reduces the amount of warp in the sawn material, as high temperature drying under the weight-strain plasticizes the sawn material to reduce warp significantly (Diawanich *et al*., 2010). Therefore, the use of the SDR process significantly reduces warp which remains the most common defect in sawn rubberwood, as reported by Ratnasingam *et al*. (2010).

Part III: Cost implications: Table 5 shows the economic implications of the two different sawing processes in rubberwood conversion. It is apparent that, although the SDR process results in a lower throughput level compared to the conventional sawing process at the saw mill, it leads to a significantly higher quality sawn rubberwood ($p = 0.05$) which fetches a premium price in the market place. Further, the application of the high temperature drying process, not only reduces the drying time but also lead to a better quality dried stock, with lesser defects. The study also proves that high temperature drying of rubberwood is both practical and economically viable and is parallel with the earlier report by Sik *et al*. (2009). Nevertheless, the maximum temperature used in this study proves to be optimum, as the unappealing darkened colour of the wood surface is minimized, although the effect of higher temperatures on the colour of the wood surface is worthy of further studies. The colour of the rubberwood surface is a primary criterion in using the materials for the manufacture of value-added wood products (Ratnasingam and Scholz, 2009).

Industrial implications: A survey of 125 rubberwood saw mills in Peninsular Malaysia revealed that the average green yield was 27%, with a further reduction in yield by almost 7% due to drying losses. Table 5 shows the comparison in process economics between the two sawing techniques used in this study. It is obvious that although the SDR process requires a much larger capital outlay, its lower operational cost and higher economic returns should prompt more rubberwood saw mill operators to seriously consider the SDR process as the conversion technique of choice for rubberwood. This is particularly true against the background of increasing production cost and the demand for better use of the raw materials available. In this context, it must be emphasized that the SDR process should be the conversion process of choice, especially when dealing with logs of more than 28 cm in diamet.

CONCLUSION

The results of this study shows that the Saw Dry and Rip (SDR) process is a more viable option compared to the conventional sawing process for rubberwood. The higher volume recovery as well as the significant reduction in the defect, warp, implies that the SDR process provides the economic benefits for saw mills operators to adopt this technique. The conventional sawing process, although is practical and widely used, is less economical due to its inherently higher wastage and low quality product. In fact, the SDR process offers a more productive solution to the conversion of rubberwood throughout South East Asia.

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