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Appropriate sawing techniques for improving teak log *(Tectona grandis)* from plantation in Lao PDR

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Abstract

The aim of this research is to evaluate log recovery in teak (*Tectona grandis*) lumber production by three sawing machines (circular saw, vertical band saw, and horizontal band saw) and three sawing patterns (lumber sawn from squared lumber sawing, plain sawing, and quarter sawing). Total 90 teak logs harvested from plantation in Laos were used for the experiment. In plain sawing pattern, vertical band saw was 68.21%, 68.20% in horizontal band saw and 65.48% in circular saw. The second level of log recovery was lumber sawn from squared lumber: 56.29% in horizontal band saw, 55.56% in circular saw, and 40.07% in vertical band saw. There was significant difference ($p < 0.05$) among three sawing patterns. Statistical comparison between three techniques sawing was high significant differences which plain saw was maximum volume of lumber. Three wood machineries comparison only time significantly the circular saw was spend time less than both band saw. It is suggested that flat sawing patterns with horizontal band saw or circular saw was very useful in regard as log recovery for teak lumber production.

Key worlds: *Teak, Plantation, Techniques, Recovery, Machinery*

1. Introduction

The world teak plantations cover 7% of the total forest area worldwide. Generally, teak plantation produces one-third of the global industrial around wood (International Timbers Trade, 2014). Lardrach (2009) reported that the total area of teak plantations available is 5,716,203 ha. The proportion of teak plantations in Asia is larger than in other continents which is 5,409,131 ha, while is it counted for 206,550 ha in Africa, 76,000 ha in Central America, and 7,022 ha in Oceania. Teak plantation (*Tectona Grandis*) in Lao People's Democratic Republic was first established in 1942, and its area has been expanded since 1980. Over the last two decades, up to 50,000 ha of teak plantations and other species have been established in the northern and southern provinces of Lao People's Democratic Republic, primarily by small landholders.

Native Species with big diameter and long length harvested from natural forests have been utilized for lumber production in Laos, because these logs have much volume the diameter of *dipterocarpus alatus* was 77 cm of average, length was 5 m, log volume was 2.3280 m^3 which sawing by vertical band saw the recovery rate of 72% (Thavone, 2014). Base on Nanthakhon (2014) study on the Techniques of Lumber Production of Kheokhounmesub Wood Factory at Borikhamxay Province with natural species (*Dipterocarpus alatus*) the log diameter was 57 cm, length was 5 m and yield was 71.01%. Bouaphavong and Sichlearnh (2013) stated that, during teak lumber production from logs in sawmills in Laos, log recovery from log to squared lumber was 30 – 40%, but the it in final products was only 20 – 26%. In addition, Phonpaserth and Pongky (2014) also pointed out that, in Luang Prabang Province, Laos, log

recovery in teak lumber production by plain sawing pattern was 58.32%, and 13.17% and 28.51% become sawdust and wood waste, respectively.

Lumber yield is increased or decreased is usually depend on the sawing techniques Bernhard Mohns and Richard (2010), the scheme also highlighted the limited (below 10%) share that the producers received in the timber value chain, local chainsaw milling and stationary bench sawmilling (log squaring) are expected to increase their share to nearly 50%. Base on Prayitno *et al.*, (2006) confirm that the advantages of this sawing technique are very fast sawing, efficient, and no time required turning logs for specific dimension of sawn lumber, the recovery rate of most of the sawmill processing teak log form community plantation was low (below 40 %). The two main types of cut-plain sawn and quarter sawn - refer to the angle between the timber face and the growth rings, the cut is such that the growth rings meet the surface at less than 45 degrees then the timber is plain sawn (British Wood Preserving and Damp Proofing Association, 2002). Based on the results from How *et al.* (2007. 2009), examined volume recovery in lumber production from round logs and irregular shaped logs by several sawing methods. As the results, the highest volume recovery (65.54%) was recorded in turning around at 90 degree; 65.29% record in sawing with a breaking; 62.54% record in flat-sawn or plain sawn; 62.05% record in live sawing or through and lowest quarter sawing. But irregular log highest volume was 54.84% record in sawing with the breaking; 54.65% record in turning round at 90 degrees; 54.55% record in turning around 180 degrees; 52.65 record in live sawing; 51.71% record in flat sawn and lowest recovery was 50.45% record in quarter sawn, the result plain sawn was higher than quarter sawn about 10% of total volume of lumbers.

Grading separate log into quality group, provide a way in which buyers and sellers can agree on value, log grading is very important for farmer, processor, and trader. The history of log grading in Laos, which there are 16 defects in 1990 but that rule has been updated in 1996 the unnecessary defect log has movement remain 9 defects identified and in 2007 was continuous updated rule which reduced defections till 4 defects identifying (Ministry of Agriculture and Forestry, 2007). Current log grading system used in Laos, there are two sets of grading rules have been identified as first one those used by Burapha company for plantation teak resource and government grading rules used for native forest logs. However, Burapha company criteria were 8 parameters such as heartwood proportion; fresh knot; dead knot (sound); rotten knot, diameter and percentage; bend; end crack; insect holes and metallic but there are 4 parameters of government criteria such as total sweep; fluting; want and pip (Hopwell *et al.*, 2014). According to Iternational Standart Organization (1998) different rules for log plantation grading which there are 9 defects such as slop of grain, deviation of grain; reaction wood; dabble pith; removed pith; scar; in bark; cancer; false and heart-sapwood. Base on study of Comparison of log grading between government and company rules by Silipanya *et al.* (2014) the method were different rules established the same log, as result Government criteria was 100% of grade A but Company criteria were 32% of grade A, 33% of grade B and 35% of grade C. The review of literature does not find any standard grading rules for plantation Teak logs.

There are three sawing machines to use by sawmills in Laos: circular saw, horizontal band saw, and vertical band saw. Based on the study of current production practices and processing efficiency by Hopwell *et al.* (2014), these sawmills were used either horizontal/vertical band saws or circular saws, or a combination of the two to breakdown round and square logs into primary processed components. In addition, some sawmills firstly produced squared lumbers from logs for selling to other sawmills or manufacturers the all products bring domestic market and export to neighbouring countries. The aim of the paper to compare the three techniques and wood machineries for teak recovery improvement.

2. Materials and methods

The equipment used in the present study was three sawing machines, tap meter, caliper, camera, data sheet, markers, computer, and statistic software.

In the present study, the following three sawing machines were used: frame circular saw (maximum size of log was 50 m^3 per day 8 hours working, Burapha Agroforestry LTd.co.)

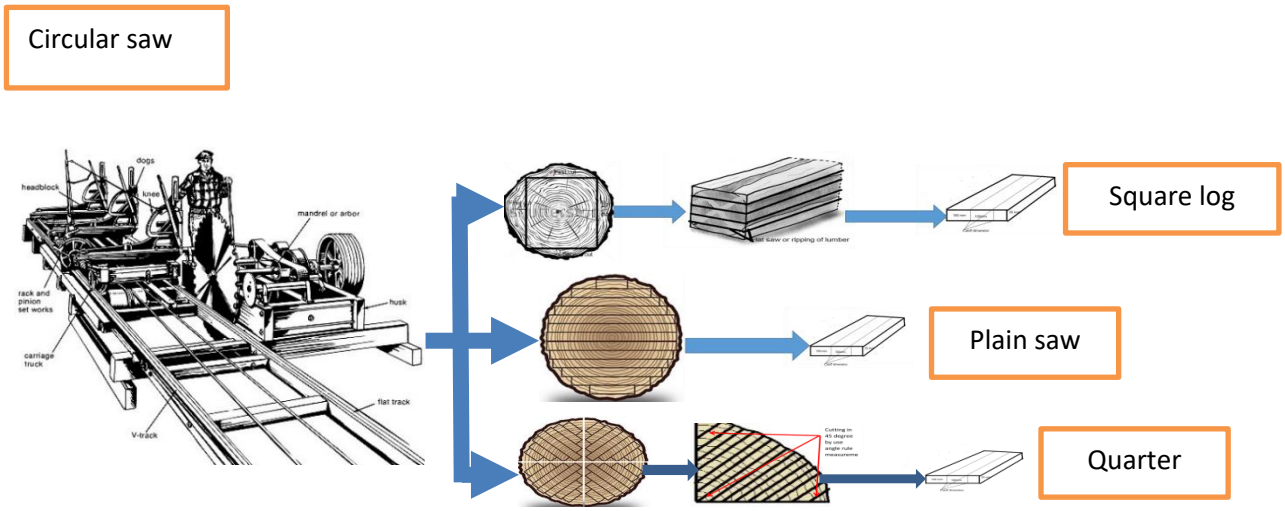

Fig. 1 Complete frame circular saw in three techniques

Vertical band saw (maximum size of log was 4 m^3 per day, MJ360B, Faculty of Forest Science.

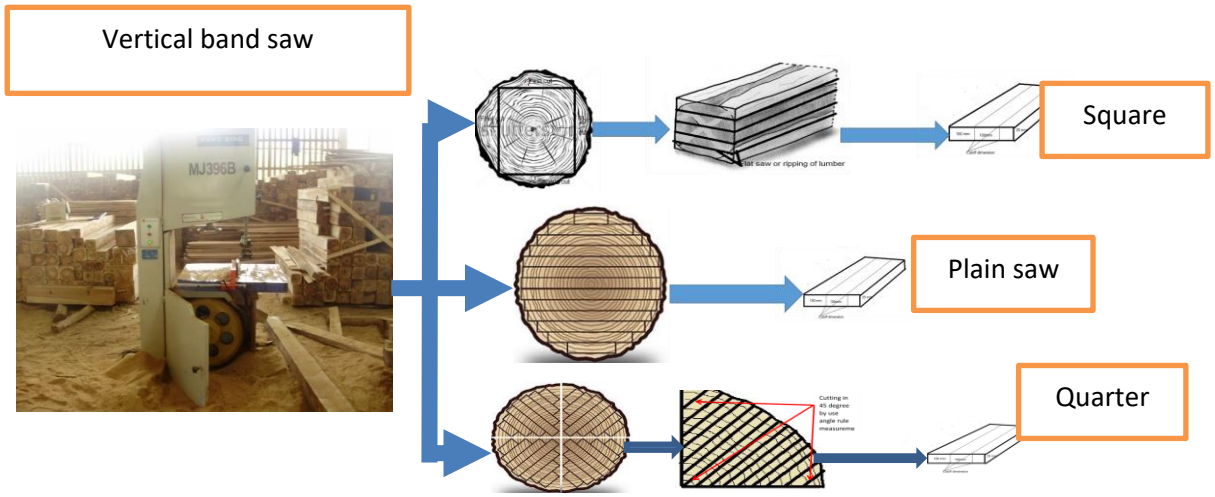

Fig. 2 Vertical band saw (MJ360 B) in three techniques

Horizontal band saw (maximum size of log was 8-10 m^3 per day, Wood-mizer, PKK Furniture Factory).

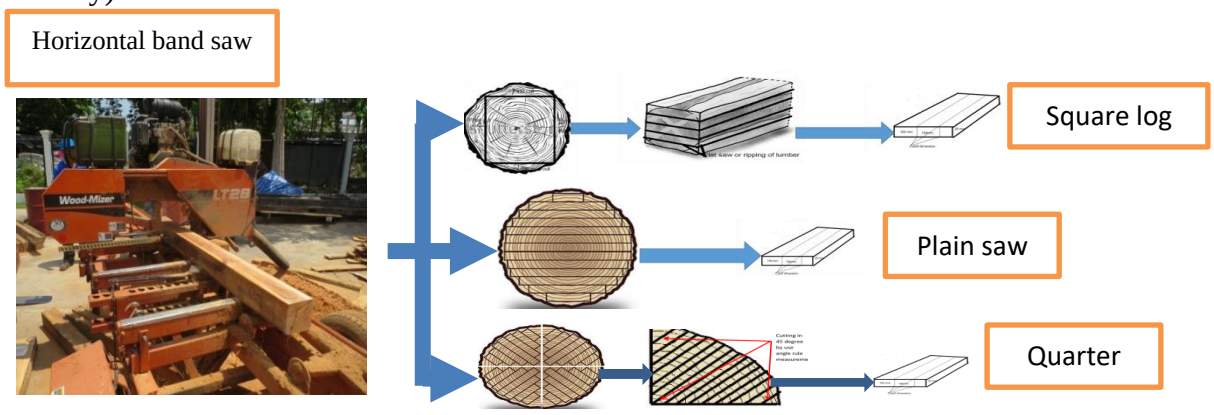

Fig. 3 Horizontal band saw (Wood-mizer) in three techniques

Selected some techniques compared with old technic, which old technic was sawing by square log but two new technic sawing by plain sawn and quarter sawn. The experiment was control by factorial method such as 3 × 3 × (Factor one was 3 wood machineries Circular saw, Vertical band saw and Horizontal band saw), Factor two was 3 techniques (Square log, Plain saw and Horizontal band saw) and Factor three was 10 log sample for each machinery and techniques, A, B, and C were teak log grade including log grade A was 2 logs, grade B was 3 logs and grade C was 5 logs) see the chart figure 1.

This research was interview of three sawyers for focus their experiences and techniques sawing from each one. 90 of logs harvested from plantation and separated into three groups such 30 of logs sawn in circular saw, 30 of logs sawn in vertical band saw and 30 of logs sawn in horizontal band saw. Any log sawn followed method and evaluation log recovery. Log volume calculated under formula the double diameter multiple pi (3.14) by length of the log and divided 4.

For analysing log volume, log recovery was interred into a spreadsheet Microsoft Excel. To detect the significant differences at 5% level among, SPSS software was used for one-way analysis of the variance (ANOVA) test.

3. Results

Techniques and machineries were important for teak log processing. Teak logs sawing processes used three methods and three machineries for testing. Table 1 shows log volume, lumber volume and recovery in combination of three different sawing machines and three different sawing patterns. Techniques had highest volume of the lumber in the plain saw and both of band saws, the average yield were 68.21 and 68.20%, old techniques in square log sawn was 56.29% of average and quarter saw maximum volume in horizontal bans saw was 38.87% of average. Techniques had an effect to the volume of lumber defection while which quarter saw techniques had no effect. Experience is important when operating the different types of saws.

In this research 10 logs were used random and separated into three classes, 2 logs for grade A, 3 logs for grade B and 5 logs for grade C. Figure 2 shows log recovery in each combination of sawing machine and pattern. The average yield of lumbers in three classes was 55.56%. When separated grade to saw in the circular saw which grade A was low recovery, in the square log A was 52.18%, B was 55.25% and C was 60.93%, in the Plain saw grade A was 51.54%, B and C were 72.84% and 72.25% of average and in the quarter saw grade A was 32.54%, Grade B was 38.21% and grade C was 37.38%. Horizontal band saw (Wood-Mizer LT 70) in three techniques are plain saw to maximum volume average of 76.61% in the grade B, 69.64% in the grade A and C is 63.41%. Square log then flat saw is highest in grade B about 62.09%, grade C 54.63% and A is 53.02%.

Recovery in square log techniques are effective with volume of lumbers which square log is 52.33% of average, ratio sawing of minimum and maximum are 20.75 and 82.83%, standard deviation (SD) is 1.84, and standard error (SE) is 2.82. A plain sawn technique has mean recovery of 67.54%, SD is 1.52 and SE is 2.78. And a quarter sawn technique has mean lumber volume of 36.33%, SD is 8.30, and SE is 1.51. Comparison between three techniques which one is square log compared with plain sawn mean different of 1.52%, SE is 3.46 and sig is 0.00 or high significant. Square log compared with quarter sawn mean different of 1.60, SE is 3.46 and sig is high significant. And plain sawn compared with quarter sawn has mean different of 3.12, SE is 3.46, and sig is high significant.

Teak lumber volume in the square log has mean 0.0293 m^3/ a log (average in 30 logs), SD is 0.0120, and SE is 0.0021. A plain sawn technique has mean 0.0330 m^3 / log (average in 30 logs), SD is 0.0129, and SE is 0.0023. In addition, Quarter sawn has mean of 0.0266 m^3 / log (average in 30 logs), SD is 0.0128, and SE 0.0013. Square log techniques had different

mean of 0.0037, SE is 0.0028 and sig 0.379 (no significant NS) compare to plain sawn techniques. Square log techniques had different mean of 0.0118, SE is 0.028 and sig is 0.00 or high significantly compared to plain sawn techniques. Finally, plain sawn techniques compared with quarter sawn techniques different mean is 0.0155, SE is 0.028, and sig is 0.00. But time is not significant for each technique.

4. Discussion

This study is plain sawn to highest recovery which it is 67.54% but lowest is quarter sawn techniques of 36.33%, square log ripping by flat-saw is 52.33%. According to How *et al*. (2009) confirm that the volume recovery of quarter sawn and flat sawn type was higher in round logs, at 51.71 to 62.84% as. Quarter sawn but it seems to be more promising in round logs where 50.45 to 57.89% can be derived. Similarly, the recovery of pure Flat Sawn was greater in round logs 52.83% than irregular logs. Base on Phanpadith and Pongki (2014) studied that the square log was ripping flat saw to get yield 57.73%. Local chainsaw milling and stationary bench sawmilling (log squaring) are expected to increase their share to nearly 50% Mohns and Richard (2010). This research flat sawn techniques are promising with How *et al*. (2009) because this techniques log recovery was above 60% but this study was lower recovery rate in quarter sawn because How *et al.* (2009) was separated between round log and irregular log the yield was more 50%. Young plantation teak was small log dimension in top log the yield sawn was less 40% of average. According to Mohns and Richard, (2010), Phanpadith and Pongki (2014) which both studied were above 50% as well as this study was 52.33%.

At establishment, the ANOVA revealed that three wood machineries presented significant different ($p < 0.05$) in log recovery, volume of lumber and times. However, the circular saw average recovery was 53.56%, SD was 19.80, and SE was 3.61. The vertical band saw average recovery was 48.46%, SD was 19.38 and SE was 3.53. And the horizontal band saw average recovery was 54.18%, SD was 16.01 and SE was 2.92. The circular saw average lumber volume was 0.0285 m^3 / log, SD was 0.014, and SE was 0.002. The vertical band saw average lumber volume was 0.0251 m^3 / log, SD was 0.013 and SE was 0.02. And the horizontal band saw average lumber volume was 0.0266 m^3 / log, SD was 0.012, and SE was 0.002.

Time recording in circular saw average time spent was 4.47 min / log, SD was 1.44 and SE was 0.26. Vertical band saw average time was 15.26, SD was 3.32 and SE was 0.60. And horizontal band saw average time was 9.25 min / log, SD was 1.64 and SE 0.30. Which compared between three wood machines to establishment time for sawn teak logs each circular saw compared with vertical band saw mean different was 10.48 min, SE was 0.59 and sig was high significant. In addition, circular saw compared with horizontal band saw differ average time was 3.46, SE was 0.59 and sig high significant.

5. Conclusion

In log recovery in the table 1, plain sawing pattern showed the highest values among three sawing patterns, while the lowest values were found in quarter sawing pattern. The lumber recovery in plain sawing pattern was, 68.21% in vertical band saw, 68.20% in horizontal band saw, and 65.65.48% in circular saw. When squared lumber from log was sawn into lumber, log recovery was the second level (56.29%) in horizontal band saw, 55.56% in circular saw, and 40.07% in vertical band saw. Finally, the quarter sawing pattern showed lower values of log recovery: 38.87% in the horizontal band saw, 36.35% in the circular saw, and 33.00% in the vertical band saw.

At establishment, ANOVA test showed a high significant different ($p < 0.05$) between three techniques log recovery, the short time sawing pattern in the circular saw and high significant. This paper has some recommendation for processors such as Plain sawn techniques highest yield of sawing pattern, it can be able apply to sawmill or processors practicing and Appropriate wood machinery

horizontal band saw wood-mizer LT70 is good for the companies to use in the sawmilling.

6. Conflict of Interest

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

7. Acknowledgments

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Table 1. Varian able of techniques sawing

Items	**Techniques**		
	Square log	**Plain sawn**	**Quarter sawn**
Log Recovery	**	**	**
Volume of lumber	**	**	**
Time	NS	NS	NS

Table 2. Variables of wood machineries

Items	**Wood Machineries**		
	Circular saw	**Vertical band saw**	**Horizontal band saw**
Log Recovery	NS	NS	NS
Volume of lumber	NS	NS	NS
Times	**	**	**