

NOVEL SAWING METHOD FOR SMALL-DIAMETER LOG

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ABSTRACT

The commercial feasibility of sawmilling mainly depends on the expected production yield. At the same time, the choice of sawing method is one of primary factors affecting yield. Therefore, choosing a reasonable sawing method is also necessary in small-diameter logs sawing process. In this study, a novel sawing method was proposed, and a comparison was made between the volume yield for the most common sawing method in China, and the yield produced by a novel sawing method. This study shows that hexagon sawing give higher yield than the other sawing methods. The mean yield for the whole diameter range is: 82.7 % for hexagon sawing, 53.3 % for live sawing, 56.7 % for hexagon sawing, 63.2 % for hexagon sawing.

KEYWORDS: Small-diameter log, sawing method, volume yield.

INTRODUCTION

Chinese fir and *Pinus massoniana* Lamb. are wide spread in China. The result of the national forest resources inventory for the seventh time indicated that the area of Chinese fir and *Pinus massoniana* Lamb. forests is vast. The proportion of these two species area from the national forest area was 47.59 %. Among the area of these two species, the proportion of thinnings was 60~70 % (Information on <http>). Because of the natural forest resources drop sharply, the imbalance of wood supply and demand are serious. In 2011, the aggregate consumption of wooden products is about

5 hundredmillion m³ in China, which including nearly 2.238 hundredmillion m³ imported timber and wooden forest products (State Forest Administration 2010). So, a solution to this imbalance of supply and demand is to use these thinning efficiently and economically.

In China, the thinnings which diameter under 16 cm are called small-diameter logs. Currently, small-diameter logs are generally used to manufacture wood-based panel, scrimber, glulam and so on. When we produce these products, small diameter logs will be cut into chip, panel, lumber and so on. Utilization ratio and volume yield are two major factors which should be taken into account in small-diameter logs cutting process.

Volume yield in sawmilling is determined by a confusing interaction of several variables, such as kerf width, allowable widths, thickness and length, edging routines, and trimming routines, sawing method and so on. Among them, sawing method is an important determinant of volume yield in the sawmill. Sawing method is the pattern used to break down the log into lumber. In order to improve the volume yield, the researchers tried some different sawing methods. At the present, the sawing methods which appropriate for small-diameter logs are live sawing, triangle sawing, trapezoidal sawing etc. (Wu and Ding 1994). How to improve the volume yield is an important subject to researchers from all over the world.

Hallock et al. (1987) compared the volume yield of eight different sawing methods. They found that the live sawing method gave markedly lower yields than the cant sawing methods. The cant sawing methods that gave the highest yield varied and depended on the diameter of the log, log length, and taper.

Gronlund (1989) carried out a similar investigation adapted to European conditions, regarding allowable thickness, width, and length of the sawn timber, and timber dimension. His results were similar to those in Hillock's study.

The methods investigated by Hallock et al. (1987) and Gronlund (1989) are relatively traditional methods that are commonly used in industry today. The low work efficiency and volume yield may be the main troubles for these existing sawing methods. Therefore, improvement of work efficiency and reduction of production costs by introducing a novel sawing method has been the main concern of Chinese sawmills. This study compared the volume yield of different sawing methods, and a bran-new sawing method with higher volume yield of major product was also proposed.

MATERIAL AND METHODS

The study examined the following four sawing methods: 1) live sawing; 2) triangle sawing; 3) trapezoidal sawing; 4) hexagon sawing.

Live sawing is illustrated in Fig. 1a. The method is the most common sawing method in China. The sawn timber was cut into board.

Triangle sawing is illustrated in Fig. 1b. The method is often used in small-diameter log sawing. In the sawing processing, the logs will be rotary-cut into cylinder firstly. After sawing, the triangular sawn timber is used to manufacture laminated wood.

Trapezoidal sawing is illustrated in Fig. 1c. The method gives a relatively high volume yield. It is one of sawing methods for laminated wood. In the trapezoidal sawing, the logs will also be rotary-cut into cylinder firstly.

Hexagon sawing is illustrated in Fig. 1d. It is a fairly new sawing method. This method in its most advanced form is not yet in industrial use.

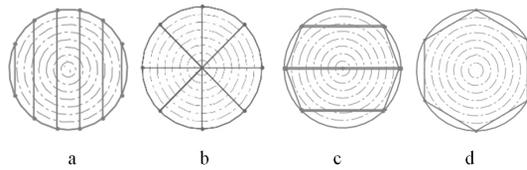


Fig. 1: Four kinds of sawing patterns.

The result of volume yield

In this study, Yield was calculated as the relation between the lumber volume and the truncated cone volume of the log. The kerf width was assumed to be 3 mm. Three kinds of top diameter were chosen to calculate yield, respectively 80, 100, 120 mm. In live sawing, when we calculated the volume of major product, we assumed the board with common thickness of 21 mm. The volumes of logs were calculated as Chinese national standards (GB-4814-84 2013). The yield for the various methods is shown in Tab. 1.

In the Tab. 1, it is easy to find that the hexagon sawing give higher yield than the other sawing methods. The mean yield for the whole diameter range is: 82.7 for hexagon sawing, 53.3 for live sawing, 56.7 for hexagon sawing, 63.2 % for hexagon sawing.

Tab. 1: Volume yield for different diameter logs.

Sawing method	Top diameter d (m)	Volume of the log V (m ³)	Volume of major product V (m ³)	Volume yield (%)	Mean yield (%)
Live sawing	80	0.021	0.011	52.4	53.3
	100	0.031	0.017	54.8	
	120	0.043	0.023	52.7	
Triangle sawing	80	0.021	0.011	52.4	56.7
	100	0.031	0.017	54.8	
	120	0.043	0.027	62.8	
Trapezoidal sawing	80	-	-	-	63.2
	100	0.031	0.019	61.3	
	120	0.043	0.028	65.0	
Hexagon sawing	80	0.021	0.017	82.7	82.7
	100	0.031	0.026	82.7	
	120	0.043	0.036	82.7	

The technology of hexagon sawing

The logs were sawn into six-sided cylinder using hexagon sawing method. Producing the six-sided cylinder, there are maybe some different methods. In this study, the method which we used was consisted of sawing and milling. After bilateral trimming and four-sides cutting, the blank of six-sided cylinder was got. At the last, these blanks were cut by a milling machine. High precision, automation and low energy consumption may be the three advantages for this sawing method. This sawing method includes these following processes.

Cross-cutting

Not all logs arriving at saw mills are straight. In fact very few are “straight” as in the true mathematical sense of the wood. Most logs demonstrate a gradual diminution of diameter, known as taper, and may also be bent or curved. This curvature or sweep is known to cause yield losses. Documentation of yield losses, via sawing studies, has been recorded by Dobie (1964) Brown and Miller (1975) Dobie and Middleton (1980) and Cown et al. (1980). Further to their sawing study, Dobie and Middleton (1980) derived the general rule of thumb that for each 0.1 increase in the ratio of sweep to small end diameter, a reduction in yield of about 7 % can be expected when compared to “straight” logs. A slightly lesser figure of 5 % was derived by Cown et al. (1980), Drake and Johansson (1987), Brakeenhielm et al. (1969), Dobie (1964), Brown and Miller (1975), Dobie and Middleton (1980). In all aforementioned studies, conventional sawing equipment that breaks the log down using a series of straight saw cuts was used. It is the combination of straight sawing and irregularly shaped logs that often cumulates in substantial yield reduction.

Considering the taper and curvature, logs should be cut off at the beginning of this saw processing. The decision as to which log should be cut off has traditionally been made by log makers based on their knowledge of the requirements and values of the different log types, visual assessment of the tree stem and experience. In this paper, small-diameter logs were cut off automatically. Logs were scanned by a scanner. After scanning, three-dimensional image of logs was got. These three-dimensional images were analyzed by the computer. Whether the logs should be cross-cut is determined by the result of analysis. After the cross-cutting, the logs would be suitable for the next process.

Bilateral trimming

Fig. 2 illustrates the diagram of the bilateral trimming. The aim of trimming process is to get two planes which would be used as datum in the next process. In order to guarantee the shape of sawn product as a six-sided cylinder, these two planes should be symmetric with the log central plane. So, the automatically centering is necessary before trimming. After centering, logs will be immovable relative to feeding device, and fed by chain board. In this feeding device, the chain board moves along the guide rail. High straightness and stability are the superiority for this feeding device.

For the bilateral trimming, a bilateral trimming saw was designed in this study. This saw is consisted of centering device, cutting device, framework, etc. The cutting device is consisted of two circular saws. In order to fit the logs with different diameters, these two circular saws move freely in the horizontal and vertical direction. The working accuracy and efficiency can fit the logs trim processing.

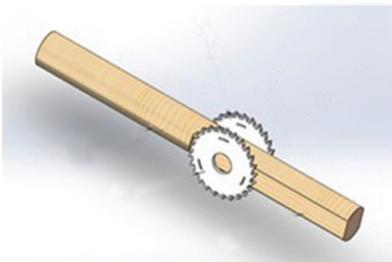


Fig. 2: Diagram of bilateral trimming saw.

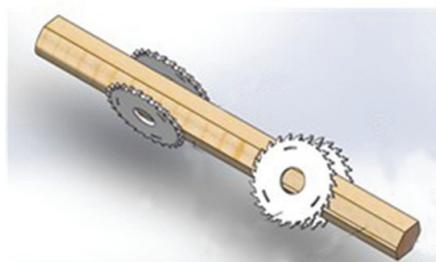


Fig. 3: Diagram of four-sides sawing.

Four-sides cutting

Fig. 3 illustrates the diagram of the four-sides cutting. After trimming, the logs are rotated 90° in order to feed smoothly. Similarly, logs automatically centering will also be done before four-sides cutting. In this cut processing, there are four circular saws. In addition, the included angle of each saw with horizontal plane is 60° . So, the six-sided cylinder was produced by bilateral trimming and four-sides cutting. The accuracy of centering and include angle are two major factors which effect the shape of six-sided cylinder.

In order to meet the four-sides cut processing requirements, a specialized saw was designed which used in this processing. The structure of this saw is similar to bilateral trimming saw, also consisted of centering device, cutting device, framework, etc. The cutting device is consisted of four circular saws. Every saw is slant, and the dip angle is 60° .

Shape processing

After sawing, a six-sided cylinder blank was got. These semi-finished products are not suitable for gluing because of their high surface roughness and low dimensional accuracy. Shape processing is necessary before gluing. In this processing, a dedicated milling machine is used to cut the six-sides cylinder. The cutting device of this milling machine is consist of four knife shafts, include two vertical knife shafts and two horizontal knife shafts. Each of the vertical knife shafts have a milling cutter which shape like "V". At the same time, each of the horizontal knife shafts have a flat cutter. So the six sides can be cut at one time. Fig. 4 illustrates the diagram of the shape processing.

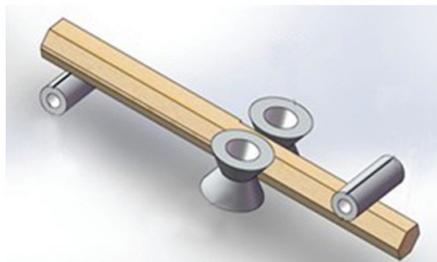


Fig. 4: Diagram of the shape processing.

RESULTS AND DISCUSSION

The calculated yield shows that hexagon sawing give higher volume yield than the other sawing methods. When sawing small-diameter logs (under 160 mm), the hexagon sawing gives about 20 % more lumber than the other sawing methods. For the volume yield, the hexagon sawing is more suitable to small-diameter logs sawing.

The benefit of hexagon sawing is not only the higher volume yield but also the higher product additional value and automation. The sawn lumber produced by hexagon sawing can be used to manufacture a new kind of laminated wood (Fig. 5). This kind of laminated wood can be applied in many occasions, such as used as beam or column in wood structure, sliced into sheet to be used as core veneer for multi-layer wood flooring, etc. At present, small-diameter logs are often used to make MDF, laminated wood board, etc. Because of these applications with low addition value, the novel sawing method was proposed. This laminated wood would replace larger-diameter logs in some occasions with some necessary modifications. So, the application fields of



Fig. 5: Laminated wood.

small-diameter logs will be broadened by this study. It is good for the improvement of use ratio and additional value for small-diameter logs. To some extent, reasonable using of small-diameter logs can resolve the contradictions of imbalanced supply and demand in timber market.

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