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Polygon Sawing: An Optimum Sawing Pattern for Oil Palm Stems

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Abstract: The shortage in wood supply makes the effort to find alternative for wood material become more and more important. It was reported that the outer parts of oil palm stems could be used as solid wood after being properly treated. Being a monocotyledon, oil palm stems have a contradictory characteristic to the conventional hardwoods and softwoods and thus the sawing patterns suitable for hardwoods and softwoods should not be suitable for the oil palm stems. Two modified sawing patterns (polygon sawing and cobweb sawing) plus one ordinary sawing pattern (life sawing) were compared in the sawing of oil palm stems. The purpose of this study was to find the most suitable sawing pattern for oil palm stems. The cobweb sawing provided the highest outer lumber recovery (35%) followed by polygon sawing (27%) and life sawing (23%). The polygon sawing provided the highest occurrence of wide lumbers, followed by the cobweb sawing and life sawing. The cobweb sawing need more than twice effective sawing time (15.4 min) than the life sawing and polygon sawing. In overall, the polygon sawing was the most suitable pattern for the sawing of oil palm stem.

Key words: Oil palm wood, life sawing, polygon sawing, cobweb sawing, the outer lumber

INTRODUCTION

The shortage of wood supply is the main issue faced by almost wood manufacturers all over the world. The supplies of wood material have left far behind the demand of it, resulted in a heavy supply-demand gap. This gap has become more serious due to the aggressive depletion of forest that lead to a reduced wood supply. In contrary, the fast population growth has resulted in an increased of wood demand.

Wood as raw material is classified into solid wood and composites wood. Among these two categories, the supply problem of solid wood is more severe than the composites wood. Many efforts have been made to reduce the utilization of solid woods by substituting their applications with the composites wood such as plywood, LVL (Laminated Veneer Lumber), PSL (Parallel Strand Lumber), particleboard, OSB (Oriented Strand Board) and MDF (Medium Density Fiberboard). Certain properties of solid wood, however, can not be contested by the composites wood. This is a reason why the demands on solid woods have never been decreased even with their skyrocketing prices. At the same time, many users perceived that possessing a product from the solid wood is worthier than that from composites wood. They also

consider that solid wood products are more reliable and stronger than those of composites wood. This is another reason why the solid wood is always under a strong demand. Under this circumstance, any efforts must be done to find new alternative materials for solid wood, either wood material from the traditional forest or other lignocellulosic material such as agriculture wastes from outside of the forest.

One of the agriculture wastes that can be used as an alternative material for solid wood is oil palm stems. There are about 3.8 million ha planted oil palm (*Elaeis guineensis*, Jacq.) in Malaysia and about 3.4 million ha in Indonesia (MPOB, 2004; Bakar *et al.*, 2005a) that lead the two countries become the largest and the second largest palm oil producing countries in the world. Among the three types of oil palm residues (stems, fronds and empty fruit bunches), the oil palm stems offer the best properties comparable to those of wood. Tens of million cubic meters of oil palm stems are resulted annually from the replanting of the old oil palm trees. It was reported that oil palm wood from the outer parts of matured oil palm stems (25-year old or older) have quite good properties. These parts of the stem could be used as solid wood after being properly treated (Bakar *et al.*, 2005b).

Being a monocotyledon, oil palm stem has no heartwood and sapwood zoning and the properties of wood taken from the outer part of stem are superior to those from the center core (Bakar *et al.*, 1998). This is contradictory to the hardwoods and softwoods, where better wood portions occur at the center core, the heartwood.

To produce solid woods, logs are converted into sawn timbers through a sawing process. There are three main sawing patterns so far widely used to saw logs, i.e., life or plain sawing, round sawing and quartered or rift sawing. These sawing patterns have been actually intended for hardwood and softwood logs, where heartwood occurred at the core and sapwood at the periphery of the logs. In many cases, the properties of sawn timber from the heartwood zone are better than those from the sapwood (Bowyer *et al.*, 2005; Desch and Dinwoodie, 1996). Sawn timbers taken from heartwood are preferable than those from sapwood. Thus, the three sawing patterns were developed by taking in consideration the heartwood factor and the sawing was intended to produce the heartwood lumber as the priority. On the other hand, the sawing pattern for oil palm stems should be intended to produce the outer lumber, i.e., the wood from the outer part of the stems. Hence, the suitable sawing pattern for the oil palm stems should be re-designed and examined.

The purpose of this study was to develop a new sawing pattern suitable for oil palm stem. For this purposes, two sawing patterns were introduced and these two sawing patterns along with one ordinary sawing pattern were compared. The objective was to find the most suitable sawing patterns that can yield more and quality outer lumber efficiently.

MATERIALS AND METHODS

Materials: Numbers of oil palm trees were felled and the stems were cut short to 2.5 m long logs. All of the trees were taken from replanting age (25 year old) oil palm plantation at south region of Sumatra Island, Indonesia. To maintain the consistency of the diameter and morphology of the logs, 1.0 m long tapered butt was cut out from each of the stem and only the next three logs were taken as the sawing test material. The diameters of logs were within the range of 43-55 cm (Fig. 1).

Method: Since only the outer part (one-third of the stem radius) of oil palm stem could be used as solid wood (Bakar *et al.*, 1998, 2005b), then two modified sawing patterns were introduced in this study. The two patterns, called polygon sawing and cobweb sawing, were designed to replace the ordinary round sawing and quartered sawing so that a maximum recovery (yield) of the outer lumber could be resulted. These two patterns plus one ordinary sawing pattern (life sawing) were evaluated in sawing of oil palm stems. The overall sawing patterns are shown in Fig. 2.

A 36 inch, band-type headrig saw equipped with an automatic carriage was used to breakdown the oil palm logs. Then, resulted cants were re-sawn into lumbers of predetermined thick (4.0 mm) and maximum width with a 25 inch bandsaw. The two saws were equipped with new tipped saw blades and operated by three skilled operators. The resulting lumbers from each log were categorized into the outer-, the middle- and the center lumbers based on the color on their ends: blue for outer lumber, red for middle lumber and white for center lumber. A lumber which contained two colors on its end, where one of the



Fig. 1: Logs of matured oil palm stem used for experiment material. Note: The end of logs were colored differently, representing one-third of log's radius, to help in identifying the original positions of the resulting lumbers had been cut from

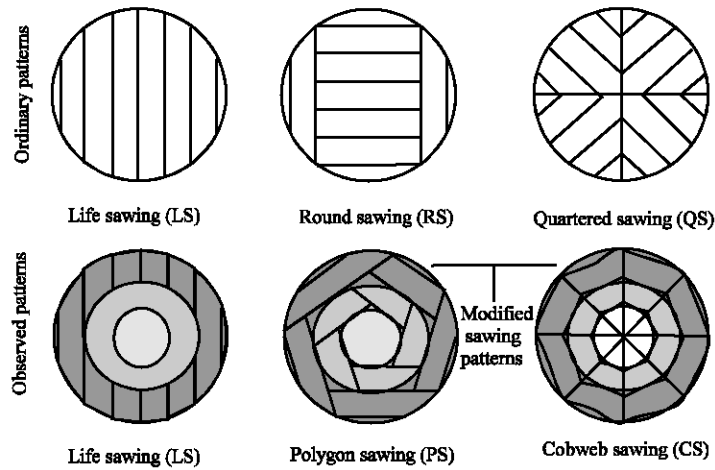


Fig. 2: Comparison of ordinary sawing patterns and observed sawing patterns

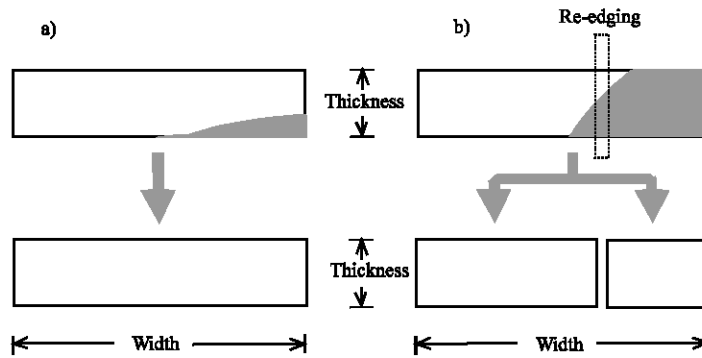


Fig. 3: Classification of the outer-, the middle- and the center lumbers based on the color on their ends. A lumber is classified into which the color is dominant (a). A lumber with crossing color is divided into two narrow strips before classification (b)

colors was only a small fraction that was not crossing the whole lumber thickness was classified into the dominant color (Fig. 3a). While, a lumber which contained two or more colors on it end, where the border of the colors was crossing the whole lumber thickness was re-edged into two or more narrow lumbers (Fig. 3b).

Three sawing parameters were measured from each of the sawing patterns, i.e., lumber recovery, sawing time and lumber quality. Lumber recovery was broken down into the outer-lumber recovery (R_o), the middle-lumber recovery (R_m) and the center-lumber recovery (R_c). The total sawing time (T_t) was broken down into the effective sawing time (T_e), i.e., the time during which the saw was working to cut the log or cant and the ineffective sawing time (T_i), i.e., the time during which the saw was in idle to wait the adjustment of log or cant on the carriage. The quality of each piece of lumber was judged by its width, where a wider lumber was considered of higher quality

than a narrow one. Based on Bakar *et al.* (2005c), the lumber widths were grouped into 5 classes: ≤ 5 , 6-10, 11-15, 16-20, >20 cm.

RESULTS AND DISCUSSION

Lumber recovery: Recovery, a volume ratio of output (resulting lumbers) and input (log), is an important indicator to evaluate the efficiency of a sawing process. A high recovery is the objective in all sawing operations. High recovery alone, however, is not enough for the sawing of material such as oil palm stem, since the quality of the oil palm lumbers (as indicated by their density) are highly varied across the radial direction (Bakar *et al.*, 1998). That was the reason why the resulting oil palm lumbers were classified into the outer-, the middle- and the center lumbers and the total recovery (R_T) was divided into the outer-lumber recovery (R_o), the middle-lumber recovery (R_m) and the center-lumber recovery (R_c).

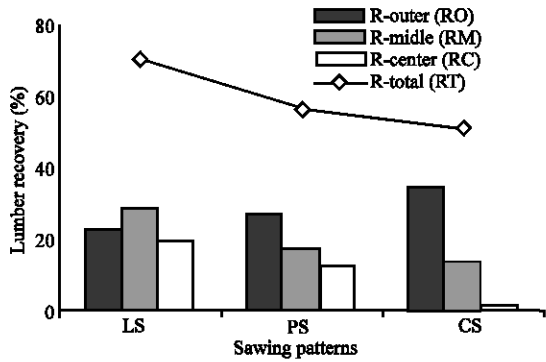


Fig. 4: Relationships between the sawing patterns and the recovery of oil palm lumber

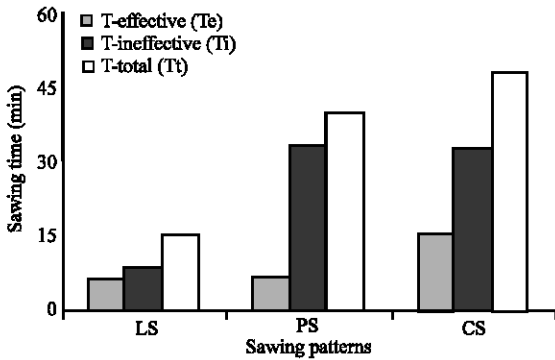


Fig. 5: Relationships between the sawing patterns and the sawing time

Relationships between the sawing patterns and the sawing recovery of each part of the lumber are shown in Fig. 4. These relationships suggest that the sawing recovery of oil palm stems are highly affected by the sawing patterns and a high total recovery R_T is not followed by a high the outer-lumber recovery R_O . Even the life sawing LS resulted in the highest total recovery R_T (70%), but the outer-lumber recovery R_O of this pattern was the lowest (23%) and two-thirds of the resulted lumbers were the middle- and center-lumbers that were low in quality. Contrarily, the cobweb sawing CS that produced the lowest total-lumber recovery R_T (50%) was the highest in the outer-lumber recovery R_O (35%) and almost two-thirds of the resulted lumbers by this pattern were the outer lumber.

For the sawing of ordinary hardwood and softwood logs that have no high radial density gradient, the life sawing LS is the most efficient and commonly used sawing pattern. But this is not the case for the sawing of oil palm stem. Oil palm stems have very high density

gradient from the center to the outer of the stem and only the outer-lumber that can be used as solid lumber (Bakar *et al.*, 1998). This means that oil palm stem must be sawn with a sawing pattern where all resulted lumbers are pure tangential. Otherwise, the resulted lumbers have to be re-edged into two or more narrow strips as shown in Fig. 3. All the lumbers resulted by polygon sawing PS and cobweb sawing CS are pure tangential, while only two piece pure tangential lumbers can be resulted in life sawing LS. Since the outer-lumber recovery R_O of the cobweb sawing CS were double as compared to the polygon sawing PS, then it can be suggested that the cobweb sawing CS are the most suitable pattern for the sawing of oil palm stems in term of single parameter of the lumber recovery.

The values of total recovery R_T in this study were relatively higher than the average recovery in ordinary (softwood and hardwood) sawing processes which are normally less than 60%. This was because many narrow strips of less than 10 cm widths were taken into account of recovery calculation. When those lumbers were excluded from calculation and only those of more than 10 cm were considered, the total recovery would become 48, 45 and 32% for the life sawing, polygon sawing and cobweb sawing, respectively.

Sawing time: The total sawing time is the function of the sawing cost. Having the shortest sawing time, therefore, become the objective in all sawing operations. Relationships between the sawing patterns and the sawing time for each log were plotted in Fig. 5.

Data on Fig. 5 suggest that the life sawing LS consumed the shortest time while the cobweb sawing CS was the longest in term of either the total sawing time T_t or the effective sawing time T_e . While the polygon sawing PS consumed about the same effective sawing time (6.7 min) to the life sawing LS and about the same total time (46.0 min) to the cobweb sawing CS. It also found that the cobweb sawing CS consumed as twice as longer effective time than the life sawing LS and polygon sawing PS. This was because the life sawing LS had a longer cutting line than the others and each resulting cants must be re-sawn piece by piece.

It is interesting to note that both polygon sawing PS and cobweb sawing CS spent plenty of ineffective time (T_i). The ineffective time of the polygon sawing PS (39.3 min) and cobweb sawing CS (32.5 min) was respectively about 4.5 times and 3.5 times longer than that of the life sawing LS. Most of these times are actually spent for adjusting log or cant on the carriage. Even during this period the saw is actually in idle, but the machines are normally kept running which results in an

Table 1: The advantages and disadvantages of the observed sawing patterns

Sawing pattern	Advantage(s)	Disadvantage(s)
Life sawing LS	Short effective and ineffective sawing time (Te, Ti)	Narrow outer lumber Low outer lumber recovery R_o
Polygon sawing PS	Wide outer lumber	Long ineffective sawing time T_i
Cobweb sawing CS	High outer-lumber recovery R_o	Long effective and ineffective sawing time (Te, Ti) Narrow outer lumber

increasing the operating cost. From this point of view it can then be suggested that the life sawing LS is the most suitable pattern for the sawing of oil palm stems in term of sawing time parameter.

Lumber quality or the outer lumber width: Since the main objective in oil palm sawing was to produce the outer lumbers, then only the quality of the outer lumbers were observed. Differ from conventional hardwoods and softwoods, the outer lumbers of oil palm wood does not contain defects such as knots, sapwood and splits and the qualities of the outer lumbers are more determined by their width. Indeed, the width of the outer lumbers will determine the potential use of the lumbers, where the wider the lumbers broader the potential will be range of use will be and the easier the lumbers to be used. It becomes logical to consider that wider lumbers are higher in quality than narrow ones.

Relationships between the sawing patterns and the outer lumber width were shown in Fig. 6. Being classified into five categories of width, the relationships suggested that each sawing pattern produced different width composition of the outer lumber. The life sawing LS and cobweb sawing CS tend to produce narrow strips which are low in quality, while the polygon sawing PS tend to produce wider lumbers which are high in quality. This is contradictory to ordinary softwood and hardwood logs sawing, where life sawing LS is normally characterized with wide lumber. As mentioned early, for oil palm lumber, other than pure tangential lumbers must be re-edged into narrow strips to separate the outer-lumber from the middle- and the center-lumber.

Based on the piece count, 77 and 88% of the outer lumbers resulted in the life sawing LS and cobweb sawing CS respectively were the narrow strips having the width of less than 10 cm. At the same time, the similar strips were amount to only 47% in the polygon sawing PS. In addition, there was no a single piece of lumber was resulted by the cobweb swing CS having the width of more than 15 cm. In contrast, three of the widest lumbers (20 cm up) and two of the second widest lumbers (16-20 cm) were resulted by the polygon sawing PS. From these, it can be suggested that the polygon sawing PS is the most suitable pattern for the sawing of oil palm stems in term of the outer-lumber width parameter.

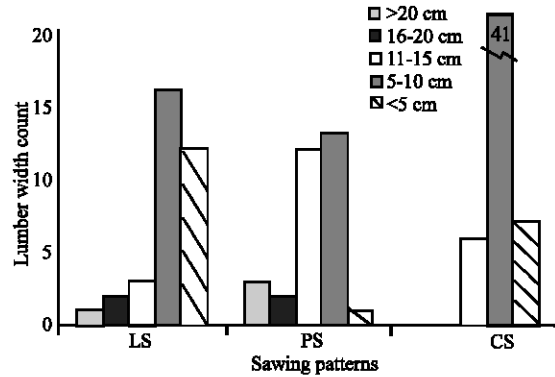


Fig. 6: Relationships between the sawing patterns and the lumber width count

The optimum sawing pattern: The previous discussions revealed that each sawing pattern has its own advantages and disadvantages. The main advantageous and disadvantageous of each sawing pattern are summarized in Table 1. Recall to the objective, the selected sawing pattern should produce a high outer-lumber recovery R_o with a wide lumber width and a short sawing process. High recovery alone is not enough if the lumbers are too narrow and the sawing times are too long as the case in the cobweb sawing CS. Similarly, short sawing times alone are also not efficient if the resulted lumbers are too narrow and low in recovery as the case in the life sawing LS. Table 1 shows that the advantageous of the life sawing LS (short sawing time) and the cobweb sawing CS (high the outer-lumber recovery) are overridden by their disadvantageous (narrow lumber width).

It is interesting to look at the polygon sawing PS which is favorable with wide lumber width and unfavorable with plenty of ineffective sawing time (T_i). This ineffective time is actually spent for adjusting the position of log on the carriage during which the saw is in idle but still in running. The ineffective time, however, are subject to reduce, especially when the operators have been trained and accustomed to the employed sawing pattern. Even the effective time may not be reduced, the total sawing time can be minimized by reducing the ineffective time. It can then be suggested that the polygon sawing PS is the most suitable pattern for the oil palm stems. The polygon sawing PS can yield quality outer-lumber of wider width with a recovery of about 27% under a relatively short effective sawing time.

The polygon sawing PS is a new sawing pattern that needs recurring log adjustments on the carriage. Therefore, skilled operators and good carriage are required to run this pattern efficiently. Otherwise the ineffective time will become longer and wedged or tapered lumber may occur. Finding this sawing pattern, however, will be very beneficial, especially to Malaysia and Indonesia, that have tens of million cubic meters of oil palm stems to be sawn annually (Bakar *et al.*, 2005c).

General characteristic of the polygon sawing is that all resulted lumbers are pure tangential lumber. Therefore, it can also be applied to other monocotyledon species such as coconut palm stem that also need to be sawn as pure tangential lumber. It may also be applied to saw decorative hardwood log when pure tangential lumber is to be produced. The diameter of log or stem, however, must be considered as it has interrelationship to the number of polygon's angles. We have no data yet about the relationship between the stem diameters to the number of polygon's angle. But, as a rule of thumb, a polygon with more angles can be used for a larger stem and that with fewer angles may be used for a smaller one. As indicated in this study, the five-angle polygon (pentagon) are appropriate for the stem with a diameter of about 50 cm. The six-angle polygon (hexagon) seems to be fit for a larger diameter stem. The four-angle polygon (square) seems to be suit for coconut oil stems that normally have smaller diameter. This is actually also known as round sawing.

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