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Study of Veneer Yield and Amount of Waste in Veneer Stripping with Spindle-less Type Rotary Lathe Machine

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***Abstract*—** In general, the log-block peeling yield on a rotary lathe machine ranges from 70 - 80% of the log volume in the form of veneer, and the remaining 20-30% is waste. This variation depends on the quality and type (species) of the log of the raw material. The veneer peeling usually consist of the face and back veneer (continuous veneer) ranging from 50% to 70% and core veneer as poly piece veneer ranging from 20 to 30%. Under certain conditions, the waste can reach up to 50% including losses due to rounding, shrinkage of the veneer, cracks, spurs, and pith (log-core). From the description above and several other observations, the research was carried out regarding this matter. There is a way to reduce the amount of waste in log peeling using rotary machines and at the same time increasing the recovery peeling. Thus, it will reduce production costs and increase profits for the company. One of the contributors to a large amount of veneer peeling waste is the use of rotary lathe veneer peeling machines with large spindles which are still widely used in veneer and plywood factories (plymill), especially in Indonesia. So far, on average half of raw logs turn into waste, and 25 percent is contributed by a rotary lathe machine. Meanwhile, on the other hand, the need for plywood products will continue to increase day by day. This is because plywood is one of the most environmentally friendly building materials and comes from renewable natural resources. Along with the development of the plywood industry, the increase of raw material needs is inevitable. So, waste products will also continue to increase too. In this regard, there must be fundamental changes in this industry, including the use of rotary lathe without spindles as the substitute from the conventional machine. In relevance to this situation, this research was directed with the aim of knowing the yield and amount of veneer peeled by a spindle-less rotary lathe machine and at the same time to find out the waste it produces. So, this information can later become a consideration for stakeholders to replace the old rotary lathe with a type spindle-less without a doubt. The results show that veneer peeling using a spindle-less rotary lathe machine increases the yield of the veneer and reduce the amount of waste. Most of the peeling results are in the form of a veneer consisting of 58.83% continuous/endless veneer for the face/back, and 22.83% of poly piece core (odd veneer) from the core veneer. The total veneer yield is 81.67%. The remaining were 1.32%, 0.93%, and 16.08% for log-core waste, cut edge finish, and round-up veneer, respectively. The spindle-less rotary lathe machine has provided increased yields and significantly reduced the amount of waste.

Keywords— Waste, rotary lathe, spindle-less, veneer

I. INTRODUCTION

Plywood is a building material product that is considered the most environmentally friendly and comes from renewable natural resources. Therefore, the plywood industry must be encouraged to make positive changes such; switches the raw materials from natural forest wood to plantation forest wood, especially Sengon Wood, changes from large-scale industry to small and medium-scale industry, changes in production machines from large rotary spindles (conventional rotary lathe) to the rotary lathe without a spindle (spindle-less). The last one is the most important factor because it promises a higher yield and a better quality of veneer. So, this paper aims to provide an overview of how much the most modern rotary lathe contributes to its side waste products in the form of a continuous veneer and a poly piece veneer core. Wood commonly used as raw material for plywood in Asia is mainly from the *Dipterocarpaceae* family. Although this wood occurs in mixed forests, half of them are dipterocarp type and are only distinguished by strength, straightness, and knuckle-freeness of the trunk, like Red Meranti, White Lauan, and Mersawa, to name a few examples. Other types are Jelutung and Ramin wood (Kollmann and Cote, 2012).

Logs for veneer production must have straight fibers. However, this condition can be tolerated as long as it is still by the quality requirements because the logs used as veneer raw materials are expensive, so they are not easy to obtain. Another requirement is that the logs must be round or cylindrical. In other research, it is also stated that to make a log veneer or plywood must be large in diameter, round, defect-free, and has moderate weight. Red Meranti, White Meranti, Nyatoh, Ramin, Agathis, Benuang are some examples (Dumanauw, 2003). The quality of round wood for the veneer is determined by the absence of knots or surface defects, straightness and cylindrical, and by the free ends of defects. The wooden Bontos is also a serious log problem for veneer making. The quality class is usually determined based on

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straightness, free from rot or softness in the middle, and free from wood streaks or other defects (Daoui et al., 2010). Furthermore, the quality of logs must be considered because it affects the quality and veneer produced and also reduces the number of logs that prove to be defective after being installed in a peeling machine. Defective logs or sawn logs can reduce the production speed of the pulping machine (Bowyer et al., 2007). More requirements that must be met by logs to be converted into veneer sheets, such as: available in large quantities, have a density between 0.35 - 0.8 g/cm^3, diameter more than 40 cm, straight and cylindrical stem, straight fibers, high mechanical properties, decorative texture, light color, and free of defects (such as knots, pinholes, broken ends or surfaces), also low price (Hrázský and Král, 2018).

There are two ways of veneer production. The first is the most widely used method for logs, which is peeled on a rotary-cutter machine. For the second way, the veneer is peeled from the prepared blocks that have a certain size using the circular peel (rotary-cutting) method on a rotary lathe machine. Meanwhile, the veneer from the wooden logs is produced by the slicing method, includes horizontal and vertical slicing. And the sawing method is used to obtain a thick veneer (Wood and Linn, 1950) . The veneer produced by rotary-peeling is the basis of the modern plywood industry. The Rotary-peeling method aims to produce endless veneers (Kollmann and Cote, 2012). Although not perfect, this veneer has a smooth surface. It is also explained that more than 90% of the veneer is peeled. But the veneer that is produced from figurative wood for furniture and for other decorative uses is obtained by cutting, while the sawn veneer is rarely produced because it produces a lot of waste.

II. REASEARCH METHODS

This research was conducted at PT Rimba Raya Lestari (PT RRL), a plywood (plymill) manufacturing plant, in Loa Kulu, Kutai Kartanegara Regency, East Kalimantan. The object of research is the log of the Meranti Merah species.

A. Veneer cutting/peeling procedure

After logs of length (10 - 17 m) were cut into certain sizes: 4 'and 8', the log-blocks were measured again by the length and diameter to calculate the input volume of raw materials. Then the blocks were taken to the log debarker machine to remove the skin and other objects attached to its surface. With the same roll conveyor, the blocks moved towards the log cleaning machine and were sprayed with high-pressure water to clean the debris that is still attached. In this case, no pretreatment such as log block steaming and boiling.

B. Log peeling

The blocks were placed on the deck of the conveyor chain for the log-block centering process and then brought to the rotary lathe. The hoist equipped with clamps performed this task until the blocks were taken over by two spindles. During the stripping process, the disc was pulled slowly so the block remains rotating against the rodent blade. So, they only clamped by the knife-holder and the nozzle wheels. The product was a continuous veneer. It was rolled up then temporarily placed on the decks of the reeling-unreeling veneer. At the same time, in the beginning, and the end of the stripping, odd-veneer (poly piece core), spur-knife waste was produced. The stripping process ends with leaving the pith (log-core).

C. Handling of veneer and other peeled products

The thickness of all peeled finishes was measured, both continuous veneer for face/back, core finish (poly piece core), and edge cut finish (spur knife waste). The radius (r, cm) was measured for the veneer on the reeling-unreeling decks to calculate the diameter (Bv, m), as well as the length (l cm). After the diameter of the winding bobbin was known (Bb, m) then the veneer volume (V cm3) was calculated. The pith (log core) was also measured in length (l) and its diameter (d) to calculate its volume, then it was directed to the stacking place through a channel under a rotary lathe equipped with a v-belt conveyor.

D. Measurements and calculations

Measurement of diameter, log-block volume, and veneer volume on rolls was calculated using equation (1) (Syafii, 2019).

$$D = \frac{1/2\left[\left(d_1 + d_2\right) + \left(d_3 + d_4\right)\right]}{2} \qquad (1)$$

where:
D = log-block diameter (cm)
d_1, d_2, d_3, d_4 = the diameter of the four measurements (cm)

The volume of log-blocks was calculated by equation (2):

$$V = \left(\tfrac{1}{4}\pi D^2\right) x\ l \qquad (2)$$

where:
V = volume (m^3)
l: length of log-blocks (m)
π = 3.14

The gross veneer volume in bobbin winding on the reeling-unreeling machine was calculated using equation (3).

$$V = \tfrac{1}{4}\pi\ (Bv^2 - Bb^2)\ x\ l \qquad (3)$$

where:
Bv = veneer winding diameter (m)
Bb = bobbin diameter (m)

Veneer recoveris (yield) were calculated by considering the volume obtained through the measurement of length, width and thichness of the veneer produced by each log (Khoo, et al., 2018).

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$$veneer\ recoveries = \frac{Volume\ of\ veneer\ from\ each\ log}{Volume\ of\ each\ log} \text{ x } 100\% \quad (4)$$

III. Results and Discussions

Preliminary observations included the diameter, length, and volume of the log-block raw materials fed to the rotary lathe machine. The log-block average diameter fed to the rotary lathe spindle-less from 30 observations of 30 log-blocks was 62.70 cm with an average volume of 0.82 m3.

Table 1. Result of Log-block peeling into veneer sheet using rotary spindle-less machine and its waste, in m^3

Bolt			Cubication results						
			Veneer			Waste			
Log-block diameter (cm)	Log-block volume (m^3)	Log-core diameter (cm)	Continuous veneer volume (m^3)	*poly piece core* volume (m^3)	Total (m^3)	*log-core* volume (m^3)	Edge cut (Spur-knife) volume (m^3)	Round-up Veneer	Total (m^3)
52.00	0.55	7.10	0.1989	0.1564	0.3553	0.01020	0.0040	0.1775	0.1917
53.00	0.57	7.10	0.2930	0.1677	0.4607	0.01026	0.0059	0.0947	0.1109
53.00	0.58	7.00	0.2671	0.1026	0.3697	0.01005	0.0074	0.1890	0.2065
55.00	0.61	6.90	0.1998	0.1564	0.3562	0.00968	0.0047	0.2442	0.2586
57.00	0.67	6.80	0.3398	0.1677	0.5074	0.00947	0.0067	0.1421	0.1583
57.00	0.66	7.00	0.2005	0.1026	0.3031	0.00999	0.0047	0.3448	0.3595
60.00	0.73	7.20	0.4021	0.1564	0.5585	0.01058	0.0087	0.1569	0.1762
62.00	0.78	6.90	0.4531	0.1677	0.6208	0.00972	0.0068	0.1473	0.1638
63.00	0.81	6.90	0.5633	0.1026	0.6659	0.00972	0.0068	0.1276	0.1442
67.00	0.91	7.00	0.4180	0.1930	0.6110	0.00998	0.0087	0.2848	0.3035
67.00	0.92	6.80	0.5074	0.2297	0.7371	0.00945	0.0091	0.1615	0.1801
60.00	0.73	7.20	0.3230	0.2231	0.5462	0.01057	0.0059	0.1715	0.1880
62.00	0.78	7.10	0.4018	0.1608	0.5626	0.01028	0.0069	0.2042	0.2213
74.70	1.14	7.00	0.7940	0.1160	0.9100	0.01000	0.0131	0.2059	0.2289
74.00	1.12	7.30	0.7490	0.1464	0.8954	0.01087	0.0111	0.1998	0.2218
63.00	0.81	7.00	0.4615	0.1564	0.6179	0.01002	0.0062	0.1778	0.1940
49.80	0.51	6.90	0.1362	0.1677	0.3039	0.00979	0.0042	0.1922	0.2062
54.50	0.61	7.30	0.2693	0.1026	0.3719	0.01095	0.0053	0.2223	0.2386
55.00	0.61	7.00	0.2405	0.1564	0.3969	0.00992	0.0034	0.2025	0.2158
59.00	0.71	7.10	0.2926	0.1677	0.4603	0.01025	0.0048	0.2324	0.2475
59.50	0.72	7.20	0.3948	0.1026	0.4974	0.01056	0.0053	0.2080	0.2238
62.00	0.79	7.00	0.3882	0.1910	0.5792	0.01001	0.0055	0.1908	0.2063
62.70	0.80	7.10	0.4121	0.1644	0.5765	0.01023	0.0046	0.2064	0.2212
63.00	0.81	7.20	0.2992	0.2674	0.5666	0.01058	0.0058	0.2271	0.2435
66.00	0.89	6.90	0.4105	0.2321	0.6427	0.00970	0.0076	0.2274	0.2447
68.00	0.94	7.10	0.4604	0.2479	0.7084	0.01029	0.0091	0.2160	0.2354
68.80	0.97	7.20	0.3086	0.4040	0.7126	0.01062	0.0108	0.2358	0.2572
74.00	1.12	7.00	0.5881	0.2778	0.8659	0.01004	0.0304	0.2156	0.2561
77.00	1.22	7.00	0.6316	0.3006	0.9322	0.01012	0.0129	0.2689	0.2919
82.00	1.38	7.10	0.9305	0.1890	1.1195	0.01031	0.0097	0.2355	0.2555
1881.0	24.5	211.4	12.335	5.4764	17.8114	0.30422	0.2362	6.1106	6.6510
62.70	0.82	7.05	0.4112	0.1825	0.5937	0.0101	0.0079	0.2037	0.2217

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From another research was stated that the result of veneer peeling on rotary lathe machines was 72.84% of the volume of logs and the remaining 27.16% was waste. The finish results for face and back (continuous veneer) varied from 51.88% (for yellow meranti) to 74.55% (for red meranti) (Schulte and Schöne, 1996). On previous research resulted that 58% of the peel results were endless veneer (complete finish), 27% odd veneer (non-intact finish for the core), 10% pith, and around 5% spur-knife waste (Syafii, 2001).

A round-up veneer is a veneer with an irregular shape, as a result of the log-block rounding process at the beginning of the stripping until the stripping produces a rolled-up veneer, added with untidy side cuts on the poly piece core. If the continuous veneer is cut in a wet state (green veneer clipping), which is usually found when drying the veneer's center-core, this process also contributes to quite a large

amount of round-up waste. So it is not difficult to understand why the waste in the form of the round-up veneer is high enough to reach an average of 16% in rotary lathe spindle-less machines, and 27.17% in conventional rotary lathe machines (Schulte and Schöne, 1996).

Table 2. The result in Percentage of log-block peeling into veneer on a spind-leless rotary lathe machine and its waste

Log-block volume (m^3)	Veneer			Waste			
	Continuous veneer volume (%)	poly piece core volume (%)	Total (%)	Log-core Volume (%)	Edge cut volume (%)	Round-up Veneer	Total (%)
0.55	44.17	28.59	72.76	1.864	0.727	24.64	27.24
0.57	60.02	29.33	89.36	1.795	1.031	7.82	10.64
0.58	54.56	17.81	72.36	1.744	1.289	24.60	27.64
0.61	38.89	25.44	64.33	1.574	0.766	33.33	35.67
0.67	59.98	25.19	85.17	1.423	1.011	12.40	14.83
0.66	36.34	15.48	51.83	1.508	0.704	45.96	48.17
0.73	63.16	21.29	84.44	1.440	1.185	12.93	15.56
0.78	72.58	21.37	93.95	1.239	0.867	3.94	6.05
0.81	80.81	12.66	93.47	1.200	0.840	4.49	6.53
0.91	52.23	21.10	73.33	1.092	0.956	24.62	26.67
0.92	60.66	25.04	85.70	1.030	0.997	12.27	14.30
0.73	53.31	30.39	83.71	1.440	0.805	14.05	16.29
0.78	59.00	20.51	79.51	1.311	0.881	18.30	20.49
1.14	77.98	10.18	88.17	0.878	1.149	9.81	11.83
1.12	71.89	13.10	84.99	0.973	0.995	13.04	15.01
0.81	65.32	19.26	84.58	1.235	0.768	13.41	15.42
0.51	44.72	32.87	77.59	1.920	0.820	19.67	22.41
0.61	59.37	16.81	76.18	1.794	0.873	21.16	23.82
0.61	54.56	25.53	80.09	1.620	0.558	17.74	19.91
0.71	55.00	23.69	78.69	1.448	0.679	19.18	21.31
0.72	67.55	14.23	81.77	1.464	0.729	16.03	18.23
0.79	62.02	24.31	86.33	1.275	0.695	11.70	13.67
0.80	63.59	20.61	84.20	1.282	0.580	13.94	15.80
0.81	48.74	33.01	81.75	1.306	0.711	16.23	18.25
0.89	57.38	26.16	83.54	1.093	0.858	14.51	16.46
0.94	60.90	26.27	87.16	1.090	0.966	10.78	12.84
0.97	41.43	41.66	83.09	1.095	1.117	14.70	16.91
1.12	61.52	24.76	86.28	0.895	2.711	10.12	13.72
1.22	59.98	24.56	84.54	0.826	1.051	13.58	15.46
1.38	77.35	13.75	91.09	0.750	0.705	7.45	8.91
24.5	1765.02	684.96	2449.98	39.604	28.025	482.40	550.02

The spindle-less rotary lathe machine has great potential to replace the old model rotary lathe which generally has large diameter spindles or discs. Although some ply mills try modifying the machine by installing an inner spindle which usually works at the end of the peeling process resulting in the diameter is lower than 12%. But it is often ineffective because the dogging pressure on the spindle is high as the peeling progress while the pith diameter progressively decreases lead the pith to vibrate. So, the log-block break before the stripping process ends. Replacing this type of rotary with the spindle-less type is an innovative step to restore the industrial glory and production of veneer and plywood to the past two decades.

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Plywood is a superior product from wood-based material, panel products made from the wood forest. Plywood has a wide range of uses, not only in housing or building construction but also in the industry of furniture, packaging, and other household stuff. Even sports equipment components and musical instruments also use plywood. Due to the wide use of veneer and plywood, efforts must be made to ensure that the yield of peeled logs is high by reducing the amount of waste that follows the results of the peeling process.

The yield description of the peeled results of the rotary lathe spindle-less machine above is quite encouraging. Although sometimes it is still inferior when compared to conventional rotary lathes when it is peeled with large diameter log-blocks (above 80 cm).

From Table 1 above, the percentage value is obtained to describe the yield. The yield is used for comparing the output of each log-block peeled off with the input. The veneer includes two forms; a rolled veneer which is commonly called the endless veneer or continuous veneer and a poly piece veneer core. For details, see Table 2 below.

A. Veneer.

The result of peeled log-block in the form of green veneer in terms of percentage shows a very high yield, to be exact at 81.67%, which is cumulative of 58.83% and 22.83% for the end-less veneer and the core veneer, respectively. This result was better where the volume of peeled green veneer ranges from 45.89% to 55.05% (Baldwin, 1995).

Similar to Baldwin, it was also identified that from a sawn-log peeling result, data were obtained: 43% peeled veneer finish and added by 1% low-quality veneer. Then the loss value due to rounding was 6%, shrinkage of the veneer was 3%, and torn veneer was 2%. Cutting losses (log end) and edge 26% and ampoule 19%. The log end and pith cutting losses were 26% and 19%, respectively (Bowyer et al., 2007).

B. Log-peeled waste.

There are three types of by-products in the log-block peeling process to a veneer, i.e., the pith (log-core), the spur knife veneer, and the round-up veneer. In most log peeling process by a rotary lathe machine usually leaves between 9 to 15% pith, but the use of a rotary spindle-less machine can reduce the amount of waste by up to 1.32%. The amount is close to the spur knife veneer that produces waste of around 0.94%. This results was better because it was stated that the amount of pith waste reached 19% (Bowyer et al., 2007). While the spur was around 1.8% to 5 % (Baldwin, 1995) (Syafii, 2001) . Fig. 1 illustrates the results of the log-block peel with a pie chart.

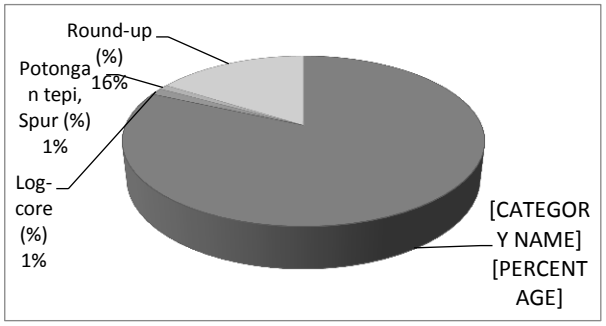

Figure 1. Pie-chart for Log-block peeling process using Rotary Lathe Spindle-less Machine

One of the advantages of a rotary lathe spindle-less machine is it can leave a pith with a minimum diameter of up to 7 cm. So, it is very effective for peeling log-blocks even with a small diameter. Logs from plantation forests are usually harvested at small diameters, under 40 cm, as in Indonesia, the most popular species is Sengon Wood. So it doesn't matter if the peeled log-block has a diameter lower than 20 cm. Philips, et al. (1998) stated that if sawn-logs with a diameter of 8 inches (16.25 cm) were peeled and left a pith with a diameter of 4 inches (10 cm), the yield was very significant, which was about 21%. Figure 2 is an example of a pith 7 cm in diameter from one of the log-block peels.

Figure 2. The pith (log-core) reaches a minimum diameter if maximizing the spindle-less type rotary lathe machine (Photo taken at PT Rimba Raya Lestari, Kutai Kartanegara, East Kalimantan).

In general, the raw material fed to the peeling machine are cylindrical because they had been sorted from the start, except in certain cases such as when there was a shortage of raw material logs. Because not cylindrical log-blocks are a significant contributor to the waste in veneer stripping. Therefore, the habit of providing good quality logs as raw material for the veneers preparation and plywood manufacture must be maintained.

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IV. CONCLUSION

The average yield of sawn-log (log-block) peeled in a rotary lathe spindle-less machine in the form of a veneer was 81.67%, consisting of 58.63% continuous/endless veneer, and 22.83% in the form of a poly piece core. The waste volume was 18,334% including log-core 1.32%, the edge cut by the spur-knife cut around 0.934%, and the round-up veneer is 16.08%, which accounted for the highest waste.

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