The study of veneer machine from oil palm stem

P Dangwilailux†, W Kalasee†, and V Akvanich†
† Department of Engineering, King Mongkut’s Institute of Technology Ladkrabang, Prince of Chumphon, Chumphon, 86160, Thailand

*e-mail: kdpanya@hotmail.com

Abstract. This study aim was to design an oil palm stem peeling machine. Oil palm veneer was selected from 28-year-old palm trunk, the height was 8 meters, and the diameter approximately 400-500 mm. The prototype veneer machine was to make the palm timber as a thin wood sheet for supplying to the plywood manufacturing industry. The veneer machine was composed of 3 units, which were 1) the roller unit 2) the blade unit, and 3) the feed screw unit. It was driven by 5 hp motors to rotate 2 rollers with speeds of 100, 120, and 140 rpm. The palm wood was rotated in the opposite direction to the blade using a 10 hp motor. It moved to the centre of the timber with forward speeds of 0.17, 0.29, and 0.59 m/min. Finally, the oil palm stems were peeled as veneer with a thickness of 1-3 mm and length of 2400 mm. The results were that the machine was able to produce the veneer product without it being broken and it had a high strength by using the roller speed of 120 rpm combine with a feed rate of 0.29 m/min.

1. Introduction

In Thailand, oil palm is an important economic crop species. It is reported that Thailand planted 0.92 million hectares of oil palm primary sources in the southern province of Chumphon, Surat Thani, Krabi, Trang in 2018 [1]. The economic lifespan of an oil palm tree is 25–30 years before the next replantation and approximately 37 thousand hectares are used for oil palm each year. Mature trees are single-stemmed and grow up to 20 m tall. The leaves are pinnate and reach between 3 to 5m long. Oil palm is the highest yielding edible oil crop in the world. It is cultivated in 42 countries in 11 million ha worldwide [2–4].

Oil palms are commonly used in commercial agriculture for the production of palm oil. Thus, oil palm is considered as a multipurpose and economically significant crop in many developing countries. The area under oil palm cultivation is likely to greatly increase over the next two decades. On the other hand, due to the economic life span of this popular crop (25 years), the producer countries have been facing a serious environmental problem concerning the solid biowaste handling in oil palm industry, particularly the oil palm trunk after replanting activities. It is predicted that more than 20 million cubic meters of biomass from oil palm trunks are presented annually [5].

Despite the properties of its veneer, its mechanical properties are low, and this is especially true for low-density timber. Solid wood has some undesirable characteristics such as cracking [6]. The laminated veneer lumber and his design included an engineered fabric that was placed between the veneer sheets to supply added reinforcement, allowing the use of lower-grade veneers for strength applications [6-7].
2. Materials and methods
The experimental oil palm trunks (OPT) were obtained from a palm oil plantation in Chumphon, Thailand. The samples were about 28 years old. The felled OPT were cut into stems 8 m in height (length) measuring from the trunk base prior to transformation into oil palm stems (OPS) logs at 0.8 m. The OPS logs were 400-500 mm in diameter. The anatomical structure of the OPS included the peripheral region (high density), the central region (median density), and the inner region (low density), as shown in figure 1.

![Figure 1. Cross-section of the oil palm stem.](image)

2.1. Veneer production
In this study, the logs were freshly peeled and converted into 1-3 mm veneer thicknesses, the diameter was reduced to 110-120 mm (use the peripheral region and central region). The rotary lathe as shown in figure 2, size 2350 × 2200 × 1000 mm was made of steel. The machine consisted of a blade and three roller gears having the direction of movement for peeling the palm stem as shown in figure 3(a). The OPS logs were inserted at the top, as shown in figure 3(b), and the peel operation was controlled by using a controller.

![Figure 2. Oil palm veneer(OPV) production machine.](image)

In this experimental the OPV for optimum usage was studied at the OPS moisture condition: 55, 65, and 75% wet basis, roller swirl condition: 100, 120, and 140 rpm, and feed rate condition: 0.17, 0.29, and 0.59 m/min at 5 of OPV specimens/condition. If the material had the high moisture content, the density was higher too. The moisture content of 55%, 65%, and 75% had increasing veneer density at 332.5, 487.5, and 712.5 kg/m³, respectively, as shown in table 1.
a) Relationship of the roller and blade b) Peeling mechanism.

Figure 3. The machine working principle: a) relationship of the roller and blade b) peeling mechanism.

Table 1. The density of the veneer at various moisture content.

| % Veneer Moisture | Average of density (kg/m³) |
|-------------------|---------------------------|
| 55                | 332.5                     |
| 65                | 487.5                     |
| 75                | 712.5                     |

2.2. Physical and Mechanical testing

Density and direct moisture content measurements were determined to study the materials physical properties. ASTM standard D-2395-14 was used for the density determination, ASTM standard D-4442-15 for the moisture content measurement. The mechanical test was conducted in this study was a tensile strength parallel to the surface (T||). ASTM standard D-3500-14 was used in T|| of the veneer carried out in accordance with ASTM standard D-1037-16 [8]. The measurements were taken by using a tensile analyzer (TA Plus texture analyzers, Lloyd Instruments as shown in figure 4, West Sussex, England) with a 1 kN static load cell (using 20 × 200 mm samples at a cross-head speed of 1.0 mm/min).

In this research, the moisture content (M) was calculated by using Eq. 1 [9]

\[ M(\%) = \frac{M_{\text{ini}} - M_{\text{o}}}{M_{\text{ini}}} \times 100 \]  

(1)

where M is the average moisture content of the specimen at the time of the test (kg water/kg wet mass), is the initial mass, and is the oven-dry mass. Analysis of initial moisture content of veneer with the hot air oven at 105°C for about 72 hours.

The density (\( \rho \)) was calculated as

\[ \rho = \frac{M}{V} \]  

(2)

where M was the mass and V was the volume of the specimen (m³).
3. Results and discussion

From Table 2, the experiment found that peeling the wood with a moisture content of 55%, at a roller speed 140 rpm, and cut feed speed of 0.29 m/min, attained a tensile strength parallel of 0.99 MPa. The veneer could be peeled as thin and would tear, as the wood has too little moisture. The wood would easily tear from each other due to the force of the roller. The OPS logs that had a moisture content of 65% had the longest peeling at a roller speed of 120 rpm, a cut feed speed of 0.29 m/min, and tensile strength parallel 1.24 MPa. This was suitable for veneer peeling, but while stripping, it was found that the moisture in the wood would come to the surface, causing the rollers to get wet and cause the timber to slide.

Veneer with a moisture content of 75% was worked at a roller speed 140 rpm and a cut feed speed of 0.29 m/min, had a tensile strength parallel 1.05 MPa. Some of the wood peeled because the moisture content of the OPS logs was too high, the rollers that are used to force the veneer could not lift the wood. Since the veneer surface was soft, the speed of the blade set had to be adjusted faster, as shown in Figure 5 (a-c) respectively.
Table 2. The thickness and tensile strength parallel of the veneer with OPS logs.

| Roller speed (rpm) | Feed rate (m/min) | Thickness of veneer (mm) | Tensile strength parallel (T||) (MPa) |
|--------------------|-------------------|--------------------------|-------------------------------------|
| 100                | 0.17              | 1.65                     | 0.62                                |
|                    | 0.29              | 2.51                     | 0.87                                |
| OPS Moisture 55%   | 0.59              | 2.80                     | 0.84                                |
|                    | 0.17              | 1.59                     | 0.71                                |
| 120                | 0.29              | 2.00                     | 0.98                                |
|                    | 0.59              | 2.58                     | 0.89                                |
|                    | 0.17              | 1.44                     | 0.70                                |
| 140                | 0.29              | 1.80                     | 0.99                                |
|                    | 0.59              | 2.32                     | 0.78                                |
| 100                | 0.17              | 1.68                     | 0.82                                |
| OPS Moisture 65%   | 0.29              | 2.52                     | 0.94                                |
|                    | 0.59              | 2.89                     | 0.93                                |
|                    | 0.17              | 1.63                     | 0.97                                |
| 120                | 0.29              | 2.05                     | 1.24                                |
|                    | 0.59              | 2.61                     | 1.07                                |
|                    | 0.17              | 1.52                     | 0.81                                |
| 140                | 0.29              | 1.85                     | 0.98                                |
|                    | 0.59              | 2.36                     | 0.83                                |
| 100                | 0.17              | 1.74                     | *                                   |
| OPS Moisture 75%   | 0.29              | 2.6                      | 0.99                                |
|                    | 0.59              | 2.92                     | 0.94                                |
|                    | 0.17              | 1.72                     | *                                   |
| 120                | 0.29              | 2.30                     | 1.06                                |
|                    | 0.59              | 2.77                     | 0.95                                |
|                    | 0.17              | 1.59                     | 0.82                                |
| 140                | 0.29              | 2.02                     | 1.05                                |
|                    | 0.59              | 2.63                     | 1.03                                |

Figure 6. Veneer sheets obtained of the roller at 120 rpm combine feed rate at 0.29 m/min.
4. Conclusion

The results of the experimental were the effects of peeling conditions due to thickness, physical and mechanical properties. The experiment had used OPS logs of different moisture content at 55%, 65%, and 75%. It was found that the thickness and strength of the veneer were related to roller speed and the feed rate of a blade. It was found, that varying the speed of the roller between 100 to 140 rpm decreased the thickness, but the length of the veneer would not peel off continuously. Therefore, we subsequently found with the speed of the roller at 120 rpm combine with a feed rate at 0.29 m/min was an appropriate operation criterion, enabling veneer production without breakage and with high strength, as shown in figure 6.

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