Investigation of Surface Roughness in Machining Oil Palm Wood

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Abstract

Oil palm industry is one of the largest agricultural plantation sectors in Malaysia. The total area under oil palm cultivation is over 2.65 million hectares, producing over 8 million tons of oil annually. The oil palm trunk is converted to oil palm wood after the replantation take place. The machining of wood process by cutting is a demanding technological process because of its specific structure. In many industries, accuracy and precision are crucial parameters for their production to achieve the best quality of cut. One of the qualities to be monitored is the surface roughness, Ra value which has direct implication on cut quality. Hence, this study was embarked to quantify the surface roughness of machining of oil palm wood. Three types of machining oil palm wood processes were conducted by using CO_2 laser cutting, CNC milling and vertical saw machine. As a result, CO_2 laser cut produced the best cut quality in comparison to other competing machining processes.

Keyword: Oil Palm wood, CO_2 laser, CNC Machine, Vertical Saw Machine, Surface Roughness

1.0 Introduction

Manufacturing of an oil palm wood was initiated by Malaysian Palm Oil Board (MPOB) in the early 1980s. It has been long observed that this type of wood has high market value due to its lightweight property, ease of manufacture and eco-friendly. Use of oil palm trunk (OPT) in wood processing not only revives the ailing plywood industry but also provide an opportunity for the industry to grow. In one study, industrial manufacturing of plywood from OPT was demonstrated to be successful and profitable (Anis.M 2006).

Machining parameters for OPT fundamentally depends on its mechanical properties. Ratanawillai (2006) investigated mechanical properties at different portions of the OPT. It was found that the mechanical properties (in term of tensile, bending, hardness and impact test) of OPT were approximately two times lower than those of teak and rubber wood (Thanate Ratanawillai 2006). In addition, its structure property is different in comparison to forestry trees since it does not have a secondary growth which typically displays growth rings, cambium, ray cells, sapwood and heartwood (Killmann and S.C. Lim 1985).

Milling is the most common form of wood machining process. It is a material removal process, which can create a variety of features on a part by cutting away the unwanted material. The milling process requires a milling machine, cutting tools, fixture and work piece. Milling machines can be manually operated, mechanically automated or digitally automated using computer numerical control (CNC). Effective monitoring system for the machining states is required in order to operate a fully automated machining system without any problem (Szwajka and Górski 2006).

CO_2 laser cutting is a technology that utilize laser to cut materials. It has been widely used since it was introduced in 1964 (Patel

1964). The first commercial use of CO_2 laser cutting was to cut plywood die boards for packaging industry (Powell 1998). Now, the laser has been employed to machine both metal and non-metallic materials. For example, Yusof *et. all* (2008) recently studied the Malaysian light hardwood have been cut using CO_2 laser.

Surface roughness is one of the most important requirements in machining process (Tsourveloudis 2010). According to Tsai *et. all* (1999) surface roughness value is an important measure to determine the surface quality of a product in machining. It measures the finer irregularities of the surface texture where the roughness increases in proportion to Ra. If the value of the surface roughness is high, this indicates that the surface is rough. Small value of surface roughness denotes a smooth surface. Surface roughness is also one of the factor that greatly influences manufacturing cost (Zhang *et al*. 2007). The formation mechanism of surface roughness is very dynamic, process reliant and complicated as it is very difficult to estimate its value through theoretical analysis (Zhang *et al*. 2007).

The surface roughness of the machined part is largely determined by the feed rate and cutting tools condition. In CNC milling, a large feed rate would give shorter cutting times but at the expsense of a poor surface finish (Javidi *et al*. 2008). Feed rate generally becomes a major parameter in CNC milling compared to other factors. Large feed rate means the work piece being machined at the high speed.

In laser cutting, surface roughness is affected by many factors. It has been shown that the roughness of the cut surface decreases as the laser power used increases. In addition, roughness value also increased when the laser cutting speed and air pressure were increased (H. A. Eltawahni, 2010).

2.0 Experimental Details

Only three samples of surface roughness values with different machining processess of dried oil palm wood were taken. A large chunk of dried oil palm was cut near the bark and carefully sectioned into three smaller samples. Each sample has a thickness of 13 mm. The Mahr Perthometer PS1 was used to measure the surface roughness of the machined surfaces and quantified in terms of µm unit. For each experiment, three readings were taken and subsequently averaged.

The samples were first cut using a CO_2 laser machine (Helius 2513). The machining parameters are shown in Table 2.1.

Table 2.1: Parameter for CO_2 laser cutting of oil palm wood

Parameter	Value
Power	1000 W
Cutting Speed	1000 mm/min
Assist Gas Pressure	4 bar
Focal Point Position	-5mm

The CNC milling machine used for this study was CNC Mitsui Seiki VT3A High Speed 3-Axis Vertical Machining Center. The Endmill HSS cutter with radius 10 mm was used for this research. A slot with depth of 1 mm was formed as shown in Figure 2.1. The spindle speed and feed rate were 4700 rev/min and 1000 mm/min respectively.

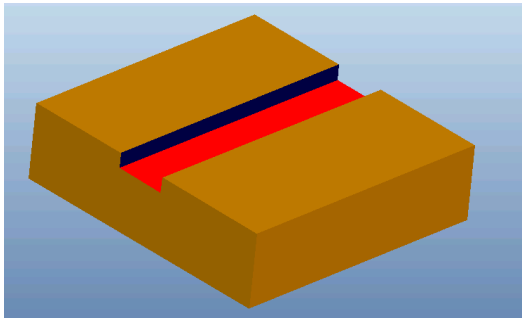

Figure 2.1: Image of slot formed by CNC milling cut

The final device used for the experiments was a sawing machine, regulated at a constant cutting speed of 2890 rev/min. The machine was simply used to make straight line cut on the oil palm wood. The roughness value will then be compared with the roughness values of oil palm wood that were cut using the CO_2 laser cutting and CNC milling machine.

3.0 Result and Discussion

The surface roughness values obtained using CO_2 laser, milling CNC Machine and vertical saw machine were compared. Table 3.1 shows the surface roughness measurements collected using Mahr Perthometer with the measurement was µm.

Table 3.1: Result of surface Roughness measurement

Machining Type	Average surface Roughness, µm	Smoothness percentage, % in comparison to vertical saw machine
CO_2 Laser Cutting	5.86	68.7
CNC Machine	9.025	51.7
Vertical Saw Machine	18.7	0

In this study, the smaller surface roughness value is more appreciated. The machining process that will give the smaller number of surface roughness will give the good quality. The result in Table 3.1 indicates that the CO_2 laser cutting has smaller surface roughness value than the other two machining processes. In addition, CO_2 laser cut and CNC milling cut produced about 69% and 52% smoother than the saw cut, respectively.

Besides that, qualitative comparison is made by comparing the enlarged image (40 times) of the surface of oil palm wood which has been cut using those three methods, as shown in Figure 3.1, 3.2 and 3.3.

Figure 3.1 Image of the surface of oil palm wood cut using Vertical Saw Machine

Figure 3.2 Image of the surface of oil palm wood cut using CNC Milling Machine

Figure 3.3 Image of the surface of oil palm wood cut using CO_2 Laser Machine

Cutting oil palm wood using the vertical saw machine resulted in the formation of ragged surface as shown in figure 3.1. Thus, a finishing process is needed to greatly enhance the surface condition such as by sanding before it can be made into any desired product. Similarly, the same feature was noticed when the wood was cut using the CNC milling machine, but with better and smoother surface. Laser cut exhibits a different condition of the cut surface. As shown in Figure 3.3 show, the cut surface is characterized by much smoother surface, no ragged edge and splinter-free. However, there are some char and burnt observed at the surface. In essence, the cut quality obtained using laser cutting is far better in comparison to other competing machining processes.

Cutting using vertical sawing machine and CNC milling machine were achieved by means of the use of cutting tools i.e. saw blade and end mill cutter respectively. To produce a cut, the cutting tool must be in contact with the workpiece. As the cutting tool moves and the

workpiece is feed to it, the cutting tools will cut the workpiece in the direction of feed by tearing away the material which comes in contact with the cutting tools. This would produce rough and splintered surfaces which are aesthetically unappealing.

However, cutting using CO_2 laser will produce a smooth and splinter free surface. This is due to the cutting mechanism of CO_2 laser. CO_2 laser is a noncontact cutting process. The cut was achieved by utilizing the heat from the laser beam. But there are some char and burnt at the surface. This is because the cellulose in the oil palm wood was reduced to carbon due to the heat from the laser beam. This layer of carbon can be removed easily.

Conclusion

In conclusion, CO_2 laser cut and CNC milling cut produced about 69% and 52% smoother than the saw cut, respectively. Thus, CO_2 proves to be more capable to produce oil palm wood product with smoother surface than vertical saw machine and CNC milling machine.

Acknwoledgment

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