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Influence of Milling Feed Rate on Surface Roughness of Natural Fiber Composite

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Abstract— **The influence of feed rate parameter of milling on natural fiber surface is investigated with constant 1700 rpm spindle speed. In this study, a surface texture-measuring instrument and optical microscope are used as measurement equipments. Ramie fiber composite samples are machined at 2, 4 and 6 mm/min feed rates each. The results shows that the sample machined at 4 mm/min feed rate has the lowest surface roughness value and its surface has a harmonious structure. In addition, many cracks and fractures appeared on the sample surface which machined at 6 mm/min feed rate due to the impact of the cutting edges.**

Index Terms: **natural fiber composite, milling, surface roughness.**

I. INTRODUCTION

Over the last three decades, fiber reinforced composite materials have become the dominant emerging materials in engineering applications such as household appliances, sporting goods, automotive, marine, defense and aerospace industries due to their superior properties such as high performance to weight ratio, vibration damping etc. With technological advances and increasing demand in market, some nano-sized additives or fillers in composite materials have been used to improve mechanical properties of composite materials. These improvements have supplied to develop the new polymeric matrix materials. Many researchers have reported that the addition of small amounts of nanoparticles, such as nanometal oxides, carbon nanotubes, nanographeme and nanoclays, lead to a noticeable improvement in thermal, mechanical, morphological, electrical and optical properties of polymer composite materials without compromising on density, toughness and manufacturing process (Herrera-Franco and Valadez-Gonzalez 2004, Sorrentino and Turchetta 2011, Azmi 2013, Pickering, Efendy et al. 2016, Shunmugesh and Panneerselvam 2016).

Nowadays, natural fiber composites are used in a wide variety of industries application include building construction, furniture, automotive and packaging due to some advantages that they offer: They are non-abrasive to machines, renewable, biodegradable and an abundant source of fiber, are of low cost and have acceptable mechanical properties. The fabrication of synthetic fibers is not a closed loop process that means by-products cannot be processed back into the production cycle. During the production of synthetic fibers such as nylon or polyester, volatile monomers and solvents that contribute to water and air pollution are released into the atmosphere It is imperative, therefore, that professionals in the textile industry begin to consider alternative resources for the raw material used for fiber. It is doubly crucial that while considering alternative resources; sustainable, renewable, and less polluting natural fibers be considered for uses hitherto dominated by synthetic fibers (Claudio 2007, Budan, Basavarajappa et al. 2011, Pal and Tandon 2013, Sanjay, Arpitha et al. 2016).

Ismail, et al. (Ismail, Dhakal et al. 2016) found that the conventional homogeneous materials can no longer effectively satisfy the growing demands on product capabilities and performance, due to the advancement in products design and materials engineering. Therefore, the fiber reinforced composites (FRCs) with better properties and desirable applications emerged. These enhanced qualities of the FRCs have emphasized the need for analyzing their machinability for further improvement of performance. They also obtained depict that an increase in feed rate and thrust force caused an increase in delamination and surface roughness of both samples, different from cutting speed. In addition, increased drill diameter and types of chips formation caused an increase in both delamination and surface roughness of both samples, as the material removal rate (MRR) increased. Evidently, the minimum surface roughness and delamination factor of the two samples for an optimal drilling are associated with feed rates of 0.05–0.10 mm/rev and cutting speed of 30 m/min.

The effect of milling feed rate parameter on surface roughness of ramie fiber composite at constant 1500 rpm spindle speed has been recently studied by Salem A. Salem, et al. (Sheggaf 2020), they found that the sample which milling with 4 mm/min feed rate has the lowest value of surface roughness as 7.39 µm, and there are no

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defects on its surface have been found, also the microscope images showed blanks and cracks on the surface of samples which milling at 2 and 6 mm/min feed rates. The present work mainly aims to investigate the influence of variable milling feed rate on surface quality of ramie fiber composite at 1700 rpm spindle speed.

II. EXPERIMENTAL PROCEDURE

The ramie fiber samples are prepared as three plates with dimensions of 100 mm × 50 mm and 5 mm thick. Adhesive glue (epoxy resin & epoxy hardener) is used to join two pieces of ramie fiber 1 mm thick for each with cast acrylic sheet 3 mm thick. A milling process is carried out on a vertical milling machine CNC type model of EMCO. 1700 rpm spindle speed, 0.8 mm cut depth and tool width 10 mm are used as constant parameters for each sample, and the experiment is conducted by 3 variations of feed rates 2, 4, and 6 mm/min. The milling process is performed along the sample and without lubrication. The final shape of sample is shown in Figure 1. The surface roughness (Ra) of samples were measured via surface texture-measuring instrument (surfcom 120A), and the optical microscope used to examine the ramie fiber composite surface after milling process is done.

Figure 1. The final shape of sample.

III. RESULTS AND DISCUSSION

Table 1 shows that the surface roughness is not the same along the cutting surface. The average value of surface roughness is 8.1 µm, and accomplished under the following parameters:

1700 rpm spindle speed , 2 mm/min feed rate , and the 0.80 mm depth of cut.

The distance (mm) is divided into 4 varieties of distances from the start edge until the end of the specimens, as shown in Figure 2.

Table 1. Surface roughness at 1700 rpm spindle speed, 0.8 mm depth of cut and 2 mm/min feed rate

Stage	Cutting Distance (mm)	Surface Roughness (Ra) (µm)
1	0-30	11.17
2	30-60	4.49
3	60-80	9.70
4	80-100	7.04

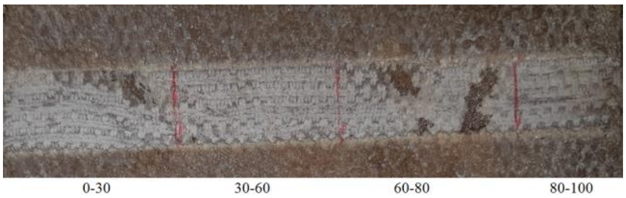

Figure 2. Photograph of the four stages of cutting surface using feed rate of 2 mm/min.

The maximum value of surface roughness is at the first stage which reaches 11.17 µm, and the drop to the lowest roughness at 30-60 mm to rise again at 60-80 mm and decrease slightly at the last stage. This indicates instability in the surface roughness, same results are found by H. Azmi, et al. (Azmi, Haron et al. 2016) as the surface roughness values fluctuated specially at start and the end of the process, and the feed rate affects the surface roughness significantly. Figure 3 shows the effect of machining process at 2 mm/min feed rate on microstructure of workpiece surface.

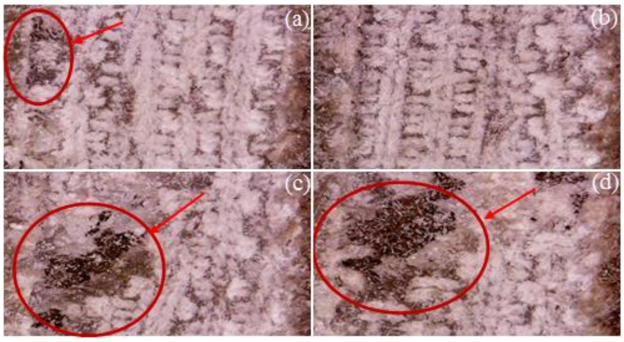

Figure 3. Microstructure of workpiece surface with 2 mm/min feed rate (a) stage 1, (b) stage 2, (c) stage 3, and (d) stage 4. x50.

The increase in surface roughness could be occurred as a result of spaces presence between the fiber composite that will affect the surface roughness of ramie fiber compound (MATERIALA 2016), as shown in Figure 3, where the appearance of some blanks resulting from the glue bubbles (part a, c, and d). Table 2 shows the surface roughness values of workpiece machined at 4 mm/min feed rate.

Table 2. Surface roughness at 1700 rpm spindle speed, 0.8 mm depth of cut and 4 mm/min feed rate

Stage	Cutting Distance (mm)	Surface Roughness (Ra) (µm)
1	0-30	4.28
2	30-60	8.20
3	60-80	8.13
4	80-100	4.45

It can be noted that the surface roughness is not the same along as the cutting surface, and the average value is 6.26 µm. The four stages of workpiece cutting surface with 4 mm/min feed rate as shown in Figure 4. The results show reduction of surface roughness at the first stage, on the other hand, the surface became rough as the milling tool proceed to the next stages, until the last part of workpiece when the surface roughness value reduce again almost as the same value of the first stage. This fluctuation in values may be attributed to the fact that the surface between the first and second stages have been affected by gaps and distortions on the surface as shown in Figure 4.

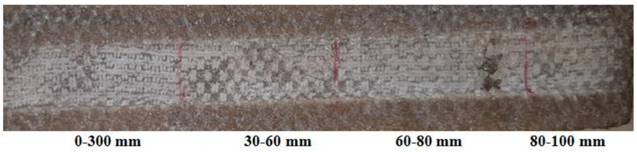

Figure 4. Photograph of the four stages of cutting surface using feed rate of 4 mm/min.

Microstructure image of the ramie fiber compound shows a harmonious structure with the appearance of blanks and some deformities on the cutting edges (last stage), Figure 5-d.

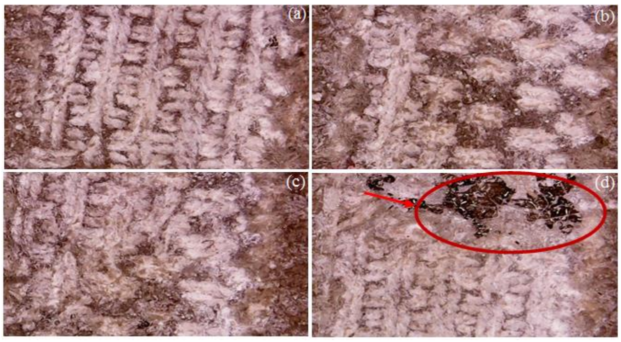

Figure 5. Microstructure of workpiece surface with 4 mm/min feed rate (a) stage 1, (b) stage 2, (c) stage 3, and (d) stage 4. x50.

Same behavior occurs when the workpiece machined at 6 mm/min feed rate compared with other samples, where the surface roughness values unstable along as the cutting surface, and the average values of surface roughness is 6.97 µm as shown in Table 3. The cutting surface of the four stages of workpiece is shown in Figure 6.

Table 3.Surface roughness at 1700 rpm spindle speed, 0.8 mm depth of cut and 6 mm/min feed rate

Stage	Cutting Distance (mm)	Surface Roughness (Ra) (µm)
1	0-30	7.36
2	30-60	6.31
3	60-80	6.60
4	80-100	7.63

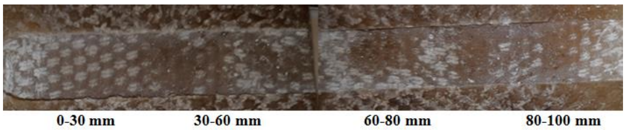

Figure 6. Photograph of the four stages of cutting surface using feed rate of 6 mm/min.

Milling at a high feed rate (6 mm/min) has a negative effect on surface structure as shown in Figure 7, where the cracks and fractures occurred along the sample surface with clear impact of the cutting edges.

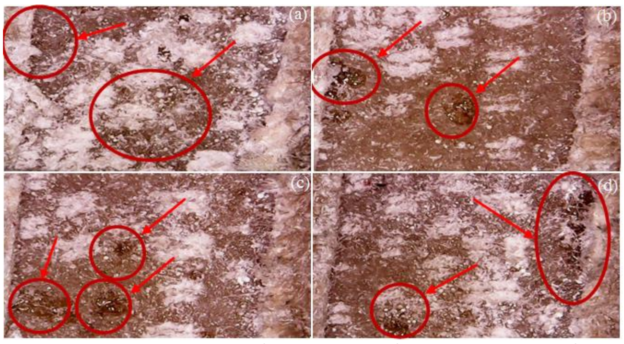

Figure 7. Microstructure of workpiece surface with 6 mm/min feed rate (a) stage 1, (b) stage 2, (c) stage 3, and (d) stage 4. x50.

The average of surface roughness values of three samples which machined at 2, 4 and 6 mm/min feed rate is shown in Figure 8, as we can see the sample at 4 mm/min feed rate is the smallest surface roughness, on the other hand using lowest feed rate has negative effect on the surface roughness value. In addition, the quality of surface affected badly at high feed rate as we can see in image 7 were the cracks formed at the surface.

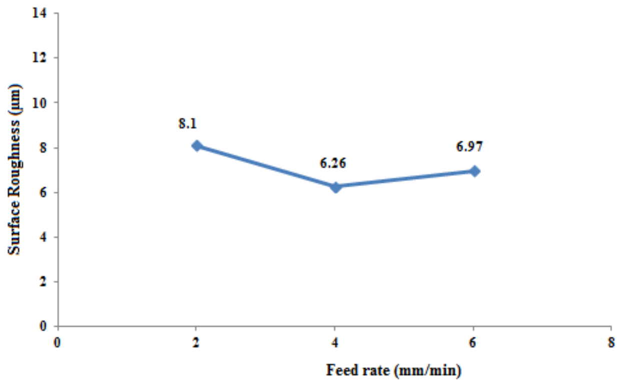

Figure 8. Effect of milling feed rate on surface roughness of ramie fiber samples with constant 1700 rpm spindle speed

IV. CONCLUSION

The influence of milling feed rate on surface roughness of natural fiber composite was investigated. From the analysis, the following can be summarized:

1. The natural fiber composite can be machined successfully using milling process, and feed rate parameter has important effect on its surface.
2. Milling with 4 mm/min feed rate and constant 1700 rpm spindle speed has the smoothest surface compared with 6.26 µm surface roughness.
3. Increasing feed rate until 6 mm/min leads to form cracks and fractures on the sample surface.
4. The natural materials, which available in our country (Libya) such as palm fronds or Stipa viridula (Halfa) can be used in engineering applications as an alternative to metal materials.

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REFERENCES

1. Azmi, A. (2013). "*Chip formation studies in machining fibre reinforced polymer composites.*" International Journal of Materials and Product Technology **46**(1): 32-46.
2. Azmi, H., et al. (2016). "*Study on machinability effect of surface roughness in milling kenaf fiber reinforced plastic composite (unidirectional) using response surface methodology*." ARPN Journal of Engineering Application and Science **11**(7): 4761-4766.
3. Budan, D. A., et al. (2011). "*Influence of fibre volume reinforcement in drilling GFRP laminates*." Journal of Engineering Science and Technology **6**(6): 733-744.
4. Claudio, L. (2007). Waste couture: Environmental impact of the clothing industry, National Institute of Environmental Health Sciences.
5. Herrera-Franco, P. and A. Valadez-Gonzalez (2004). *"Mechanical properties of continuous natural fibre-reinforced polymer composites*." Composites Part A: applied science and manufacturing **35**(3): 339-345.
6. Ismail, S. O., et al. (2016). *"Effects of drilling parameters and aspect ratios on delamination and surface roughness of lignocellulosic HFRP composite laminates*." Journal of Applied Polymer Science **133**(7).
7. MATERIALA, R. K. P. (2016). "*Investigation of the cutting forces and surface roughness in milling carbon-fiber-reinforced polymer composite material*." Materiali in tehnologije **50**(4): 591-600.
8. Pal, V. K. and P. Tandon (2013). "*Identification of the role of machinability and milling depth on machining time in controlled depth milling using abrasive water jet*." The International Journal of Advanced Manufacturing Technology **66**(5-8): 877-881.
9. Pickering, K. L., et al. (2016). "*A review of recent developments in natural fibre composites and their mechanical performance*." Composites Part A: applied science and manufacturing **83**: 98-112.
10. Sanjay, M., et al. (2016). "*Applications of natural fibers and its composites: An overview*." Natural Resources **7**(3): 108-114.
11. Sheggaf, S. A. S. a. Z. M. (2020). Effect of Milling Parameters on Surface Roughness of Ramie Fiber Composite. Third International Conference on Technical Sciences (ICST2020), Tripoli - Libya, National Technical Commission and Technical Education.
12. Shunmugesh, K. and K. Panneerselvam (2016). "*Machinability study of Carbon Fiber Reinforced Polymer in the longitudinal and transverse direction and optimization of process parameters using PSO–GSA*." Engineering science and technology, an international journal **19**(3): 1552-1563.
13. Sorrentino, L. and S. Turchetta (2011). Milling of carbon fiber-reinforced plastics: analysis of cutting forces and surface roughness. 18th International Conference of Composite Materials, Citeseer.