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# Investigation of Surface Roughness by using the Vibration Assisted Milling Process of Glass Fiber Reinforced Polymer

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*Abstract-* This project has presented an approach to reducing surface roughness of milled work pieces of glass fiber reinforced polymer via excitation of the first axial mode of the vibration milling device. A combined application of numerical and experimental analysis has confirmed the validity of the proposed approach. Milling experiments demonstrated that excitation of the axial mode in the vibration milling tool leads to an appreciable reduction in the surface roughness of mild steel and glass fiber work pieces. We proposed a new technique to measure the surface roughness of material with vibration assisted milling process. For this process the main material used was glass fiber re enforced polymer but also the additional material were used like mild steel. Controlling vibration phenomena in production is one of the approaches for improving their efficiency. This also applies to cutting tool vibrations generated during machining, when the magnitude of the vibrations directly influences work piece surface quality. Conventional milling process gives rough surface which was the problem to the machining industries therefore recent developments to solve this problem are described in which one of the process is vibration assisted milling process. It is also a kind of natural idea which nobody has been done before on milling process. In this research the surface roughness of glass fiber reinforced polymer is tested under two main process, Vibration assisted milling process and conventional milling process and then the results obtained were compared.

*Keywords: glass polymer, vibration device, end mill cutter, milling machine, surface roughness.*

## I. Introduction

Glass fiber is a material consisting of numerous extremely fine fibers of glass or Fiber glass is a type of fiber-reinforced plastic where the reinforcement fiber is specifically glass fiber. The glass fiber may be randomly arranged, flattened into a sheet (called a chopped strand mat), or woven into a fabric [1]. Milling machines were first invented and developed by Eli Whitney to mass produce interchangeable musket parts. Although crude, these machines assisted man in maintaining accuracy and uniformity while duplicating parts that could not be manufactured with the use of a file. Development and improvements of the milling machine and components continued, which resulted in the manufacturing of heavier arbors and high speed steel and carbide cutters. These components allowed the operator to remove metal faster, and with more accuracy, than previous machines [2]. The main aim of this study is to improve the surface roughness of materials, finally a study of using vibration device with milling machining is described and it is demonstrated that using a vibration device with milling machining can give a better surface roughness rather than that of conventional or normal milling process. This paper summarize a few experimental studies we have been engaged in to improve surface roughness of glass fiber reinforced polymers. The milling process remove material by performing many separate, small cuts. This is accomplished by using a cutter with many teeth, spinning the cutter at high speed, or advancing the material with a cutter slowly. The speed at which the piece advances through the cutter is called feed rate (feed)F = f. u. N. [3]

## II. Experimental Description

In this research two processes are used to measure the surface roughness of glass fiber reinforced polymer and mild steel, these two processes are;

1) Vibration assisted milling process (with vibration mechanism)
2) Conventional milling process (without vibration mechanism)

### *a) Vibration assisted milling process of glass fiber*

During this process we placed the vibration device to the bottom of the work piece and tightly attached with work piece in milling machine (Fig 1) and turned on the vibration device which is connected to motors and battery (Fig 2) applying the voltage of 2 volts to the vibration device (Fig 3). When the vibration mechanism is on it slightly vibrate the work piece and thus the cutting tools move with high speed and small amplitude and start the surface roughness test using different RPM (revolution per minute) and constant feed rate and depth cut in cutting process[4]. Firstly the glass fiber was machined with three different Cutting speed (cs) of 15, 20 and 25 with 12 mm cutter tool Using 48

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mm/min feed rate and 2 mm depth of cut for the rpm of 403, 538 and 792 ,the rpm and feed was obtained by using equation 1 and 2 respectively ,the surface roughness response was 3.36 $\mu$m, 3.51 $\mu$m and 3.96 $\mu$m respectively using surface roughness tester ( Fig 4,5), Thus shows that with low rpm the surface roughness of glass fiber with vibration assisted milling process is better than that of using high rpm using the feed rate of 48 mm/min (Table 1). Bar chart 1, also shows the rpm vs roughness analysis results.

$$Rpm=cs*1000/3.14*D \quad (1)$$

Where cs is the cutting speed [5]and D is the diameter of cutting tool. So the nearest rpm Obtained for 12 mm cutting tool is 403, 538 and 792 respectively.

$$FR=Rpm*T*CL \quad (2)$$

Where FR is the calculated feed rate in mm/min, T is the number of teeth on the cutter and CL is the chip load or feed per tooth.

Secondly the glass fiber was machined using the same technique with 197 rpm and different feed rates of 26 mm/min and 35 mm/min, the cutter diameter of 20 mm and the depth of cut of 2 mm, the surface roughness response was 2.78 $\mu$m for 26 mm/min feed rate and 2.38 $\mu$m for 35 mm/min feed rate, showing that with low feed rate and higher cutter diameter the surface roughness obtained will be better (Table 2). Bar chart 2 Shows the analysis graph wise.

The same method was repeated for the mild steel but this time we obtained 2.81 $\mu$m, 4.09 $\mu$m and 3.54 $\mu$m surface roughness for 403, 538 and 792 rpm respectively, which shows a little different results than that of glass fiber. It is due to the use of different material, Table 3 shows the experimental results of mild steel after machining process [6]. Bar chart 3 shows the analysis in graph wise.

This is because of the phenomenon that controlling vibration in production machines is one of the approaches for improving their efficiency. This also applies to cutting tool vibrations generated during machining, when the magnitude of the vibrations directly influences work piece surface Quality. Continuous efforts to enhance cutting performance have revealed that machining quality may be improved if a tool is assisted with high-frequency vibrations. During the resulting vibration cutting process, the tool periodically loses contact with the chip leading to a reduction in machining forces, friction, and temperature in the cutting zone and the formation of thinner chips, as well as simultaneously preventing generation of micro-cracks on the cutting edge and work piece surface. As a consequence, this improves cutting stability, surface finish, and tool life when compared to conventional machining [7].

*b) Conventional milling process*

The same experiment is repeated without vibration device for glass fiber and for mild steel which was an alternative material and studied surface roughness test under different RPM (Revolution per minute). Firstly the glass fiber was machined and then tested with surface roughness tester for measuring the surface roughness with three different Cutting speed (cs) of 15, 20 and 25 with 12 mm cutter tool Using 48 mm/min feed rate and 2 mm depth of cut for the rpm of 403, 538 and 792, Using the same machine and cutting tool (End milling cutter) but the only difference is the vibration device is not used and milling is conventional [8] so there is no transfer of vibrations (Fig 6) and the surface roughness of glass fiber using surface roughness tester obtained was 4.13 $\mu$m, 5.73 $\mu$m and 5.83 for 403, 538 and 792 rpm respectively (Table 1) (Bar chart 1), which shows different and not good results as that of vibration assisted milling process. Secondly the glass fiber was machined without vibration device and then tested with surface roughness tester using the same method and the same equations (1 & 2) for rpm and feed rate considering the cutting speed, diameter of the cutter, number of teeth on the cutter and feed per tooth as previous with cutting tool of 20 mm, rpm of 197, feed rates of 26 mm/min and 35 mm/min, the surface roughness for 26 mm/min feed rate was 2.95 $\mu$m and for 35 mm/min feed rate was 2.53 $\mu$m which also give different surface roughness results compare to vibration assisted milling process (Table 2), (Bar chart 2).Thus the same procedure is done for the Mild steel for rpm of 403, 538 and 792 and the surface roughness measured after machining with conventional milling process was 4.04 $\mu$m, 4.22 $\mu$m and 4.48 $\mu$m respectively, showing different and not good results as compared to vibration assisted milling process [9].

It is because of the Chip width starts from zero and increases which causes more heat to diffuse into the work piece and produces work hardening. Tool rubs more at the beginning of the cut causing faster tool wear and decreases tool life. Chips are carried upward by the tooth and fall in front of cutter creating a marred finish and re-cutting of chips. Upwards forces created in horizontal milling tend to lift the work piece, more intricate and expansive work holdings are needed to lessen the lift created [10].

## III. Results and Discussions

The results are detailed in tables and chart.

## IV. Conclusions

In this research two different material are used, one is Glass fiber and the other one is Mild steel.

First of all glass fiber is machined using conventional milling having cutter diameter 12mm,Feed rate 48 mm/min, depth of cut 2mm and the machining operation is done under different rpm which gives different surface roughness .Then the same material is machined using vibration assisted milling process ,In this process the vibration device is attached to the bottom of the work piece and having cutter diameter 12 mm and the machining operation is done under different rpm, which also gives surface roughness. Next compare the surface roughness that is obtained through conventional milling and vibration assisted milling process.

Then the same material is used having cutter diameter 20mm, feed rate 26mm/min for one case and 35mm/min for another case under same Rpm (197) using the same machining processes as above.

Then Mild steel is machined using conventional milling having cutter diameter 12mm,Feed rate 48 mm/min, depth of cut 2mm and the machining operation is done under different rpm which gives different surface roughness .Then the same material is machined using vibration assisted milling process, In this process the vibration device is attached to the bottom of the work piece and having cutter diameter 12 mm and the machining operation is done under different rpm, which also gives surface roughness. Next compare the surface roughness that is obtained through conventional milling and vibration assisted milling process.

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We seek excuse for any errors that might occur in this report despite of our best effort.

## References Références Referencias

1. Investigation of the wear behaviour of a glass-fibre-reinforced composite and plain polyester resin HaşimPıhtılıNihatTosun, Composites Science and TechnologyVolume 62, Issue 3, February–March 2002, Pages 367-370
2. http://web.mit.edu/2.670/www/Tutorials/Machining/mill/Description.html
3. "A study on the effect of feed rate and cutting speed on surface roughness and material removal rate of mild steel" A A Latif, M R Ibrahim, A Z Amran and E A Rahim Published under license by IOP Publishing Ltd IOP Conference Series: Materials Science and Engineering, Volume 257, conference 1
4. "Effect of low-frequency vibration on workpiece in EDM processes"† GunawanSetia Prihandana1, Muslim Mahardika1, M. Hamdi2,3 and Kimiyuki Mitsui4, Journal of Mechanical Science and Technology 25 (5) (2011) 1231~1234
5. https://www.ns-tool.com/en/technology/technical_data/cutting_speed/
6. "Corrosion Characteristics of Mild Steel under Different Atmospheric Conditions by Vapour Phase Corrosion Inhibitors" Harish Kumar Vikas Yadav.
7. Brehl, D.E., Dow, T.A. (2008). Review of vibration assisted machining. Precision Engineering, vol. 32, no. 3, p. 153-172, DOI:10.1016/j. precisioneng. 2007. 08.003.
8. "Prediction of Cutting and Feed Forces for Conventional Milling Process Using Adaptive Neuro Fuzzy Inference System (ANFIS)" *KanhuCharan Nayak, Rajesh Kumar Tripathy, Sudha Rani Panda, Shiba Narayan Sahoo.*
9. Twardowski, P., Wojciechowski, S., Wieczorowski, M., Mathia, T. (2011). Surface roughness analysis of hardened steel after high-speed milling. Scanning, vol. 33, no. 5, p. 386-395, DOI:10.1002/sca.20274.
10. "The Effects of Cutting Tool Thermal Conductivity on Tool-Chip Contact Length and Cyclic Chip Formation in Machining with Grooved Tools" A. K. Balaji', G. Sreeram', I. S. Jawahir' (21, E. LenP (1).

## Figures

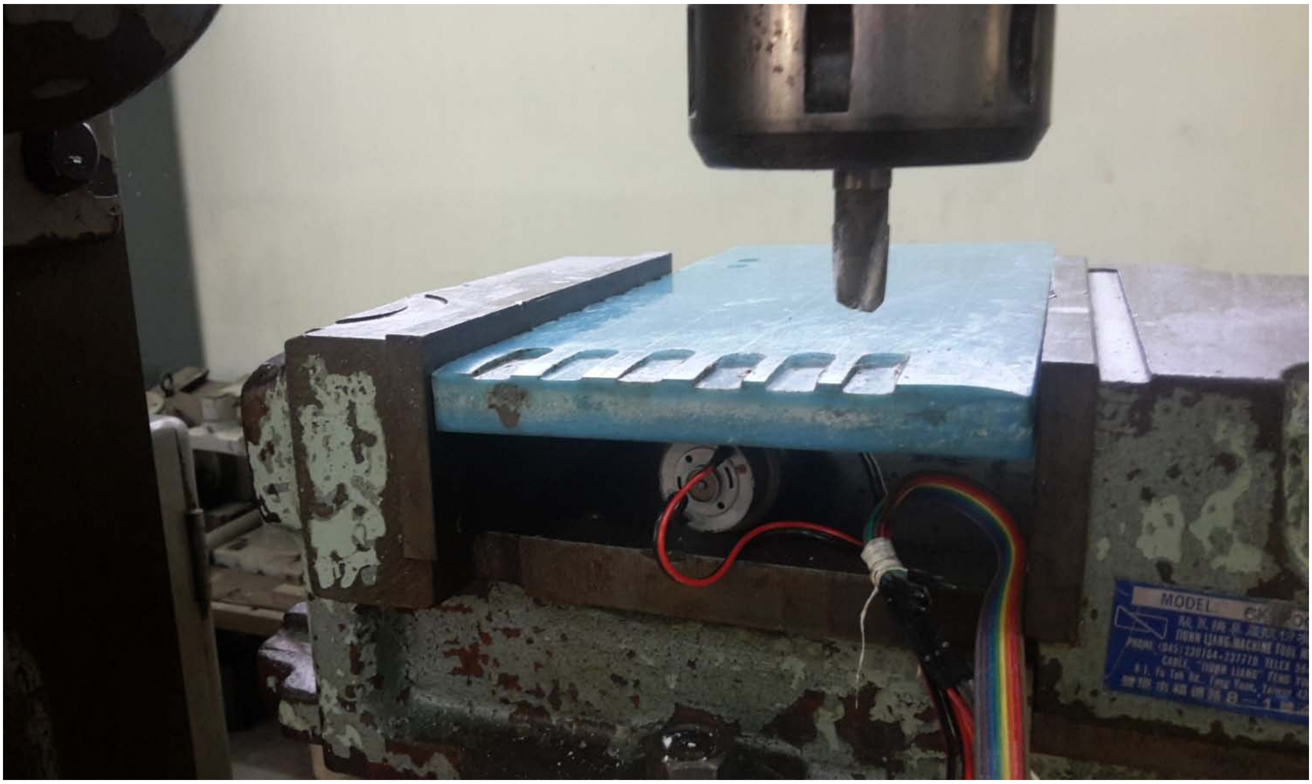



*Fig. 1:* Vibration device attached to the work piece

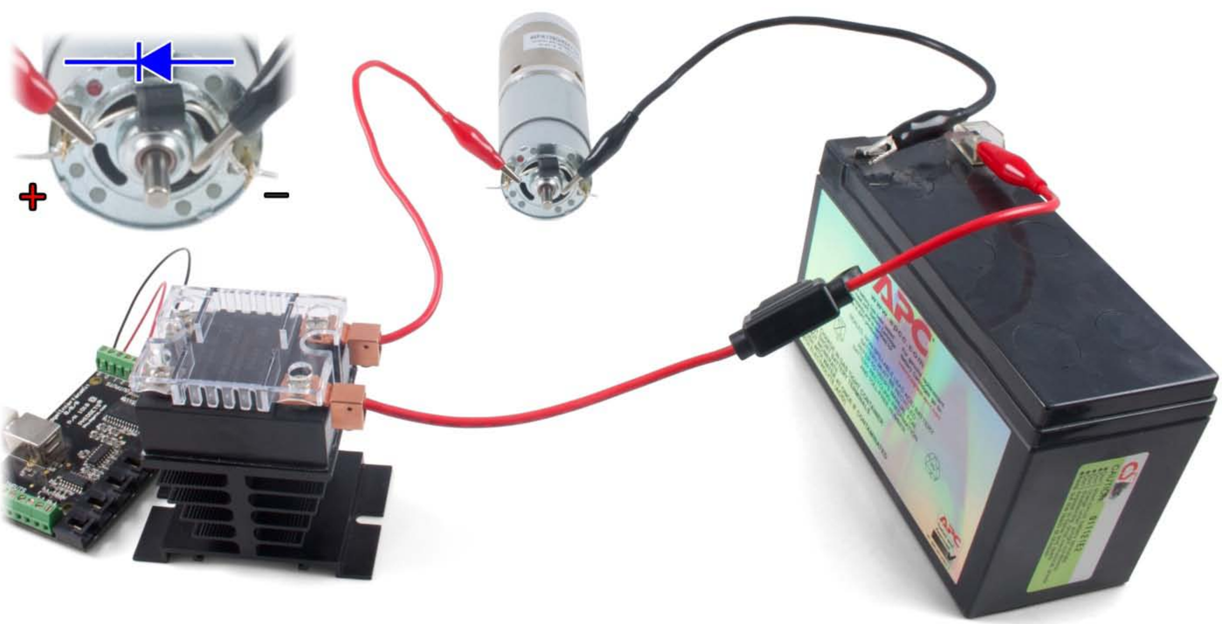



*Fig. 2:* Vibration device connected to the battery

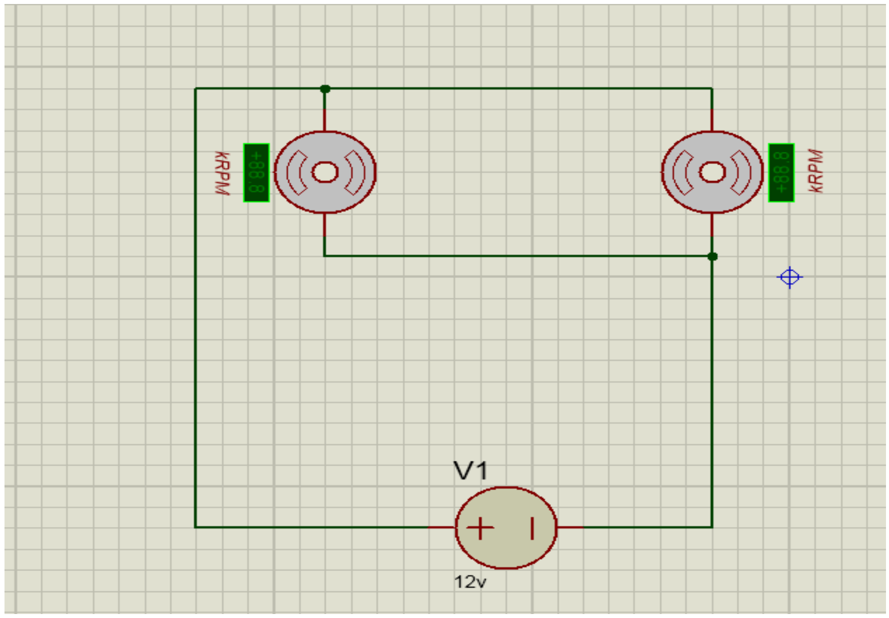



*Fig. 3:* Circuit Diagram, Applying voltage

*Fig. 4:* Surface roughness tester instrument


*Fig. 5:* Experimental setup of measuring surface roughness

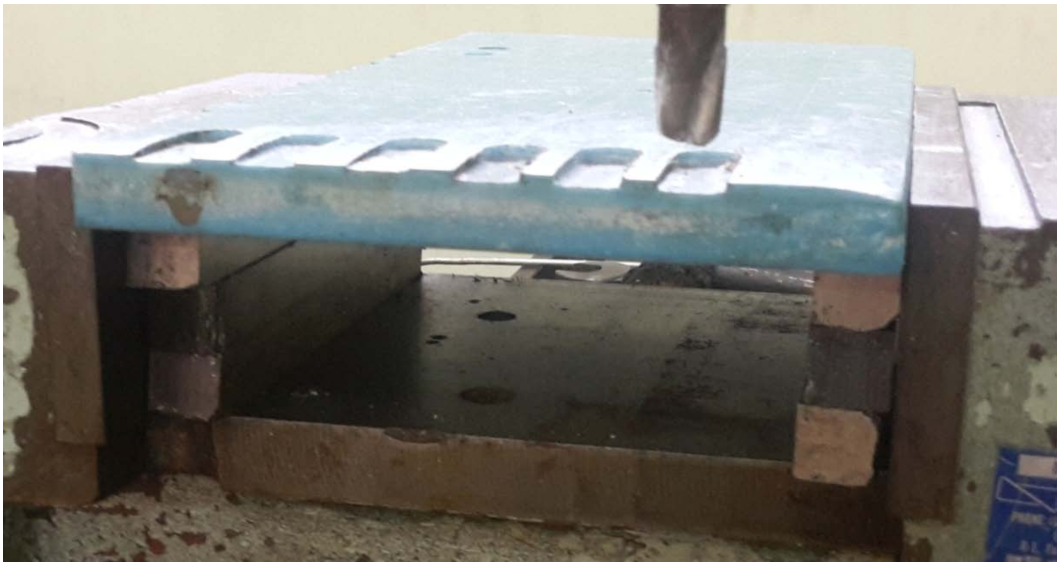


*Fig. 6:* Conventional Milling Process

*Data tables:*

The results obtained during this research are as follows;

*Data Table 1*

| Observation | RPM | Feed rate (mm/min) | Depth of cut (mm) | Surface roughness with vibration (µm) | Surface roughness without vibration (µm) |
|---|---|---|---|---|---|
| 1 | 403 | 48 | 2 | 3.361 | 4.139 |
| 2 | 538 | 48 | 2 | 3.514 | 5.735 |
| 3 | 792 | 48 | 2 | 3.960 | 5.887 |

Cutter diameter =12 mm, Material used = Glass fiber

*Data Table 2*

| Observations | Rpm | Feed rate (mm/min) | Depth of cut (mm) | Surface roughness with vibration (µm) | Surface roughness without vibration (µm) |
|---|---|---|---|---|---|
| 1 | 197 | 26 | 2 | 2.781 | 2.959 |
| 2 | 197 | 35 | 2 | 2.389 | 2.538 |

Cutter diameter = 20 mm, Material used = Glass fiber

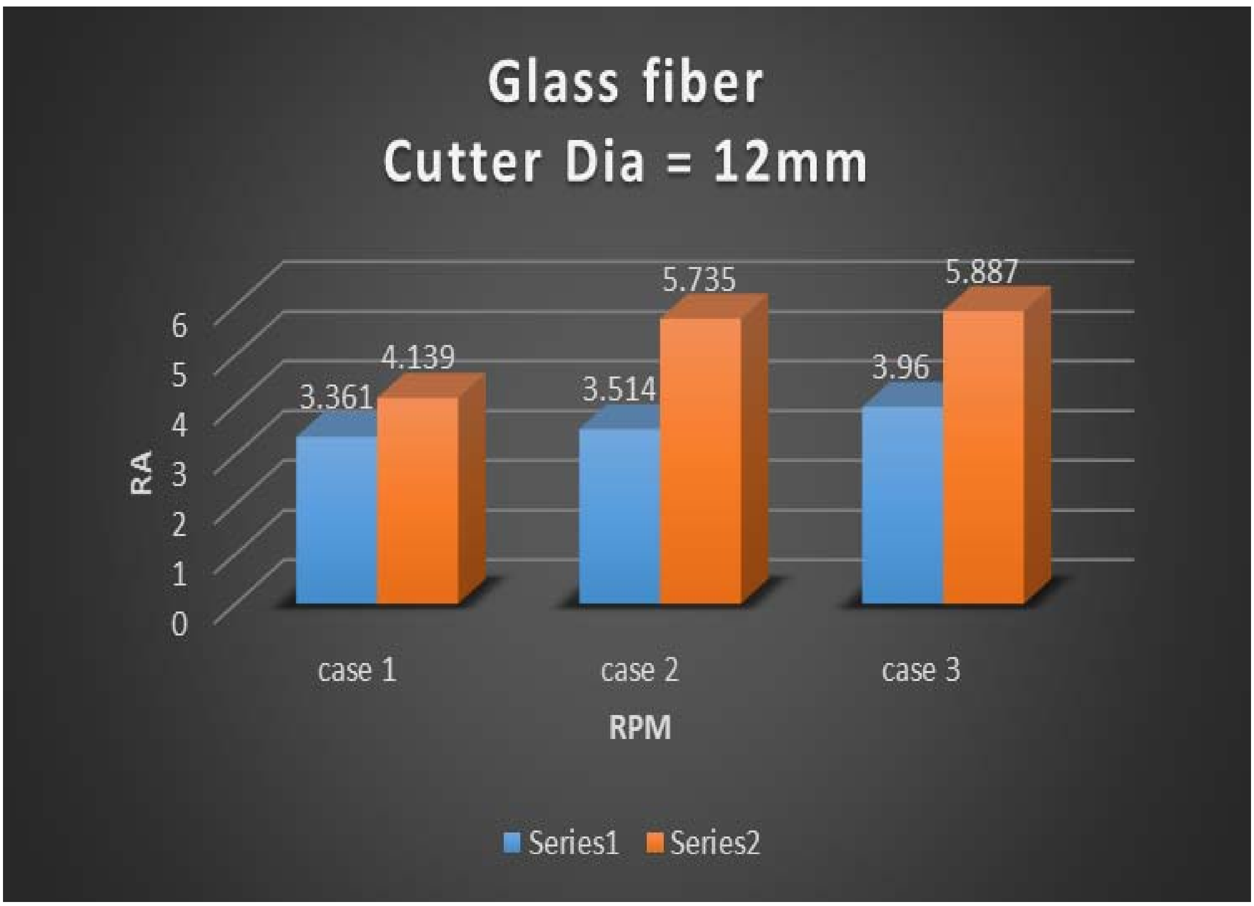
*Data Table 3*

| Observations | RPM | Feed Rate (mm/min) | Depth of cut (mm) | Surface roughness with vibration (µm) | Surface roughness without vibration (µm) |
|---|---|---|---|---|---|
| 1 | 403 | 48 | 2 | 2.871 | 4.041 |
| 2 | 538 | 48 | 2 | 4.091 | 4.221 |
| 3 | 792 | 48 | 2 | 3.546 | 4.481 |

Cutter diameter = 12mm, Material = Mild steel

*BAR CHARTS*

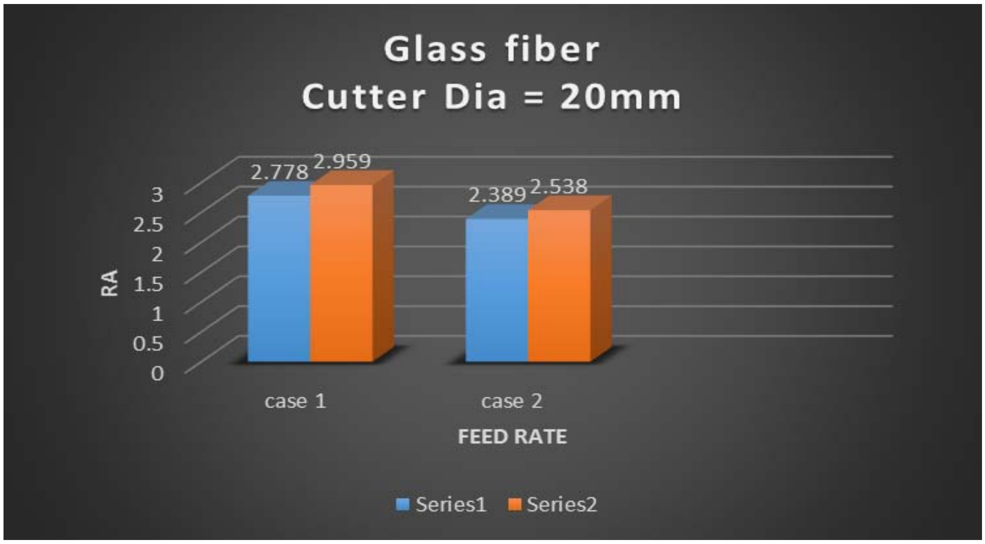
*Bar chart 1:*




Glass fiber, cutter diameter 12mm
Case1 =403 rpm
Case2=538 rpm
Case3=792 rpm

Blue bar represent the surface roughness of glass fiber that obtained through vibration assisted milling process and the orange bar represent the surface roughness of glass fiber that obtained through conventional milling process.

*Bar chart 2:*




Cutter diameter =20mm, Material = Glass fiber

Case1=26mm/min
Case2=35mm/min

Blue bar represent the surface roughness of glass fiber that obtained through vibration assisted milling process and the orange bar represent the surface roughness of glass fiber that obtained through conventional milling process.

*Bar Chart 3:*


Cutter diameter=12mm, Material=Mild steel

Case1 =403 rpm
Case2=538 rpm
Case3=792 rpm

Blue bar represent the surface roughness of glass fiber that obtained through vibration assisted milling process and the orange bar represent the surface roughness of glass fiber that obtained through conventional milling process.