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Investigation of surface roughness on fiber reinforced composite using abrasive water jet machining

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Abstract—The main objective of this work is to investigate the surface roughness on fiber reinforced silicon carbide nano composite using abrasive water jet machining. Epoxy resin, glass fibres and silicon carbide (nano particles) in varying percentage is used to fabricate the composite laminates. Obtaining different composites of varying nano particle, it is machined through abrasive water jet machining, to check the surface roughness in the machined edges and sides. Using surface roughness tester surface roughness value has been calculated.The surface were analyzed using scanning electron microscope (SEM)

Keywords: Epoxy Resin, Glass Fiber, Surface Roughness, Abrasive water jet machining, Scanning Electron Microscope.

I. INTRODUCTION

Composites are one of the most widely used materials because of their adaptability to different situations and the relative ease of combination with other materials to serve specific purposes and exhibit desirable properties. Fiber reinforced polymer (FRP) composites are increasingly being used in a large number of applications because of its higher advantages they offer compared to materials. The advantages FRPs offer compared to other materials are well experienced and include high strength to weight ratio, high modulus, high fracture toughness, and corrosion and thermal resistance. In addition to these advantages, the relative ease of manufacture of components using FRPs, thus low cost of production, makes these materials candidates for more and more applications.[1] Abrasive water jet machining (AWJM) is an emerging machining process and also a traditional machining in which the material removal takes place due to abrasion. A stream of abrasive particles mixed with water is subjected to the surface of the with high velocity. Epoxies are best known for their excellent adhesion, chemical and heat resistance, mechanical properties, and outstanding electrical insulating properties [2]. Epoxies are more expensive than polyesters, and cure times are longer, but their extended range of properties can make them the cost/performance choice for critical applications.

II. EXPERIMENTAL PROCEDURE

A. Material fabrication

Matrix Material	Epoxy Resin Ly 556
Reinforcement	Glass Fiber (WRM And CSM)
Nano Filler	Silicon Carbide (0,1,2,3 wt %)

The entire process is carried out by hand layup technique. Epoxy resin (LY556) with hardener HY951 as the matrix phase and glass fiber of woven roving mat and chopped strand mat as reinforcement phase. In addition to this two phases, silicon carbide in varying percentages is used as Nano particles. In order to improve the strength of the composite, Silicon carbide is mixed with the matrix phase. Silicon carbide (sic) is mixedwith epoxy resin as a first step in the material preparation process. The mixture is stirred for 120 minutes at 800 rpm using high speed mechanical stirrer.
The mould of galvanized iron of dimensions (320x320 mm^2) was used as mold for fabrication work. Then poly vinyl alcohol (PVA) is applied on the mould, which act as a releasing agent. Chopped strand mat and woven roving mat are laid alternatively for about six layers with the binder mixture in between each layer. Roller helps in laying the fibers uniformly and removes the air bubbles in the resin, and it also helps us in giving homogenousmaterial.

Fig.1 Fabrication process

Then the laminates are given a setting time for about 48 hours. The laminates where separated from the mould after the resin is set. Four samples were prepared with varying percentages in silicon carbon(nano particles) 0, 1,2and 3wt% for the testing and analyzing purposes.

Fig.2 Finished and cut samples having (a) 0, (b) 1, (c) 2 and (d) 3 wt% of Silicon carbide.

B. *Analysis of material*

SEM test is carried out to get a detailed view of compositional dispersion of the materials added to the sample. The surface fractures and flaws in materials are analyzed in detail. A small part of the material fabricated is cut as specimen to carry out the test.

Fig.3 Scanning Electron Microscope

The SEM test was carried out in Annamalai University, inCentralized Instrumentation and Service Laboratory (CISL).

The details about the scanning electron microscope are as follows:

Magnification: X18 to 3 00 000
Accelerating Voltage: 0.5 KV to 30 KV
Max. Specimen Size: 32mm diameter x 10 mm.

The scanning electron gives us the detailed description regarding the material bonding between epoxy resin, fiber and nano fillers. It also gives the information regarding the distribution of silicon carbon within the matrix and reinforcement phase.

C. *Abrasive water jet machining*

Abrasive water jet machining is non conventional machining process. Machining of composite materials is difficult due to the heterogeneity and heat sensitivity of the material and the high abrasiveness of the reinforcing fibers. This results in damage being introduced into the work piece and very high tool wear, and so AWJM is used to machine our composite, as it is also advantageous in many aspects.[3].A pressure of 3800 bar is given to water through a nozzle diameter of 1.1 mm, and a standoff distance of 2mm. The traverse speed is 1800mm/min.
The abrasive used isgarnetic 80 mesh, at a mass flow rate of 600 mg /min.

Fig.4AWJM (specimen cutting)

III. RESULT AND DISCUSSION

1. Effect of AWJM:

As this project depicts that the test is based on surface roughness of the material after the machining, the material is tested and analyzed for its nature after AWM is done. The cut edges of material are smooth, when it is compared to the cutting with axe blade or milling machine cutter. As it is a water cutting process, at a high pressure, chances are there for water to enter the laminates incase of improper fabrication or binding. It is a major disadvantage as there are chances of material delamination and damage.

2. SURFACE ROUGHNESS TEST

After machining is done the specimen is taken for surface roughness test. The result analyzed is that the roughness is said to increasewith increase in nano composite.[4]

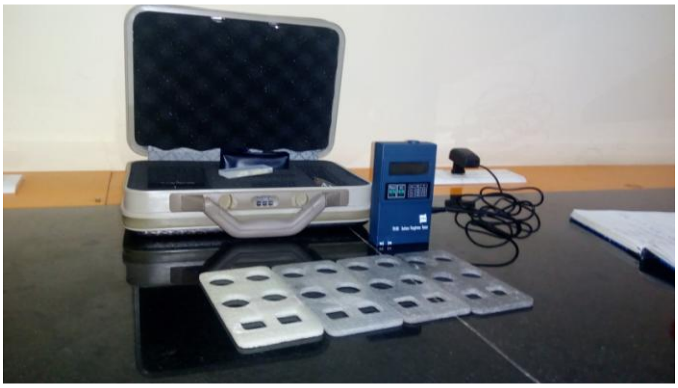

Fig.5(surface roughness tester)

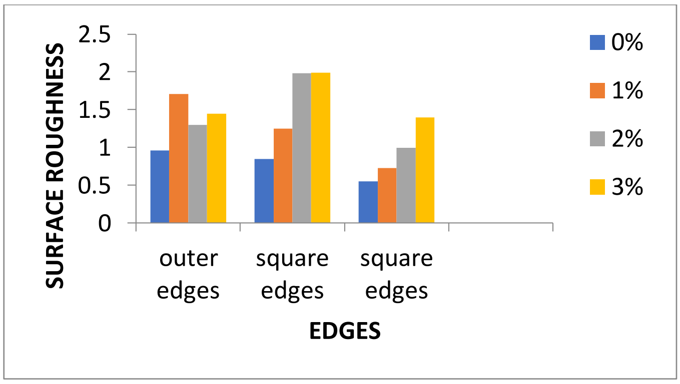

Fig. 6 Surface roughness of Nano composites

The above graph indicates the changes in surface roughness of the material. The surface roughness is measured in surface roughness tester at various edges of the material. The analyzes is done in between the percentage variations in of nano particles and the machined edges. As the percentage of nano particles increases the roughness level also increased. At neat sample(0 wt %), the roughness level in the normal surface, as well as in the machined surface through AWJM is quite smooth, that is the roughness is less. At 1wt %, the roughness is quite increased atnormal and alsoin machined surface. At all type of cuts, the roughness variations are less, and the major changes takes place in the type of machining and the nano particles weight percentage.

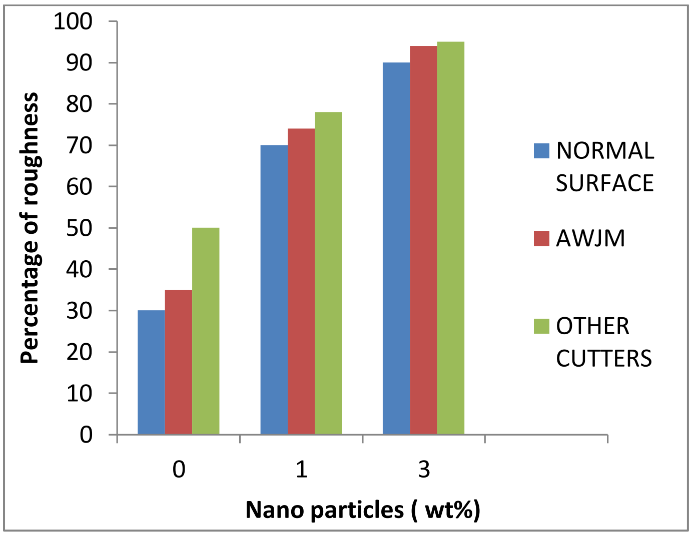

Fig.7 Nanocomposites vs percentage of roughness

In the above graph, it's clearly evident that surface roughness is low when compared to other machining process. The analyzes thus proves that the AWJM gives a better surface finish than other machining processes.

IV .CONCLUSION

- The nanocomposites sampleswere successful prepared by hand lay-up techniques by varying wt % of silicon carbide.
- The SEMimage shows that the nanoparticles are uniformly dispersed within the matrix material.
- AWJM is a effective cutting process for fiber composites which gives a good surface finish compared to other cutting processes, and it is also economically worthwhile.
- This machined composite sample can be used forelectronic,MEMS devices and automobiles applications.

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