Mechanical Properties of Titanium Carbide Powder Filled Epoxy Composites

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ABSTRACT

The epoxy matrix composites have gained great importance in last few decades. The powder Titanium dioxide is considered to be a good due to excellent properties as potential reinforcement of composite materials. In this work, TiO_2 with 10 micron size were selected and its mechanical and morphological properties were evaluated. The samples were prepared by hand layup technique. The Mechanical were evaluated. From the test results, it was observed that the mechanical properties were improved with increasing filler powder. SEM images show good dispersion and adhesion of matrix and reinforcement

Keywords—*epoxy, powder, composites*

I.INTRODUCTION

Composites are found increasing usage in the areas of in aeronautic, automotive and marine because their preparation is simple. Also they possess very high strength to weight ratio.The performance of machines can be significantly increased by using polymer matrix composites. The main point in reducing weight is to increase in fuel economy. The machine can made lighter in order to make the low fuel consume low, and their performace of the engine is improved by the same amount of fuel. Thereby making their use more cost effective. Also composites are used manufacturing large roller blades, sleeve bearings and bushes, etc, in industries to optimize the performance. The nature of composites produced are not easily attainable in regular materials. Since the matrix and reinforcement members are easily available, their applications are extremely viable. Polymers and ceramics are generally in demand because of their better mechanical properties .It is known that the polymer has smaller strength. This can be overcome by utilizing polymers embedded with filler material. Incorporation of metallic powder increases the mechanical property of the composite but it is found that weight of the composite material may also increases more than required.

II. EXPERIMENTAL DETAILS

2.1 Materials

The composites were made by hand lay-up technique. According to the standard weight percentage of composites materials, the weight fraction of epoxy and filler materials were taken. The composites were allowed to cure for 24 hours in Owen so that the excess matrix material could run out. The specimens were then taken and using wire cutting the samples were taken for mechanical test

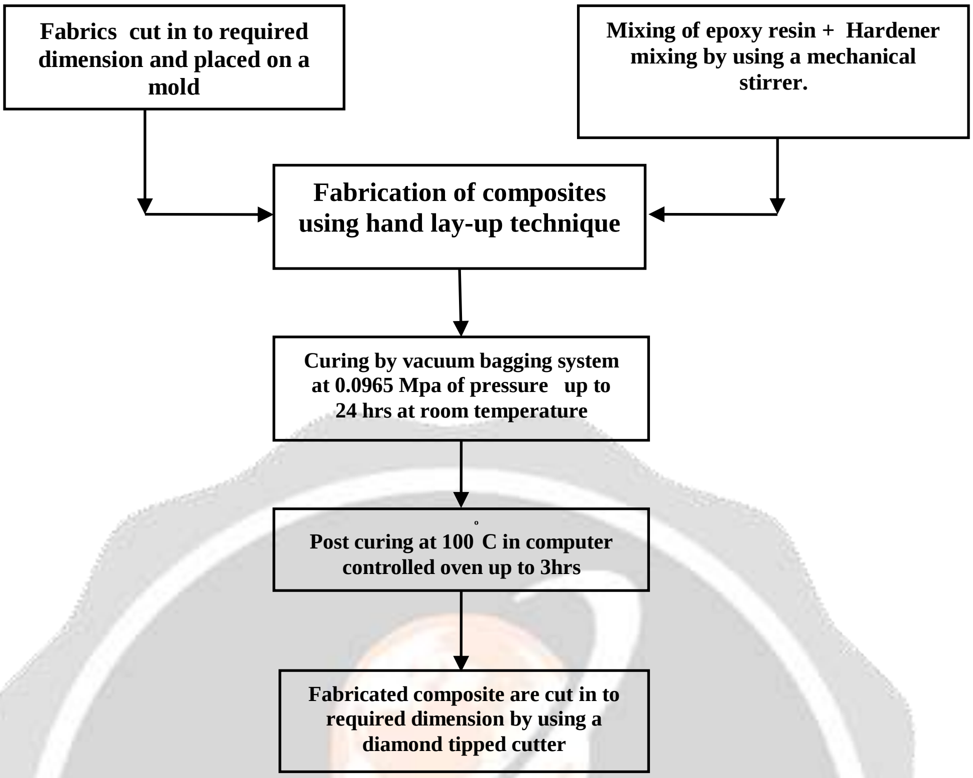

Fig. 3.3. Typical flow chart of fabrication and processing methodology of composites

III.OBJECTIVE OF THE PROJECT WORK

For the successful design of a composite material from basalt fiber as reinforcement, primarily the basic mechanical tests such as tensile strength and flexure strength have to be conducted. The application of these very high quality fibers has already been started as reinforcement in both thermoplastic and thermoset matrix composites. Due to the high abrasive wear resistance of basalt, basalt fibers may be considered as a future alternative reinforcement for wear resistance composites. Among the commercially available epoxy resin they has been chosen because they found wide industrial application based on FRP materials.

1. To fabricate basalt fabric reinforced composites with epoxy resin.
2. To check for the mechanical properties of the reinforced basalt fibre.
3. To check for the abrasive wear resistance of the reinforced composite

3.1 Specimen preparations

The laminate used in this study was fabricated by dry hand lay-up technique. E-glass plain weave roving fabric, which is compatible to araldite LY 556 epoxy resin, is used as reinforcement. The matrix was prepared by mixing epoxy resin, LY 556 and hardener HT 972 in the ratio 100:10 by weight at curing temperatures ranging from 80 to180^{0}C. Graphite particulate fillers are dried in controlled temperature of 200^{0}C for about 2 hrs before incorporation into epoxy. The calculated amount of graphite particulate filler is incorporated to the epoxy mixture with constant stirring followed by 3 % by weight. The stacking procedure consists of placing the fabric one above the other with the resin mix, well spread between the fabrics. The whole assembly is pressed in a hydraulic press and allowed to cure under vacuum for 24 h at room temperature. Post curing was done at 120^{0}C for 4 h using an electrical oven. The laminate so prepared had a size 300 x 150 x 2 mm. Finally from the composite laminate prepared, according to ASTM standards, the composite laminate plate will be cut by using the diamond coating knife to get the test specimen depending on the kinds of experiments to de performed. To avoid stress concentration, before the experiment, Aluminum plates with edges angled at 60^0 were attached with epoxy adhesive on both ends of all composites. The gauge length of the composite specimens was 50 mm. Fig.3 shows the all test specimens ‘dimensions.

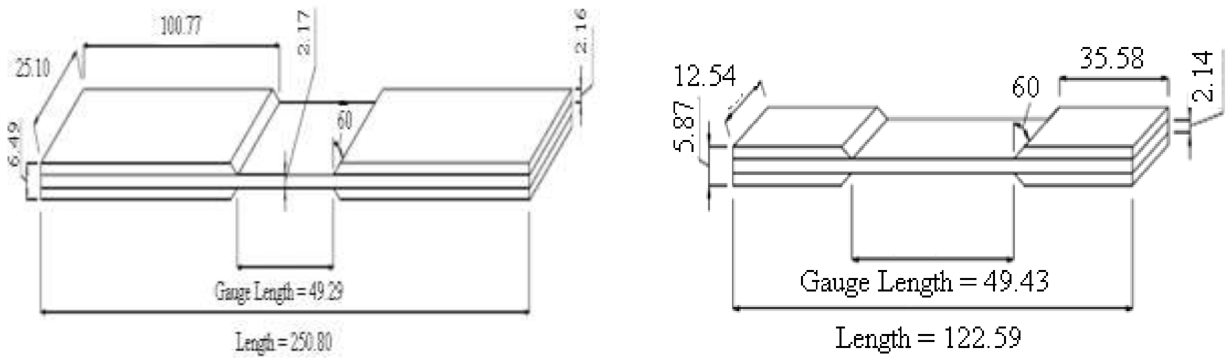

Figure 3. (a) Dimensions of tensile test specimen (b) Dimensions of compression test specimen

3.2 Testing procedure

Mechanical test is performed in order to compare the mechanical properties as well as the failure resistance properties of glass/epoxy laminates with and with out graphite particulate filler made from ASTM D 3039.

3.2.1 Electronic type universal testing machine

There are many types of testing machines. The most common are universal testing machines, which test materials in tensile, compression or bending.

Principal of Operation

Operation of the machines is by hydraulic transmission of load from the test specimen to a separately housed load indicator. The hydraulic system is ideal since it replaces transmission of load through levers and knife edges, which are prone to wear and damage due to shock on rupture of test pieces. Load is applied by a hydrostatically lubricated ram. Main cylinder pressure is transmitted to the cylinder of the pendulum dynamometer system housed in the control panel. The cylinder of the dynamometer is also of self-lubricating design. The load transmitted to the cylinder of the dynamometer is transferred through a lever system to a pendulum. Displacement of the pendulum actuates the rack and pinion mechanism which operates the load indicator pointer and the autographic recorder. The deflections of the pendulum represent the absolute load applied on the test specimen. Return movement of the pendulum is effectively damped to absorb energy in the event of sudden breakage of a specimen.

Tensile tests were performed using fuel instruments & engineers pvt.ltd.(FIE) universal testing machine. The standard specimen specified in ASTM D 3039 was specimen that has 2.17 mm thickness with 250.80 mm length and 25.10 mm width .The specimens were tested at 8mm/min rate. The tensile strength was calculated from the stress- strain curve. A load-cell with a capacity of 600kN was used to monitor the applied load. The fracture surfaces of the composites were obtained from the tensile test specimen. Tensile test specimens were examined using scanning electron microscopy (SEM). Fig.4 shows the electronic type universal testing machine with data acquisition system.

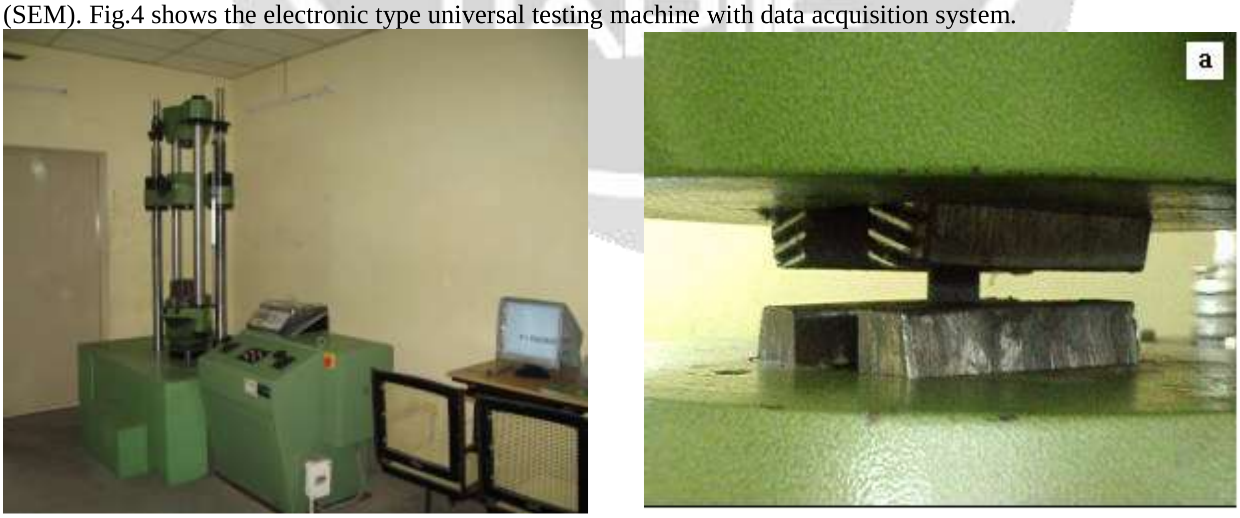

Figure 4. Hydraulic universal testing machine with data acquisition system and machine set up of figure (a).

Figure 5. Tensile test specimen before and after tensile testing.

Figure 6. Compression test specimen before and after compression testing.

4. RESULTS AND DISCUSSION

4.1. Tensile properties

The tensile test results are summarized in Table 1 a typical stress–strain plot is presented in Fig. 7(a) of glass/epoxy laminate Point 'A' indicates the tensile strength. The specimen was separated into two parts during loading at a strain as indicated by point 'A'. The strain corresponding to point 'A' is 0.18 (mm/mm). A typical stress–strain plot is presented in Fig.7 (b) of glass/epoxy laminate with titanium carbide powder. Point 'A' indicates the tensile strength. The specimen was separated into two parts during loading at a strain as indicated by point' A'. The strain corresponding to point 'A' is 0.1644 (mm/mm). The failure was observed at the gauge section.

Table 1.Results of tensile test

Parameters	glass/epoxy laminate	glass/epoxy laminate with titanium carbide powder
Thickness mm	2.79	2.17
Width mm	25	25.10
CSA mm^2	69.75	54.47
Tensile load KN	19.86	17.22
Tensile strength Mpa	284.73	316
IGL mm	50	49.26
FGL mm	55.98	52.58
% of elongation	11.96	6.74

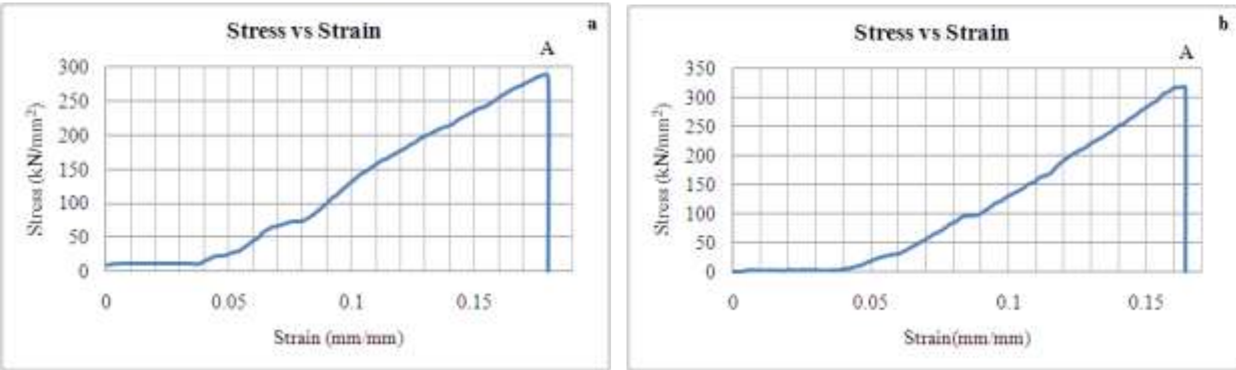

Figure 7. Stress-strain diagrams of (a) glass/epoxy laminate and (b) glass/epoxy laminate with titanium carbide powder.

4.2 Compression properties

Table 2 shows results of compression test of glass/epoxy laminates with and without titanium carbide powder.

Table 2.Results of compression test

Parameters	glass/epoxy laminate	glass/epoxy laminate with titanium carbide powder
Thickness mm	2.14	2.43
Width mm	12.54	12.45
CSA mm^2	26.84	30.25
Compression load KN	1.29	4.35
Compression strength Mpa	48	143.80

Typical compression load – displacement curves for glass/epoxy laminates with and without titanium carbide powder is shown in Fig.8. The curves represent a progression of performance increasingly resistant to deformation. The experiment was performed under quasi-static compressive loading for glass-epoxy laminate up to final fracture. It has been observed that the laminated plate bent globally until complete fracture occurred as expected. Fig.4 shows the final deformed and damaged shape of the plate after the compression test. Fig.8 (a). show the comparison of load versus displacement curve for the glass-epoxy laminate plate, with different angle orientations. It is interesting to note that the laminate perform in a similar fashion whereby their behavior is almost linear before reaching the peak load. On the other hand, beyond that peak points of the load ‑ displacement curves majority of the laminate experienced large displacements before fracture, which proved that these bi-woven laminates are able to absorb large amounts of energy before fracture. Table 2 summarizes the ultimate load and compression strength for the laminate size. The results have revealed that fiber orientation directly affects the distribution of load between the fibers and the matrix. Characteristic compressive load – displacement curves for glass/epoxy laminates with basalt powder is shown in Fig. 8(b). The curves represent a progression of behavior gradually more resistant to deformation. The experiment was performed under quasi-static compressive loading for glass-epoxy laminate up to ultimate fracture. It has been observed that the laminated plate twisted globally until complete fracture occurred as expected.

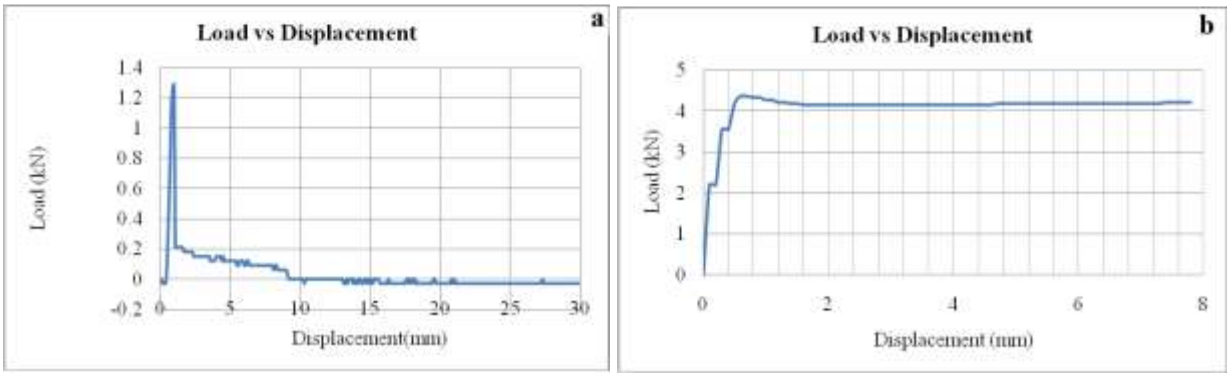

Figure 8. Stress-strain diagrams of (a) glass/epoxy laminate and (b) glass/epoxy laminate with titanium carbide powder.

4. CONCLUSIONS

- Mechanical experiment was conducted on glass/epoxy laminates with and without graphite particulate filler up to failure.
- The addition of the graphite particulate filler led to the improvement of the mechanical strength of the glass/epoxy laminates with filler.
- Break surfaces were observed by scanning electron microscopy. SEM micrograph displaying possible failure modes in the tensile laminate was fiber pullout and fiber breakings from the bi-woven.
- Two modes of fiber breakage were observed in the failed samples of compression laminate one of them was from the fiber kinking; another example of fiber breakage appeared to be a brittle fracture. The fracture surface show a lot of hackles in the epoxy matrix, various fiber/matrix debonds, and broken fiber.

5.REFERENCES

The template will number citations consecutively within brackets [1]. The sentence punctuation follows the bracket [2]. Refer simply to the reference number, as in [3]—do not use "Ref. [3]" or "reference [3]" except at the beginning of a sentence: "Reference [3] was the first . . ."

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