# Mechanical Properties Of Composite Materials Reinforced With Short Random Glass Fibers And Ceramics Particles

**Ismail Ibrahim Marhoon**

**Abstract:** In this research, Epoxy matrix composites reinforced with short random glass fibers and $TiO_2$ particles with different weight fractions (3, 6, and 9 %wt.) were prepared and then the mechanical testing were measured by tensile, impact, and hardness. The results showed the mechanical properties improve with increasing weight fraction. The impact energy of hybrid composite is better than compared with the composite reinforced with glass fiber alone at same weight fractions.

**Keywords:** Epoxy, Polymer composite, Weight fraction, Titania Particle, Short fibers, Mechanical properties, Tensile strength..

## 1. INTRODUCTION

Polymer Matrix Composites (PMCs) like (Glass Fiber Reinforced Polymer Composites, GFRP) is widely used in various engineering application, because of the following advantages: The Polymer Matrix Composites is easy to manufacture and does not require expensive tools, so that it is considered to be low cost. Its density is low, that it has strength to weight ratio, leading to widely using in the space application [1]. Because of the widely using of the Polymer Matrix Composites, it needs to add materials. These materials are either Fillers or Reinforcements, depending on the additive effectiveness on the mechanical properties of the final product. Fillers are used mainly to reduce the cost of the final product, while the Reinforcements are used to improve the mechanical properties of the final product [2]. Examples of the additive Reinforcements are $CaCO_3$, $AL_2O_3$, SiC, which work on improving the mechanical properties of the final product such as hardness, decrepitude and crawl in addition to improving the thermal properties [3, 4]. Polymer matrix composites reinforced with the above-mentioned materials is using in many applications such as manufacturing cars and mechanical and electrical tools [5]. In 2004, the researcher (Qi Zhang et.al.) studied properties of the Polymer Matrix Composites reinforced by powders, the researcher and his colleagues used different kinds of powders, like Magnesium hydroxide and Aluminum hydroxide with a different granular sizes to reinforced the rubber, they found that the mechanical properties (stress and elongation resistance) are improving when reducing the granular size [6]. In 2006 the researcher (Edcleide M. Arraujo et.al.) studied the mechanical properties of Polymer Matrix Composites Reinforced by glass fibers with a reinforcing ratio (20, 30, 40, 50, 60 wt %), and compared them by those reinforced by damaged glass fiber with the same reinforcing ratio. The researchers found that it is possible to reinforce the polyester by damaged glass fibers, especially after it gave the poly matrix a high impact resistance [7].

In 2008 the researcher (Osama Asi) studied the effectiveness of adding alumina particles (10% wt) on the mechanical properties of matrix composites with an epoxy basis Reinforced by Glass Fibers. The researcher showed that bending resistance and bending coefficient are increasing respectively by 33% and 78% when adding alumina particles compared to the matrix composites not reinforced by the alumina particles [8]. In 2009, the researcher (Urmimala Maitria et.al.) studied the mechanical properties of the polymer matrix composites reinforced by diamond powder, they used polyvinyl alcohol as a base material, and diamond powder as a reinforced material with a weight fraction (0.6 % wt). The researchers found that hardness and flexibility coefficient for the Polymer Matrix improved when reinforcing by diamond powder [1]. The current research aims to study the effectiveness of adding titania on the manner of matrix composites with a basis of Epoxy reinforced by parts of glass fibers with a different weight fraction (3, 6, 9 %wt), its manner in the mechanical tests such as, bending and impact tests, and to compare its manner with the matrix composites with a basis of Epoxy reinforced by glass fibers in a singular way with the same weight fraction mentioned above.

## 2. EXPERIMENTAL

### 2.1 Materials

Epoxy resin Quickmast 105 manufactured by Jorden Company as a base material, which is in a form of sticky and transparent at room temperature, it is one of the types of thermosetting Polymers, which turns from the liquid state to solid state by adding the hardener manufactured by the same above mentioned company. The hardener, which in a form of a transparent liquid added to the Epoxy resin with (1 part) per (3 part) of the resin at room temperature. Table (1) shows the properties of Epoxy used in research according to the specifications of manufactured company

- *Ismail Ibrahim Marhoon, lecturer In Materials Engineering Department, College of Engineering, Mustansiriyah University, Baghdad, Iraq. E-mail: isibmr@uomustansiriyah.edu.iq*

***Table 1.*** *The specifications of epoxy used in this research and technical data are specified at 25° C.*

| Properties | Typical Results |
|---|---|
| Flexural Strength | >45 N/mm2 |
| Compressive Strength | >70 N/mm2 |
| Tensile Strength | >25 N/mm2 |
| Young's Modulus | 16 GPa |

Two kinds of reinforcement Materials are used. Glass fibers of (E-glass) in a form of discontinuous fibers with a length (6 mm) are used in this research. Table no. (2) Shows the mechanical and physical properties of glass fibers. Particles In this research they was titania in a form of a fine powder with granular size (<53 µm). The granular size is specified by using Electric Sieves.

***Table 2.*** *Shows some Glass whisker properties.*

| Properties | Typical Results |
|---|---|
| Tensile Strength | 520 MPa |
| Modulus of Elasticity | 75 GPa |
| Elongation at Break | 4.8 % |
| Shear Modulus | 30 GPa |
| Thermal Conductivity | 1.35 W/m.K |
| Max. Service Temp. | 630°C |

### 2.2 Composite preparation

A mold with a base and sides made by glass is make. The sides are moving and connected to the base by stabilizers. The dimensions of the used mold are (250×250×5 mm). Figure (1) Shows the glass mold that made which is used in preparation the samples of research. The way used is the manual (Hand-lay-up moulding) in manufacturing the samples of research. That concludes to samples of Epoxy reinforced by cutting parts glass fibers with a (three) weight fractions (3, 6, 9, % wt), it made by mixing the Epoxy with the hardener with a rate (1 part) hardener per (3parts) of resin. The mixing is made by adding the cutting parts of glass fibers, mixing is continued for (10) minutes until the mixture homogenized. The mixture is pouring in the rubber mold in a form of a stream from one side of the mold to ensure regular and continuous flowing. While the samples of Epoxy reinforced by cutting parts glass fibers and titania particles at the same weight fractions mentioned above, was made by mixing titania particles with resin and hardener and then with chopped glass fibers. Then mixing for (10) minuets, and pouring the mixture in the glass mold.

***Fig. 1*** *Glass Mold*

### 2.3 Tests methods of Composites

Charpy Impact Test is used; that the samples used are with a standard dimensions (80×10×4 mm) without notch according to the universal regulation (ISO-179). Samples of tensile is prepared with a standard dimensions and with a span to depth ratio (5mm) according to the specification of the American standard (ASTM D638 - 14). The method used in hardness test is (Shore D), the sample used in this method is circular with a diameter of (40 mm) and with a depth of (4 mm) according to the specification (ASTM D2240).

## 3. RESULTS AND DISCUSSION

### 3.1 Impact Test

Figures (2) show the effect of changing the weight fraction on the absorbed energy required to the fraction for the Polymer Composites Reinforced by glass fiber and titania particles. The diagram show the absorbed energy required to the fraction increased by increasing the weight fraction in a nonlinear relationship, that due to the reinforcement materials which role as an obstacle in front of the growing crack through the overlapping materials, especially the titania particles, which prevent the growing of crack, and results to change the crack and its direction by turning it to a group of minor cracks. This changing in shape and direction of the crack leads to increase the surface area of the fraction and the outgoing energy. All these resulted to increase the material resistance, this happened better when there is a connect between the base material and the particles as in titania particles and the base material. While in case of that there is less connect, the reinforcement is done with a different technique depending on facing the crack with the weak surface and loss some of its energy in it [9, 10]. It is impossible to make the resins more resistant against the growing of the crack by adding particles of a certain materials [11, 12].

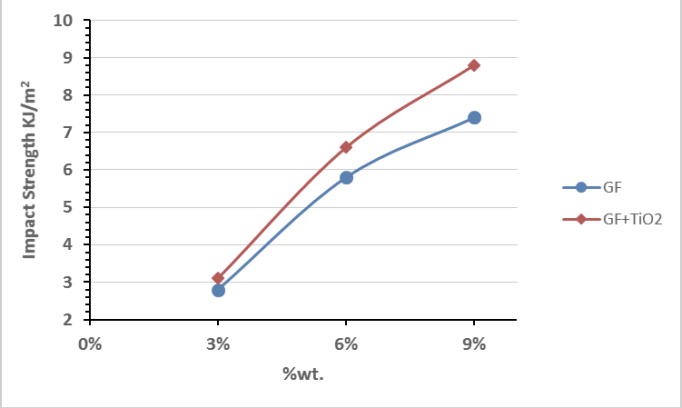


***Fig. 2*** *Effect short random glass fibers and titania particles on impact strength of Epoxy*

### 3.2 Hardness test

Figures (3) show the effect of weight fraction of the added materials on the hardness, we noticed that the hardness increased a little bit by adding the glass fibers in a singular way, which agreed with the researcher (Edcleide M. Araujo) and his colleagues [7] that glass fiber effects on the hardness of polymer matrix composites reinforced by the

glass fibers. In addition, we noticed that the hardness of polymer matrix composites reinforced by the glass fibers with the titania particles increased by increasing the weight fraction. From the aspect of hardness it can be considered as a standard to the deformation of metal that the material can be suffered under the outsider influence. That the adding of particles increases the material hardness because of its resistance to the deformation. Reinforcing the Polymers with some of particles leads to increasing the hardness of the surface and the resistance against plastic deformation. The type of the added particles to the Epoxy has a high effect on the hardness of the final matrix composites, depending on the hardness of the added particles. The hardness of titania particles is high, so that we noticed that the samples reinforced by the glass fibers and the particles of titania is higher than that of short random glass fiber for the weight fractions (3, 6, 9% wt), because that the titania is a ceramic material has a high hardness[13].

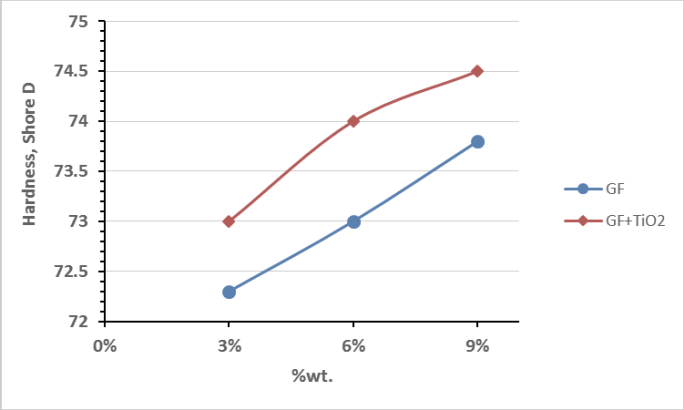


***Fig. 3*** *Effect short random glass fibers and titania particles on hardness of Epoxy*

### 3.3 Tensile Test

Figures (4) represent the effect of the load on the deviation rate for a different weight fractions with a positive relationship. From the figures, it is noticed that the increasing weight fraction of the added materials, leads to rise the tensile strength when the fiber was influenced by a certain load. The samples that reinforced by the glass fibers only with a weight fraction gave a lower tensile strength as compared with the samples reinforced with the glass fiber with the titania particles (means the hybrids) with the same weight fractions gave a higher tensile strength. as example, samples with a weight fractions (6%) the tensile strength when reinforcing by glass fibers is 47 MPa, in another hand when reinforcing by glass fibers with titania is 54 MPa. These show that in the matrix composites reinforced by glass fibers and titania particles, there is an interconnection between the reinforcement and the matrix higher than in that between glass fibers and matrix, because the tensile test is a slow stress allowing the simple crack to interact with the particles,. Also the tensile resistant is highly effected by the connection strength between base and reinforcement [11, 14]

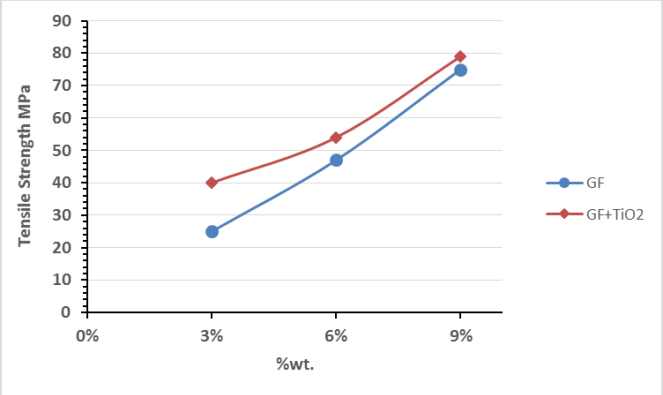


***Fig. 4*** *Effect short random glass fibers and titania particles on tensile strength of Epoxy*

## 4. Conclusions

Adding short and random glass fiber in a singular way and glass fiber with titania particles to the polymer matrix, results to improving the mechanical properties such as: impact, hardness and Tensile. Hardness increases by increasing the weight fraction of polymer matrix composites reinforced by glass fibers and the titania particles for the weight fractions (3, 6, 9% wt), and gave a better results than in glass fiber alone for the same weight fraction. Absorbed energy of the fraction gave a better results for the samples reinforced by glass fiber and titania particles with a weight friction (3, 6, 9% wt) compared to the samples enforced with glass fiber only for the same weight fraction.

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