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Particle Weight Fraction Effect on Bending of Epoxy particle Composite

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ABSTRACT

Epoxy matrix reinforced by particles of silica and alumina with different weight fractions were investigated for mechanical properties such as stress-strain and bending. The filler particles content was varied from 2%, 4%, 6% and 8% by weight of total matrix in the composites were subjected to bending tests. The composites showed improved in bending properties with increase filler content, composite materials have significantly higher modulus of elasticity than the matrix material.

Keywords: epoxy composite, young modulus, bending, stress-strain.

1. INTRODUCTION

Polymer - particle composites have received considerable interest in the materials field because of their potential for large gains in mechanical properties. However, polymers are usually combined with filler materials to improve mechanical, thermal, electrical properties and stability [1].
Epoxy is a thermoset polymers, after curing (the uncured base resins are thermoplastic) have better mechanical properties than most other castable plastics [2]. Epoxies resins may reinforce with organic fillers [3], but it widely reinforced with inorganic particles such as carbon [4], Aluminum-trihydrate [5], Graphite [6]. By inserting the inorganic compounds as fillers, the properties and performances of polymers improve such as enhancing crack resistance, reducing shrinkage, influencing mechanical strength etc, and hence has a lot of applications depending upon the inorganic material present in the polymers.
The size of particles, the interfacial adhesion, the dispersed inorganic filler in polymer matrices, compatibility between filler and matrix phases are important effect on performance of composite [7].
Bending properties are strongly affected by the quality of the interface in composites, i.e. the static adhesion strength as well as the interfacial stiffness, which plays a major role in promoting the filler reinforcement [8]. Bending stress-strain could be used to study the changes induced by addition of filler.
In the present work, materials have been prepared a series of filled epoxy composites with filler loading to study the effect of the filler content on bending.

2. CHRACTERIZATIONS AND MEASUREMENTS

Article foundation used in this research is the epoxy rating type (Quick mast 105) as it is in the form a viscous liquid at room temperature, which is up to (18-30 ^{o}C) turns to solid-state after add hardener to epoxy rating by (2:1) any (2gm) of epoxy is added to (1gm) of hardener.
Then the two types of reinforcement materials (ceramic powder) were used to string the epoxy rating.

- Alumina Al_2O_3
- Silica SiO_2

Molding method was used hand-layup molding in the sample preparation process, as has been prepared:-
1-Sample of epoxy minutes alumina compatible
2 - Sample of the epoxy minutes silica compatible
Where in this process, in addition to strengthening materials epoxy rating and mix with it before intransigence, as silica foam was added to the mix during mixing to prevent deposition of ceramic materials by (1gm) for each sample as is this article.
After the completion of the solidification process for all samples for 24 hours the samples are extracted from the mold is then the process of heat treatment electric oven at a temperature up to (50 ^{o}C) for two hours after the cut samples by special models mechanical tests.

3. RESULTS AND DISCUSSION

Hook's behavior of the material is distinguished by the bending test. The materials were tested by three point test; where the ratio (mass/deflection) is supposed as criteria of material obeys to Hook's law. For epoxy the load to material strain is around unity, which is mean it is obeys linearly Hook's law as shown in figure (1). The (mass/ deflection) ratio for samples reinforced with silica is near unity, this is not for (6 %) sample which gives the highest ratio, samples reinforced with alumina shows increasing in (mass/deflection) ratio than silica samples as shown in figure (2) and figure (3).That indicates the applied stress to material strain is propionate as one to one, i.e. material is behave in Hook's law, material response to load is not equally where material behave is not Hook's.

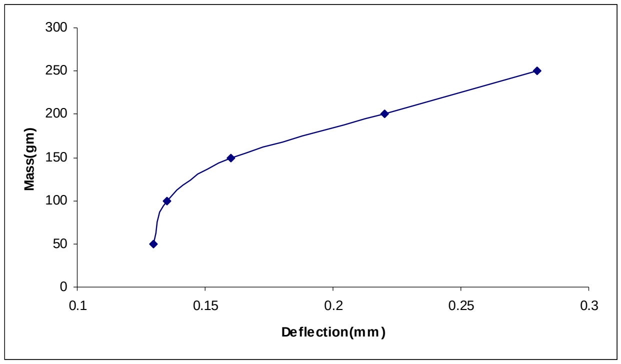

Figure 1 Mass-deflection of epoxy (gram)

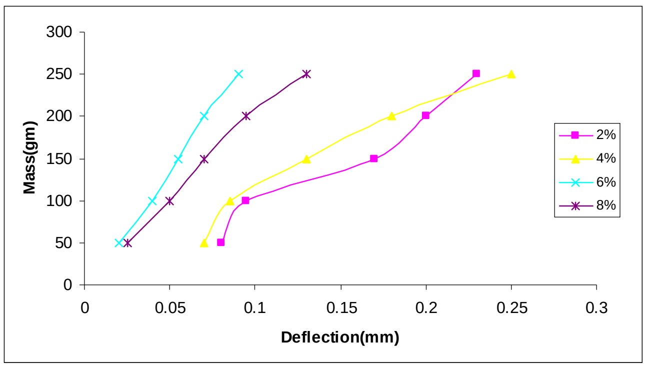

Figure 2 Mass/deflection of epoxy reinforced with silica (gram)

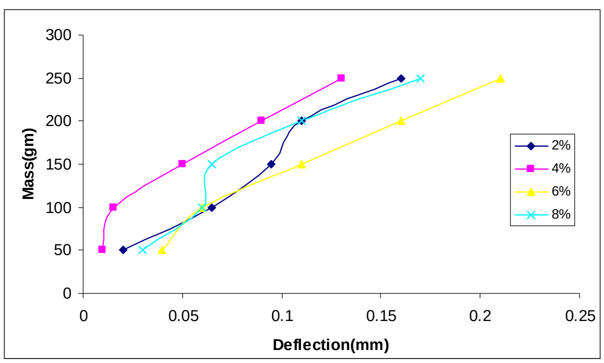

Figure 3 Mass/deflection of epoxy reinforced with alumina (gram)

The stress – strain relationship is defined by Hook's law:

$$\sigma = E\varepsilon \qquad (1)$$

Where σ is stress ($\sigma = F/A$ in Mpa) F: is applied load (in N), and A: is area under test (in mm^2), ε is strain (unitless), and E is Young modulus (Gpa).

Form bending test Young modulus is calculated by equation:

$$E = \frac{gL^3}{4*(bd^3)} x \frac{\Delta M}{\Delta S} \qquad (2)$$

Where: ΔM and ΔS are mass of load (in Kg) and deflection (in mm) respectively and $\frac{\Delta M}{\Delta S}$ is represent the slope of curve variation mass with deflection.

The stress-strain relation is diagrammed for epoxy, epoxy-silica composite, and epoxy-alumina composite as illustrated in figures (4), (5), and (6). Materials shows elasticity range behaves, that is compatible with (mass/deflection) ratio criteria.

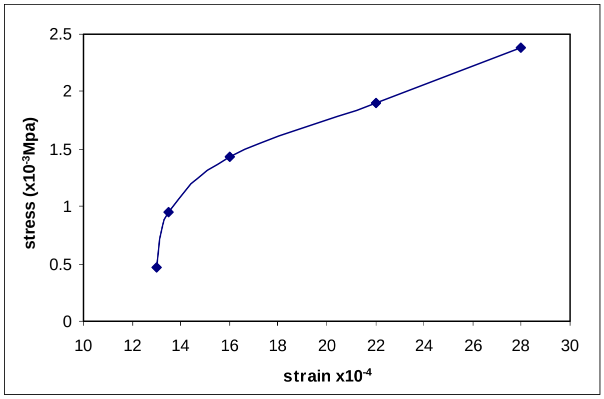

Figure 4 Stress-strain relation of epoxy (MPa)

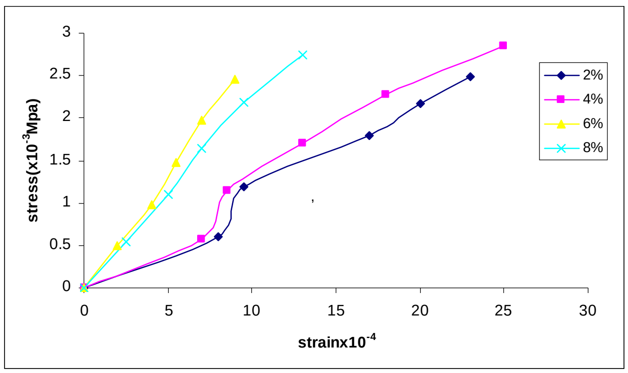

Figure 5 Stress-strain relation of epoxy/silica (MPa)

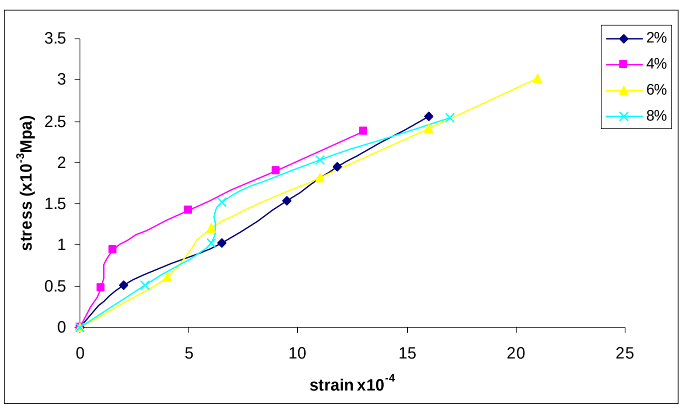

Figure 6 Stress-strain relation of epoxy/alumina (MPa)

Young modulus (the modulus elasticity), were determined for epoxy composite of silica filler and alumina filler. Generally Young modulus gained increasing with concentration for both fillers. Samples with Silica filler show increasing in elasticity with filler weight and providing maximum elasticity at 6% filler weight, and alumina addition gives maximum Young modulus at 4% , where elasticity give seldom decreasing with filler weight as given in figure (7) and figure (8). Table (1) provides the Young modulus for particles reinforced epoxy matrix composites. It is observed that the modulus increases as the filler concentration increases because of absence of voids in the composite, good mixing of the filler in the matrix, the decreasing is due to decreased availability of epoxy material to bond all the filler particles in the matrix.

Table 1: Young modulus of materials

Material	Filler Weight	Young Modulus
Epoxy	0 %	493.5 MPa
Epoxy-Silica composite	2 %	432.4 MPa
	4 %	526.6 MPa
	6%	1196.1 MPa
	8 %	873.2 MPa
Epoxy-Alumina composite	2 %	614.1 MPa
	4 %	596.2 MPa
	6 %	546.1 MPa
	8 %	692.0 MPa

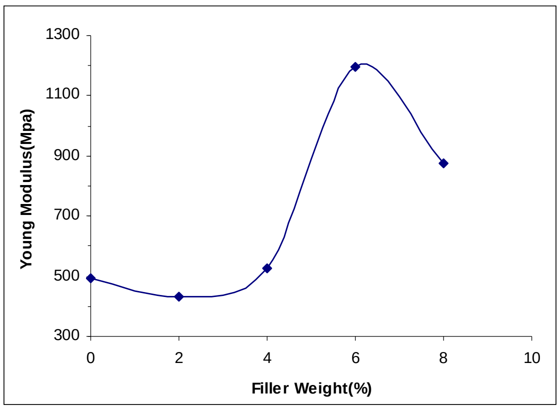

Figure 7 Young modulus variation with silica filler weight (MPa)

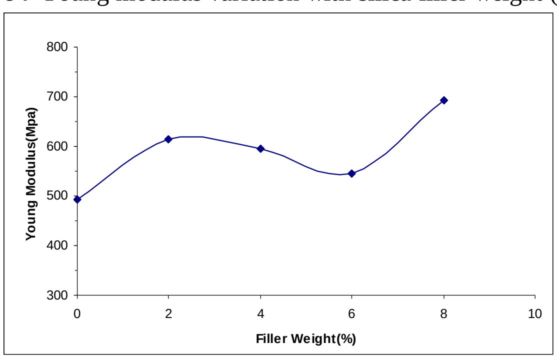

Figure 8 Young modulus variation with alumina filler weight

4. CONCLUSION

Elasticity of composite materials is significantly higher than that of the matrix material and it is progress to the weight fraction of reinforcement material, but it become more effective at 6% for silica. The highest modulus of elasticity is that of the composite with which is 2.423 times higher than that of the matrix material. While of composite with 8% alumina has modulus of elasticity 1.402 times higher than that of the matrix material.

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