Strength Analysis of Particle Reinforced Epoxy Resin Composite Materials by Experimentation

Mr Aniket U. Chanshetti[1] Mr Nachiket G. Chanshetti[2]
[1]Senior Lecturer [2]Assistant Professor
[1]SSWP Solapur [2]BGTI Hyderabad

Abstract— Composite materials are made of two or more constituent material with significantly different physical or chemical properties that when combined produces a material with different characteristics than its constituents. Present work deals with study of tensile and flexural strength of polymer matrix composite material reinforced with titanium dioxide (TiO2) and tungsten carbide (WC) particles. Test specimens were prepared by reinforcing TiO2 and WC particles at three different weight percentage (15%, 20% and 25%). Test specimens were prepared by casting technology in wooden moulds. Tensile and flexural tests were performed on universal testing machine. All tests were performed as per the ASTM standards. From test results it was found that tensile and flexural strength of specimen goes on increasing with addition of WC particles. Tensile strength decreases for TiO2 reinforced composite specimens.

Key words: Reinforced Composite Materials

I. INTRODUCTION

One of the important property of polymer matrix composite material is that we can easily enhance its mechanical properties by adding different filler particles in it. Most of the modifications in mechanical properties are done by adding in organic fillers, metal particles and ceramic fillers in polymer matrix. Percentage of filler materials also having great influence on mechanical properties. Changes in mechanical properties of composite materials are studied by different experimental technique. Effect of these reinforcing particles mainly depend upon the particle size, shape and degree of dispersion in polymer matrix. [1-3].

Among different types of reinforcing particles TiO2 and WC particles attracted attention because of drastic change in mechanical properties and because of low cost [4]

Epoxy resins are famous thermosetting resins for polymer matrix composites, Epoxy has series of good properties like good stiffness, dimensional stability and chemical resistance. Epoxy has good adhesion properties with different types of reinforced particles. Epoxy resins along with fiber reinforcement has higher strength to weight ratio compared to steel[5] [6].

Inclusion of nano particles reduce the interfacial interaction between resin and reinforcement. Dispersion of nano particles in matrix phase also has influence on mechanical and thermal behavior of composites. Many fabrication methods were tried for uniform distribution of these nano particles into the matrix phase of polymer composites [7].

Epoxy matrix modified with Al_2O_3, TiO_2, and SiO_2 micro particles in glass fiber epoxy composites shows good mechanical properties but in case of Al_2O_3 agglomeration of particles is observed.[10][11].

Present work is focused on reinforcing the TiO_2 and WC in epoxy matrix no other reinforcement was used to clearly study the effect of these particulate fillers on epoxy resin. Samples with 15, 20 and 25 wt. % of TiO_2 and WC were fabricated and mechanical properties such as tensile and flexural strength were checked.

II. EXPERIMENTAL

A. Materials

For present experimentation work epoxy Lapox T 22 resin and K6 hardener were selected as matrix system. It is supplied by Atul Ltd. Gujrat. The filler TiO_2 was obtained from Fisher Scientific, Mumbai. WC was obtained from Reliable Bearing Company, Mumbai.

B. Fabrication

Filler particles TiO_2 and WC were added to the epoxy resin in three different weight percentage and stirred continuously for 15 min.in a glass beaker. It was continued till the particles get dissolve in resin. After that K6 hardener was added to the mixture for curing. Hardener and epoxy ratio was 1:10. Hardener was added slowly by continuous stirring. Following table shows different sample composition.

The mixture of epoxy along with hardener and reinforcing particles was poured into the wooden moulds to which wax and release agent is applied. Specimens were cured for 24 hours after that they were removed from moulds and cut as per the standard dimensions. Specimen dimensions were as per the ASTM standards

C. Tensile Properties

Tensile tests for different specimens was carried out on universal testing machine model-TUE-C-400. By pulling material we can find its tensile strength and by measuring deformation at various loads we can plot stress strain curve, which will help to predict material behavior at various loads.

D. Flexural Properties

3-point bending test was performed on UTM machine to determine flexural properties of specimen. Specimen was laid on supports. Distance between supports is 70 mm.

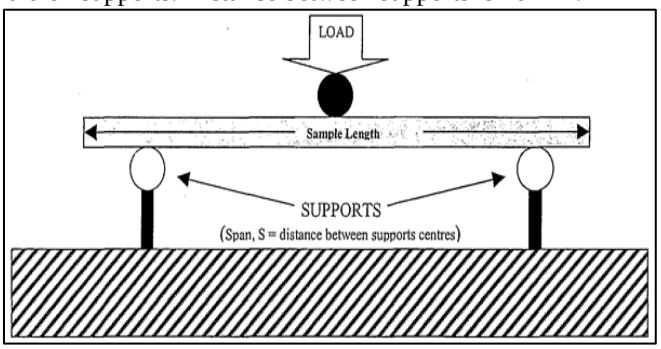

Fig. 1: 3 Point bending test

III. RESULTS & DISCUSSION

A. Tensile Test

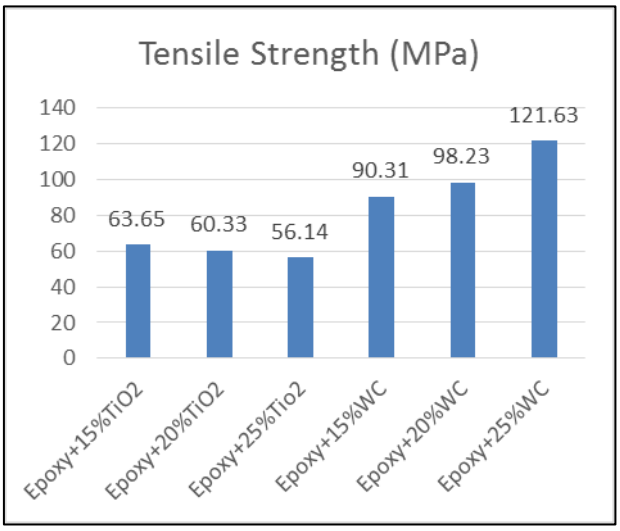

Fig. 2: Effect of fillers on tensile strength

As shown in Figure-2, it is observed that 25% of WC filled epoxy composites has a highest tensile strength of 68.33 MPa. WC reinforced epoxy composites shows slight increase in tensile strength compared.TiO_2 filled epoxy shows decrease in tensile strength compared to WC filled epoxy.25% of TiO_2 filled epoxy has lowest tensile strength of 32.12 MPa. Metal oxides effects strength in two ways one is weakening effect due to stress concentration and another is reinforcing effect. In this case weakening effect is predominant and hence composite strength is lower than matrix. In other case reinforcing effect is predominant so results in increase in tensile strength.

B. Flexural Test

Flexural strength shows the ability of material to withstand forces which are applied perpendicular to its longitudinal axis. As shown in figure 3, TiO_2 fillers in epoxy matrix results in decrease in flexural strength. 25% WC filled epoxy has higher flexural strength of 121.63 MPa. 25% of TiO_2 filled epoxy has lower flexural strength than 20 and 15 % of TiO_2. Main reason behind this is interfacial adhesion between TiO_2 and epoxy is weak compared to intermolecular forces of epoxy matrix. Porosity in the specimen increase with TiO_2 filler content. This is reason behind decrease in flexural strength of TiO_2 filled epoxy.

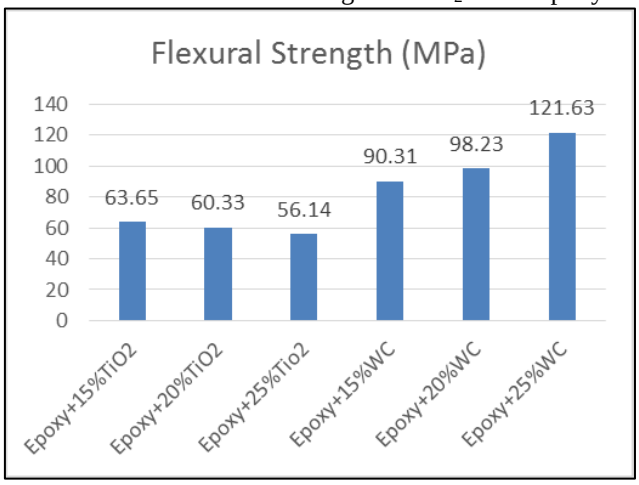

Fig. 3: Effect of fillers on flexural strength

IV. CONCLUSIONS

Effects of TiO_2 and WC content on epoxy resin system was studied. Relation between filler percentage and mechanical properties was studied experimentally and following conclusion were drawn.

- 25% of WC filled epoxy shows high tensile strength of 121.63 MPa. 25% of TiO_2 filled epoxy has lower tensile strength of 56.14 MPa compared to 15 and 20% of TiO_2 filled epoxy. TiO_2 content in epoxy system reduces the tensile strength compared to WC.
- Flexural strength is high (103.83 MPa) for 25% WC filled epoxy compared to other combinations.
- WC reinforcement in epoxy resin system increases tensile and flexural strength. WC reinforcement makes epoxy ductile.
- TiO_2 reinforcement makes epoxy stiffer. Porosity is more in TiO_2 reinforced epoxy composites. Method of stirring also has influence on mechanical properties.

REFERENCES

[1] K.S. Harishanand, H. Nagabhushana, B.M. Nagabhushana, Parimesh Panda, Richeek Gupta, M.S. Muruli, N. Raghavendra, K.R. Vishnu Mahesh, " Comparative study on mechanical properties of ZnO, ZrO_2, CeO_2 Nanometal oxides reinforced epoxy composites", Advances in Polymer Science and Technology: An International Journal 2013, ISSN 2277-7164 pp. 7-13.

[2] AmalNassar, EmanNassar, " Thermo and mechanical properties of fine silicon carbide/ chopped carbon fiber reinforced epoxy composites", Universal Journal of Mechanical Engineering (2014), pp. 287-292

[3] M. Boopalan, R. Jude VimalMicahel, K.S. Yoganand, M.J. Umapathy, " A study on mechanical properties of zinc oxide reinforced epoxy composites", Vol. 25, No. 5 (2013), pp.2931-2932.

[4] Thomas P. Selvin, Joseph Kuruvilla, Thomas Sabu, "Mechanical properties of titanium dioxide filled polysterene micro composites", Materials Letters 58 (2004), pp. 281– 289.

[5] Sato T, Tanigake T, Suzuki H, Saito Y, Kido O, Kimura Y, et al. Structure and optical spectrum of ZnO nanoparticles produced in RF plasma. J Cryst Growth 2003; 255: 313–316.

[6] Renee M. Rodgers, Hassan Mahfuz, Vijaya K. Rangari, Nathaniel Chisholm, Shaik Jeelani. "Infusion of SiC Nanoparticles into SC-15 Epoxy: An Investigation of Thermal and Mechanical Response." Macromolecular Materials and Engineering. Volume 290, Issue 5, 2005 Pages 423–429.

[7] Haydar Faleh, Riadh Al-Mahaidi, Luming Shen. "Fabrication and characterization of nanoparticle reinforced epoxy." Composites Part B: Engineering Volume 43, Issue 8, December 2012, Pages 3076–3080.

[8] Devaraj, Eand Haseebuddin.M.R, "Study of mechanical and Wear behavior of carbon fiber reinforced epoxy resin composites with alumina filler additions", International Journal of Engineering Research & Technology IJERT, Vol. 2 Issue 10, October – 2013 pp. 2602-2607.

[9] Ikram A. Al-Ajaj, Muhannad M. Abd, and Harith I. Jaffer, "Mechanical Properties of Micro and Nano TiO_2/Epoxy Composites", 2013, Volume 1, Issue 2, pp 2320–2325.
[10] S. Rajesh a, B.Vijaya Ramnathb, C. Elanchezhianb, N.Aravindc, V.Vijai Rahuld,S. Sathishd., "Analysis of Mechanical Behavior of Glass Fibre/ Al2O3- SiC Reinforced Polymer composites", 2014, Procedia Engineering, pp. 598 – 606.
[11] Ramesh K. Nayak, Alina Dash and B.C.Ray, "Effect of epoxy modifiers (Al_2O_3/SiO_2/TiO_2) on mechanical performance of epoxy/glass fiber hybrid composites", Procedia Materials Science, 2014, pp.1359 – 1364.
[12] Prashant S N, Madev Nagaral and V Auradi, "Preparation and evaluation of mechanical and wear properties of al6061 reinforced with graphite and sic particulate metal matrix composites", 2012, IJMERR, Vol. 1, No. 3.

