Study the Effect of Glass Fibers on Mechanical Properties of Epoxy Composites

Raghad Hussein Mohammed
School of Applied science, University of Technology/Baghdad
Email: Composite_79

Received on: 15/7/2012 & Accepted on: 4/4/2013

ABSTRACT

The tensile behavior, flexural strength and impact strength were studied in this research for some epoxy composites. First, epoxy composite reinforced with carbon fibers (chopped), secondly,hybrid epoxy composite reinforced with carbon fibers (chopped) and glass fibers (woven roven) with volumefraction(30) % for each type.The tests were done at room temperature (34±2 ºC). In this work the hybrid composite (C+G/Epoxy) have the higher mechanical properties than that composite (C/Epoxy).The results shown that the exists of woven glass fiber increasing the tensile behavior, flexural strength and impact strength of hybrid composite in comparison with the composite reinforced with randomly chopped carbon fibers.

Keywords: Epoxy Composites, Hybrid, Strength, Mechanical Properties.

دراسة تأثير الياف الزجاج على الخصائص الميكانيكية لمتراكبات الايبوكسي

الخلاصة

في هذا البحث تم دراسة سلوك الشد، متانة الانحناء وقوة الصدم لبعض متراكبات الايبوكسي. النوع الاول تضمن متراكب ايبوكسي مدعم بالياف الكاربون المقطعة اما النوع الثاني تضمن متراكب ايبوكسي هجين مدعم بالياف الكاربون المقطعة والياف الزجاج المحاكة وبكسر حجمي (30%) لكل نوع. الاختبارات اجريت ضمن درجة حرارة المختبر(34±2º C). في هذا العمل المتراكب الهجيني (C+G/Epoxy) امتلك خصائص ميكانيكية اعلى من المتراكب (C/Epoxy). النتائج اوضحت ان اضافة الياف الزجاج المحاكة ادت الى زيادة الشد، متانة الانحناء ومتانة الكسر للمتراكب الهجيني بالمقارنة مع المتراكب المدعم بالياف الكاربون المقطعة فقط.

الكلمات المفتاحية :متراكبات الايبوكسي، الهجائن، المتانة، الخصائص الميكانيكية .

INTRODUCTION

Polymer matrix composites are finding increasing uses during the last four decades in high technology as well as conventional applications. A variety of fiber and resin systems are available to the designers. The designers are looking for high specific stiffness, high specific strength, enhanced dimensional stability, energy absorption, corrosive resistance as well as reduced cost while selecting the material systems for typical applications. Composites made of the same reinforcing material system may not be suitable if it undergoes different loading conditions during the service life. Hybrid composites are the best solution for such applications [1].

Hybrid composite is defined as ‘‘Composites consist with two or more kinds of components” .In hybrid composite, construction components fill in gaps and utilize the advantage and characteristics of each other. In our definition, there are three types of hybrid composites; the fibre hybrid, the matrix hybrid, and the interfacial hybrid. The fibre hybrid means using different fibers in one fabric. The matrix hybrid means to combine two or more kinds of resin in one composite. The interfacial hybrid means to combine two or more types of fibre bundles with different surface treatments. These hybrid technologies improve the mechanical properties of composites [2].

Carbon and glass fibers are often used in the same polymeric resin matrix to form hybrids. Carbon fiber provides a strong, stiff and low density reinforcement but is relatively expensive and brittle, while glass fibers is relatively cheap and has better fracture property but it is strength and stiffness arerelatively low. By hybridization, it is possible to design the material to better suit various requirements [3].

Fiber hybrid composite realized higher tensile properties (modulus, initial fracture stress,strength) than that of single material system.This positive effect called (Hybrid Effect) was confirmed in fiber hybrid composite in case of static tensile test. On the other hand, impact property is one of the important properties for the structural material in aerospace and astronautics application[2].Moreover continuous fiber/epoxy composites have been widely used for structural applications due to their excellent mechanical properties [4].

Bunsell and Harris.,studied hybrid composite materials made of carbon and glass fibers. Two types of hybrid materials were made, with the alternate layers either unbonded or bonded together [1].

The work of Dukes and Griffiths, however, found an increase in the flexural modulus of 13.9– 59.7 GPa when carbon fibre was added to the second layer (from each surface) of an eight-ply unidirectional glass laminate. Kalnin, found that the flexural strength decreases rapidly as an all-glass reinforcement is progressively replaced by graphite fibre. Conversely, upon introducing glass fibre into a graphite composite, its strength declines in proportion to the decrease in graphite fibrecontent [5].

Aim of this research was to improve the mechanical properties of composites by using hybrid technology.

EXPERIMENTAL PART

Preparation of composite

In this research Hand lay –up molding technique is used in preparing composites. The composite was made using a stainless steel mould having dimensions (25x25)cm^2. The composite was prepared with one volume fraction of chopped carbon fibers (30%V_f). The ratio of hardener which was added to epoxy is (1:1.5), every 1.5gm from transparent epoxy resin adding 1 gmhardener, then mixed the solution very well before poured it to obtain homogeneity.The chopped carbon fibers were mixed with resin then put in mould. This process repeated with another second hybrid composite. Four laminates ofE-glassfiber have been added to the mould and the resin poured on to fibers .The moulds were left for 24 hour to cure. Then the moulds were heated for 50 ˚C for 3 hour to complete the curing process, the produced samples have been cut out to obtain specimens of testing that agree with (ASTM) standards.

Calculations for the two molds were obtiendfrom the following equation:

$$\Phi = \frac{1}{1 + \frac{1-\Psi}{\Psi} \cdot \frac{\rho_f}{\rho_m}} \qquad \cdots (1)$$

Where:

Φ: is the volume fraction of fibers.
Ψ: is the weight fraction of fibers.
ρ_f : is the density of fibers
ρ_m : is the density of matrix

Measurements

In this research the mechanical investigate were:

1)Charpy impact test was used to measure the impact strength, which may be defined as toughness or ability of material to absorb energy during plastic deformation. Toughness takes into account both the strength and ductility of the material[6].The dimensions of specimens, width and thickness were measured and recorded, hammer of (30 Joul) was used in this test with specimens of impact .The test was carried out in accordance with ISO-179 [7]. The impact strength value was calculated by dividing the energy in KJ recorded on tester by cross sectional area of specimen. The impact strength can be calculated from the following equation:

$$I.S = E/ A \qquad \ldots (2)$$

Where:
I.S: impact strength.
E: fracture energy.
A: cross sectional area for the specimen.

2)Flexural (bending) test was used in this work. The dimensions and thickness of specimen were measured and recorded.The test was carried out in accordance with ASTM-D790 [8]. The flexural modulus was calculated from this test.
The flexural modulus was calculated from the following relationship:

$$F.S. = 3PS/ 2bt^2 \qquad \ldots (3)$$

Where:

F.S: Flexural strength.
P: applied force till the failure of specimen occurs.
S: Span.
B: width of specimen.
T: thickness of specimen.

3)The tensile test was used in this work. The length of specimen is (57mm).The thickness and width were measured and recorded. Tensile load is applied at a rate (1 ton).The velocity of pulling is (1mm/min) and by utilization of the connected graphic plotter, the relation of (p – l) is obtained. This relationship would be modified to relation of (stress- strain) curve to calculate the ultimate tensile strength (UTS) for the specimens. The test was carried out in accordance with ASTM-D638 [9].The maximum (peak) load (Fmax) was recordedultimate tensile strength as follows:

$$\sigma = P / A \qquad \text{... (4)}$$

Where: P: load (N), A: cross sectional area

$$\varepsilon = \Delta L / L \qquad \text{... (5)}$$

Where ε: Strain, ΔL: length change, L: original length

$$E = \text{Stress/Strain} \qquad \text{... (6)}$$

Where E: Modulus of elasticity.

The samples were tested in this research shown in Figure (1)

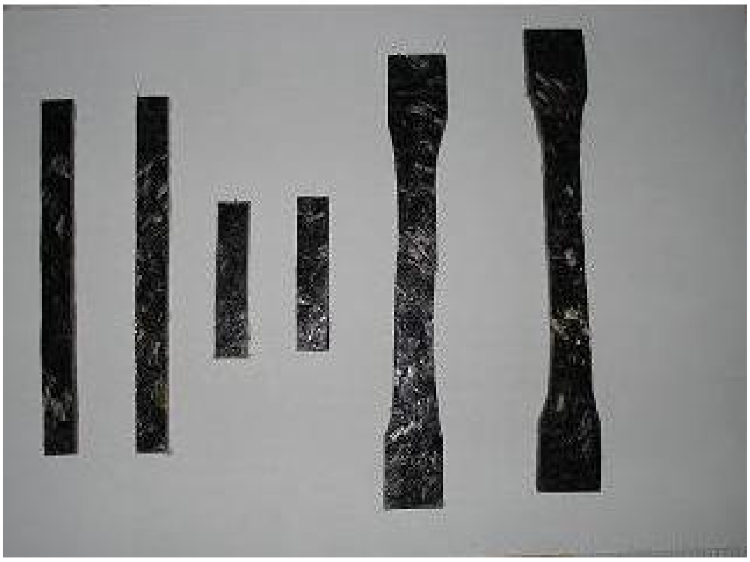


Figure (1) shown samples of the two molds.

RESULTS AND DISCUSSION

Impact strength

The resistance to impact is one of the key properties of materials. The results of impact strength for a sample of a composite reinforced with chopped carbon fibers are smaller than the results of hybrid composites reinforced with glass fibers / chopped carbon fibers this can be seen in Table (1). The carbon fibers reinforced composites which are susceptible to impact damage because of the brittle characteristics of the reinforced fibers; show low impact energy absorption [10],while the impact strength of hybrid is higher than composites because glass fibers are added to carbon fiber to provide additional resistance to impact and damage.These results agree with Michael Kinsella et. al[11], they found that the impact performance and resistance to stress corrosion of the composite components are as important as strength in this application. Carbon fibers are poor in the first respect, and excel in the latter; the inverse is true of GRP in general[11]. Moreover., these results agree with Bajpai al. et., they found that the samples reinforced with e-glass fibers which have good ability to absorb large share of impact stresses and kinetic energy so fibers role should be crack stopper[12].

Flexural strength

Hybridization with glass fiber insignificantly enhanced the mechanical properties of the composites. The increase in flexural properties of the hybrid composites was observed.

From the results in the Table (1) reinforcing of epoxy resin with glass fibers increased the flexural strength, this attributed to the fact that the reinforcement imparted by the fibers allowed stress transfer from the matrix to the fibers[13].

The longer glass fibers improve flexural strength. While randomly orientated short carbon fibers do not lead to this in directionality of properties and do not give such high strength. These results agree with V.C.S. chandrasekaran et .al., they found that the better adhesion between epoxy resin and glass mat with the addition of carbon[14].

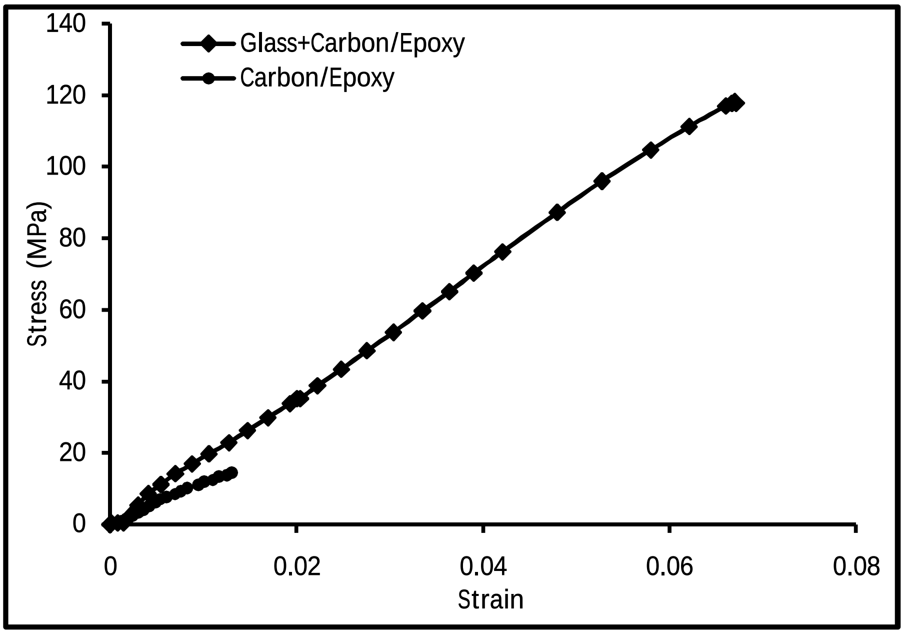
Tensile strength

The Figure (2) shows the ultimate stress of hybrid composite (G+C/Epoxy) is more than ultimate stress of (C/Epoxy) composite because continuous fibers give the highest tensile strength.

It has been noticed that the tensile strength ofhybrid composites reinforced with glass woven roven fibers is higher than the composite reinforced random chopped carbon fibers because of the length and the alignment of fibers which leads to distribute the load on the length of fibers [15]. While in the composite reinforced with random fibers the load is concentrated at the end of short fibers and the alignment of fibers is randomly distributed in the matrix which makesthe control of transmission of the load from the matrix to the fibers through the interface region is weak [16].

Table (1)The results of mechanical tests for the samples .

Specimens	Impact Strength KJ/m^2	Flexural Strength MPa	Ultimate Tensile Strength (MPa)	Young's Modulus (MPa)
Composite Carbon/Epoxy	23.09	981.611	14.420	1215.7
Hybrid composite Carbon+Glass/Epoxy	87.5	1417.5	118.20	1799



Figure(2) The relationship between stress and strain for hybrid and composite.

CONCLUSIONS

1) The results of impact strength for (C/epoxy) are smaller than the results of (C+G/epoxy), because of carbon fibers have brittle characteristics, while glass fibers have resistance to impact and damage.
2) Reinforcing with (C+G/epoxy) leads to increase the flexural strength, that mean the reinforcement with mat glass fibers allowed stress transfer from the matrix to fibers, while randomly short carbon fibers do not lead to this.
3) The ultimate stress of (C+G/epoxy) is more than ultimate stress of (C/epoxy) because continuous fibers give the highest tensile.

REFERENCES

[1].Kedar S. Pandya, C. Veerraju, N.K. Naik, "Hybrid composites made of carbon and glass woven fabrics under quasi-static loading" Materials and Design Vol.32, 4094–4099,(2011).

[2].Tomohiko S., Asami N., Hiroyuki H.," Effect of CF/GF fibre hybrid on impact properties of multi-axial warp knitted fabric composite materials", Composites: Part A,Vol. 40,1982–1990,(2009).

[3].Shao,Y.Fu, Bernd L., Edith M., Chee Y.Yue, Xiao Hu and Yiu W. Mai,"Hybrid effects on tensile properties of hybrid short- glass- fiber and short- carbon-fiber-reinforced polypropylenecomposites"journal of materials science ,Vol.36, No.5, 1243-1251,(2001).

[4].Cho, J. Chen J.Y. and Daniel I.M, "Mechanical enhancement of carbon fiber/epoxy compositesby graphite nanoplatelet reinforcement", ScriptaMaterialiaVol.56, 685–688, (2007).

[5].Chensong, D. Heshan A. Ranaweera-Jayawardena, Ian J. Davies,"Flexural properties of hybrid composites reinforced by S-2 glass and T700S carbon fibres",Composites: Part B ,Vol.43, 573–581,(2012).

[6].Rajput,R.A, "Atext book of Material Science", 6th edition, Sanjeevkumarkataria for S.K. kararia and Sens: Delhi,(2004).

[7].ISO-179 "determination of charpy impact properties"(2011).

[8].ASTM-D790 "flexural properties of unreinforced and reinforced plastics and electrical insulating materials"(2000).

[9].ASTM-D638 "tensile propertiesof plastics"(1999).

[10].Kang T. J., Kim C. , "Impact energy absorption mechanism of largely deformable composites with different reinforcing structures" , Journal Fiber and Polymers Vol. 1, No.1,45-54,(2000).

[11].Michael K., Dennis M., David C., John M.and Mark K.,"Mechanical PropertiesofPolemeric CompositesReinforced With High Strength Glass Fibers"advantex is a registered trademark of Owens Corning Inc,(2001).

[12].BajpaiR.,Mishra V.,PragyeshA.andcdattS.,"Surface modification on PMMA : PVDF polyblend: hardeningunder chemical environment", Bull. Mater. Sci, Vol. 25, No.1, 21–23, February (2002). © Indian Academy of Sciences.

[13].Dr. Emad S. AL-Hassani&Sheelan R. Areef, "The Effect of Fiber Orientation on Creep Behavior And Flexural Strength In Epoxy Composites",Eng. & Tech. Journal, Vol.28, No.7,988-997, (2010).

[14].ChandrasekaranV.C.S., AdvaniS.G., SantareM.H. ,"Influence of resin properties on interlaminar shear strength of glass/epoxy/MWNT hybrid composites", Composites: part A, Vol.42,1007-1016,(2011).

[15].Makarov G. et al. "Deformation and fracture of unidirectional GERPcomposite at high strain rate tension" School of Engineering Sciences, uk(2004).

[16].Asloun EL. M., Donnet J.B., Schultz J. ","On the estimation of the tensile strength of carbon fibres at short lengths",Journal of Materials Science,Vol.24, No.10,3504-3510,(1989).