

Study the Effect of Fillers on the Glass Fiber Reinforced Composites

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Received on: 25/12/2012 & Accepted on: 11/6/2013

ABSTRACT

This study was carried out to investigate the effect of ceramic fillers (aluminum oxide Al_2O_3 and titania TiO_2) and industrial wastes (red mud and copper slag) with weight fraction (10% wt) on the mechanical properties of composite material consist of epoxy reinforced with glass fiber with weight fraction (40/50)% wt. Some tests are carried out like: impact strength, tensile strength and hardness and results have been compared with composite material reinforced only with glass fiber (50/50)% wt. The results show that the composite reinforced with TiO_2 had higher value of impact strength and lowest value of tensile strength compared with other composites, while composite material reinforced only with glass fiber had higher value of tensile strength. Also, it can be seen that all hybrid composites have hardness values higher than that of composite material reinforced only with glass fiber and the highest hardness value was for the composites material reinforced with Al_2O_3 .

Keywords: Hybrid Composites, Unsaturated Polyester, Ceramic and Industrial Wastes Fillers, Mechanical Properties.

دراسة تأثير الحشوات على المواد المترابطة المدعمة باللياف الزجاج

الخلاصة

تم اجراء هذه الدراسة لبحث تأثير حشوات سيراميكية (او كسيد الالمنيوم و او كسيد التيتانيوم) ومخلفات صناعية (الطين الاحمر وخبث النحاس) ذات كسر وزني 10% على الخصائص الميكانيكية لمواد مترابطة متكونة من ايبوكسي المدعم باللياف الزجاج وبكسر وزني (50/40)%. أجريت بعض الاختبارات مثل : قوة الصدمة وقوة الشد والصلادة وتمت مقارنة النتائج مع المادة المترابطة المدعمة باللياف الزجاج فقط وبنسبة (50\50)%. اوضحت النتائج ان المادة المترابطة المدعمة باوكسيد التيتانيوم امتلكت اعلى قيم قوة صدمة واقل قيمة مقاومة شد مقارنة بالمترابكات الاخرى بينما امتلكت المادة المترابطة المدعمة باللياف الزجاج فقط اعلى قيمة مقاومة شد. وكذلك يمكن ملاحظة ان كل المترابكات الهجينة امتلكت قيم صلادة عالية مقارنة مع المادة المترابطة المدعمة باللياف الزجاج فقط وكانت اعلى قيمة صلادة للمادة المترابطة المدعمة باوكسيد الالمنيوم.

INTRODUCTION

Use of low cost easily available fillers may be useful to bring the cost of component down. Study of effect of such filler addition is necessary to ensure that the mechanical properties are not affected adversely by such an addition. Available references suggest investigation on a large number of materials to be used as fillers in polymers but only a few of them deal with the material systems containing fibers and fillers simultaneously. The purpose of use of fillers can be divided into two basic categories, first, to improve the properties of the material, and second to reduce the cost of component [1]. It has also been reported that the fracture surface energies of epoxy and polyester resin and their resistance to crack are relatively low [2]. But if particulate filler is added to these resins, the particles inhibit crack growth. As the volume fraction of filler is varied, the fracture energy increases up to critical volume fraction and then decreases again [3]. Recently, it has been observed that by incorporating filler particles into the matrix of fiber reinforced composites, synergistic effects may be achieved in the form of higher modulus and reduce material costs, yet accompanied with decreased strength and impact toughness [4]. Polymer composites with both discontinuous and continuous fiber reinforcement possess usually very high specific (i.e. density related) stiffness and strength when measured in plane. Therefore, such composites are frequently used in engineering parts in automobile, aerospace, marine and energetic applications [5].

Srivastava V.K. and Shembekar P.S. investigated the tensile fracture and fracture properties of epoxy resin filled with fly ash particles [2]. Nikhil G. et al. Studied the effect of filler addition on the compressive and impact properties of glass fiber reinforced epoxy. The compressive strength of the materials is found to decrease; whereas steep increase in impact strength is observed by introduction of very small quantity of fillers [1]. Subhrajit reported the processing and characterization of titania filler epoxy- glass fiber composites. He found that hardness, tensile and impact strength are found to increase with increase in weight fraction of the glass fiber [6]. Biswas S. and his group studied the effect of ceramic fillers on mechanical properties of bamboo fiber reinforced epoxy composites. They found that by incorporating the industrial wastes fillers into the bamboo fiber reinforced epoxy, as expected are achieved in the form of modified mechanical properties. Inclusion of fiber in net epoxy improved the tensile and flexural strength of the composites. But with incorporation of particulate fillers, the tensile strength of the composites are found to be decrease in most of the cases [7].

The main goal of the current research is to investigate the effect of several kinds of fillers (conventional and industrial wastes) on the mechanical properties of glass fiber reinforced epoxy.

EXPERIMENTAL WORK

Materials

- Epoxy resin and its hardener are supplied by Ciba Geigy India Ltd.
- Ceramic fillers (Alumina (Al_2O_3) and titania(TiO_2)) used in this study were supplied by NICE Ltd India.

- Industrial wastes(copper slag from Sterlite Industries India Limited(SIIL), Tutieorin, Tami Nadu, India was made used of and red mud was supplied by ALACOBA Barazil).
- Glass fiber fabrics were used as reinforcement in composites preparation; the woven fabric was supplied by Teximpiantis.p.a. With thickness of 0.22 mm and weight of 290 g /cm². All fillers are sieved to obtain a particle size in the range 70 - 90µm and their physical characteristics were depicted in Table (1).

Preparation of samples

In this study five composites materials samples were prepared by conventional hand-lay-up technique. A glass mould having demotions of 150*150*10mm is used for composite fabrication. To prepare the composite material reinforced only with glass fiber (50/50)%wt, epoxy resin and its hardener were thoroughly mixed in ratio (10:1) by weight as recommended and stirred at low speed until it become uniform. The matrix was pured into mold slowly in order to avoid air trapping. The mixture was left for some time so that it becomes a little tacky. After that, the woven glass fiber was laid on the matrix layer, which was covered by another layer of matrix by puring the matrix slowly onto the surface of the glass fiber. Three layered composite was cured at room temperature at constant load (4 kg) for 24 hours until it was dried. Similar procedure was adopted for the preparation of hybrid composites of different fillers (40wt% Epoxy + 50wt% glass fiber + 10wt% filler) but fillers are firstly mixed in the mixture of epoxy resin and its hardener before the glass fiber are reinforced in the matrix.

Composition of composites was depicted in Table (2).

Tests

Tensile Measurement

The tensile strength was carried out at room temperature by INSTRON tester (1195) testing machine with gage length of (32mm), applied load of (50Kg) with speedof (12.5mm/min). Measurements dimensions of tensile bar were: length 32mm; width 7.8mm and thickness 3.2 mm according to ASTM-D638.

Impact Strength

The charpy impact test on unnotched specimens was determined using (5 Jules) pendulum impact testing machine. The measurements dimensions of impact specimen was: length 55mm and width: 10 mm according to ISO-179.

Hardness

The hardness testing was carried out using Shore D Hardness Tester (TH210) testing machine.

RESULTS AND DISCUSSION

Impact strength

Figure (1) shows the values of impact strength of all composites. It is interesting to note that composite reinforced with TiO₂ had higher value of impact strength due to the interfacial reaction and provides an effective barrier for pinning and bifurcation of the advancing cracks (8). While the other hybrid composite had low valuesof impact strength this is because that these composites become stiffer and harder and this will reduce the composites resilience and toughness and lead to lower impact strength[9].Also, from the figure it can be seen that composite material reinforced only with glass fiber had the

lowest value of impact strength this is may be due to the formation of void which leads to crack propagation results in complete disattachment of fiber from matrix and so results in less energy absorption [10].

Tensile strength

Tensile strength for all composites were reported in Figure (2).It can be seen composite material reinforced only with glass fiber had the higher value of tensile strength, while the composite reinforced with TiO_2 had the lowest value. This is because that the corner points of the irregular shape of the particulate result in stress concentration in the epoxy matrix [11]. However, it also depends on other factors such as the size and shape of the filler in the composites [8].Also, it can be noted that the hybrid composite reinforced with red mud had higher value of tensile strength compared with other hybrid composites, while the composite reinforced with Al_2O_3 and copper slag had approximated values. All hybrid composites had low value of tensile strength may be due to the distribution of the particles along with the matrix which results in poor stress interface between matrix and filler [12].

Hardness

The measured hardness values of all composites are presented in Figure (3). It can be seen that composite reinforced with Al_2O_3 had highest value of hardness as compared with other composites. While composite reinforced with TiO_2 and red mud occupying the second order, then the composite reinforced with copper slag. The high value of hardness is because that the matrix transfers some of the applied stress to the particles, which bear fraction of the load [13].Also, it can be noted that composite reinforced only with glass fiber had the lowest value of hardness compared with all composites.

CONCLUSIONS

- a) The hybrid composite reinforced with TiO_2 had higher value of impact strength while the other hybrid composites had approximated value of impact strength, while the composite reinforced only with glass fiber had the lowest value of impact strength.
- b) The composite reinforced only with glass fiber had higher value of tensile strength. The hybrid composite reinforced with red mud had higher value of tensile strength compared with other hybrid composites, while the hybrid composite reinforced with TiO_2 had the lowest value.
- c) The composite reinforced with Al_2O_3 and copper slag had approximated value of tensile strength.
- d) For hybrid composites the composite reinforced with Al_2O_3 had higher value of hardness as compared with other composites. While Composite reinforced only with glass fiber had the lowest value of hardness compared with all composites.

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Table (1) Characteristics of fillers [11, 14].

Characteristics	Copper slag	Red mud	Titanium dioxide	Aluminum dioxide
Density(g/cc)	1.44-1.62	1.36-1.6	4.23	3.95-4.1
Specific gravity	2.8-3.8	2.6-3.4	4.1	3.4-4.0
PH	<5.70	11-12.5	6.0-8.0	7.0-9.0
Melting point °C	-	-	1843	2072
Boiling point °C	-	-	2972	2977

Table (2) Composition of prepared composites.

No. of sample	Composition
1	50wt% Epoxy + 50wt% glass fiber
2	40wt% Epoxy + 50wt% glass fiber + 10wt% TiO ₂
3	40wt% Epoxy + 50wt% glass fiber + 10wt% Al ₂ O ₃
4	40wt% Epoxy + 50wt% glass fiber + 10wt% Copper slag
5	40wt% Epoxy + 50wt% glass fiber + 10wt% Red mud

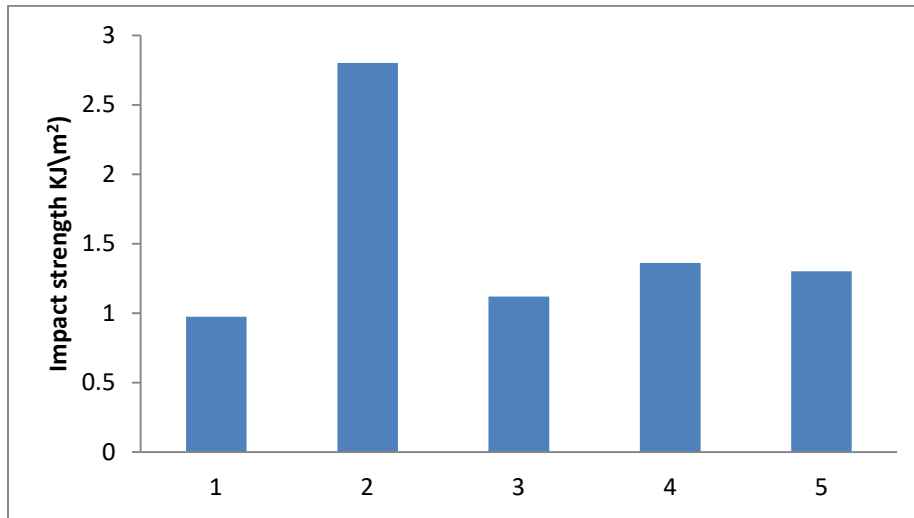


Figure (1) the impact strength for all samples.

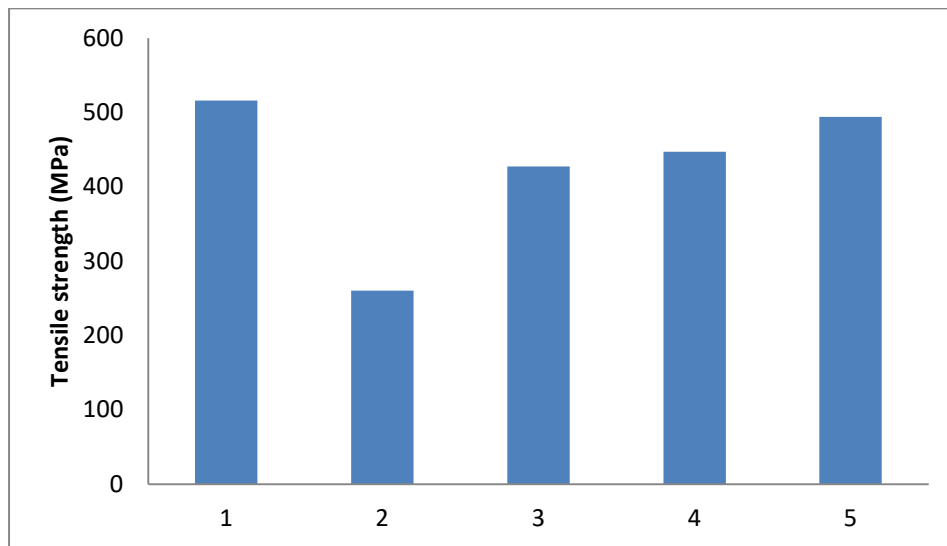


Figure (2) the tensile strength for all samples.

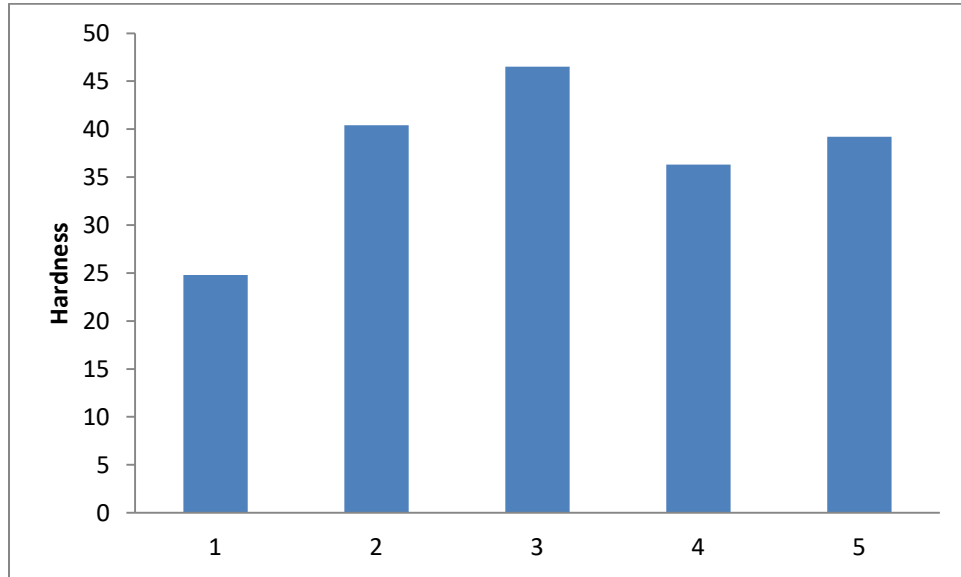


Figure (3) The hardness for all samples.