EFFECT OF PARTICLE ON FRACTURE TOUGHNESS OF SYNTHETIC FIBERS REINFORCED EPOXY HYBRID COMPOSITES

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Abstract

In the present investigation, Fracture Toughness of hybrid composites consists of glass –carbon fiber with fly ash as secondary filler reinforced epoxy composites which was fabricated hand layup technique was assessed. The fly ash filler was loaded at varying rate of 10%, 20% and 30% by wt. in the hybrid prepared. In order to understand the fly ash filler being used in the development of hybrid laminates, the Energy Dispersive X-ray analysis was carried out, which revealed the presence of elemental composition of the filler used and Scanning Electron Microscopy Analysis of the filler system for the determination of size and morphology of particles present in the reinforcing filler that will be used in forming hybrid material. The fracture toughness was measured using the single edge notched bend specimen at the room temperature and at different loading rate of crosshead in computerized universal testing machine as per ASTM standards. An attempt to understand the influence of fly ash particles addition on the fracture toughness of a glass – carbon fiber reinforced epoxy hybrid composite was made. From the experimental results, it was found that the secondary reinforcement, fly ash filler, which was in micron sized-particles, has improved the fracture toughness property to some extent in the hybrid system when compared.
Keywords: Fracture Toughness, Glass fiber, Carbon fiber, Fly Ash, Filler.

1. Introduction

Composite materials are becoming very competitive over other conventional materials, as it possesses unique characteristics that can be tailored made, as it composed of matrix and reinforcement and some time it comes with interfaces too. The matrix system always provides good binding action and protect from environment and delamination. The reinforcement plays a very vital role in providing good strength and stiffness to the composites [1].

The reinforcement is of different types such as carbon, glass, Kevlar etc. It seems polymer matrix is doing remarkable work in the area of composite world, as it has two types mainly thermosets and thermoplastics. The special properties of composites such as high strength, resistance to elevated temperatures, light weight, wear resistance and many other properties. Since the composites are very distinct materials, they find applications in various engineering fields, namely the transportation, marine, aerospace, aviation and other industries also [2].

The composite when used in hybrid form can really change the applications in specific areas. The combination of different reinforcements either natural or synthetic with matrix systems has always resulted in better properties and meeting the changes in the modern world. The composites have been trending with the addition of filler system, may be organic or inorganic types. The filler inclusion into the hybrid composites has a significant role to play, as it is called

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as secondary reinforcing material. The fillers are of different category depending upon size and shape, namely micron or nano sized. The filler presence in the material system may enhance the crucial property between matrix and reinforcement. Fillers can improve the bonding ability between matrix and reinforcement, thereby improving the strength and withstanding the externally applied load. The chemistry of filler says that, if filler fuses with other material and overcome the possibility of voids, it can be a technical advantage for the material property and its usage.
Fly ash as a filler has been identified as a specific reinforcing material to the composites which is a by-product of thermal power plant which inherits various other elements such as silica, carbon, aluminium and other races. Fly ash being is easily available and affordable. Flay ash can be used as a good filler which has some abilities to resist temperature, provide strength, wear resistance and moisture resistance and etc [3].

When it comes to comparing the conventional material such as metals with composites regarding the assessment of property. The testing and characterizing the most complex property among other is fracture toughness of materials in its hybridization state. Fracture toughness is associated to the quantity of energy necessary to produce fracture surfaces. For metals at room temperature enough amount of energy is required for fracture, because plastic deformation accompanies the fracture process. The purpose of fracture mechanics concepts has shown the parameters that affect structural integrity. A fracture study is similarly applied to polymers and ceramics materials. Polymer composite materials often exhibit combination of ductile and brittle type failure nature. Following are some of the fracture modes that can occur in polymer composites such as Interlaminar fracture, delamination or intralaminar fracture, matrix cracking or matrix-fiber debonding, fiber pull-out, fiber breaking, etc [4].

In order to understand the fracture toughness property of the composite materials evaluated by many researchers or scientists, literature survey was carried out. Glass fiber with CTBN-modified epoxy matrix and added silica nano particles has the important role in the improvement the fracture toughness of hybrid system[5]. The critical stress intensity parameter for the silica filled polyester matrix composites is independent of the initial notch depth while evaluating the fracture toughness under four point bending [6]. The fracture energy has not contributed in fiber pull-out in the material system but that elastic constraint has affected lightly [7]. The dynamic fracture toughness and dynamic stress intensity factor of Carbon ceramic filled epoxy composites were much higher when compared with other sets of material system [8]. The main observations in the fracture toughness test by single-edge notch bend test (SENB) was found to be have fiber-matrix debonding to matrix failure with this increase in loading rate [9]. Fabricated Glass-epoxy reinforced hybrid composites filled with modified CTBN rubber particles with zirconium toughened alumina nano particles addition resulted in improved fracture toughness of hybrid when tested as per SENB method [10]. Different methods or modes of assessing the fracture property have been explained [11]. Glass epoxy reinforced graphite filled hybrid composite was tested under mode-I fracture toughness and the results reveal that graphite filler at optimum amount improved the toughness of the material system [12]. Silica as reinforcing particles of 1.56 and 0.24μm sized - epoxy composites tested for fracture toughness resulted in improved fracture energy when the particle size were smaller size under SENB method [13]. The aim of this experimental work is to present and discuss the ability of Fiber Reinforced Polymer Matrix Composites with filler addition and different cross head loading.

2. Materials & Fabrication Method

Woven roving bi-directional carbon fiber of 300 gsm and E-glass fabric of 200 gsm with epoxy grade of Lapox (L-12) with hardener K-6 at ratio of 100:10 proportions was used. The fly ash filler with particle size measured under SEM less than 5 microns shown in the figure 1 and the EDAX analysis was carried out using Scanning Electron Microscope (SEM), JSM-IT300 (JEOL, Japan), on the particle to reveal the elements present. On the test, it was found that silica, carbon, aluminium contents were present is as shown in the figure 2. The Hybrid laminates were fabricated at varying rate of filler at 10%, 20% and 30% by weight using Hand Layup technique with the thickness of approximately 6.25 mm. The specimens were cut according the ASTM D5045 [14] standard using abrasive jet machining to achieve near net geometry of the samples for single notch edge bend test under three-point bending mode as shown in figure 3. The table 1 shows hybrid composites at prepared at different compositions.

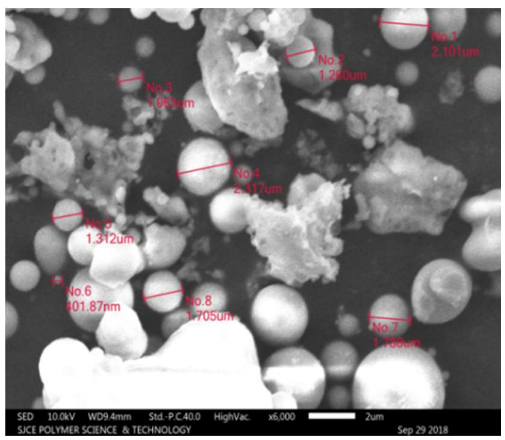

Figure 1. SEM of Fly ash Particles

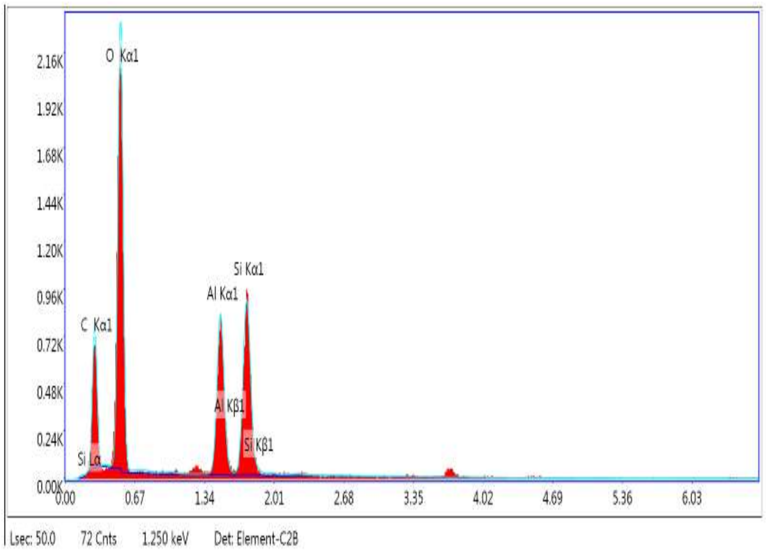

Figure 2. EDAX result of fly ash filler

Figure 3. SENB Specimens

Table 1. Hybrid Composites Fabricated at Different Compositions

Material Code	Hybrid Composition
CGE10F	45% R + 45%M + 10% F
CGE20F	35% R + 45% M + 20% F
CGE30F	

25% M + 45%M + 30% F

3. Experimentation

The Fracture Toughness Test of Single Edge Notch Bend method on hybrid composite specimens was conducted on 100 KN capacity Kalpak universal testing machine. The fracture testing was carried out at 1 mm/min and 10 mm/min cross head velocity as per ASTM D5045 [14]. Figure 4 shows a trail sample undergoing fracture test.

Figure 4. SENB Testing Mode

The figure 5 shows the specimens after the test, which reveals how the crack would have extended to certain distance before the samples were broken.

4. Results & Discussion

The results reveal that the cracked regions of hybrid composites in the notch tip area are evidently seen. There may be some micro-cracks that are formed and further gradually increase quite slower trend. The cross head loading rate at 1 mm/min and 10 mm/min have affected the materials resistance and further the load would have caused initiation of the crack in the hybrid and later transverse breaking would have occurred along with the different fiber layers and may be also due to longitudinal cracking along with the composite layers near the crack zone. The possibility is that, first the matrix would have cracked and later stage the fibers layers may have undergone fracture [12]. The specimen with 10 wt% fly ash filler addition into hybrid has K_{IC} value of 18.79 and 18.55 MPa $m^{1/2}$ at 1 mm/min and 10 mm cross-head loading rate respectively. Among all the hybrid composites tested, fly ash filled C-G E hybrid composites showed the maximum fracture toughness at filler content of 10% by weight [12].

Table 2. Fracture Toughness Assessment under 1 mm/min cross-head loading

Material Code	**Critical Stress Intensity Factor K_{IC} (MPa.m$^{1/2}$)**
CGE10F	18.79
CGE20F	15.80
CGE30F	15.69

Table 3. Fracture Toughness Assessment under 10 mm/min cross-head loading

Material Code	**Critical Stress Intensity Factor K_{IC} (MPa.m$^{1/2}$)**
CGE10F	18.55
CGE20F	16.88
CGE30F	11.16

Figure 5. Fractured Specimens

Conclusions

An experimental investigation has been conducted to assess the fracture toughness of C-G-E Fly ash filled hybrid composites at varying compositions. The results show that the hybrid laminates were fabricated successfully by hand layup technique at three different combinations. Following conclusions are drawn from this possible study that, the fracture energy of the C-G-E hybrid composites has been improved with filler addition at 10% by wt. and varying cross-head loading rate on hybrid has very less effect [12]. By visual inspection, we can make out that, there is some small amount of delamination in fibers, cracks in the matrix and possibility of fiber breakage [12].

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