Effect of Filler Addition on The Mechanical Characterization of Polyamide Matrix Reinforced With Glass Fiber

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Abstract-*This study was conducted to analyze the effect of micro filler such as cenosphere with different composition introduced into the glass fiber reinforced Polyamide matrix. The composite is prepared by Injection molding technique. A mechanical test was done as per ASTM Standard and a comparison was made between the different specimens. It further indicates that the incorporation of cenosphere as a filler results in improvement of flexural modulus of glass fiber reinforced polyamide composite.*

Keywords*-*Cenosphere, Glass fiber, Polyamide

I. INTRODUCTION

Composites are one of the most advanced engineering materials in present trend. Progresses in the field of materials science and technology have given birth to these wonderful materials. Composite materials are created by two or more components with fillers or reinforcing fibers and a compactable matrix which are heterogeneous in nature [1].The matrix may be metallic, ceramic or polymeric in origin. It gives the composites their shape, surface appearance, environmental tolerance and overall durability while the fibrous reinforcement carries most of the structural loads thus giving macroscopic stiffness and strength [2]. Composite material can provide unique physical and mechanical properties because it combines the most desirable properties of its constituents. At present, composite materials play very important role in aerospace industry, automobile industry and other engineering applications because of their outstanding performances. High performance composites made from glass, carbon fibers in polymeric matrices have been studied extensively because of their application in aerospace and automobile technology. Polymer and their composites are ever increasing usage for numerous industrial applications such as bearing material, rollers, seals, cams, wheels and clutches.

In composite technique, particulate fillers are added into the polymers may provide a good method to improve their stiffness, modulus and reduce costs. Short fiber reinforcement polymers are attractive because of their ease of fabrication, and superior mechanical properties [3]. Short fibers have been extensively used over the last decades as reinforcements of thermoplastic polymeric matrices. They are in cooperated into plastics with the main objective of improving the mechanical properties of the polymer with respect to long fiber composites [4]. The ever growing use of reinforced thermoplastics in various industrial applications has led to a demand of always higher mechanical performance for injection molded parts [5].

Polyamide is known as nylon 66. Both these nylons have high resistance to abrasion, low friction characteristics and good chemical resistance. They also absorb water easily and components in wet or humid conditions will expand, precluding their use in applications where dimensional stability is required. Cenosphere is a by-product of the combustion of pulverized coal at the thermal power plants which consists of silica and alumina are filled with air or gases [6,7]. In the previous studies use of cenosphere is noted to decrease the density of the material due to its micro spherical nature. Cenosphere is a hydrophilic material found in fly ash. So far it is used as filler in polymers like PP, PS, and HDPE [8].

In this paper, unfilled glass fiber reinforced polyamide resin composites were selected as the main test specimen and then cenosphere was added into this unfilled structure as a filler material at a different amount of 1.5% and 3% of resin and there by new glass fiber reinforced polyamide is formed. Various mechanical tests such as tensile, flexural and impact were carried out on those samples. Each results were showed in the form of graphs.

II. EXPERIMENTAL DETAILS

2.1 Materials:

Polyamide 66 used as a matrix was obtained by GLS polymer ltd., Bangalore, India. E- Glass fibers were used as reinforcement. Cenosphere was procured from Jindal power plant having particles of average size of about 25 - 50µm. Cenosphere was used as obtained without any purification or chemical modification or surface treatment. Optim (E126) was used as coupling agent.

Material	Tensile Strength (MPa)	Tensile Modulus (MPa)	Flexural strength (MPa)	Flexural modulus (MPa)	Izod impact strength (J/m)
Sample 1 (G+PA)	90.433	1670.82	156.9	6274	43.33
Sample 2 (G+PA+CN)	78.33	1300.81	133.6	6436.33	35.62
Sample 3 (G+PA+CN)	67.1	1439.56	115.7	6305.67	34.41

The composition of all the specimens is listed in Table 1.

Material	Glass fiber (wt .%)	PA66 (wt .%)	Cenosphere (wt .%)
Sample 1 (G+PA)	40	60	Nil
Sample 2 (G+PA+CN)	38.5	60	1.5
Sample 3 (G+PA+CN)	37	60	3

2.2 Preparation of polymer composites:

The composites were prepared using a twin screw extruder (HT 30). The four heating zones were set to 230ºc, 235ºc, 240ºc and 245ºc.The compounded extrudates were immediately quenched in water and cooled in air till ambient temperature. Then the extruded strands were chopped into granules and dried and these granules are heated for 2 hours at 120ºc before injecting. Injection molding was maintained at a temperature between 240ºc to 255ºc from the hopper to the ejection nozzle. At pressure 100N/cm^2, the material is injected into the mold. According to ASTM standards the samples for tensile, flexural and impact testing were obtained.

2.3 Measurement of Mechanical properties:

Tensile properties:

All samples were measured in the tensile mode using the INSTON UTM (Model 1125) in accordance with ASTM D638. Tensile strength and tensile modulus were measured at speed 50mm/min.

Flexural properties:

Flexural strength and modulus were measured using INSTON UTM (Model 1125) in accordance with ASTM D790 at speed 2mm/min.

Impact properties:

The notch for impact test was made using a motorized notch – cutting machine. Notched Izod impact strength was determined at ambient condition according to ASTM D256 using impact tester having striking velocity of 3.46m/s. Each data point was the average of at least three measurements.

III. RESULTS AND DISCUSSIONS

Mechanical properties:

The results of the experiments are discussed with increase in cenosphere filler loading in glass fiber reinforced polyamide composites. The polyamide resin content (60%) was identical for three composites for comparison purposes.

The effect of filler weight fraction on the measured mechanical properties of the composites is illustrated in Figure 1 to 5 and is also listed in table 2.

Tensile properties:

It can be seen that unfilled composite has high tensile strength compared to filled glass fiber reinforced composite. The tensile strength and tensile modulus has decreased with increase in the cenosphere content. The main reason for reduction in the tensile property is due to the random orientation and less weight percentage of short glass fibers. Tensile strength and tensile modulus of a cenosphere filled and unfilled glass fiber reinforced polyamide composites as shown in Figure 1 and Figure 2 respectively.

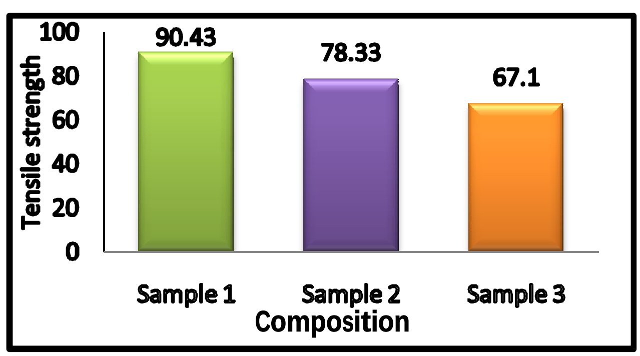

Figure 1: Tensile strength of a CS filled and unfilled G+PA composites.

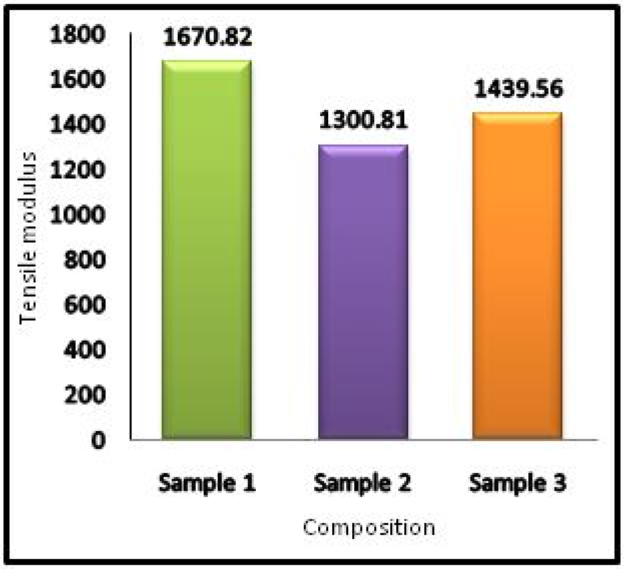

Figure 2: Tensile modulus of a CS filled and unfilled G+PA composites.

Flexural properties:

Flexural strength has been decreased with an increase in cenosphere content as shown in figure 3. Whereas flexural modulus has been increased and it was maximum at sample 2 i.e. 1.5% of cenosphere. In the present work, the cenosphere used are of bigger size particle with less surface area therefore it is clear that the density and higher silica content of cenosphere is responsible for the enhancement in flexural modulus in cenosphere filled glass reinforced polyamide composite. Figure 4shows flexural modulus of a cenosphere filled and unfilled glass fiber reinforced polyamide composites.

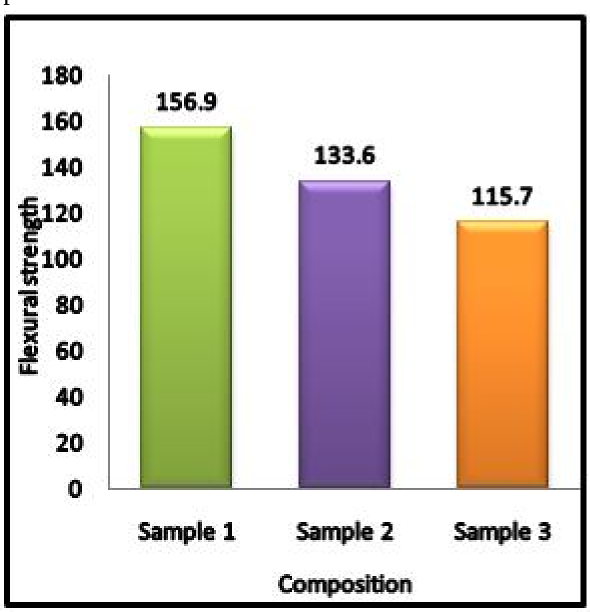

Figure 3: Flexural strength of a CS filled an unfilled G+PA composites.

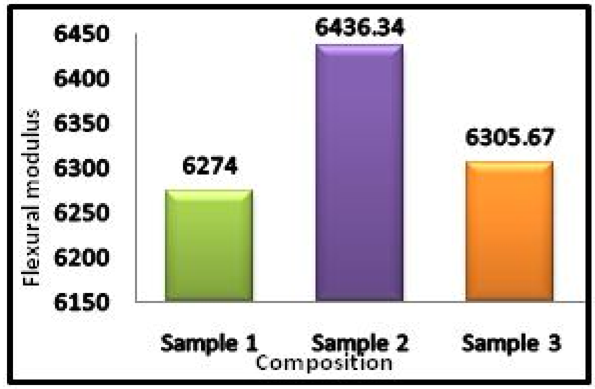

Figure 4: Flexural modulus of a CS filled and unfilled G+PA composites.

Impact strength:

From IZOD impact test, it is found that impact strength of an filled composites has been decreased with increase in the cenosphere content. Maximum impact strength has noticed in the unfilled composite. Figure 5 shows the Impact strength of a cenosphere filled and unfilled Glass fiber reinforced Polyamide composites.

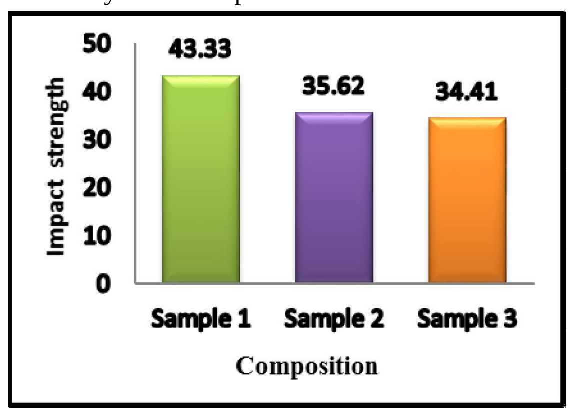

Figure 5: Impact strength of a CS filled and unfilled G+PA composites

IV. CONCLUSION

Based on the experimental results, some conclusions can be drawn as follows:

1. Due to the addition of cenosphere (1.5 and 3%) into glass fiber reinforced polyamide, tensile property and impact strength are reduced compared to unfilled composite.
2. A significant increase in the flexural modulus is found with increase in cenosphere content. The maximum flexural modulus is achieved at 1.5% of cenosphere filled composite.

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