© 2017 IJSRST | Volume 3 | Issue 6 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

Analysis of Mechanical Properties of High Density Polyethylene, Fly ash and Carbon nanotubes Reinforced Hybrid Composite

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ABSTRACT

The present ongoing energetic human race can't visualize its progress without bringing the conception of development in composite materials. An assortment of researches is occurring in this field to achieve the desired standard. Fly ash and CNT reinforced polymer composite has a greater effect on mechanical properties of materials due to its composition and size respectively. Now a day's composites are used in vast areas like automobile, transportation and aerospace etc. due to having unique properties like light weight, better abrasive resistance, in toxic and eco-friendly nature. Polymer matrix composites with synthetic reinforcement have better properties than natural polymer matrix reinforced composites. However synthetic composite are costly, non-biodegradable, and causes pollution in the environment when they are discharged. Utilization of inorganic fillers obtained from waste material has gained an importance due to burden on environment. One such source is utilization of waste fly ash particles which are interesting because of their low density, low cost, strong filling ability, and smooth spherical surface. In the present work A polymer matrix hybrid composite was fabricated by compression molding process with addition of varying weight percentage (5 wt.%, 10% wt. and 15wt. %) of fly ash maintaining the constant weight percentage (1wt. %) of CNTs in high density polyethylene(HDPE) polymer. Mechanical properties (like, impact strength, flexural strength and tensile strength) were tested for developed composites. The results revealed that impact strength increases from 5 to 15 weight% of Fly ash, Flexural strength increases from 5to10 weight% and then decreases slightly. Tensile strength decreases with increasing weight % of Fly ash from (5 to 15wt %).
Keywords : HDPE, CNT, Fly ash, Reinforcement, Polymer Matrix Composite.

I. INTRODUCTION

Composite materials has attracted researchers all over the world due to its unique feature of having property of both its constituents .Hence it becomes possible to have a material with all the desired properties. It becomes boon for many industries like Aerospace, Military, Automotive and many other industries. Composite materials are gaining popularity due to having following properties: High strength and Stiffness. Light weight ease of fabrication, less expensive, high corrosion resistance, High wear resistance, High chemical resistance, High toughness and High environmental degradation resistance. Material with these characteristics are desirable in aerospace military automobile and many industry Typical engineered composite materials includes :Mortars, Concrete ,Reinforced plastics, such as fibre reinforced polymers, Metal composites , Ceramic composites (Composite ceramics and metal matrices) Composite materials are generally used for bridges building and structures. Most advanced usage include spacecraft and aircraft in demanding environment. Polymer Matrix Composite consists of a polymer resin matrix combined with fibrous reinforcing dispersed phase. Reinforcement in a polymer matrix composite provides high strength and stiffness. Polymer Matrix Composite are very popular due to their low cost and simple fabrication method. The PMC is designed so that the mechanical loads to which the structure is subjected in service are supported by the reinforcement. The function of the matrix is to bond the fibers together and to transfer loads between them. The advantages of PMCs are their light weight coupled with high stiffness and strength along the direction of the reinforcement. This combination is the basis of their usefulness in aircraft, automobiles, and other moving structures. Other desirable properties include superior corrosion and fatigue resistance compared to metals.

II. EXPERIMENTAL

2.1 Materials

Following materials are selected in the present work for fabrication of high density polyethylene fly ash and carbon Nanotubes hybrid composite samples. a. Matrix Material: High Density Polyethylene b. Reinforcement: Multi walled carbon Nanotubes (MWCNT) and c. Fly ash: Silica (59.5%), Alumina (20.3%), FeO /Fe2O3 (6.5%), remaining being FeO, MgO and unburnt coal etc.

2.2 Fabrication of composites

Composite materials can be synthesized by various methods such as compression molding, injection molding, hand lay-up method etc. We have used Compression moulding process to prepare sample. Firstly materials were collected from local sources. Now 132gram mixture comprising of high density polyethylene, fly ash and carbon nanotube are taken for ball milling operation. Mixture is put into ball milling machine. Ball milling operation is done for 2 hours. After ball milling operation mixture is brought out. Now wax is applied on die so that mixture does not stick. Now mixture is put into die uniformly .Die is kept into its place in hydraulic compression moulding machine. After switching machine on sample is heated up to temperature 180°C.Temperature of both upper and lower part of hydraulic compression moulding machine is heated up to 180 when it reaches temperature of 180°C alarm starts beeping. Hence heater is switched off and it is water cooled for next 4 hours till it reaches room temperature. After reaching room temperature die is taken out and sample is also taken out. Resulting sample is machined into standard sizes for testing.

2.3 Characterization of composite

A numbers of tests are performed to analyze the mechanical behaviour of the composite.

2.3.1 Tensile Testing

Tensile test are performed to measure the ability of material to withstand stress in tension. In this test sample is analyzed under control tension until failure of material occur. A result from tensile test provides measure for selecting a specimen for applications. It predicts the behaviour of the material under different types of forces. Maximum elongation, young’s modulus, poison’s ratio; yield strength, reduction in area and ultimate tensile strength can be calculated by this test.

2.3.2 Flexural Testing

Flexural test is performed to find out the strength of material before breaking during bending. It also provides values of flexural strain, flexural stress and flexural stress strain behaviour of the material. Generally three point bending test is used to analyze the behaviour of the composite. For this test sample preparation is simple, however results are sensitive to strain rate and specimen loading geometry.

2.3.3 Impact Testing

To understand the toughness of any material impact tests are suitable test. In this test, the test is performed to understand the toughness of material. During the test, specimens are subjected to large amount of force for a very small period of time. This test indicates the energy absorption capacity of a material before failure. Large impact energy simply refers to high plasticity and high toughness.

III. RESULTS AND DISCUSSION

3.1 Mechanical properties analysis of hybrid polymer composite:

The mechanical behaviour of HDPE & Fly ash and CNT reinforced polymer composites with their various compositions are described here. Mechanical tests were carried out using at Central Institute of Plastics Engineering and Technology (C.I.P.E.T.), Bhopal. Specimens were developed according to ASTM sample specification for polymer and plastic materials.

Table 1. Readings of Mechanical Tests

Composite composition	Tensile Strength (M Pa)	Flexural Strength (M Pa)	Impact Strength (J/m)
HDPE+5%Flyash+1%CNT	19.66	4.076	26.52
HDPE+10%Flyash+1%CNT	12.23	24.372	51.31
HDPE+15%Flyash+1%CNT	11.63	24.226	76.12

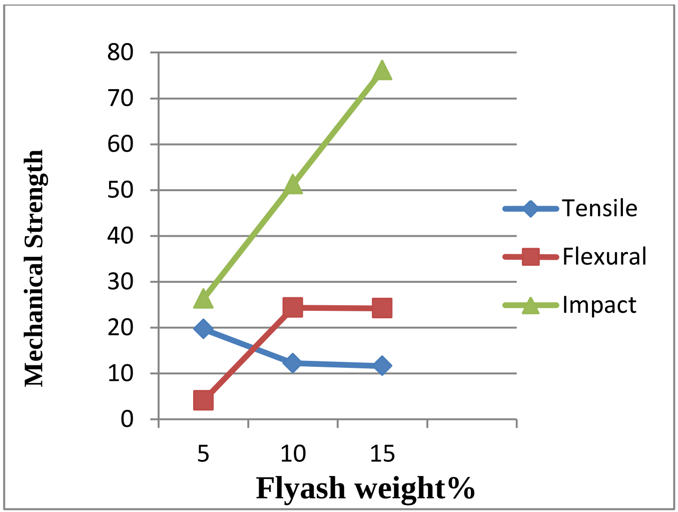

Figure 1. Effect of variation of Fly ash wt% on Mechanical Properties

3.2 Discussion

The results show that impact strength increases as the weight percentage of fly ash is increased. The value of impact strength varies from 26.52 to 76.12 J/m. The maximum impact strength is of 76.12 J/m in case of 15 weight % of Fly ash. The increase in the impact strength with the increased weight percentage of Fly ash may be due to the fact that more energy will have to be used up to break the coupling between the carbon nanotubes layers. Good adhesion between the Carbon nanotubes and matrix is also responsible for the good resistance to crack propagation during impact test.

The results show that with increase in wt. Percentage of fly ash, flexural strength first increases and then decrease slightly. The increase in flexural strength with 10 weight percentage of fly ash of Carbon nanotubes reinforced HDPE Composite may be due to agglomeration of fly ash particle with HDPE matrix around the carbon nano tube and hollowness of fly ash particle which resist the bending.

The results outcome in the tensile testing of the standard samples of different percentage variation shows the trend of decrement of the tensile load. This shows that after the Fly ash reinforcement the results have gone down and it decreases more with increasing weight percentage of Fly ash. The decrease in tensile strength with fly ash is attributed to hollowness of fly ash particle which decreases the elongation and also due to agglomeration of fly ash particle on the CNT surface.

IV. CONCLUSION

Following conclusions are outcome from the synthesis and experimental analysis of mechanical behaviour of the Fly ash, Carbon nanotubes reinforced High density polyethylene polymer composite. Hybrid Polymer matrix composite with High Density Polyethylene as matrix ,Fly ash and Carbon nanotubes as reinforcement has been fabricated successfully using compression moulding technique. The concept of fly ash incorporation into High density polyethylene composites was found very useful way of utilization of fly ash waste. The high energy wet milling process is simple, economical and faster method to activate the surface of fly ash. When the composites were investigated for impact properties, the incorporation of activated fly ash was found to offer increased resistance for crack propagation due to their rigid nature.Further Carbon nanotubes incorporation leads to increase in impact strength .Hence impact strength increases with increasing weight percentage of fly ash. The flexural strength first increases with increase in fly ash content but further addition of fly ash decreases the flexural strength. Flexural strength is maximum for 10 weight percentage of fly ash with 1weight percentage of Carbon nanotubes reinforced High density polyethylene composite. The tensile strength decreases with increasing weight percentage of fly ash and is maximum for 5 weight percentage. Fly ash being wastes of thermal power plant its application for fabrication of composite having higher strength will be of great use as it will reduce burden on environment.

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