Effect of Fly Ash as Filler on Glass Fiber Reinforced Epoxy Composites

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***Abstract*- Fly ash, a waste by-product is generated abundantly by combustion of coal in thermal power plant. The present study deals with the comparison of percentage variation filler contents on composites and pure composite material.As per ASTM D 3039 the CAD model is designed andthree different specimens of various filler contents (10%, 30%, and 40%) and one pure composite specimen were numerically analyzed on ANSYS 16.0 and experimentally tested on UTM. It was found that the pure composite materialenhanced themore strength.**

***Key words* - EpoxyComposite, Fly ash filler material, FEM, Experimental test on UTM**

I. INTRODUCTION

Now a day's composite material are widely used in automotive, aerospace industries. Composite materials are light in weight compared to metals and woods. Their lightness is important in various industries for example less weight means better fuel efficiency. Glass fiber reinforced epoxy composites are results in an attractive combination of physical and mechanical properties which cannot be obtained by monolitic materials. Epoxy resins are widely used as matrix in many fiber reinforced composites; they are a class of thermo set materials of particular interest to structural engineers owing to the fact that they provide a unique balance of chemical and mechanical properties combined with wide processing versatility. Within reinforcing materials, glass fibers are the most frequently used in structural constructions because of their specific strength properties. The ease of availability of glass fiber and economic manufacturing techniques adopted for production of components. Developments are still under to increase their properties. One of the method to increase the strength of glass fiber reinforced epoxy composites is to add various filler materials. These filler materials are act as additional reinforcing components and show their mechanical properties. Among various filler materials fly ash is one of the filler material that can be used as filler on composites to enhance their mechanical properties.

Fly ash is a waste by-product which is generated by combustion of coal in thermal power plants. Increasing production of fly ash year by year, from the coal based thermal power plant, it affects serious problem in terms of safe disposal and utilization. The utilization of fly ash as filler materials are generally acts as inert materials which are used in composites to reduce the material cost, to improve the mechanical properties to some extent and in some cases to improve process ability. Reduction in filler size gives better enhancement in properties due to uniform distribution of particles in polymer matrix. As per ASTM C618 fly ash has been classified into two categories, Class F and Class C. Generally it is a mixture of oxides rich in silicon (SiO_2), iron (Fe2O3) and aluminum (Al_2O_3). It dependsupon the source of coal;which contains different properties of silica, alumina, oxides of iron, calcium, magnesium etc along elements like C, Ti, Mg, etc. So that the fly ash has properties combined of spherical particles and that of metals and metal oxides.

II. LITERATURE SURVEY

Baljeev Kumar, Rajeev Garg and Upinderpal Singh have studied the utilization of fly ash as filler material in polymer composites is considered important from both economic and commercial point of view. Fly ash is used as reinforcing filler in High density polyethylene (HDPE) to develop lightweight composites. After surveying they have conclude that if fly ash is used as reinforcing filler material in High density polyethylene (HDPE) some studies have pointed to the excellent compatibility between fly ash and polymer.Modification of Fly ash accompanied by compatibilization leads to the substantial improvement properties of the composites. However, it is obvious that the potential as reinforcing fillers in polymers especially for Fly ash/HDPE composites have not been fully brought into play.[1]

K.Thomas Paul, S.K.Sathpathy, I Manna, K.K.Chakraborty, G.B. Nando et al. studied the size reduction of fly ash from micrometer level to nano level which is achieved by high energy ball milling. The average particle size has been reduced from 60μm to 1480 nm, a reduction of nearly 405 times in magnitude.[2]

S.R. Chauhan, Anoop Kumar, I Singh and Prashant Kumar et al. studied the design and experiment method which can be used to analyze the coefficient of friction and the dry sliding wear of polymer matrix composites and found the results, coefficient of friction decreases with the addition of 10 wt % to 20 wt % of fly ash and wear resistance is increased for the addition of 10 wt % to 20 wt % of fly ash. [3]

R.Satheesh Raja,K.Manisekar, V.Manikandan et al. studied the effect of fly ash filler size on mechanical properties of polymer matrix composites. The composite specimens are prepared in the four different sizes (50 µm, 480 nm, 350 nm, and 300 nm) of fly ash filler materials by using CAD molding process. Mechanical testing such as hardness and impact test was carried out. It is found that the 300 nm size fly ash filler impregnated polymer composite yields better impact energy (14 J) and hardness value (35 Hv) than others. Thus by decreasing the size of fly ash filler leads to increase the interference bond between the polymeric matrix and the solid fillers.[4]

Jitendra Gummadi, G.Vijay Kumar, Gunti Rajesh have prepared the five different particle sizes of fly ash are used for sample preparation. Percentage variation of fly ash in polypropylene is 0, 10, 15, 20, 25. The composite test specimens are prepared using injection molding machine with hand layup technique as per ASTM D3641 standards. Bending tests on the specimens are carried out by using tensometer. Modulus andFlexural strength are calculated from the obtained load values and the result is analyzed for the prepared samples.With fly ash added to the Polypropylene improves flexural modulus and flexural strength ,but dramatically decreases percentage elongation at break. Finest particles showed best flexural strength at all concentrations. [5]

Patil Deogonda, Vijaykumar N Chalwa et al. have used TiO_2 and ZnS as filler material on GFRP laminated composites and evaluates the Tensile, Bending and Impact strength increases with addition of filler material.ZnS filled composite shows significantly good results than TiO_2 filled composites.ZnS filled composite shows more tensile load in comparison with unfilled and TiO_2 filled composites.TiO_2 and ZnS filler material makes material harder and brittle which is the reason for reduction in impact toughness value.[6]

S.D. Saravanan, M.Senthil Kumar et al. have studied the effect of mechanical properties on rice husk ash reinforced Aluminum alloy (AlSi10Mg) matrix composites. A rice husk ash particle of 3,6,9 & 12% by weight were used to develop metal matrix composites using liquid metallurgy route and found the results that the tensile strength, compression strength, and hardness increases with increase in weight fraction and ductility get decreases with increase in weight fraction of rice husk ash.[7]

From the above literature survey it is clear that, the tensile tests were conducted for TiO_2, ZnS and rice husk ash as filler material on composites and some flexural, impact test were conducted for fly ash as filler material with the different size of fly ash. So in this project, different composite specimens will be prepared by varying percentage of fly ash& carry out tensile test on UTM.

III. DESIGN AND ANALYSIS

A. *Material Specification:*

The materials used to prepare the specimen are E-Glass fiber, Epoxy resin (LY556), Hardener (HY951)

Material :Epoxy, Glass Fiber, Fly Ash

Young’s Modulus: 5000 - 35000 MPa

Poisson's Ratio : 0.24 - 0.4

Density of Epoxy : 1800 - 1850 kg/m^3

Density of fly ash : 1100 kg/m^3

Table 1: Filler Material Specimen Details

	E-Glass mat		
Sr. No.	*Glass fibre content %*	*Epoxy*	*Filler content in % (fly ash)*
1	60	40	-
2	50	40	10
3	30	40	30
4	20	40	40

Table 2: Test specimen detail

Test specimens	ASTM	Size
Tensile test specimen	D-3039	250x25x2.5 mm.

B *CAD MODEL*:-

To prepare the CAD model of specimen ANSYS 16.0 Design modeler is used.

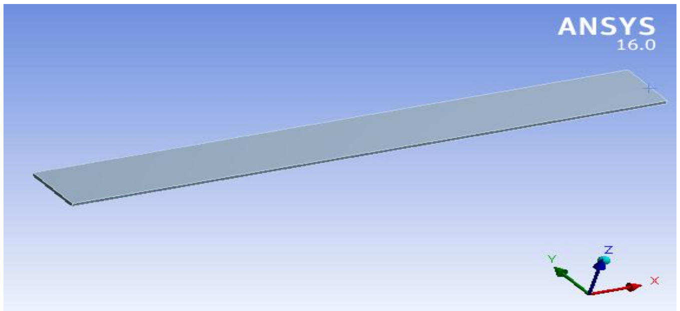

Fig1. CAD Model of specimen

C. Discretization or Meshing:-

For the discretization of model a hexahedron element with standard program controlled solidmesh is used. Number of node populations are 2640 and element populations are 1890.

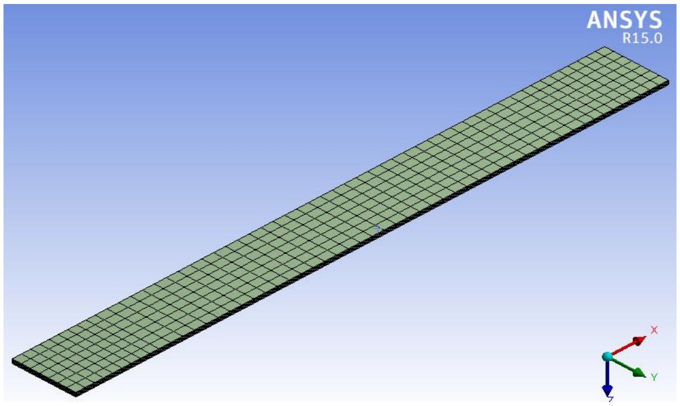

Fig2. Discretization of specimen

D. *Boundary Condition & Loading*:-

To apply tension on specimen one end is made to fix and another end is applied with tension load.

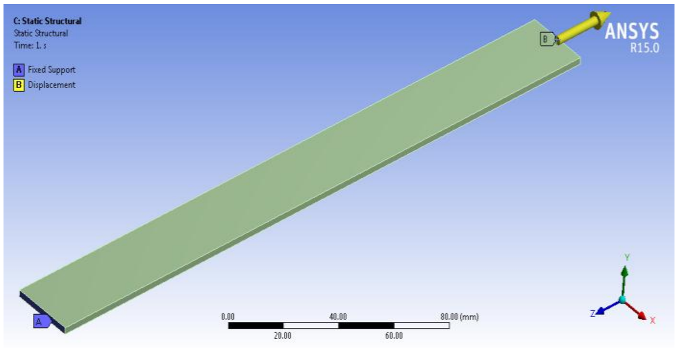

Fig3. Boundary conditions and loading on specimen

E. *Orientations:-*

Given orientations are on X-axis = Normal directions, Y-axis = Transverse directions, Z-axis = Fiber directions.

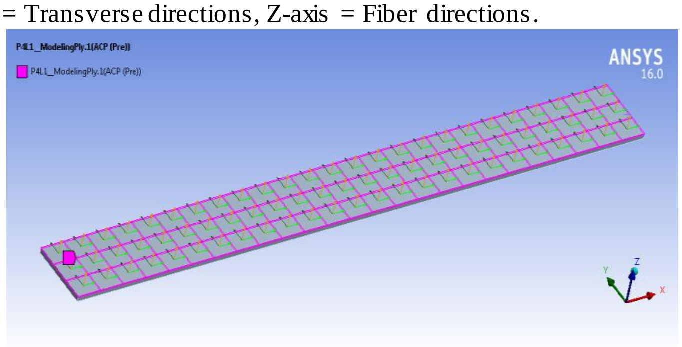

Fig4. Orientations of specimen

F. *Plies:-*

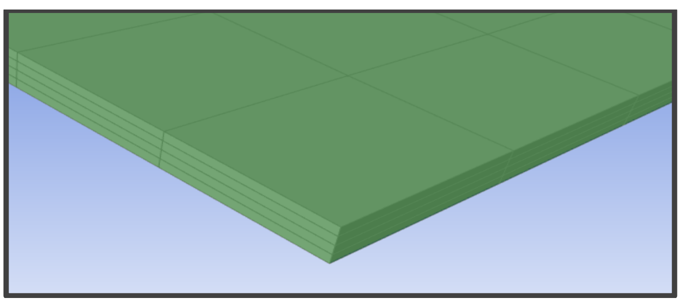

Fig5. Plies of specimen

IV. FINITE ELEMENT ANALYSIS

Normal Stress Plot:-

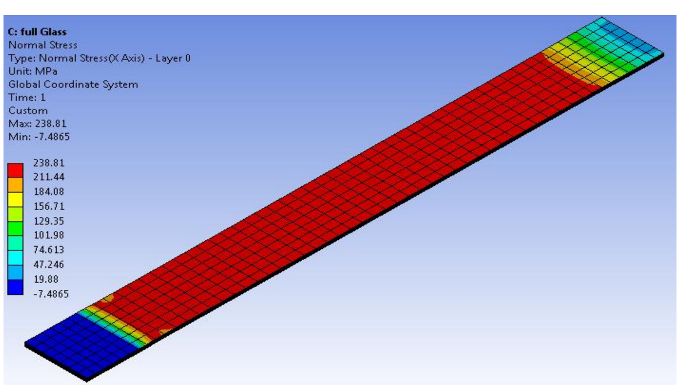

Fig 6. Normal stresses of Pure Composite Material

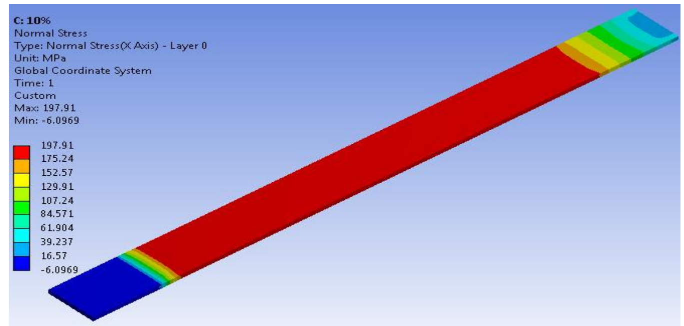

Fig7. Normal stresses with the filler content of 10 % Fly ash on Composite Material

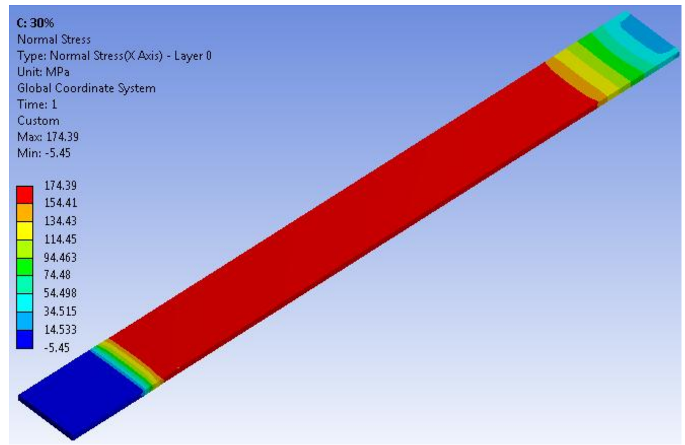

Fig8. Normal stresses with the filler content of 30 % Fly ash on Composite Material

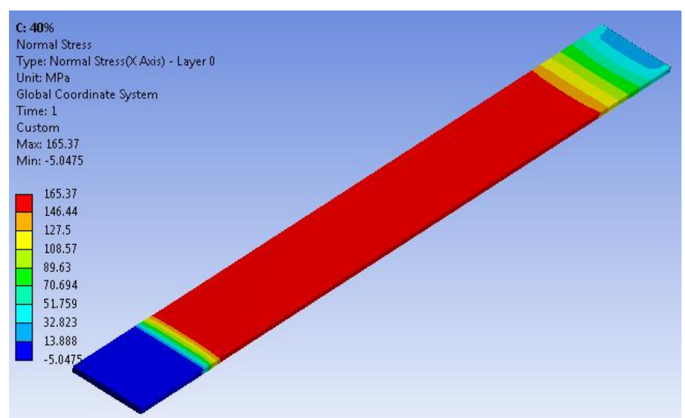

Fig9. Normal stresses with the filler content of 40 % Fly ash on Composite Material

V. EXPERIMENTAL WORK

A. *Fabrication Process*

The fabrication of composite material is done by Hand lay-up technique. Glass mat is positioned manually in the open mould and resin is into glass plies. Entrapped air is removed manually with the roller to complete the laminate structure.

The fibers are manually placed into one sided gel coated male or female mould. A matrix of thermosetting resin is rolled onto the fibers using hand roller. More layers can be added and, after drying,the composite part can be removed from the mould.

Fig10. Test Specimens of various (10%, 30%,40%) of fly ash content and pure composite material.

VI.TENSILE TEST OF COMPOSITE MATERIAL

The test specimens are fabricates in accordance with the ASTM D3039.The test is conducted on UTM/E-40 with resolution of piston movement 0.1 mm.

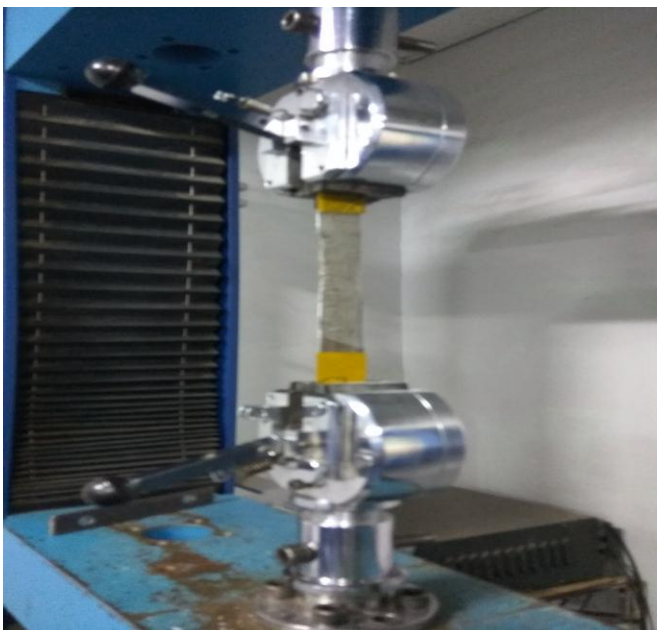

Fig11. Specimen on UTM during tensile test

Fig12. Specimen of fly ash content of 40% after testing

VII. RESULT AND DISCUSSION

Table 3: Finite Element Analysis Results

Sr.No.	*Filler content in % (fly ash)*	*Force (N)*	*Normal Stresses in (MPa)*
1	-	10000	238.81
2	10	9500	197.91
3	30	9000	174.39
4	40	8500	165.37

Table 4: Experimental Results

Sr.No.	*Filler content in % (fly ash)*	*Force (N)*	*Normal Stresses in (MPa)*
1	-	10789	213.33
2	10	10270	181.26
3	30	9751	159.95
4	40	8105	147.31

Above table shows the finite element analysis and experimentalresults of different composite specimens with the varying percentage of fly ash and pure composite material.

VIII. CONCLUSION

In this present work the residues from the thermal power plant is utilized as filler material in the glass fiber reinforced epoxy composites. The CAD model and analysis is carried out on ANSYS 16.0.The composites specimens are prepared on the basis of variation in filler content (10%, 30%, 40%) of fly ash and one pure composite material. Numerical analysis was performed on above three specimens and on one pure composite material. It is found that the pure composite material requires maximum forces (10000 N by FEM and 10789 N by Experimental) and composite material with 40% filler content of fly ash requires minimum forces (8500 N by FEM and 8105 N by Experimental).Thus by increasing the percentage of filler content the tensile strength is decreases. It is concluded that pure composite material showed significant strengthwhen compare to filler content of 10%, 30% and 40%. But, as the fly ash is waste product and easily available so, we can use it in the composite material for the cost reduction to get the required strength.

REFFERENCES

[1] Baljeev KumarRajeev Gargand Upinderpal Singh "Utilization Of Flyash As Filler In Hdpe/Flyash Polymer Composites: A Review" International Journal of Applied Engineering Research, ISSN 0973-4562 Vol.7 No.11 (2012)

[2] K. Thomas Paul S. K. Satpathy I. Manna K. K. Chakraborty G. B. Nando"Preparation and Characterization of Nano structured Materials from Fly Ash: A Waste from Thermal Power Stations, by High Energy Ball Milling "Nanoscale Res Lett (2007) 2:397–404

[3] S.R. Chauhan Anoop Kumar, I. Singhand Prashant Kumar "Effect of Fly Ash Content on Friction and Dry Sliding Wear Behavior of Glass Fiber Reinforced Polymer Composites - A Taguchi Approach" Vol. 9, No.4, pp.365-387, 2010

[4] R.Satheesh Raja, K.ManisekarV.Manikandan "Effect of fly ash filler size on mechanical properties of polymer matrix composites"

International Journal of Mining, Metallurgy & Mechanical Engineering (IJMMME) Volume 1, Issue 1 (2013) ISSN 2320–4060 (Online)

[5] Jitendra Gummadi, G.Vijay Kumar, Gunti Rajesh "Evaluation of Flexural Properties of Fly Ash Filled Polypropylene Composites" International Journal of Modern Engineering Research (IJMER) Vol.2, Issue.4, July -Aug 2012 pp-2584-: 2249-6645

[6] Patil Deogonda, Vijaykumar N Chalwa "Mechanical Property of Glass Fiber Reinforcement Epoxy Composites" International Journal of Scientific Engineering and Research (IJSER)ISSN (Online): 2347-3878 Volume 1 Issue 4, December 2013

[7] S.D.Saravanan, M.Senthil Kumar "Effect of Mechanical Properties on Rice Husk Ash Reinforced Aluminum alloy (AlSi10Mg) Matrix Composites" International Conference On DESIGN AND MANUFACTURING, IConDM 2013

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