RESEARCH ARTICLE OPEN ACCESS

Analysis of Fly Ash as Filler on Glass FiberReinforced 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 percentage variationof fly ash plays an important role in the enhancement of mechanical properties of glass fiber reinforced epoxy composite. The presentstudy deals with the effect of percentage variation filler contents on composites. As per ASTM D 3039 the CAD model is designed andthreedifferentspecimensofvariousfillercontents(10%,30%,and40%)andonepurecompositespecimenwerenumericallyanalyzedon ANSYS16.0.It was foundthat thepurecompositematerialenhanced themorestrength.
Keywords: EpoxyComposite, Flyashfillermaterial,FEM, UTMExperimentation

I. INTRODUCTION

Nowaday'scompositematerialarewidelyusedinautomotive,aerospaceindustries.Compositematerialsarelightinweightcomparedtometalsandwoods. Theirlightness is important in various industries for example lessweight means better fuel efficiency. Glass fiber reinforcedepoxy composites are results in an attractive combination ofphysical and mechanical properties which cannot be obtainedbymonoliticmaterials.

Epoxyresinsarewidelyusedasmatrixinmany fiberreinforcedcomposites;theyareaclassofthermosetmaterials of particularinterest to structural engineers owingto the fact that they provide a unique balance of chemical andmechanicalpropertiescombinedwithwideprocessingversatility. Within reinforcing materials, glass fibers are themost frequently used in structural constructions because oftheir specific strength properties. The ease of availability ofglass fiber and economic manufacturing techniques adoptedforproductionofcomponents.Developments arestillundertoincreasetheir properties.One of themethods toincreasethe strength of glass fiber reinforced epoxy composites is toadd various filler materials. These filler materials are act asadditional reinforcing components and show their mechanicalproperties.Among variousfillermaterialsfly ash is oneofthe filler material that can be used as filler on composites toenhance theirmechanical properties.

Flyashisawasteby-productwhichisgeneratedbycombustionofcoalinthermalpowerplants.Increasingproductionofflyashyearbyyear,fromthecoalbasedthermal power plant, it affects serious problem in terms ofsafe disposal and utilization. The utilization of fly ash as fillermaterials are generally acts as inert materials which are usedin composites to reduce thematerial cost, to improve themechanical properties to some extent and in some cases toimprove process ability. Reduction in filler size gives betterenhancementinpropertiesduetouniformdistributionofparticles in polymer matrix. As per ASTM C618 fly ash hasbeenclassifiedintotwocategories,ClassFandClass C.Generally it is a mixture of oxides rich in silicon (SiO_2), iron(Fe2O3) and aluminum (Al_2O_3). It depends upon thesourceof coal; which contains different properties of silica, alumina,oxidesofiron,calcium,magnesiumetcalongelementslike
C, Ti, Mg, etc. So that the fly ash has properties combined ofspherical particlesand thatof metalsandmetaloxides.

II. LITERATURE SURVEY

BaljeevKumar,RajeevGargandUpinderpal Singhhavestudied the utilization of fly ash as filler material in polymercomposites is considered important from both economic andcommercial point of view. Fly ash is used as reinforcing fillerin High density polyethylene (HDPE) to develop lightweightcomposites.Aftersurveyingtheyhaveconcludethatifflyashisusedasreinforcingfillermaterialin Highdensitypolyethylene(HDPE)somestudieshavepointedtotheexcellentcompatibilitybetweenflyashand polymer.Modification of Fly ash accompanied by compatibilizationleadstothesubstantialimprovement propertiesofthecomposites.However,itisobviousthat thepotentialasreinforcing fillers in polymers especially for Fly ash/HDPEcompositeshavenotbeenfullybrought into play.[1]

K.ThomasPaul,S.K.Sathpathy,IManna,K.K.Chakraborty,

G.B. Nando et al. studied the size reduction of fly ash frommicrometer level to nano level which is achieved by highenergyballmilling.Theaverageparticlesizehasbeenreduced from 60μm to 1480 nm, a reduction of nearly 405timesinmagnitude.[2]

S.R. Chauhan, Anoop Kumar, I Singh and Prashant Kumar etal. studied the design and experiment method which can beused to analyze the coefficient of friction and the dry slidingwear 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 theadditionof10wt %to20wt%offlyash. [3]

R.Satheesh Raja, K.Manisekar, V.Manikandan et al. studiedthe effect of fly ash filler size on mechanical properties ofpolymermatrixcomposites.Thecompositespecimensareprepared in the four different sizes (50 μm, 480 nm, 350 nm,and300nm)offlyashfillermaterialsbyusingCAD molding process. Mechanical testing such as hardness andimpact testwas carriedout.It is found that the 300 nm sizefly ash filler impregnated polymer compositeyields betterimpact energy (14 J) and hardness value (35 Hv) than others.Thusbydecreasingthesizeofflyashfillerleadstoincrease the interference bond between the polymeric matrix and thesolid fillers.[4]

JitendraGummadi,G.VijayKumar,GuntiRajeshhave preparedthe five different particlesizes of fly ash are usedforsamplepreparation.Percentagevariationofflyashinpolypropyleneis0,10,15,20,25.Thecompositetestspecimens are prepared using injection molding machine withhandlayuptechniqueasperASTMD3641standards.Bendingtestsonthespecimensarecarriedoutbyusingtensometer.ModulusandFlexuralstrengtharecalculatedfrom the obtained load values and the result is analyzed forthepreparedsamples.WithflyashaddedtothePolypropyleneimprovesflexuralmodulusandflexuralstrength ,but dramatically decreases percentage elongation atbreak. Finest particles showed best flexural strength at allconcentrations.[5]

PatilDeogonda, Vijaykumar N Chalwa et al. have used TiO_2andZnS as fillermaterial on GFRP laminated compositesandevaluatestheTensile,BendingandImpactstrengthincreaseswithadditionoffillermaterial.ZnSfilledcomposite shows significantly good results than TiO_2 filledcomposites. ZnS filled composite shows more tensile load incomparisonwithunfilledandTiO_2filledcomposites. TiO_2andZnSfillermaterialmakesmaterialharderandbrittlewhichisthereasonforreductioninimpacttoughnessvalue.[6]

S.D.Saravanan,M.SenthilKumaretal.havestudiedthe effect of mechanical properties on rice husk ash reinforcedAluminum alloy (AlSi10Mg) matrix composites. A rice huskash particle of 3,6,9 & 12% by weight were used to developmetal matrix composites using liquid metallurgy route andfoundtheresultsthatthetensilestrength,compressionstrength,andhardnessincreaseswithincreaseinweightfraction and ductility get decreases with increase in weightfractionofricehuskash.[7]

From the above literature survey it is clear that, the tensiletests were conducted for TiO_2, ZnS and rice husk ash as fillermaterial on composites and some flexural, impact test wereconducted for fly ash as filler material with the different sizeof fly ash. So in this project, different composite specimenswill be prepared by varying percentage of fly ash& carry outtensile testonUTM.

III. DESIGN AND ANALYSIS

A. MaterialSpecification:

ThematerialsusedtopreparethespecimenareE-Glassfiber,Epoxyresin(LY556),Hardener(HY951)
Material: Epoxy, Glass Fiber, Fly AshYoung'sModulus:5000 -35000MPa
Poisson'sRatio:0.24-0.4
Density:1800-1850kg/m^3

Table1: FillerMaterialSpecimen Details

	E-Glassmat		
Sr. No**.**	Glassfibercontent %	Epoxy	Fillercontent in% (flyash)
1	60	40	-
2	50	40	10
3	30	40	30

4	20	40	40

Table2: Testspecimendetail

Testspecimens	ASTM	Size
Tensiletestspecimen	D-3039	250x25x2.5mm.

B. CADMODEL:

To prepare the CAD model of specimen ANSYS 16.0 Designmodelerisused.

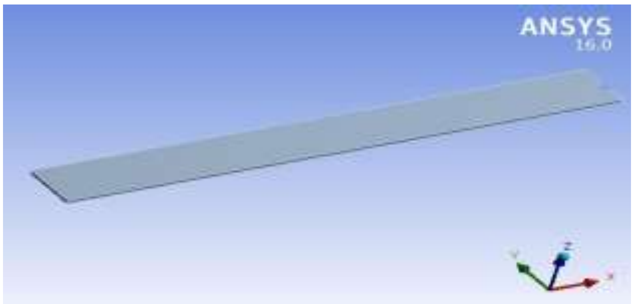

Figure1: CAD Model ofspecimen

C. DiscretizationorMeshing:

For the discretization of model a hexahedron element withstandardprogram controlledmeshisusedandhavingthenumberofnodes2640and numberofelements 1890.

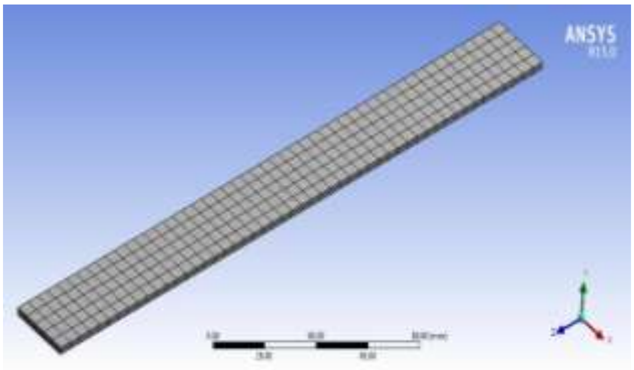

Figure2: Discretizationofspecimen

D. BoundaryCondition&Loading:

To apply tension on specimen one end is made to fix andanother endisappliedwithtension load.

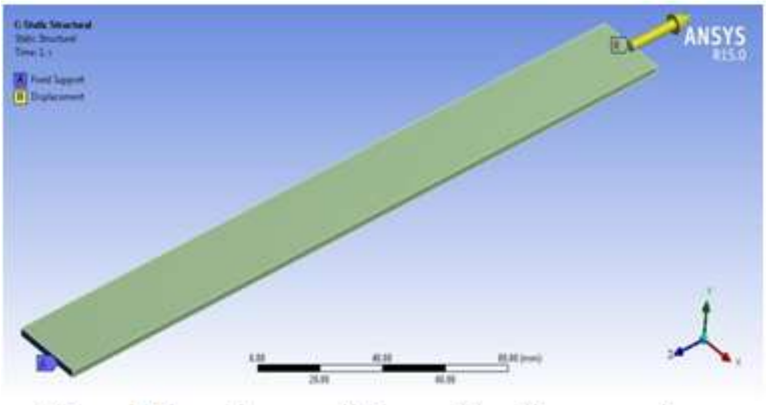

Figure3: Boundaryconditionsand loadingonspecimen

E. Orientations:

GivenorientationsareonX-axis=Normaldirections,Y-axis =Transversedirections,Z-axis=Fiberdirections.

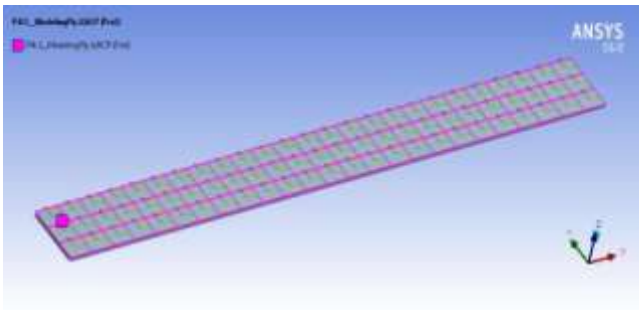

Figure4: Orientationsofspecimen

F. Plies:

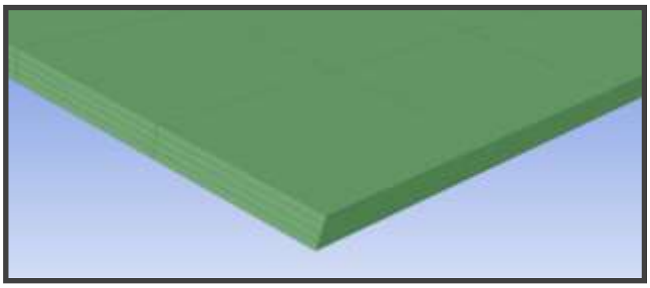

Figure5: Pliesofspecimen

IV. FINITE ELEMENT ANALYSIS

NormalStressPlot:

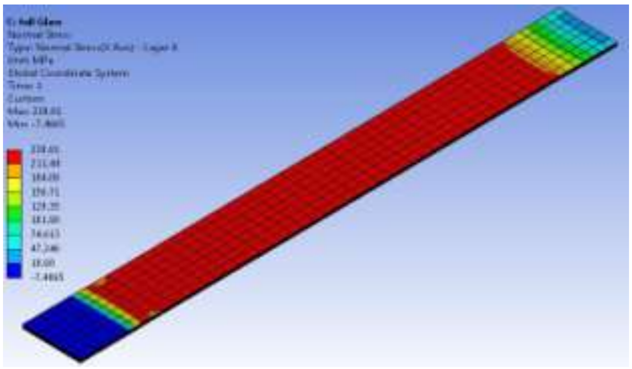

Figure7: NormalstressesofPureCompositeMaterial

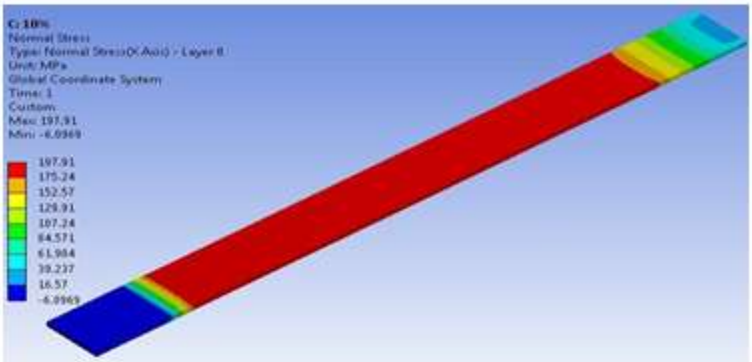

Figure 8: Normal stresses with the filler content of 10 % FlyashonCompositeMaterial

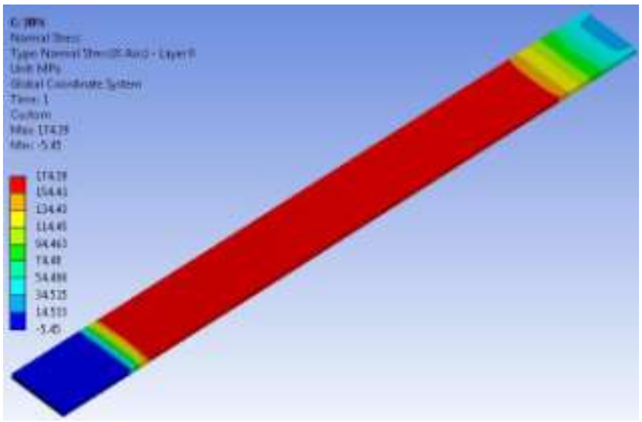

Figure 9: Normal stresses with the filler content of 30 % FlyashonCompositeMaterial

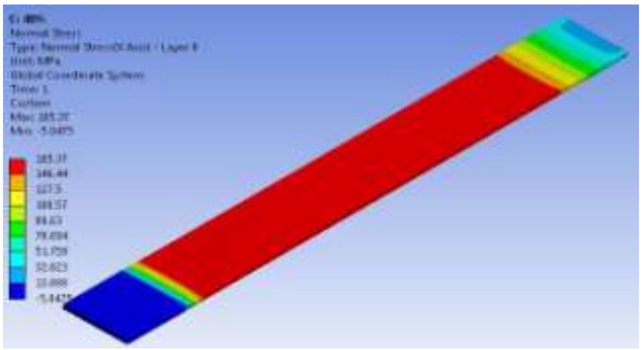

Figure 10: Normal stresses with the filler content of 40 %FlyashonCompositeMaterial

V. EXPERIMENTAL WORK

A. Fabrication ProcessHandLay-upTechnique

The fabrication of composite material is done by Hand lay-uptechnique.Glassmatispositionedmanuallyintheopenmould and resin is into glass plies. Entrapped air is removedmanuallywiththerollertocompletethelaminatestructure.

The fibers are manually placed into one sided gel coated maleor female mould. A matrix of thermosetting resin is rolledonto the fibers using hand roller. More layers can be addedand, after drying, the composite part can be removed from themould.

Figure 11: Test Specimens of various (10%, 30%,40%) offlyashcontentandpure compositematerial.

A.TensileTestofCompositeMaterial:

ThetestspecimensarefabricatesinaccordancewiththeASTMD3039.ThetestisconductedonUTM/E-40withresolutionofpistonmovement0.1mm.

Figure12: SpecimenonUTM duringtensiletest

Figure13: Specimenofflyashcontentof40%after testing

VI. RESULT AND DISCUSSION

Table3: FiniteElementAnalysisResults

Sr. No.	Fillercontentin %(flyash)	Force(N)	NormalStressesin (MPa)
1	-	10000	238.81
2	10	9500	197.91
3	30	9000	174.39
4	40	8500	165.37

Table4: ExperimentalResults

Sr. No.	Fillercontentin %(flyash)	Force(N)	NormalStressesin (MPa)
1	-	10789	213.33
2	10	10270	181.26
3	30	9751	159.95
4	40	8105	147.31

Abovetableshowsthefiniteelementanalysisandexperimental results of different composite specimens withthevaryingpercentageofflyashandpurecompositematerial.

VII. CONCLUSION

In this presentwork theresiduesfrom the thermalpowerplant is utilized as filler material in the glass fiber reinforcedepoxy composites. The CADmodel and analysis is carriedout on ANSYS 16.0.The composites specimens are preparedon the basis of variation in filler content (10%, 30%, 40%) offly ash and one pure composite material. Numerical analysiswas performed on above three specimens and on one purecompositematerial.Itisfoundthatthepurecompositematerial requires maximum forces (10000 N by FEM and10789 N by Experimental) and composite material with 40%filler content of fly ash requires minimum forces (8500 N byFEM and 8105 N by Experimental).Thus by increasing thepercentage of filler content the tensile strength is decreases. Itis concluded that pure composite material showed significantstrength when compare to filler content of 10%, 30% and40%.

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