



National Conference on Futuristics in Mechanical Engineering
Madan Mohan Malaviya University of Technology

DEVELOPMENT OF EPOXY-THERMOPLASTIC BASED SYNTACTIC FOAM FOR STRUCTURAL APPLICATION

Pooja Kannojiya Student, Dept. of Mechanical Engg. (Buddha Institute of Technology Gida, Gorakhpur)	Vipin Kumar Student, Dept. of Mechanical Engg. (Buddha Institute of Technology Gida, Gorakhpur)	Shubham Kumar Student, Dept. of Mechanical Engg. (Buddha Institute of Technology Gida, Gorakhpur)	Vivek Yadav Student, Dept. of Mechanical Engg. (Buddha Institute of Technology Gida, Gorakhpur)	Mr. Dharendra Kumar Assistant Professor, (Buddha Institute of Technology Gida, Gorakhpur)
---------------------------------------------------------------------------------------------------------------------------	-----------------------------------------------------------------------------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------	-----------------------------------------------------------------------------------------------------------------------	------------------------------------------------------------------------------------------------------------------

ABSTRACT

The present work is focused on the synthesis and study of the deformation behavior of epoxy resin/ plastic syntactic foams. Different densities syntactic foams with 0 to 40 volume percentages of plastic were prepared by casting method for the present investigation. The high viscosities of the resin- plastic mixture (putty like consistency) beyond 40 volume percentage prevents processing of higher plastic content syntactic foam. The effect of plastic content on tensile, compression, Flexural and impact properties were studied in detailed. Syntactic Foam means a closed packed cell or matrix. In this project we make a composite material with the help of Epoxy Resin and Adding the Reinforcement is waste Thermoplastic and study the mechanical properties of this composite material.

Keywords: Epoxy resin, Hardener, Thermoplastic, Syntactic foam.

INTRODUCTION

Syntactic foam are composite materials. It is closed cell composite material mixed in a resinous matrix. Which have very good mechanical properties, insulation properties, low thermal expansion and low moisture absorption capacity, etc. It is developed for sea application because it is light in weight also its application in ship structure and spacecraft. Syntactic foam are used as core material as a sandwich structure in composite. The advantage of syntactic foam have over conventional open cell structure, honey comb structures. A composite

material is a material made from two or more constituent materials with significantly different physical or chemical properties. When combined, produce a materials with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure, differentiating composites from mixtures and solid solutions.

LITERATURE REVIEW

Ho Sung Kim *et.al.*[1] work on fracture and impact behavior of hollow microsphere/epoxy resin composite authors

National Conference on Futuristics in Mechanical Engineering
Madan Mohan Malaviya University of Technology

observed that the impact strength of composite decrease with increase in volume percentage of glass micro balloon this was due to the breakage of specimen at high volume fraction and strength of glass balloon was less.

G Raghvendra *et.al.* [2] studied A Comparative Analysis of Woven Jute/Glass Hybrid Polymer Composite With and Without Reinforcing of Fly Ash Particles authors observed that glass fiber had less bonding nature than jute fiber jute outer layer behaves as brittle because it shows maximum erosion at 90° . After addition of fly ash composite behavior was same and it shows maximum at 60° which indicate semi brittle behavior of composite.

Bibin John *et. al.* [12] worked on the effect of low density reinforcement on mechanical properties of syntactic foam of made of cynateester. The authors used two types of glass micro balloons having grade of K25 and K37 and performed different testing. From the study the authors concluded that the tensile strength of the syntactic foam were decreased by increasing volume fraction but the syntactic foam with K 37 shows high tensile strength than the K 25 except at higher volume percent. This is the evidence of higher resin to micro balloon bonding in K 37. On increasing volume fraction of the glass microspheres, interfacial bonding between matrix and filler (*viz.*, glass microspheres) decreases and results in decrease in tensile strength.

Ulku Yilmazer *et.al.* [16] studied on tensile, flexural and impact properties of a thermoplastic matrix reinforced by glass

fiber and glass bead hybrids on notched and unnotched sample Authors observed that impact energy decrease with increase in volume fraction of glass beads because vacuole growth in impact test is absent and at high speed extensibility of matrix was reduced.

Chun-Ki Lam *et.al.*[21] studied Cluster size effect in hardness of nanoclay/epoxy composites authors observed that hardness of composites increase with increase in nanoclay up to a optimum level and then decreasing, this was due to the cluster size of nano clays reaches a crucial limit and the reinforcing function of clay decrease with increase in nano clay in composite.

METHODOLOGY AND EXPERIMENTAL PROCEDURE

Materials

Epoxy resin (Araldite LY556) and hardener (HY951) supply by Herenba Instruments & Engineers Chennai, India was used as a matrix material and curing agent respectively. Araldite (LY556) was highly viscous; having density and viscosity of 1.15g/cc and 10000-12000 mPa-s respectively. Hardener (HY951) was low viscous having density 0.98g/cc was used for room temperature curing. The resin to hardener ratio used was 10:1.

Reinforcement

The reinforcement is used in this project waste thermoplastic. Which is banned in some states because it is not destroy easily.

National Conference on Futuristics in Mechanical Engineering
Madan Mohan Malaviya University of Technology

This is major problem of pollution and rises the very dangerous disease.

Specimen processing

The present work is focused on making the composites material by adding the reinforcement and check its mechanical and physical characteristics. In this project we used the (0 to 40%) volume percentage. First of all we make a zero percentage based specimen and perform mechanical characteristic like impact test ,hardness test, tensile test and compressive test. The zero percent based specimen make without adding reinforcement. In this type of specimen only epoxy hardener are mixed according to its calculation. After this we make other specimen to use the (10 to 40%) volume percentage of reinforcement and perform the above test measured value is compared with the zero volume percentage measured value. By analysis of the above observed value we plot the graph for the showing the behavior of composites material. Stir casting method was used, in the present study, to process syntactic foams with varying volume percentage (0-40 volume %) of thermoplastic. Required amount of resin, hardener, and thermoplastic, depending on the volume percentage of the resultant foam were calculated (as shown below).

Preparation of Mold

In the present study the dimension of the mould used to prepare specimen for tensile and flexural testing is 150mm×65mm×8mm. At first wooden bits (of thickness 8.0mm)

were cut according to the dimension of 150mm and 65mm respectively. Then these wooden bits were wrapped with plastic tape. A flat wooden board fixed with a transparent plastic sheet was used to form the base of the mold. The wrapped wooden bits were fixed firmly (with the help of nails) in rectangular shape as shown in figure. The purpose of the transparent plastic sheet is to prevent sticking of the mixture and ease removal of the specimen after room temperature curing.

In this test the components are subjected to Impact (Shock) loads, these loads are applied suddenly. The stress induced in these are performed to asses shock absorbing capacity of materials subjected to suddenly applied loads. These capabilities are expressed in form of Rapture energy, Impact strength, & Modulus of rapture. Two types of Impact test are commonly used i.e. Charpy test and Izod Test. In presence work only perform Charpy test.

In Charpy test, the specimen is placed as cantilever position and specimen have V-shaped notch of 45°. The notch is located on tension side of specimen during impact loading. Depth of notch is generally taken as $t/5$ to $t/3$ where t is thickness of specimen.

RESULTS AND DISCUSSION

Impact testing

Impact strength curve of the syntactic foam with different volume percentage of waste thermoplastic are shown below.

In impact test the impact strength of composite material is varying according to volume of waste thermoplastic. Impact

National Conference on Futuristics in Mechanical Engineering
Madan Mohan Malaviya University of Technology

strength of various sample is increases with increasing volume % of Reinforcement up to 30% and then start decreasing.

Calculation for required amount of casting material for different volume % of syntactic foam

In this subsection, calculation of required amount constituent materials (e.g. epoxy resin, hardener, and thermoplastic) are described for x volume% of epoxy and y volume% of filler.

The calculation for weight estimation for matrix and filler are as follow:-

Calculation for matrix

Density of epoxy =1.15g/cc

Density of hardener =0.98g/cc

Density of thermoplastic =0.95 g/cc

Here epoxy to hardener ratio used was 10:1

Percentage of epoxy in matrix= $(10/11) \times 100 = 90.9\%$

Percentage of hardener in matrix= $(1/11) \times 100 = 9.09\%$

By applying rule of mixture for obtaining density of matrix

Density of matrix= density of epoxy × volume fraction of epoxy+ density of hardener × volume fraction of hardener

Density of matrix= $(90.9/100) \times 1.15 + (9.09/100) \times 0.98$

Density of matrix=1.12g/cc

Volume of mould = $150 \times 65 \times 8 (\text{mm}^3) = 78000 \text{ mm}^3$

Let volume percentage of epoxy and thermoplastic taken was x and y respectively.

Density= mass/volume

$1.12 \times 10^{-3} = \text{mass} / (x \times 78000)$

Mass of matrix= 87.36x g

Mass of epoxy= $(90.9 \times 87.36x) / 100$

Mass of epoxy= 79.41x g

Mass of hardener = $(9.09 \times 87.36) / 100$

Mass of hardener = 7.94x g

Mass of filler

Density of filler= mass/volume

$0.95 \times 10^{-3} = \text{mass} / (y \times 78000)$

Mass of filler= 74.1y g

Similar manner it was calculated in respective places for different tests.

where, m_i = Initial mass and m_f = Final mass

CONCLUSIONS

With the increase in thermoplastic content, energy absorption capacity of the syntactic foam increases from 3.1 kJ/m² (for pure resin) to 8.305 kJ/m² up to a critical volume fraction (30 vol.%). This is because of the fact that the bond strength between matrix (epoxy+hardener) and reinforcement (thermoplastic) start decreasing after 30 vol.%

REFERENCES

- 1) Kim Ho Sung, Khamis Mohammad Azhar. Fracture and impact behaviours of hollow micro-sphere/epoxy resin composites. Compos Part A: Appl Sci Manuf 2001;32:1311-7.
- 2) G. Raghavendra, Shakuntala Ojha, S.K. Acharya, S.K. Pal. A Comparative Analysis of Woven Jute/Glass Hybrid Polymer Composite With and Without Reinforcing of Fly Ash Particles.

National Conference on Futuristics in Mechanical Engineering
Madan Mohan Malaviya University of Technology

- 3) Giulio Malucelli, Francesco Marino
abrasion resistance of polymer nano
composite- A review.
- 4) J.R.M.d' ALMEDIA. An analysis of the
effect of the diameters of glass microspheres
on the mechanical behavior of glass-
microsphere/epoxy-matrix composites.
- 5) Klaus Friedrich, ZhongZhang ,Alois K.
Schlarb. Effects of various fillers on the
sliding wear of polymer composites.
- 6) Aare Aruniit ,JaanKers , JüriMajak ,
Andres Krumme , and Kaspar Tall . influence
of hollow glass microspheres on the
mechanical and physical property of and cost
of particle reinforced polymer composite.
- 7) K.C. Yung , B.L. Zhu , T.M. Yue , C.S.
Xie. Preparation and properties of hollow
glass microsphere-filled epoxy-matrix
composites.
- 8) C. Swetha¹, Ravi Kumar. Quasi-static uni-
axial compression behavior of hollow glass
microspheres/epoxy based syntactic foams.
- 9) A. Marot and B. A. Othman, "The
potential Use of Bamboo as Green Material
for Soft Clay Reinforcement System", 2011
International Conference on Environment
Science and Engineering, IPCBEE vol.8
(2011) © (2011) IACSIT Press, Singapore, pp.
129-133.
- 10) D. S. V. Prasad, M. A. Kumar and G. V.
R. Prasadaraju, "Behavior of Reinforced Sub
Bases on Expansive Soil Sub grade", Global
Journal of Researchers in Engineering, 2010,
Vol. 10(1), pp. 2–8.
- 11) G. L. Siva Kumar Babu and A. K.
Vasudevan, "Strength and Stiffness Response
Coir Fiber-reinforced Tropical Soil", Journal
of Materials in Civil Engineering, 10.1061/
(ASCE) 0899-1561(2008), Vol. 20:9(571), pp.
571-577.
- 12) John Bibin, Reghunadhan Nair CP,
Ambika Devi K, Ninan KN. Effect of low-
density filler on mechanical properties of
syntactic foams of cyanate ester. Mater Sci
2007;42:5398–405.
- 13) Nikhil Gupta , Raymond Ye, Maurizio
Porfiri. Comparison of tensile and
compressive characteristics of vinyl
ester/glass microballoon syntactic foams.
Composites: Part B 41 (2010) 236–245.
- 14) Gupta N, Kishore, Woldesenbet E,
Sankaran S. Studies on compressive failure
features in syntactic foam material. J Mater
Sci 2001;36:4485–91.
- 15) C. Swetha, Ravi Kumar. Quasi-static uni-
axial compression behavior of hollow glass
Microspheres/epoxy based syntactic foams.
Materials and Design 32 (2011) 4152–4163.
- 16) YilmazerUlku . Tensile, flexural and
impact properties of a thermoplastic matrix
reinforced by glass fiber and glass bead
hybrids. Composites Science and Technology
44 (1992) 119-12.
- 17) Wouterson Erwin M, Boey Freddy YC,
Hu Xiao, Wong Shing-Chung. Specific
properties and fracture toughness of syntactic
foam: effect of foam microstructures. Compos
Sci Technol 2005;65:1840–50.
- 18) Viot Ph, Shankar K, Bernard D. Effect of
strain rate and density on dynamic behaviour
of syntactic foam. Compos Struct
2008;86:314–27.
- 19) Gupta Nikhil, Maharsia Rahul.
Enhancement of energy absorption in
syntactic foams by nanoclay incorporation for

National Conference on Futuristics in Mechanical Engineering
Madan Mohan Malaviya University of Technology

sandwich core applications. Appl Compos Mate 2005;12:247–61.

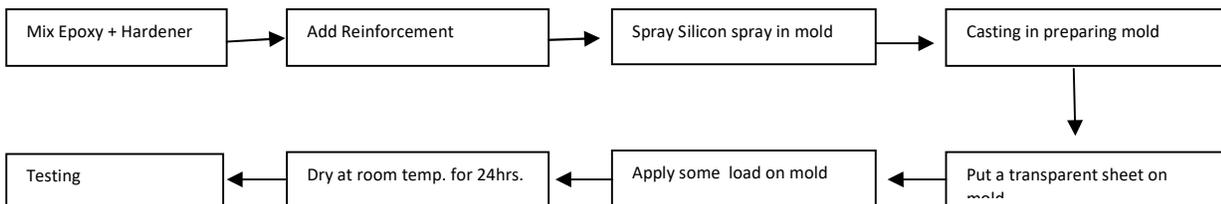
20) Shakuntala Ojha, Samir Kumar Acharya , Raghavendra Gujjala. Characterization and Wear Behavior of Carbon Black Filled Polymer Composites. Procedia Materials Science 6 (2014) 468 – 475.

21) Chun-Ki Lam, Hoi-yan Cheung, KintakLau,Li-min Zhou. Man-waiHo,DavidHui.cluster size effect in hardness of nanoclay/epoxy composite. Composites: Part B 36 (2005) 263–269.

Fig- Preparation of moldPreparation of syntactic foam



The flow chart for preparation of the syntactic foam is shown in figure-



*National Conference on Futuristics in Mechanical Engineering
Madan Mohan Malaviya University of Technology*

Fig- Flow chart for preparation of Syntactic foam



Fig-Prepare Sample

Mechanical Characterization

Impact Test



Fig-Impact testing machine

National Conference on Futuristics in Mechanical Engineering
Madan Mohan Malaviya University of Technology

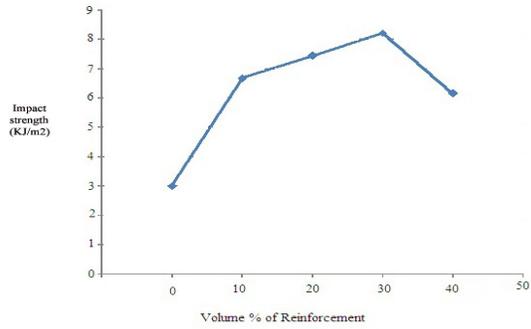


Fig- Variation of impact strength with volume % of Reinforcement