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Evaluation of Toughness on Varied Thickness of Chopped Strand Mat /PU-foam Sandwich Structures

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Abstract:- Sandwich composites structures now a days drives the several industrial aspects counting form low density to potential resistance to external loading conditions. Glass fiber reinforced polymer composites is widely used many industrial application particularly in the automotive industry due to advantages such as low weight, ease of processing, price and noise suppression. Sandwiched structure forms a new option for automotive industry. A sandwiched structure is a special type of sandwiched–structure composite that is fabricated by attaching two thin but stiff skins to a light weight but thick core. The core material is normally low strength material, but its higher thickness provide the sandwiched structure composite with high bending stiffness with low overall density. Keeping this in mind our present study concern about the preparation of sandwich composites by using glass fibre as skin and polyurethane foam as a core material and sample was prepared by hand layup method for two different thickness of the core which influence greatly on the mechanical properties of material. Testing of samples according to ASTM standard was done and phenomenal observations are accurately noted and results are tabulated. The qualitative comparison has been made to samples of different thickness to recommend the applicability of sample. It was observed that remarkable changes have been recorded as thickness of the sandwich affects greatly on resistance to toughness which aims to absorb more energy upon loading. The experimental reading has been tabulated for all the loading conditions and performance oriented comparison is highlighted to show case the reasonable factor for the drastic changes under impact loading conditions.

***Key Words*: sandwich Structures, Light weight materials, Impact resistance of composites.**

1. INTRODUCTION

Composites are considered to be foundation material for all commercial applications, basically from domestic to aerospace applications. However, the cost of traditional composite materials is also considerable. Random chopped fiber-reinforced composites (RFCs) have emerged as promising alternative materials for lightweight structures due to their low cost and mass production capabilities [1]. Their potential application in, for example, automotive industry has been documented. In order to expand their use, accurate material characterization is required. The main difficulty in fully exploring model their geometry at the micro-level for high fiber volume ratios (35-40%). This difficulty becomes even more obvious at high aspect ratio fibers [2]. Glass-fiber reinforced composites (or glass- fiber reinforced plastics, GFRP) have seen limited use in the building and construction industry for decades. Because of the need to repair and retrofit rapidly deteriorating infrastructure in recent years, the potential for using fiber – reinforced composites for a wider range of applications is now being realized[3]. The impact energy of low-strength metals that do not show change of fracture mode with temperature is usually high and insensitive to temperature. For these reasons, impact tests are not widely used for assessing the fracture-resistance of low-strength materials whose fracture modes remain unchanged with temperature. Impact tests typically show a ductile-brittle transition for low-strength materials that do exhibit change in fracture mode with temperature such as body-centered cubic (BCC) transition metals. Generally high-strength materials have low impact energies which attest to the fact that fractures easily initiate and propagate in high-strength materials. The impact energies of high-strength materials other than steels or BCC transition metals are usually insensitive to temperature. High-strength BCC steels display a wider variation of impact energy than high-strength metal that do not have a BCC structure because steels undergo microscopic ductile-brittle transition. Regardless, the maximum impact energy of high-strength steels is still low due to their brittleness[4].The reports studies on short fiber reinforced composites by different investigators are found to have focused mostly on the strength properties of the composites. They have described the influence of fiber shape in short glass fiber composites [5]. They have studied the flexural properties of misaligned short fibers reinforced polymers by taking into account the effects fiber length and fiber orientation. Recently, efforts to reduce the weight of automobiles by the increased use of plastics and their composites, have led to a growing penetration of short-fiber reinforced injection molding thermoplastics into fatigue-sensitive applications [6]. In general, short-fiber/polymer matrix composites are much less resistant to fatigue damage than the corresponding continuous fiber reinforced polyester (GRP) is widely used in pressure vessel and pipe line system for chemical industry [7].Keeping this historical evidence in mind the present study highlights the preparation of chopped strand mat glass fabrics sandwiched with polyurethane foam by varying the thickness and the mechanical tests have been done upon preparing the samples according to testing conditions. Comparative results resemble the influence of core thickness on mechanical properties of light weight materials.

2. MATERIALS & METHODOLOGY

2.1 THE RAW MATRERIALS USED

- S glass fiber(chopped strand mat)
- Epoxy Resin
- Hardener
- Polyurethane Foam (PU Foam)

2.1.1 Glass fibre

Glass fiber has roughly comparable mechanical properties to other fibers such as polymers and carbon fiber[8]. Although not as strong or as rigid as carbon fiber, it is much cheaper and significantly less brittle when used in composites. Glass fibers are therefore used as a reinforcing agent for many polymer products; to form a very strong and relatively lightweight fiber-reinforced polymer (FRP) composite material called glass-reinforced plastic [9].chopped strand Mat fibre used for the present study is as shown in figure.1

Fig.1: Chopped strand mat fiber glass

Glass fibers are used successfully for reinforcing material for rubbers has been studied. High initial aspect ratio can be obtained with glass fibers, but brittleness causes breakage of fibers during processing[10]. The mechanical properties of types of different glass fibres are shown in table 1.

Table 1: Comparison of S- Glass and E- Glass

Fiber type	UTS (MPa)	Density (g/cm^3)	Thermal expansion (μm/m·°C)	Softening T (°C)
E-glass	3445	2.58	5	846
S- glass	4890	2.46	2.9	1056

2.1.2 Polyurethane foam

Polyurethane (PUR and PU) is a polymer composed of organic units joined by carbonate (urethane) links. While most polyurethanes are thermosetting polymers that do not melt when heated, thermoplastic polyurethanes are also available [11]. Polyurethane polymers are traditionally and most commonly formed by reacting a di- or poly-isocyanate with a polyol. Both the isocyanates and polyols used to make polyurethanes contain, on average, two or more functional groups per molecule Polyurethanes are produced by mixing two or more liquid streams.

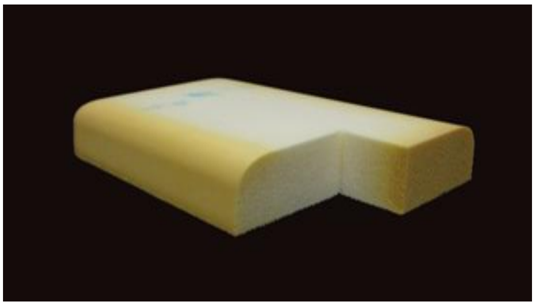

Fig.2: PU-foam readily apparent is the discoloration that occurs over time

Polyurethane insulation is lightweight but strong, with a density ranging between 30 kg/m^3 and 100 kg/m^3 depending on the application. For special applications that are subject to extreme mechanical loads, the density of the PUR/PIR rigid foam can be increased to 700 kg/m^3[12].Even at low densities, polyurethane keeps excellent mechanical properties such as compressive stress, compressive strength and creep.

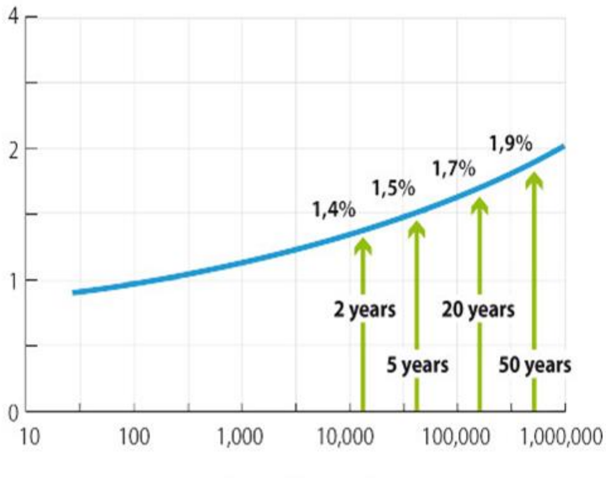

Fig.3: Deformation of Polyurethane foam with respect to time

2.1.3 Epoxy

Epoxy resins are thermosetting resins, which cure by internally generated heat. Epoxy systems consist of two parts, resin and hardener. When mixed together, the resin and hardener[13]. When mixed together, the resin and hardener activate, causing a chemical reaction, which cures (hardens) the material. Epoxy resins generally have greater bonding and physical strength than do polyester resins[14]. Most epoxies are slower in curing, and more unforgiving in relation to proportions of resins and hardener than polyesters. Commercially available forms of epoxy is as shown in figure.4

Fig.4: General purpose Epoxy

Resin systems are relatively low in viscosity and contain low- loss filler for improved physical characteristics. Castings, which are shrinkage free, void free and low in thermal expansion, are easily prepared. The electrical characteristics are not scarified.

3. EXPERIMENTAL METHODS

Hand layup Method

Hand lay-up is an open molding method suitable for making a wide variety of composites products from very small to very large. Production volume per mold is low; however, it is feasible to produce substantial production quantities using multiple molds[15]. Hand lay-up is the simplest composites molding method, offering low cost tooling, simple processing, and a wide range of part sizes. Design changes are readily made. There is a minimum investment in equipment. With skilled operators, good production rates and consistent quality are obtainable.

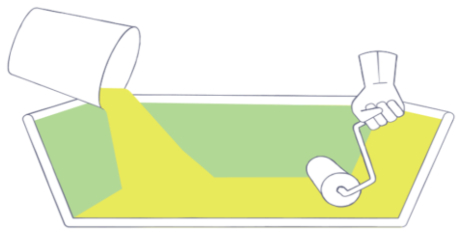

Fig.5 : Hand Lay-up Process

3.1 STEPS INVOLVED IN MAKING THE MATERIAL

PU Foam and fiber glass is cut into 200*200 mm dimension. Two pieces of PU Foam is cut into required dimension. Six sheets of Fiber Glass are cut for one sample and ten for another as per required dimension (200*200). Samples preparation steps are followed with the ready arrangement as shown in figure 5. First the foam layer (3mm) is securely placed in the mould and layer of resin is coated over it. Care should be taken that the layer should not have excess amount of resin since it contributes to wastage. Then the first layer of fiber mat is placed properly over the foam and then again a coating of resin is applied over it. After each layer formation, mixture is applied on the layer of mat and then allowed to bond with each other .The coating of resin is done with the help of special brush which is strictly used for fiber purpose. After the final layer is coated with the resin the mixture is spread evenly by using hand rolls. After the material has been formed, it is kept for drying and applying suitable quantity of load on it. Two sets of specimens have been prepared having thickness of 11mm & 15mm. Prepared samples are shown in figure.6 and samples prepared are cut in to required dimensions for testing by using electric hacksaw shown in figure.7.

Fig.6 : Prepared Sample thickness 11mm & 15mm

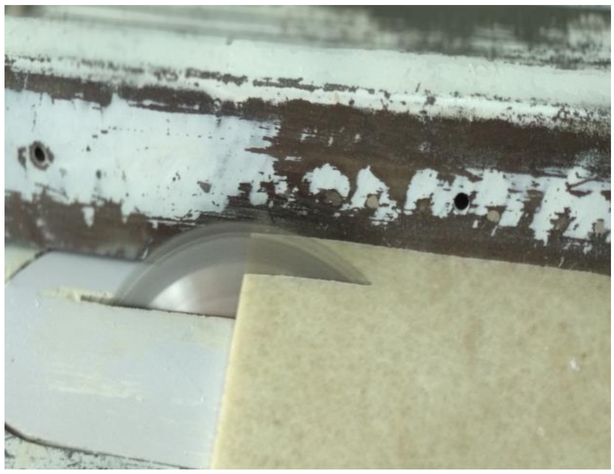

Fig.7 : Material has been cut into required Dimension

3.2 IMPACT TEST

The charpy impact test [ISO 179] is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture.

Experimental setup for impact test is as shown in figure.8. This absorbed energy is a measure of a given material's notch toughness and acts as a tool to study temperature-dependent ductile-brittle transition. It is widely applied in industry, since it is easy to prepare and conduct and results can be obtained quickly and cheaply.

The qualitative results of the impact test can be used to determine the ductility of a material. If the material breaks on a flat plane, the fracture was brittle, and if the material breaks with jagged edges or shear lips, then the fracture was ductile. Usually a material does not break in just one way or the other, and thus comparing the jagged to flat surface areas of the fracture will give an estimate of the percentage of ductile and brittle fracture.

Impact test has been conducted with the help of impact testing machine as shown in figure according to ISO 179 standard where charpy impact on the prepared sandwich samples are directed to sudden loading conditions the test results and effect of thickness on tough ability of a material is discussed clearly to conclude the strain of material after being prepared with varying the core thickness values of the sandwich composites.

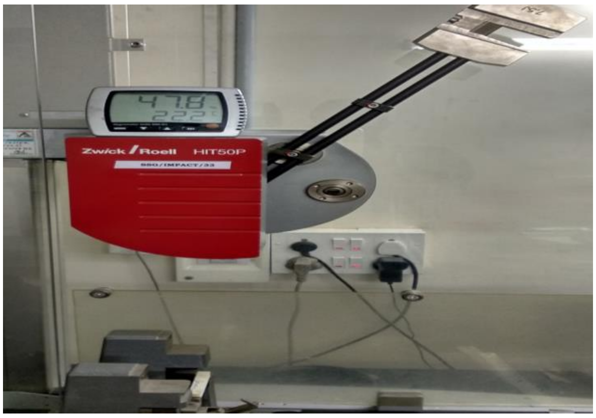

Fig.8: Impact Test Machine

4. RESULTS AND DISCUSSIONS

Charpy impact test has been conducted by using impact testing machine for the samples prepared for different thickness to counter the influnce of thickness on the impact strength.

Bellow table 2&3 highlights the experimental values for various papprametres of impact testing is clearly detailed.

Table.2: Different parameters of Impact testing for sample with 11mm thickness.

Sample	W (%)	Absorbed energy j	Impact strength kj/m^2	Thickness mm	Width mm	Frictional loss j	Type of failure
1	84.2	6.32	52.55	11	11	.02	P
2	60.5	4.54	42.12	11	11	.02	P

Series graph:

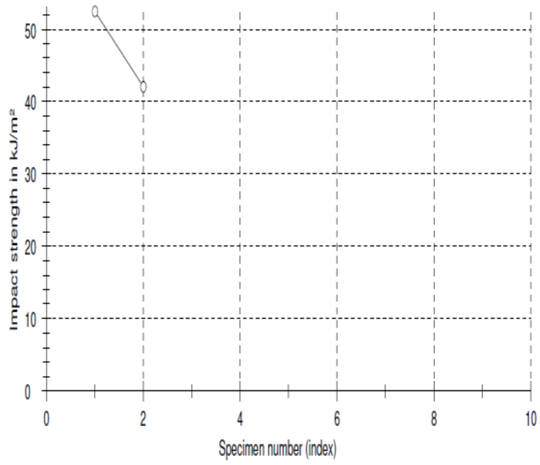

Fig.9: Graphical representation of Impact strength verses Specimen number of 11mm Dimension specimen

Table.3: Different parameters of Impact test of 15mm thickness dimension specimen

Sample	W (%)	Absorbed energy J	Impact Strength Kj/m^2	Thickness Mm	Width Mm	Frictional Loss J	Type of failure
1	39.9	9.98	66.43	15	11	.05	C
2	37.6	9.41	63.40	15	11	.05	C

Series graph:

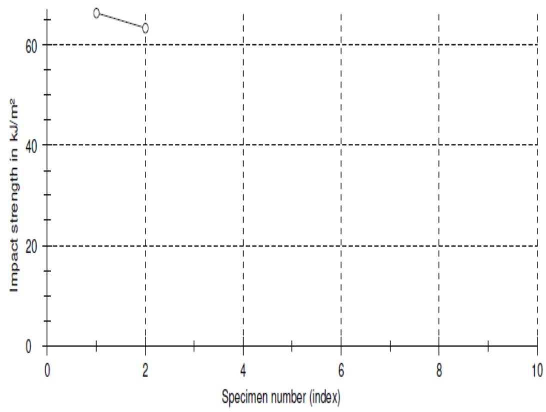

Fig.10: Graphical representation of Impact strength verses Specimen number of 15 mm Dimension specimen

Above figures 9 & 10 depicts the behavior of material under impact loading which describes the impact strength of the sample against corresponding material thickness. The core values of the test are derived by amount of energy absorbed by the material when the shock load is applied which resembles the matrix toughness of the samples which is varied greatly with the thickness of the samples are considered.

Comparison of Impact strength

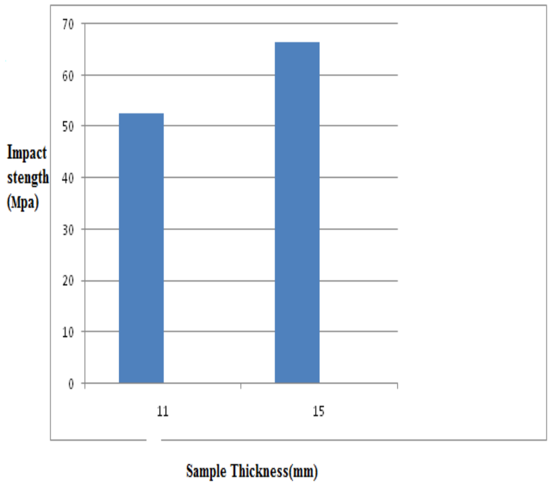

Fig.11: Comparison of impact strength for samples having different thickness

It was more predominant for the samples where increase in thickness gives rising trend in toughness of the composites where amount of energy absorbed aginest applied load is ended with upmost value of the sample considered as shown in figure.11 and the impact strengh of the material thus observed which records nearly 26% rise in strength of the sample which is having more thcikness compared with the least due to toughned matrix which inturn gives rise to better resistance to impact loading.

5. CONCLUSIONS

Experimental work on evaluating impact properties of sandwiched composite with chopped glass fibre and polyurethane foam with different thickness has been conducted successfully and the following main conclusions can be drawn from this study:

- The successful fabrication of sandwiched composite of Fiber glass and polyurethane foam of different thickness has been done by simple hand lay-up technique.
- The present work modifies the mechanical properties of composites as the sandwiched composite performs comparatively better than other type of composites.
- Compared with respect to different thickness of composites, the composites of higher thickness shows greater compactness and provides larger surface area to withstand external load
- In Impact test, results obtained records the value of 26% increase in the impact strength with the increase in the thickness of the sandwich structures which clearly concludes the greater thickness imparts excellent load bearing abilities.

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