Comparative Study of Thermal Property (HDT) of Hybrid Composites Prepared using Glass Fiber, Sugarcane Bagasse and Human hair

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Abstract— The main aim of this research work is to prepare hybrid composites and to compare them on the basis of thermal property namely Heat Deflection Temperature (HDT). For preparation of composites, hand lay-up method is used. Unsaturated polyester (UP) resin is principal binding material (50wt %) while Cobalt naphthenate is used as an accelerator (0.5wt %) and Methyl ethyl ketone peroxide (MEKP) is used as a hardener (1wt %). 400 gsm chopped strand mat of E- glass fiber is primary reinforcement material while sugarcane bagasse and human hair fiber waste are used as additive fiber in glass fiber reinforced plastic (GFRP) for preparing hybrid composite. An exothermic reaction occurs in which energy released is more than the energy supplied, this extra energy in the form of heat is due to formation of new bonds by cross-linking. Post curing, prepared composites are evaluated on Heat Deflection Temperature (HDT).

Key words: Glass fiber, UP resin, human hair, sugarcane bagasse, Heat Deflection Temperature, Myler film

I. INTRODUCTION

A composite material is a material that consists of two or more constituents which are not soluble in each other. One constituent is known as reinforcement material and the other is known as matrix material [2]. When composite material is made up of two or more reinforcement materials it is known as hybrid composite [3]. On the basis of matrix, composites are classified into three types- Metal Matrix Composite (MMC), Ceramic Matrix Composite (CMC) and Polymer Matrix Composite (PMC). Among these three types of composites PMC is very popular due to its simple manufacturing principle and easy production of complicated shapes. Fiber Reinforced Plastic (FRP) which is a PMC is a thermosetting material. In FRP one phase is known as polymer matrix phase while the other phase is known as reinforcement phase. Epoxy, Vinyl ester or Polyester is generally used in polymer matrix phase while carbon fiber, aramid fiber or glass fiber is used as a reinforcement material.

Thermal properties play a vital role in evaluating the product performance as well as predicting the processibility characteristics in plastics for specific applications. These properties are of great importance to the engineers and designers in designing the machines and tool for shaping of plastics. High temperature makes plastic more sensitive to mechanical stress and vulnerable to chemical attack, while lower temperature generally makes them less ductile. In designing a part it becomes pre-requisite to understand the thermal shear history of a material during processing, assembling, finishing, shipping and end use to ensure that it retains its integrity. Various performance properties of polymers also depend upon temperature requirements. An imbalance in the toughness and stiffness of the polymer occurs below and above specific temperature range, depending on the molecular structure of the material.

Heat Deflection Temperature is a relative measure of a material's ability to perform for a short time at elevated temperatures while supporting a load. The test measures the effect of temperature on stiffness. It is defined as the temperature at which a standard test bar deflects 0.25mm under a stated load of either 0.455 MPa or 1.82 MPa. When heated at the rate of 2°C/min.

II. MATERIALS AND METHOD

A. *Materials:*

Chopped strand mat of E-glass fiber of 400 gsm, unsaturated polyester resin, MEKP, Cobalt naphthenate, Myler film, Human Hair, Sugarcane Baggasse. Glass fiber, Resin, Hardener, Accelerator and Myler film are purchased directly from market and sugarcane bagasse and human hair are collected from local sources.

B. *Designation of Composites:*

Refer table 1

Sr.No.	Composite	Composition
1	C	UP resin (50wt %) + glass fiber (50wt %)
2	C1	UP resin (50wt %) + glass fiber (48wt %) +sugarcane bagasse (2wt %)
3	C2	UP resin (50wt %) + glass fiber (46wt %) + human hair (4wt %)
4	C3	UP resin (50wt %) + glass fiber (44wt %) + human hair (4wt %) + sugarcane bagasse (2wt %)

Table 1: Designation of composites

C. *Sheet Preparation of GFRP:*

Layer based hand lay-up method used for sheet preparation of glass fiber reinforced plastic (GFRP). Unsaturated polyester resin mixed with cobalt naphthenate 0.5wt% used as an accelerator which increases the reaction rate of process. After mixing accelerator with the resin, 1wt% MEKP is mixed into it as hardener, which is used for curing purpose. Liquid resin is applied with the help of brush on the fiber mat placed on the Myler film. Myler film plays two important roles; it behaves as a mould as well as provides better surface finish. Resin passes through the mat. After applying resin on one layer the subsequent layers are placed in the same way. Then the sheet is pressed by hand roller so that the matrix binds the fiber completely. Another Myler film is placed on the top so as to get better curing results and surface finish [1].

III. EXPERIMENTAL SETUP

A. Test specimen and conditioning:

Specimens of dimensions 127 mm in length, 13 mm in depth and width from 3 mm to 13 mm are taken for determination of HDT. Dimensional tolerance of the order of ±0.13mm over the length of the specimen is maintained for easy reproducibility and repeatability. A minimum of two test specimens shall be used to test each sample at each fiber stress. The test bars are cut from the sheet. The specimens should have smooth, flat surface and should be free from sink marks or flash.

The test specimens should be conditioned at 23 ± 2°C (73.4 ± 3.6F) and 50 ± 5 % relative humidity for not less than 40 hrs prior to test.

B. Equipment:

Fig. 1: HDT Testing Machine

HDT testing machine consists of the following:

1) Specimen supports: Metal supports for the specimen of 100 ± 2 mm, allowing the load to be applied on top of the specimen vertically and midway between the supports.
2) Immersion bath: A suitable liquid heat-transfer medium (oil-bath) in which the specimen shall be immersed.
3) Deflection measurement device: Dial gauge or any other indicating or recording device including electric displacement sensing apparatus may be used for the measurement of specimen deflection of at least 0.25 mm.
4) Weights: A set of weights of suitable sizes so that the specimen can be loaded to a fiber stress of 0.455 MPa ± 2.5% or 1.82 MPa ± 2.5%. The mass of the rod that applies the testing force shall be determined and included as part of the total load.

C. Procedure:

ASTM D648, Standard Test Method for Deflection Temperature of Plastics under Flexural Load in the Edgewise Position. According to the method, width and depth of each specimen is measured at several points along the span. An average value of these readings is taken to obtain the nominal width and depth value of the specimen. The test specimens are positioned edgewise in the apparatus to ensure that they are properly aligned on the supports so that the direction of the testing force is perpendicular to the direction of the molding flow. The thermometer bulb which is a sensitive part of the temperature measuring device shall be positioned as close as possible to the test specimen (within 10 mm) without touching it. The liquid-heat transfer medium shall be stirred thoroughly to ensure that temperature of the medium is within 1.0°C at any point within 10 mm of the specimen.

The oil bath shall be at ambient temperature at the beginning of the test so that the temperatures raised or lowered for the earlier test shall not create any error. After achieving the ambient temperature carefully apply the loaded rod to the specimen and lower the assembly into the bath. Adjust the load so that the desired stress of 0.455 MPa or 1.82 MPa is obtained. Adjust the deflection measurement device to zero or record its starting position 5 minutes after applying the load. Heat the liquid heat-transfer medium at a rate of 2.0 ±0.2°C/min. The temperature is recorded of the liquid heat-transfer medium at which the specimen has deflected the specified amount at the specified fiber stress.

Weight required to transfer the force on the test specimen:

The load (P) is calculated as:

$P = 2Sbd^2 / 3L$

Where

S = Max. Fiber stress in the specimen of 0.455 MPa or 1.82 MPa

b = Width of specimen, mm

d = Depth of specimen, mm

L = Width of span between support, mm

A bar of rectangular cross section is tested in the edgewise position as a simply supported beam with the load applied at its center to give maximum fiber stresses of 0.455 MPa or 1.82 MPa. The specimen is immersed under load in a heat transfer. The temperature of the medium is measured when the test bar has deflected 0.25 mm. This temperature is recorded as Heat Deflection Temperature (HDT) of material.

Fig. 2: Specimen after HDT test

IV. RESULT AND DISCUSSION

composites	Specimen	Weight used to transfer force (gms)	Temperature (◦C)	Mean temperature (◦C)
C	1	160	246.2	250.65
	2	168	255.1	
C1	1	175	233.2	221.90
	2	178	210.6	
C2	1	180	254.0	249.00
	2	182	244.0	
C3	1	189	180.0	185.00
	2	188	190.0	

Table 2: HDT test results

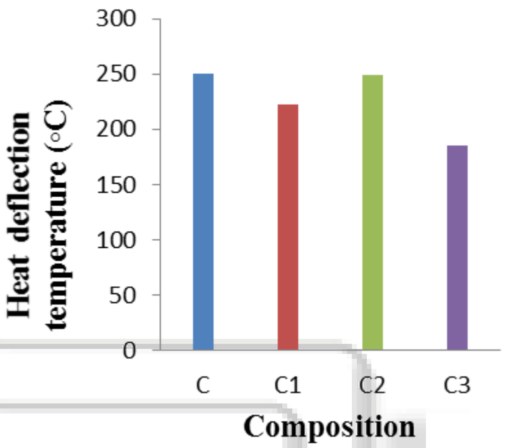

Fig. 3: comparison composites on the basis of HDT

Fig.3 shows the comparison composites on the basis of heat deflection temperature (HDT). Y-axis represents HDT while composition represented on X-axis. HDT of all composites is represented by taking mean of HDT of both 2 samples.

Above results show that heat deflection temperature of composites decreases by mixing sugarcane bagasse into GFRP. On the other hand there is only marginal change in heat deflection temperature of composite while human hair is mixed with it. Composite C shows the maximum HDT followed by C2 (almost equal temperature) and C1 while C3 represents the minimum among all composites.

V. CONCLUSION

Thermal properties play a vital role in evaluating the product performance as well as predicting the processibility characteristics in plastics for specific applications. These properties are of great importance to the engineers and designers in designing the machines and tools for shaping of plastics. Heat Deflection Temperature is a relative measure of a material's ability to perform for a short time at elevated temperatures while supporting a load. The test measures the effect of temperature on stiffness.

It is concluded that Heat Deflection Temperature of hybrid composites does not posses Heat Deflection Temperature as high as base composite 'C'. Composite C shows the maximum HDT followed by C2 (almost equal temperature) and C1 while C3 represents the minimum deflection temperature among all composites.

VI. FUTURE SCOPES

Though Thermal Property of the composites namely 'C1', 'C2' and 'C3' are less than that of base composite 'C' but the usage of bagasse and hair fibers should be increased because reinforcing material is a waste material. These waste materials create problem to the environment because hair is a non bio-degradable material which is not well managed or utilized. The waste materials can be utilized for many of the beneficial uses in a cost effective manner and by using them their threat to environment can also be curtailed. The promotion of usage of these materials may result in a better and a healthier environment and also a cost effective technique for production of many essential goods.

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