Heat Distortion Temperature and Shear Property Examination of Composites using Recycled Glass Fibres and Recycled PPCP

Bikramjit Singh, Gajendra Dixit, Savita Dixit

Abstract*: Pollution from plastic materials has become a severe problem all around the world. Plastics, due to their long lasting properties are utilized majorly in almost every application from packaging, electrical appliances, vehicle parts etc. the major concern related to plastics are that they are non-degradable and hence are harmful for environment. Several researches have been done in utilizing plastic material in addition with some other materials to form a composite material which has better properties than pure substances. Plastics with glass fibres are one such of composition where the new material formed can be used for several day to day applications. Hence the present work focuses on, manufacturing of a composite material from recycled glass fibres and recycled polypropylene co-polymers (PPCP) in varying ratios. A total of six specimens are made and results for Heat deflection temperature (HDT) 70:30 has the best results compared to other compositions. Results are also calculated for shear strength for the same composition of specimen, which shows better results compared to wood material (plywood). This experiment provides a solution for utilizing the waste plastic material found in waste lands and scrapyards which continuously pollute the environment.

Keywords: Plastic, HDT, Shear strength, glass fibers, PPCP.

I. INTRODUCTION

In the present time period, the sources of renewable energy depending on the polymers which are degradable biologically are emerging on a vast scale and are gaining much more attention towards them as they are expected to be a source of replacement for petroleum based polymers which are used in current time as they are non-degradable and are highly toxic for the environment. The degradable polymers not only solve the problem of waste polymers but also bear excellent mechanical and engineering properties which are used are alternative materials in most of the industries. These advantages of such polymers increase their utilization as well as manufacturing for day to day useful items. (Tábi, Hajba and Kovács, 2016) Heat deflection temperature (HDT) is particularly important for outdoor applications in the summer where some material surfaces can be exposed to temperatures well above 40^{o} C. when it comes to product design the parameter of HDT (heat deflection temperature) plays a very crucial role. It signifies the limitation regarding foremost stability of any material in operation involving the physical deformation or change of shape under thermal loads. (Chan *et al.*, 2006)

A. Plastic Waste

The problem of waste plastic is a worldwide issue, nevertheless it fluctuates from region to region. The major concern comprises of disposal of plastic material, it is a valuable material having excellent property such as light in weight, better durability, easy in moulding in different shapes, and cheaply available. Plastic materials are disposed in the environment after its usage, nevertheless since they are non-biodegradable; they tend to exist in the environment for long period of time. The MSW (municipal solid waste) contains around 10-12% of plastic waste which is fired up in the open environment. This results in release of toxic and harmful carbon gases which pollutes the atmosphere such as Dioxins, Furans, Mercury and Polychlorinated Biphenyls (Rinku Verma*, K. S. Vinoda, M. Papireddy, 2016).

Several plastic materials such as (PE), (PP) and (PS) on incomplete burning might generate elevated concentrations of carbon monoxide gases. On the other hand PVC produces dioxins and carbon black. (Gupta, Dr. Rakesh Kumar and Project, 2007)

It becomes essential to utilize waste plastic material to reuse them into useful products and applications. This protects the environment as well as prevents from toxic chemical effects and avoids the problem of disposal. Hence, the experiment performed in the present research is carried out as an initiative under the Clean India by Honourable Prime Minister of India as an attempt to provide a fruitful solution for non-degradable polymers which adversely affect the environment.

II. METHODOLOGY

A. Characterization of Recycled Glass Fiber and Recycled Polypropylene Co-Polymer Material

To prepare processed GF and PPCP into a mass or group an agglomerator (Made by J.J Industries, Indore) of 25kg output is utilized. Further the obtained agglomerated mixture is then fed into the heated mold having Outer area 12'' X 12'' in dimension with 5'' X 5" area of core and cavity. Further the mold is filled by using a PLC controlled Hydraulic Compression Molding Machine (Manufactured by Hind Hydraulics, Mumbai) having Maximum clamping tonnage of 40 tons and a maximum temperature range of 350 °C.

Revised Manuscript Received on January 05, 2020
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III. RESULTS

With the use of above described methodology, further samples of different volume ratio were prepared to perform the testing and result evaluation procedure on them. There were five samples prepared using the above experimental methodology they were:

Table- I: Composition structure of Recycled PPCP (RPPCP) and Recycled Glass Fiber (RGF)

S.No.	Percentage of RPPCP	Percentage of RGF	Final Ratio
1.	100%	0%	100% RPPCP
2.	90%	10%	90 % RPPCP-10% RGF
3.	80%	20%	80% RPPCP-20% RGF
4.	70%	30%	70% RPPCP-30% RGF
5.	60%	40%	60% RPPCP-40% RGF
6.	65%	35%	65% RPPCP-35% RGF

A. HDT Measurement

The calibration of heat distortion temperature is carried out in a three-point mode as per the standards of ASTM D-648 by the means of Vicat / HDT-Tester (Coesfeld GmbH & Co. KG, Germany). The total number of samples is conditioned prior to the experiment testing and kept at temperature of 24 ± 2 °C and 50 ± 5% RH for duration of 48 hours. Then after the specimens were put under deflection load by the means of 0.25mm beneath a surface load comprising 0.455 MPa and a temperature source of 2 °C min^{-1}.

Table- II: HDT Values for various composition

S.No.	Description	HDT in °C
1.	R- PPCP	82
2.	90 **Table- II: HDT Values for various composition** %RPPCP-10% RGF	89
3.	80% RPPCP-20% RGF	99
4.	70% RPPCP-30% RGF	106
5.	65% RPPCP-35% RGF	111
6.	60% RPPCP-40% RGF	120

Table-II shows the results obtained for HDT in all the test specimens. It can be clearly seen that HDT at the initial stage with pure RPPCP material has 82°C temperature. This temperature gradually rises when RGF is added with RPPCP Following; specimen 2 shows the result value of 89°C**.** Similar pattern of rising HDT is observed at specimen 6 with HDT value of 120°C.

The influence of RGFs on the thermo mechanical behavior of RPPCP was researched and calibrated. The temperature at which any material which is polymeric in nature undergoes deformation with respect to constant application of load is known as HDT. Higher values in the HDT remarks that composite material bears superior workability under elevated temperature conditions. RGFs have been found to improve the HDT of RPPCP the HDT temperatures of different compositions of the composites indicated in Fig 1. The HDT of 100% RPPCP was found to be 82 ° C whereas the addition of 10% RGF with RPPCP increased the HDT by 7°C to 89 °C, higher than that of only RPPCP. The penetration of RGFs results in important improvements in the stiffness, therefore elevating the HDT comprised in the RPPCP matrix. Further it becomes essential to comprehend that RGFs have very important part in dominating HDT in RGF/RPPCP composite. From the above we can see that any increase in the percentage of RGF increases the HDT of the composite.

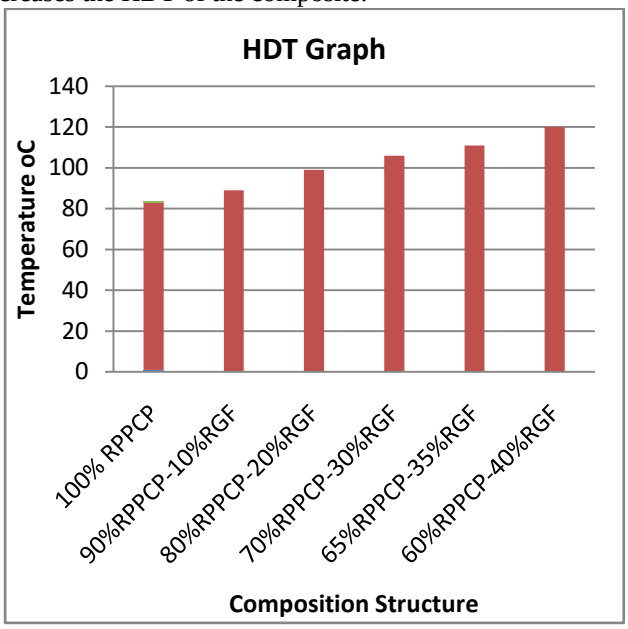

Fig. 1.Graph showing composition vs HDT

B. Shearing

While performing shear test, a load is applied on a material acting in simultaneously two opposite directions. Universal tensile testing machine is used for performing this test, in which fixture of special type is needed according to the polymer material's standard dimension. A fixture is used to held specimen and subsequently, load is applied until it shows breakage. This load is noted down at which the test sample fails.

RGF and RPPCP composites have wide range of applications in sectors depending on the adhesion quality and properties of inter-linked Fibres.

Values of shear strength of sample 70% Recycled PPCP 30% Recycled Glass fibre.

Table- III: Values of Shear strength of the composite sample (70 RPPCP-30 RGF)

Specimen (4mm thickness)	Max load (N)	Shear strength (MPa)
1.	4896	97.42
2.	5527.51	110.0
3.	4518	89.90
4.	5655.15	112.51
5.	5427	108.3

Table-III shows the results obtained for shear strength for specimen with composition 70% Recycled PPCP 30% Recycled Glass fibre. Five trials were conducted by varying the maximum load and correspondingly shear strength values were observed. It can be clearly seen that, shear strength increased with increase in maximum load starting from trail 3

with maximum load value of 4518 N which gives 89.90 Mpa as shear strength. Further, trial 5 shows 5427 N maximum load with shear strength as 108.3 Mpa. Similar, increase in shear strength is observed with maximum load value of 5655.15 N which shows shear strength of 112.51 Mpa. This result provided a range of 89.90 Mpa to 112.51Mpa shear strength for the test specimen.

Plastic materials have its wide application used as packaging material. The plastics constitute of approximately 40% as packing material globally. They have created energy efficient& sustainable, as well as hygienic along with cost effective material used in the system. (Siddiqui and Pandey, 2013).From the above table, it can be seen that values of shear strength for the samples is in between the range from 89.90 MPa to 112.51 Mpa. The most common application of glass fibre and PPCP material is in the packaging material used for transportation of goods. This composite material can be used in the place of plywood packaging material as the plywood has Shear strength between 6MPa to 8MPa. On the other hand, the shear strength of the composite (70 RPPCP-30 RGF) material is more than plywood; hence it can be used in hard packing. Also the lower bases of solar panels are made from these materials as it has high strength and mechanical properties.(Hirayama *et al.*, 2017)

IV. CONCLUSION

Plastics are non- biodegradable organic polymers, they are being used excessively, and large piles of plastic wastes end up in landfills and oceanic garbage islands. From the results it is clear that the HDT increases due to the presence of glass contents in the composition as the binding property is improved in ratio 70:30, further the increase in HDT results in strong compaction of molecules of PPCP and GF hence the interlinking of RGF and RPPCP increases. On the other hand the specimen with ratio 70:30 shows better shear strength compared to other compositions since increase in HDT values makes the specimen tough which offers good resistance to shearing; hence it can be used for packaging materials for goods, can be used as panel boards and also can be used in replacement to plywood and normal woods in terms of applications. Further, the effect of HDT and the change of molecular structure among the specimens can be investigated by the means of X-Ray Diffraction test.

ACKNOWLEDGMENT

I would like to Thankfully acknowledge my Guide Dr. Gajendra Dixit and Co-Guide Dr. Savita Dixit for the kind support extended to me in preparing and finalizing my research paper for publishing in the esteemed journal I would also like to express my sincere thanks to Mr Yogesh and Mr Neeraj for the timely support in helping me at times of troubles while preparing the paper

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Bikram jit Singh was born in Agra U.P on 26th Jan 1969.He is currently pursuing his PHd in Mechanical Engineering from MANIT Bhopal his area of research is Plastics polymers and composites .He is working as Technical Officer At Central Institute of Plastics Engineering And Technology under Ministry of Chemicals and fertilizers Govt of India since 1992. He has worked on numerous projects pertinent to development of substitutes to conventional materials in the field of defence, packaging and automobiles. He is currently working actively with the municipal corporation for effectively implementing Plastic waste management and its recycling into many useful products.

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