INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING

ISSN (ONLINE): 2321-3051

Vol.2 Issue.12,

December 2014.

Pgs: 24-31

EXPLORATION OF EFFECT OF COPPER FILLER MATERIAL ON THERMAL PROPERTIES OF PALMYRA FIBER REINFORCED COMPOSITE

P.PADMAVATHI[1], C.J.RAO[2]

[1.] M.Tech Student (Thermal Engineering), Aditya Institute of Technology and Management, Tekkali.
E mail: padma.vathi89@gmail.com

[2.]Professor &HOD. Mechanical Engg. Dept. Aditya Institute of Technology and Management, Tekkali.

Abstract

Recently, thermoplastic and thermoset polymers are combined with natural fibers to produce the composites, which possess better strength and good resistance to fracture. Due to an excellent property profile, these composites find wide applications in packaging, building and civil engineering fields. The present work aims to elucidate the optimization of thermal properties such as thermal conductivity, specific heat.Thermal degradation measurement by Thermo-Gravimetric Analysis (TGA) and Thermal Diffusivity of Palmyra reinforced polymer composites with chemical treatment and addition of copper powder materials. The composite specimens were prepared with different weight percentages of palmyra fiber and copper powder in polymer matrix.

Keywords: Palmyra fiber, natural composite, Chemical treatment, Copper powder, Thermal properties.

1. Introduction

Material characteristics play an important role in manufacturing and design engineering. Knowledge of the response of the work material during manufacturing is essential for adopting more efficient, effective and economical processing methods. Proper understanding of the response of the work material under different situations is possible only if the characteristics of a material are known. Composites with natural fibres are gaining increasing attention for a variety of applications. Natural fibres such as jute, coir, sisal, and Palmyra belong to this category [1]. Glass, carbon, boron and Kevlar fibres are being used as reinforcing materials in Fibre Reinforced Plastics [FRP] which have been widely accepted as materials for structural and non-structural applications. Synthetic fibres are not eco-friendly. Hence attention has been focused on the utilization of natural fibres for the production of fibre-reinforced materials. One of the natural fibre-polymer composites are investigated by Paramasivan and Abdulkalam, A.P.J. [2] using sisal fibres and epoxy matrix. The fabrication process attempted by them includes winding and lamination. It is found that the fabrication of these composites is fairly easy and cost of production is quite low. Winding of cylinders with longitudinal or helical and hoop reinforcements is successfully carried out. Tensile strength of the sisal-epoxy composites is found to be 250-300 MPa, which is nearly half the strength of fibre glass –epoxy composites for the same volume fraction. However due to low density of sisal fibre, however, the specific strength of sisal composites is comparable with that of glass composites. The unidirectional modulus of sisal-epoxy composites is found to be about 8.5GPa. This study indicates the feasibility of developing composites incorporating one of the abundantly available natural fibres, to be used in the field of consumer goods, low-cost housing and civil structures. However, no attempt is made in this work on the performance of such composites to assess the effect of exposure to weather or the performance of the components in actual use. There are also reports [2] of sisal-polyester composites using electron probe microanalysis for evaluating filler dispersions in polyester composites. Chopped sisal fibre polyester composites are prepared by the press moulding technique. Mechanical properties of the composites are evaluated through accelerated weathering tests conducted pertaining to

ASTM D-520 specification. It is found that the specific modulus of the composite is 1.90 compared with 2.71 for glass fibre reinforced plastics, while the specific strength is of the same order as that of polyester and 30% less than glass fiber reinforced plastics. Accelerated testing revealed little change in initial modulus, reductions of 5% in ultimate tensile strength, 16% in flexural strength and 5.4% in water absorption. Lakkad.S.C. et al [6] compared the values of ultimate tensile and compressive strength and Young's modulus of elasticity of bamboo specimens with those of mild steel and glass reinforced plastics. But they have not specified the specic-name of the bamboo specimens tested. There are more than 500 species of bamboo available in India and each has different mechanical properties. Jindal.U.C. [7] studied the mechanical properties of bamboo specimens made from Dendrocalamus Stricutus specie of bamboos. The specific ultimate tensile strength of bamboo specimens is nearly six times the specific ultimate tensile strength of the mild steel. Bamboo specimens have maximum stiffness along the fibers and minimum transverse to the fibers. The variation of the modular ratio (i.e. the ratio of Young's modulus along the fibers and transverse to the fibers) of bamboo specimens under different fiber orientation is similar to the variation of modular ratio of other fibre-reinforced composites. Fiber incorporated plastics have been very popular due to their flexibility, their lightness and the ease of fabrication of complicated shapes with economic savings in contrast to fiber reinforced metals/alloys. In addition, these composites can be easily substituted for conventional materials in several areas such as the building industry, transportation and consumer goods. Some of these attempts made in recent times for the utilization of natural fibres through composite material technology have indicated their potential as substitute for the conventional materials such as wood and glass fibre reinforced plastics (GFRP) in many applications. There are, however, a number of limitations, including cost factor and their performance over a long time duration, which need further research. Extensive literature is available on the production and mechanical behavior of composites obtained by reinforcing epoxy with fibre of glass, boron, carbon silicon carbide etc. Many researchers in the past have developed composites with natural fibres such as sisal henequen, jute, banana, cotton, etc. [3, 4, 5, 8], but the work on the Palm Fibre Reinforced Plastic Composites [PFRP] is not available in the literature.

2. Preparation of Samples

Steps in preparation of polymer fiber reinforced composite samples using Hand Lay technique.

2.1 Extraction of Palmyra Fibers from Palm Tree

Palmyra fiber is available in the form of bract on a Palmyra tree. First dried bracts are collected from Palm trees. Then the fibers inside the bract are segregated. They are soaked in water for 24 hours. Using a knife, the black layer on top of the fiber is scrapped off. These fibers are dried in sun for 2 days to remove the moisture. If necessary they should also be put in an oven for 2 hours at 70^{o}C to ensure that all the moisture is completely removed.

2.2 Chemical Treatment of Fibers

In this work only chemically treated fibers are used. Cleaned fibers are kept in 4% (NaOH) solution for 4 hours for chemical treatment. The fibers are then removed and cleaned in water. They are kept in sunlight for 24 hours to remove moisture entirely. The fibres are then cut as per the required dimensions as per ASTM test sample specifications.

2.3 Mold Preparation

Thermal conductivity test samples should be of circular shape with 50 mm diameter and 10mm thickness. To prepare the mold, a 50 mm diameter hole is cut in a 10 mm thick rubber sheet. This cut rubber sheet is affixed to a cleaned tile with mansion hygienic wax. The tile is cleaned thoroughly with shellac NC thinner solution.

During preparation of the circular sample, it is observed that the fiber concentration is much higher at the center than at the periphery. To get a nearly homogenous fiber distribution in the sample, in this research a large rectangular sample of 165 mm x 55 mm x 10 mm is prepared, out of which the required circular samples are cutout.

Fig.1: Chemically Treated Palmyra Fibers

Fig.2: Mold for Sample Preparation

2.4 Determining Quantities of Fiber and copper

The maximum amount of fiber or copper powder that can fit in the mold is taken as 100%. To fit in maximum amount of fiber, fibers are spread layer upon layer very closely and ramming is done after each layer mold is found to be 8 gm, which is taken as 100% (FB100). The weight of maximum copper powder quantity is found to be 32gm, which is taken as 100% (CU100).

2.5 Polyester Bonding Material

Polyester resin is durable, comparatively inexpensive, has superior corrosion resistance, has good ran 4413, which is a general purpose polyester resin is used as matrix material.

Property	**Value**
Resin	ECMALON 4413
Colour	pale yellow
Viscosity	500-600 CPS (Brokfield Viscometer)
Specific Gravity	1.13 grams/c.c.
Temperature	25^0 C
Acid Number (mg KOH/g)	22
Monomer content	35%

Table.1: Properties of Polyester Resin

2.7 Catalyst and Accelerator

Curing or cross-linking of polyester is achieved by adding a catalyst (initiator) plus an accelerator (promoter) at room temperature. The function of catalyst is to speed up a chemical reaction by providing an alternate reaction pathway with lower activation energy. The function of accelerator is to alter chemical bonds and speed up the chemical process. In this work, cobalt accelerator along with Methyl Ethyl Ketone Peroxide (MEKP) catalyst is used.

Optimum quantity of catalyst and accelerator must be used. If more quantity is used, the specimen cures faster but will be of lesser strength and poor appearance. If lesser quantity is used, then the sample takes very long time (more than 8 hours) to cure. In this work approximately 2ml catalyst and 2 ml accelerator is used, which gave a curing time of around 4 hours.

2.8 Hand Lay Technique

2.8.1 Clean the mold with shellac NC thinner solution. Apply a thin coating of poly-vinyl alcohol on the interior tile surface and along the edges of the rubber sheet. Dry it for a day.

2.8.2 Fill the mold with required mass of fibers by spreading them as homogenously as possible.

2.8.3 Take the required mass of copper powder in a measuring jar.

2.8.4 Pour small amounts of liquid polyester in the copper powder jar and stir it thoroughly.

2.8.5 Add catalyst to this paste using a syringe and stir it fast.

2.8.6 Add accelerator to this mix and stir it fast. Extreme caution should be taken in ensuring that the catalyst and accelerator does not get into direct contact with each other. Else they both react chemically extremely rapidly with issuing out fire.

2.8.7 Immediately apply this paste on top of the fibers which are filled in the mold, otherwise it would solidify rapidly in the measuring jar itself.

2.8.8 To ensure that no air bubbles are trapped inside, take a transparency sheet and cover it over the mold immediately by using rolling operation.

2.8.9 Place a tile on top covering the entire mold and its contents. Place sufficient weight (roughly 50 kg) on top of the mold and leave it undisturbed in a closed room for 1 day until the composite cures.

Fig.2: 100Wt%Fiber composite

Fig.3: Copper powder

3. Thermal Testing Results

Thermal Tests conducted are:

1) Thermal Conductivity measurement
2) Specific Heat Capacity measurement
3) Thermal Diffusivity is computed.
4) Thermal Degradation measurement by Thermo-Gravimetric Analysis (TGA)

To investigate the effect of aluminum powder filler material on the thermal properties of the chemically treated palmyra fiber composites, 5 samples are prepared.

Sample Name	Polyester gm	Fiber Gm	Al gm	Relative CU %
CU0	13	8	0	0%
CU25	10.5	6	3.75	25%
CU50	7	4	7.5	50%
CU75	4.5	2	11.25	75%
CU100	26	0	15	100%

Table.2: Sample's Composition by Weight

Sample	Weight	Volume	Density

Name	(kg)	(m^3)	(kg/m^3)
AL0	0.020	2.50E-05	1277.5
AL25	0.022	1.78E-05	1844.4
AL50	0.023	2.50E-05	1197.63
AL75	0.028	2.14E-05	1210.95
AL100	0.031	1.79E-05	1732.6

Table.3: Sample's Density

3.1 Thermal Conductivity

Thermal conductivity of the samples is measured at 50^{o}C using guarded heat flow test method as per ASTM E1530 specifications. Unitherm Model 2022 manufactured by ANTER Corp., Pittsburgh, PA is used for this test

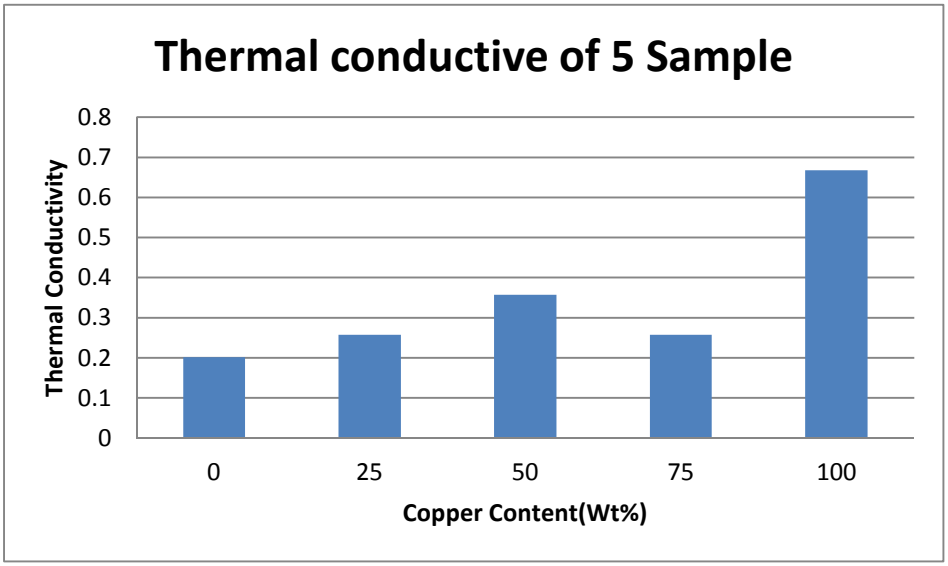

Fig.4: Thermal conductivity of specimens at 55^{o}C.

3.2 Specific Heat Capacity

Differential Scanning Calorimeter (DSC) technique using Double Furnace setup is used for measuring specific heat capacity. DSC is a thermo- analytical technique in which the difference in the amount of heat required to increase the temperature of a sample and reference is measured as a function of temperature. Compared to Single Furnace setup, Double Furnace DSC gives more accurate readings over larger temperature range, with more rapid response time as it measures the heat flow change of the sample directly. Test equipment used is Netzsch Simultaneous Thermal Analyzer STA 449F5 Jupiter.

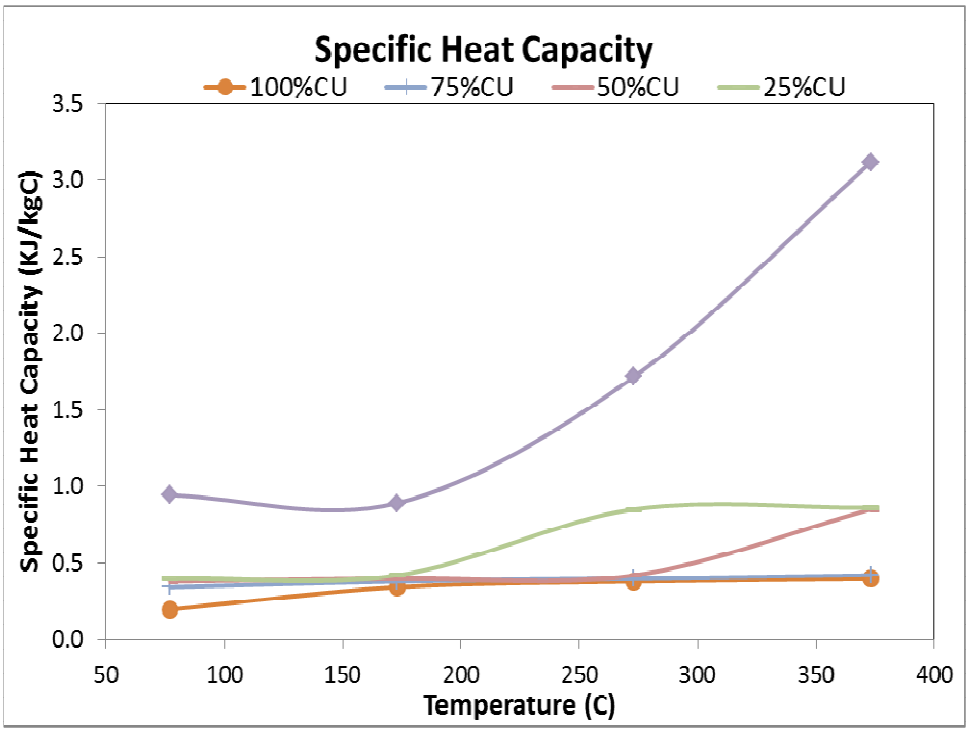

Fig.5: Sample's Specific Heat Capacity

3.3 Thermal Diffusivity

Although thermal diffusivity can be experimentally measured by flash method, in this work it is calculated after knowing thermal conductivity, specific heat capacity and density.

$$\alpha = \lambda/(\rho C_p)$$

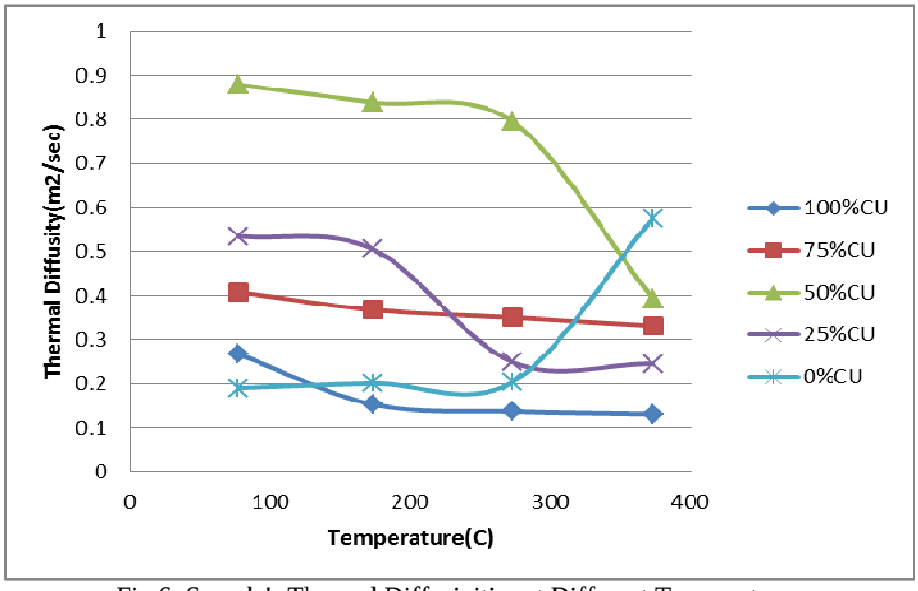

Fig.6: Sample's Thermal Diffusivities at Different Temperatures

3.4 Thermal Degradation by TGA

Thermo-Gravimetric Analysis (TGA) is a technique in which the mass of a substance is monitored as a function of temperature or time as the sample specimen is subjected to a controlled temperature program in a controlled atmosphere. TGA measures a sample's weight as it is heated or cooled in a furnace. The loss in weight over specific

temperature ranges provides an indication of the composition of the sample, including volatiles and inert filler, as well as indications of thermal stability.

All the measurements were performed as per ASTM E1131 standard using high resolution Perkin Elmer TGA7 Thermo-gravimetric Analyzer. The samples weighing between 10 and 20mg are placed in a platinum pan and tests are performed within the temperature range of 20–700^{o}C at a heating rate of 5^{o}C/min under nitrogen atmosphere at flow rate of 50 ml/min. TG and DTG curves were analyzed to study the high temperature degradation behavior.

The TGA curves (Fig.7) of specimens provide three distinct temperature regions, wherein the samples experience major weight loss. A small weight loss was observed during Phase-1 attributed to the evaporation of moisture. Actual degradation happens in second region attributed to the thermal degradation of hemicelluloses, cellulose and lignin together with polymeric matrix and thereafter the rate of decomposition was slow.

As can be seen from curves, the thermal decomposition onset temperature is highest for CU100% with the corresponding least amount of weight loss %. Thus 100% Copper powder composite has the greatest thermal stability or the least thermal degradation. Among the remaining composites.

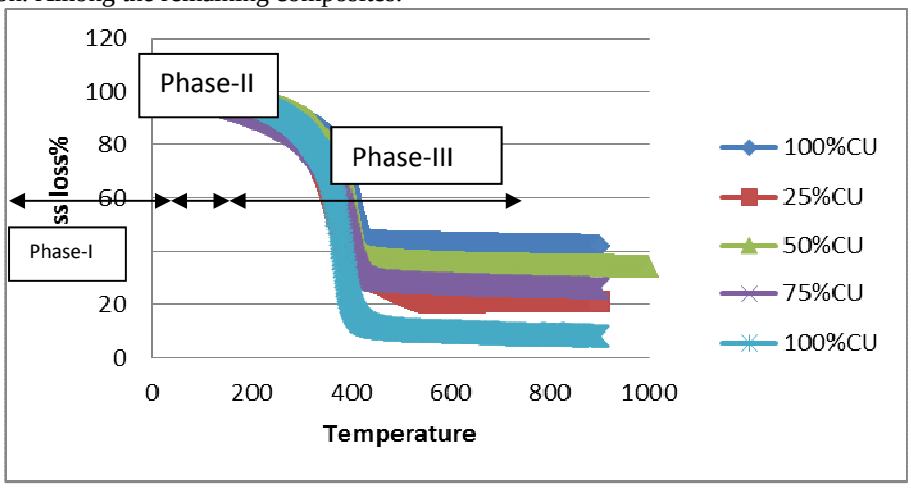

Fig .7: Sample's Thermo-Gravimetric Curve

4. CONCLUSIONS

(i) Thermal conductivity of the composite increases with increase in the copper filler content. But it gives more thermal conductivity at 50Wt% of copper compering than 25and 75Wt% of copper.

(ii) The response of specific heat capacity for a 75Wt% copper composite for a given temperate is varying considerable But other % copper does not showing any remarkable variation.

(iii) Thermal diffusivity of the composite decreases with increase in temperature except for 0Wt%copper.

(iv) 100% copper filler composite has the highest thermal degradation onset temperature and also the least amount of weight loss. Thus it has the highest thermal stability.

References

[1] ***A.R.Prasad*** *"Bamboo reinforced plastic composites"* .XIII National conference on Indian society of mechanical engineering ISME2003, (December 2003).

[2] ***Parmasivam, T and Abdulkalam, A.P.J***., "On the study of natural fiber composites" Fiber Science and Technology I (1974) pp. 8588.

[3] ***Satyanarayana, K. G., Sukumaran, K., Kulkarni, A. G., Pillai, S. G. K. and Rohatgi, P. K.***, *"Fabrication and properties of natural fiber reinforced polyester composites. Composites"*, 17 (October 1986) pp 329-33.

[4] ***Madhava, M. R., Suha Raman, Pavithran, C., Prasad, S.V. and Rohatgi, P. K***., "*Ultrasonic velocity and attenuation in coir-polyester composites*". Paper presented at the 2nd National Symposium on Ultrasonics, New Delhi. Ultrasonics Society of India, New Delhi, (February 1982).

[5] ***Fardons Mubark and Han Augustin***, "*Composite hard board from pith and depithed bagasse-filled plastics*". *Research & Industry (India)*, 29 (February 1954). pp. 108-113.

[6] ***Sefain, M. Z., Fedl, M. A. and Rakha, M.,*** "*Influence of pressing time in fiber board making*". *Research &Industry (India)*, 29 (April 1984) pp269- 272.

[7] ***Pakotiprapha, B., Pama, R. P. and Lee, S. I***., "Study of Bamboo Pulp and Fibre Cement Composites," *Int. J. Hous. Sci. Appl.*, Vol. 3, No.3, (1979) pp. 167-190.

[8] ***Jindal, U. C***., "*Development and testing of bamboo fibre reinforced plastic composites*" J. of comp. mat. Vol.20.Jan1986. pp.19-29.

[9] ***V.V.S.Prasad, KNS Suman, DN Rao, NRMR Bhargava*** "Testing of Palm Fibre as Reinforcement Material In Polyester Composites"