Study on Mechanical Properties of Hemp-Jute-Glass Fibre Reinforced Polyester Composites

***M. Indra Reddy, P. Vijaya Kumar Raju[1], N.R.M.R. Bhargava[2]**
[1]Department of Mechanical Engineering, S.R.K.R. Engineering College, Bhimavaram-534204, India
[2]Department of Metallurgical Engineering, A U College of Engineering (A), Andhra University, Visakhapatnam-530003, India
***Corresponding author: E-Mail: reddy.indra.m@gmail.com**

ABSTRACT

Recently, natural fibre composites are gaining popularity due to its eco-friendly properties and lot of research based on natural fibres for varied applications are carried out. Natural fibres are inexpensive, biodegradable, tough, and renewable. An experiment was performed to study the tensile, flexural and impact energy characteristics of polyester composites made through the reinforcement of Hemp, Jute and Glass fibre as 1:1:1 ratio into an unsaturated polyester resin. The fibre content in the composite ranged from 20 to 40 by volume percentage and the variation of mechanical properties like tensile, flexural as well as impact characteristics in every case were examined. The experimental results demonstrate that the tensile, flexural and impact strength rose with increase in fibre content.

KEY WORDS: Natural fibres, Polyester composites, Mechanical properties.

1. INTRODUCTION

Composite materials are non-uniform solids comprising two or more distinct materials, which are mechanically bonded together. All the components retain their identities in the composite and maintain their characteristic structures as well as properties. Typically, structures of composites comprises two phases: matrix as well as reinforcement. Matrix refers to continuous phases, while the reinforcement refers to discontinuous ones. The responsibility of reinforcement is the attainment of strength of the composite, while the matrix is to bond the reinforcement. Some identifiable interface is present between the materials of matrix as well as reinforcement. But, composite materials typically have a fusion of characteristics, like stiffness, strength, weight, high temperature performance, hardness, conductivity and corrosion resistance, that is impossible with the individual components. A composite is created when two or more materials are combined for providing a fusion of characteristics which cannot be got through other means. Composite materials, particularly, the fibre reinforced polyester highlight how various materials can function in a synergic manner. Analysing these characteristics reveals that they rely on a) the characteristics of every individual component, b) relative amount of the various phases, c) orientations of the different components, d) degree of bonding between the matrix and the reinforcement, as well as e) the size, shape, as well as distribution of the discontinuous phase. Materials involved may be organic, metallic, or ceramic. Hence, a vast range is present and composite materials may often be created for meeting a required set of engineering characteristics (Mekap & Palsule 2012). Several kinds of composite materials as well as various techniques to classify them are present. One such technique has its basis in the matrix materials that include polymer, metal, as well as ceramic.

Emergent awareness about environment is encouraging natural fibre reinforced polymer composites. Natural fibres, like jute, hemp, banana, asian palmyra, coconut, bamboo etc are being used to substitute glass and other fibres in polymer composites. Significant efforts are being directed to develop eco-composites and green composites. Natural fibre polymer composites are finding applications in product materials and also in engineering and high tech materials (Mekap & Palsule, 2012). The advantages of natural fibre reinforced polymer like lightweight (low density), environmental friendly, economical, flexibility and customize it to required application. This can be an excellent alternative to traditional fillers (Zini, and Scandola, 2011; Bogoeva-Gaceva, 2007; Pandey, 2010).

Dispensation, structure, properties and applications of natural fibre polymer composites, life cycle consideration and the growing market for these materials have been regularly reviewed (Reddy, 2016; Mallick 2007; Taylor, 1985). If contrasted with predictable organic fibres (that is, glass or carbon fibres), natural fibres offer several benefits like abundance, bio-degradability, flexible for processing hence decreasing apparatus wear, minimum health hazard, higher sound absorption, superior energy recovery, lower cost, low weight, satisfactory specific characteristics, as well as ease of separation. Additionally, the easy disposability due to the biodegradable characteristics of natural fibres by composting or incineration is an added advantage (Fiore, 2015).

Amongst all natural fibres, jute fibres seem to be the most frequently used fibres. Like all other natural fibres, jute fibres are as well lingo-cellulosic in nature with more percentage of cellulose than lignin (Singh, 2013). The key bottlenecks in the wide-ranging usage of the fibres in thermoplastics are poor compatibility between the fibres as well as the matrix, as well as the characteristic high moisture absorption that results in dimensional change in lignocellulosic based fibres (Karnani, 1997). The hydrophilic nature of the natural fibres has adverse effect on mechanical property, dimensional and thermal stability. The hemp fibre is obtained from the palm which grow to a height of 30 meter. The hemp is obtained from the fan shaped leaves of the palm. The hemp fibre is resistant to friction and heat and also has low density (Reddy & Srinivasa Reddy, 2014).

Glass fibre is a fibre reinforced polymer which is a lightweight, strong, and robust material. It is more flexible than carbon fibres and less expensive. Glass fibres are the most frequently used fibres in the reinforced polymer industry as well as one of the most versatile. Fibres made from glass are built in several variants for particular purposes. It generally has silica content higher than 50%, and the composition with various mineral oxides provides the resultant product its distinctive features. E-glass is called as a general-purpose fibre in the industry because of its strength as well as electrical resistance. It is alkali-free, extremely electrically-resistive glass build with alumina-calcium borosilicates. It is a frequently utilized fibre in the reinforced polymer composite industry. Glass fibres have strong features such as higher strength, flexibility, stiffness as well as resistance to chemical damage. It can be in the form of roving's, chopped strands, yarns, fabrics, as well as mats. All the types of glass fibres have distinctive characteristics and are utilized for several applications in the form of a polymer composite.

The manufacture of high performance engineering materials from renewable resources is an aspiring objective presently being pursued by research scholars all over the world. The environmental benefits of renewable raw resources are plain: they conserve previous resources, are ecologically sound, do not lead to health issues and so on. Natural fibres have previously set a path as mere filler material in automobile parts. Natural fibres such as banana, jute, sisal, Palmyra, coir, oil pal fibre have all been confirmed to be excellent reinforcement in thermoset as well as thermoplastic matrices.

In the present study, hemp, jute and glass fibre reinforced ecologically friendly polyester composites are fabricated by the hand lay-up process. The mechanical properties like tensile, flexural, as well as impact strengths are estimated. The outcomes denote that the incorporation of hemp as well as jute fibres with glass fibre improves the strengths significantly, and the procedure of fabricating composites decreases the problems associated with environmental anxieties. It is suggested that these environment friendly hemp-jute-glass fibre reinforced polyester composites be used as alternative materials.

2. EXPERIMENTAL PROCEDURE

Materials: The materials used in this experiment for fabrication are hemp, jute, glass fibre, unsaturated polyester resin, and methyl ethyl ketone peroxide (MEKP) and cobalt naphthenate. The hemp, jute and glass fibers were obtained from local sources as shown in figure.1. The unsaturated polyester resin of grade ECMALON 4411, Methyl Ethyl Ketone Peroxide (MEKP) as well as cobalt naphthenate were bought from a local dealer in Kakinada.

Figure.1. (a) Hemp Fibre; (b) Jute Fibre; (c) Glass Fibre

Preparation of composites: The composite samples were prepared, utilizing polyester matrix for assessing the reinforcement capacity of Hemp, Jute and Glass Fibres. These fibres were considered 1:1:1 by ratio at each volume fraction of a composite. The amount of accelerator and catalyst mixed with resin was 1.5% by volume of resin each, at room temperature. Hand lay-up technique was used for filling up the prepared mould with a suitable quantity of polyester resin mixture as well as Hemp, Jute as well as Glass fibres, beginning as well as ending with layers of resin. The fibre deformation as well as movement ought to be decreased for yielding excellent quality, fibre reinforced composites. The composite specimens were cured for twenty four hours and a compressive pressure of 0.05 MPa was applied on the mould. The specimens were separated from the mould and during post curing, the specimens cured at 70˚C for two hours. The specimens were prepared with varying percentage volumes of Hemp, Jute and Glass Fibres. In this paper, the experiments were conducted for composites made of 20, 30% and 40% volume of fibre.

Tensile test: The tensile behavior of the Hemp, Juteand Glass fibre reinforced polyester composites were prepared according to the standard ASTM D 638M. The dimension of the composite specimens prepared were: 165 mm (length), 12.7 mm (width) and 3 min (thick). The specimens were evaluated at a cross-head speed of 2.5 mm/min, utilizing a Tensile testing machine supplied by Associated Scientific Engg. Works, New Delhi

Flexural test: The three - point bend tests were carried out as per ASTM D 790M for measuring flexural characteristics. For flexural testing the dimensions of the specimen prepared was 125 mm (length), 12.7 mm (width) and 3 min (thick). For the three point bending test, the distance of the outer rollers was 64 mm and a strain rate of 0.2 mm/minute was applied on the specimens while testing. This test was used as it required lesser material for every test as well as eliminated the need for accurate determination of centre point deflections with testing equipment. The specimens were tested using the same testing machine mentioned above at same crosshead speed. Flexural strength (σ) of the composite was computed utilizing the following relation: $\sigma = 3PL/2bt2$

Wherein L refers to the support span (distance of the outer rollers - 64 mm): b - width: t – thickness and P - maximum load.

3. RESULTS AND DISCUSSION

Physical properties: The density of the Hemp, Jute and Glass Fibre was found to be 1.48, 1.46 and 2.55 g/cm^3 (Wambua, 2003) respectively.

Tensile Properties: The variation of mean tensile strength with differing volume of fibre is given in Figure.2. It was observed that by increasing the volume of fibre in the composite, the tensile strength also increases. The percentage increase in tensile strength of the composites at the maximum fibre content (40 volume percentage of fibre) is discovered to be 21.40 MPa. The increase in tensile strength is due to the resin transmitting as well as distributing the applied stress to the Hemp, Jute and Glass fibre.

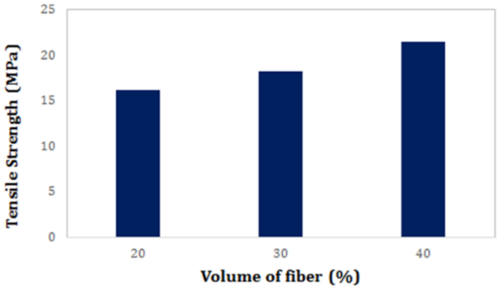

Figure.2. Tensile strength of composite with varying volume of fibre

Flexural Properties: The flexural behaviour of Hemp, Jute and Glass fibre reinforced polyester composites are given in Figure 3. The plots display the same trend noted for tensile characteristics and a similar cause is recognized as mentioned previously. Flexural strength of the composite at maximal fibre content is around 69.56 MPa.

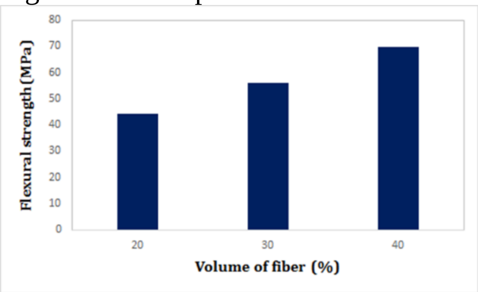

Figure.3. Flexural strength of composite with varying volume of fibre

Impact Properties: The outcomes of pendulum impact test are given in Figure 4. As the volume percentage of Hemp, Jute and Glass fibre increases, the value of impact strength also rises. The Impact strength of the composite at maximum fibre content is about 1.1J.

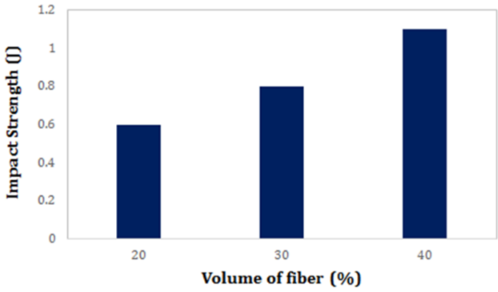

Figure.4. Impact strength of composite with varying volume of fibre

4. CONCLUSION

Composite materials, particularly, the fibre reinforced polyester highlight how various materials can function in a synergic manner. In the current study, Hemp, Jute and Glass fibre reinforced composite specimens were prepared. The tensile, flexural as well as impact characteristics of the composite samples with the fibres were discovered to rise with fibre content, proving the reinforcing action of the fibres. Thus the composites of Hemp, Jute and Glass fibre polyester composites were possessed better mechanical properties and found to be light in weight. Hence these composite materials may be utilized for application in automobile components, building construction, electronic packages, and so on.

REFERENCES

Bogoeva-Gaceva G, Avella M, Malinconico M, Buzarovska A, Grozdanov A, Gentile G and Errico M.E, Natural fiber eco-composites, Polymer composites, 28 (1), 2007, 98-107.

Fiore V, Di Bella G and Valenza A, The effect of alkaline treatment on mechanical properties of kenaf fibers and their epoxy composites, Composites Part B: Engineering, 68, 2015, 14-21.

Karnani R, Krishnan M and Narayan R, Biofiber-reinforced polypropylene composites, Polymer Engineering & Science, 37 (2), 1997, 476-483.

Mallick P.K, Fiber-reinforced composites: materials, manufacturing, and design, CRC press, 2007, 619.

Mekap D and Palsule S, Secondary Fiber/Recycled Polypropylene Composites, Asian J. Research Chem, 5 (5), 2012, 655-659.

Pandey J.K, Ahn S.H, Lee C.S, Mohanty A.K and Misra M, Recent advances in the application of natural fiber based composites, Macromolecular Materials and Engineering, 295 (11), 2010, 975-989.

Reddy M.I and Srinivasa Reddy V, Dynamic mechanical analysis of hemp fiber reinforced polymer matrix composites, International Journal of Engineering Research & Technology (IJERT), 3 (9), 2014, 410-415.

Reddy M.I, Srinivas Ch, Anil Kumar M & Manikanth V, The Effect of Copper and Aluminium Foil on Mechanical Properties of Natural Fiber Reinforced Plastics, Advanced Materials and Manufacturing characterization, 6 (2), 2016, 1-5.

Singh A.A, Effect of water absorption on interface and tensile properties of jute fiber reinforced modified polyethylene composites developed by Palsule process, Applied Polymer Composites, 1 (2), 2013, 113-124.

Taylo M.P, Corning Glass Works, Fiber-reinforced composites, U.S. Patent 4,511,663, 1985, 1-6.

Wambua P, Ivens J and Verpoest I, Natural fibres: can they replace glass in fibre reinforced plastics?, Composites science and technology, 63 (9), 2003, 1259-1264.

Zini E and Scandola M, Green composites: an overview, Polymer composites, 32 (12), 2011, 1905-1915.