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A Review on Investigation on Short Sisal Fiber Reinforced Epoxy Composites Materials

Tarun Kuber[1], Sanjay Goyal[2], Ashish Yadav[3]

M. Tech, Scholar, Department of Mechanical Engineering , MPCT , College , Gwalior, MP

Associate Professor, Department of Mechanical Engineering, MPCT, College, Gwalior, MP

Assistant Professor, Department of Mechanical Engineering, MPCT, College, Gwalior, MP

Abstract: *The aim of this work is to study the influence of sisal fiber content on mechanical (i.e. tensile, flexural, impact, hardness and abrasion resistance) and thermal (i.e. TGA)properties of composites by varying the fiber and epoxy percentage. The composite was prepared by melt-mixing method, followed by compression molding process. Now-a-days, The natural sisal/bamboos from renewable natural resources offer the potential to act as a reinforcing material for polymer composites alternative to the use of glass, carbon and wood. Among various natural fibers, sisal or bamboo is most widely used natural fiber due to its advantages like easy availability, low density, low production cost and satisfactory mechanical properties. For a composite material, its mechanical behavior depends on many factors such as fiber content, orientation, types, length etc.*

Keywords: Tensile, Flexural, Impact, Hardness, fiber, Abrasion .Resistance.

Introduction

Conventional Materials and their Limitations

It is difficult to draw up a table of materials characteristics in order to assess the relative strengths and weaknesses of metals, plastics and ceramics because each of these terms covers whole families of materials within which the range of properties is often as broad as the differences between the three classes. A comparison in general terms, however, can identify some of the more obvious advantages and disadvantages of the different types of material. At a simplistic level, then:

Plastics are of low density material. They have good short-term chemical resistance but they lack thermal stability and have only moderate resistance to environmental degradation. They have poor mechanical properties, but are easily fabricated and joined.

Ceramics may be of low density (although some are very dense). They have great thermal stability and are resistant to most forms of attack (abrasion, wear, corrosion). Although intrinsically very rigid and strong because of their chemical bonding, they are all brittle and can be formed and shaped only with difficulty.

Metals are mostly of medium to high density. Many have good thermal stability and may be made corrosion resistant by alloying. They have useful mechanical properties and high toughness, and they are moderately easy

to shape and join. It is largely a consequence of their ductility and resistance to cracking that metals, as a class, became (and remain) the preferred engineering materials.
On the basis of even so superficial a comparison it can be seen that each class has certain intrinsic advantages and weaknesses, although polymer pose fewer problems for the designer than either metals or ceramics.

1.2 Introduction to Composites Materials
Shortcoming of conventional material forced the scientific community to work on other class of material and after rigorous research they come out with composite material. Composite is defined as any material that is a combination of two or more distinct constituents. Considering the definition, it would incorporate bricks, concrete, wood, bone as well as modern man-made composite such as plastic reinforced with long or short fiber. The man-made composite captured a huge market in around past five decades, where structure fabrication with low weight in combination with high strength and stiffness is of concerned. Apart from above definition of composite, in addition three other criteria have to be satisfied before we call material a composite. Firstly, all the constituents forming the composite have to be present in reasonable proportions. Secondly, all the constituents used for making composite should possess different properties such that the composite's properties are noticeably different from the properties of the constituent sand the effect of any one constituent should not pre-dominant the composite properties. Lastly, a synthetic composite is usually produced by deliberately mixing and combining the constituents by various means[1]. Composite materials are extending the horizon of the designers in all branches of engineering. Composite materials are combines in such a way as to facilitate us to make enhanced use of their virtues while diminishing to some extent the effects of their insufficiencies. This process of optimization can release a designer from the constraints associated with the selection and manufacture of conventional materials. They can make use of tougher and lighter materials, with properties that can be tailored to suit particular design requirements. And because of the ease with which complex shapes can be manufactured, the complete rethinking of an established design in terms of composites can often lead to both cheaper and better solutions [2].The term 'composite' provides slight indication of the huge series of different arrangement that are comprised in this class of materials. Composite materials create scope for ingenuity which may available to the materials scientist and his customer, the design engineer.Again, by following the same definition, two or more distinct phase means they should have chemically distinct inter phase and it is again important that specification of these constituent is possible by any mean. Among the two distinct constituent one should be a continuous phase which is often present in greater quantity in the composite, though it is not always true. This continuous phase is called matrix. The normal view is that it is the properties of the matrix that are improved upon when incorporating another constituent to produce a composite. The other constituents are known as reinforcing phase. In most cases the reinforcement is harder, stronger and stiffer than the matrix, although there are some exceptions. The geometry of the reinforcing phase is one of the major parameters in determining the effectiveness of the reinforcement; in other words, the mechanical properties of composites are a function of the shape and dimensions of the reinforcement.

Classification of composites can be made in two different categories, first on the basis of matrix materials as shown in figure 1.1 in which it can be metal matrix composites, ceramic matrix composites and polymer matrix composites. It is observed that polymer matrix is further categorized as thermoset composites and thermoplastics composites.

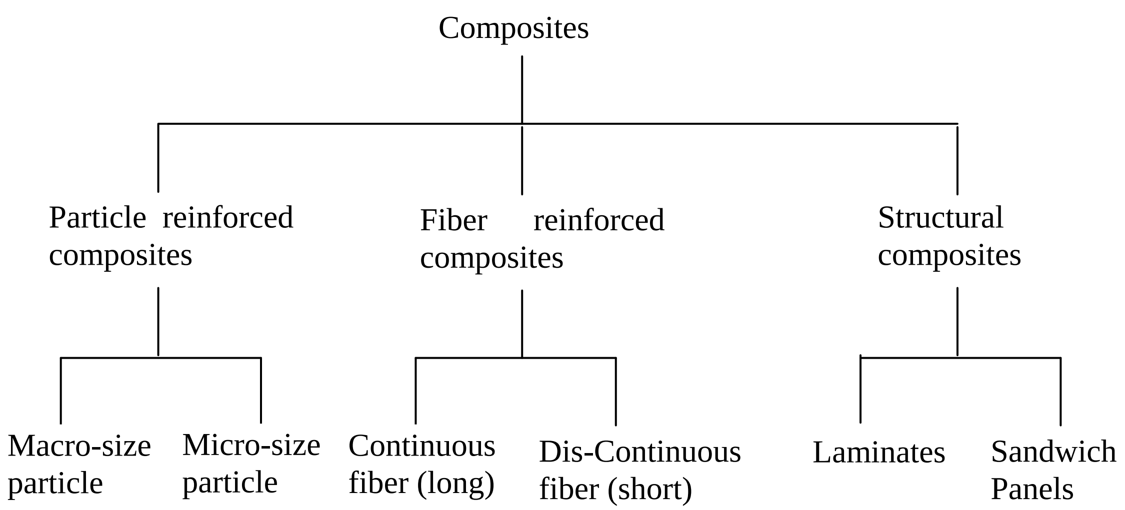

Figure 1: Composites classifications on the basis of reinforcement type.

Second, on the basis of reinforcement, as shown in figure 1.2 in which it is classified as particulate reinforced composites, fiber reinforced composites and structural composites. In particulate reinforced composites, particle may be of macro-size or micro size, similarly in fiber reinforced, fiber may be continuous or dis-continuous where as structural composites may be categorized as laminates or sandwich panel type composites. Each category of composites had its own application and market based on their property, availability, manufacturability and cost.

II. Literaure Review

The use of natural fiber as a filler material in composite was earlier reviewed by Saheb and Jog [1] in late 90's as natural fiber reinforced composites was emerging area at that time in the field of polymer science. Among the various advantage offered by natural fibers like low density, high specific properties, biodegradable and non-abrasive, the natural fibers had certain limitations as well. They are incompatible with most of the matrix and had moisture absorption behavior. They presented the natural fiber reinforced composites with special reference to the type of fiber, treatment of fibers and interface of fiber and matrix.

Komuraiah et al. [2] presented the chemical composition of natural fibers and the effect of it in various mechanical properties. They reported that the main components of natural fibers are cellulose, hemi cellulose, lignin, pectin and wax. Out of this wax is highly undesirable as it reduce the adhesion between fiber and polymer. They further studied that the composition of these natural fibers were primarily dependent on the geographical location where the plants are grown up. They concluded that all fiber has the same constituents but the compositions of each constituent vary with fiber and their way of grown up.

Mohammed et al. [3] reviewed widely used natural fiber reinforced polymer composites and their applications. They also discussed the effect of different chemical treatments applied to the natural fibers when they reinforced in various polymers. Impacts of surface modification on various properties like water absorption, tribology, viscoelastic behavior, relaxation behavior, flames retardancy, and biodegradability properties of NFPCs were also discussed in their article.

Machado et al. [4] present an overview of physical and mechanical properties of natural fiber reinforced composites. They studied the effect of service condition on the properties of such composites. They studied the behavior of composites when it was used for short term application and for long term application.

Fan and Fu [5] in their study first classified the type of natural fiber that can be used for construction purpose. Then on the basis of identification of various applications in construction site, they explore the hierarchical structure of such natural fibers.

Gopinath et al. [6] performed experimental study with jute as reinforcement material in epoxy and polyester matrix. They fabricated composites with maximum filler content of 18 % by weight with both the polymers and evaluated different mechanical properties like tensile strength, flexural strength, impact strength and hardness. In their study they reported that epoxy as matrix material had better compatibility with jute as compared to polyester as matrix material and hence epoxy based composites has better mechanical properties when compared to polyester based composites.

Pereira et al. [7] reported the variation in impact resistance provided by epoxy matrix composites reinforced with aligned and continuous jute fiber. The maximum percentage of jute fiber is incorporated in epoxy was 30 % by volume in their analysis. They measured the impact energy absorbed by material with Charpy impact testing machine. In their study they found that the amount of energy absorbed by composite increases with increase in fiber volume fraction. They further compared their result with different published results and found that energy absorbed with jute as filler material is better that most of the natural fiber i.e. Ramie, coir and Curaua.

Mohanty et al. [8] used jute fiber as reinforcement after modifying its surface. This surface modification involves dewaxing, alkali treatment, cyanoethylation and grafting. After the chemical treatment of fiber, Fourier-transform infrared spectroscopy and thermogravimetric analysis were performed on it. They concluded that with surface treated fiber in Biopal, tensile strength is increased by 50%, bending strength is increased by 30% and remarkable increase of 90% is reported in impact strength when compared to neat Biopal. They found that treatment of surface will increase the adhesion between fiber and matric with the help of scanning electron microscopy. This is the main reason of increase of various mechanical properties.

Similarly Kumar et al. [9] reduces the moisture content of the fiber by providing it with alkali treatment using NaOH solution. They found that, this preprocess of fiber reduces the wettability and thickness of fiber as has low moisture absorption. This certainly increases the adhesion between fiber and matrix. They concluded that usage of treated fiber will certainly increase the mechanical properties of the composites.

On the same note, Basak et al. [10] treated the surface of jute fiber and observed improvement in physical appearance of the jute fiber. They reported that there is no significant improvement in the mechanical properties of treated fiber reinforced epoxy composites.

Another natural fiber which is of interest currently and is extensively used is basalt fiber which has exceptional properties over glass fiber. The protuberant benefits of these composites comprise high specific mechano-physico-chemical properties, biodegradability and non-abrasive qualities. Keeping that in mind Dhand et al. [11] presents a review of basalt fiber used as a reinforcement material. In their work, they combined the work performed by various researchers and also present the classification of basalt fiber. They further include the detail of properties obtained by various researchers which includes mechanical, thermal and chemical resistant properties.

Amuthakkannan et al. [12] concentrate their study on the length and content of basalt fiber in polymer composites. They tried to establish the relationship between mechanical properties and length and content of fiber. They performed their study with polyester resin and performed various destructive tests on the fabricated composites. Further they also examined the failed composites under scanning electron microscopy. It is always necessary to have good interfacial bond between fiber and polymer to improve the physical properties of the composites. Apart from physical properties, various mechanical and thermal properties of the composites were also dependent on the interfacial bonding and also on fiber length and orientation.

Pak et al. [13] investigate basalt fiber/polypropylene composites and evaluate dynamic mechanical and thermal analysis. They studied the grafting effect of maleic anhydride polypropylene on the basalt fibers which ultimately improves the bonding strength and thermomechanical properties of the composites.

Bauer et al. [14] used continuous basalt fiber and present a probable polymer composite for high performance application. They provide a unique combination of mechanical and functional properties as low cost. They procured the fiber from different vendors and investigated their composition, physical parameters and probable defects. Later they establish structure-property relationship for the most potential fiber sort out after introductory analysis.

Muñoz et al. [15] used flax fiber with epoxy matrix upto 50 wt% of fiber using resin transfer moulding. They studied the effect of flax fiber in water absorption behavior of the epoxy matrix. Later they performed tensile and flexural testing of water immersed specimens and evaluated the result. Their analysis revealed that fiber gets swelled due to water absorption and this will actually beneficial as far as mechanical properties of composite is concerned.

Huang et al. [16] work on the response of impact or shock load on the flax/epoxy composites. The outcome of their study was that the cross-ply samples retained their structural integrity at peak pressures that were sufficient to break unidirectional samples.

Haggui et al. [17] provided a complete set of static and fatigue loading data of thermoplastic composite fabricated using liquid resin infusion. They studied the fatigue tensile behaviour by estimating the material stiffness degradation. The fatigue results obtained were than concluded in an S-N curve in their later work.

Campana et al. [18] studied the impact of processing at high temperature upon mechanical properties of fabricated composites. They found that post curing of composites at temperature slightly decreases the tensile properties of the matrix used in polymer composites. They further observed that interfacial adhesion between fiber and matrix not play major role in improving the mechanical properties of the composite. They concluded that the probable reason for that is the intrinsic weakness of the material.

Perremans et al. [19] analyzed the damping behavior of the flax fiber composites. They further found that the measured value is inferior when compared to the theoretical value which is mainly because of the limited compatibility between the fiber and matrix. To enhance the compatibility between fiber and matrix, three different types of chemical treatment were performed on fiber by them. The chemical treatment done by them enhances the mechanical properties of the composites and the improvement and benefit of chemical treatment were reported in their work.

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III. Problem Identification

On the basis of exhaustive literature review, it has been found that there is certain knowledge gap in earlier investigation, and on the basis of that problems are identified as follows:

1. In any of the earlier investigation, sisal fiber has not been used in its short form, rather long sisal fiber were used by many researcher as a reinforcement material.
2. Detailed study of physical behavior i.e. density, void content and water absorption rate of sisal fiber reinforced epoxy composite is missing in earlier investigation.
3. Mechanical behavior of sisal fiber reinforced epoxy composites has not been discussed in detail in earlier investigation.
4. Sliding wear analysis of such fiber matrix combination has not been discussed in past by any researchers.
5. Generation of sisal fiber is huge in India mainly in the southern part of the country, rather its proper utilization as reinforcement in polymer composites are always remains a less studied area. Though, it was established that reinforcing potential of sisal fiber is good and comparable to many other natural fibers.

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