Static and dynamic behavior of Jute reinforced epoxy composites with and without Silicon Di oxide as epoxy modifier: A Review

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Abstract- *In recent days many of the researchers are attracted to the natural fibers due to their potential to replace synthetic fibers in many primary applications (wind turbine blades, beams etc.) and unique properties such as low density, good specific properties compared to synthetic fiber. In this present work similar attempt is made to study the effect of Silicon Di oxide as filler on the dynamic behavior of the jute fiber reinforced epoxy composites, so that we can go a step closer in replacing synthetic fibers by natural fibers in primary applications. The dynamic behavior of the material refers to the natural frequency, damping and mode shapes of the material. The dynamic behavior is obtained for Jute epoxy woven composites with filler and without filler and they are compared. SiO2 or silica is selected as secondary reinforcement or filler as it is easily available and also increases the flexural and tensile modulus of the FRP composites.*

Key Words: Composite materials, Dynamic behavior, silicon dioxide, primary applications, Natural fibers.

1. INTRODUCTION

A composite is when two or more different materials are combined together to create a material having unique and superior properties, which is impossible to get from individual materials. The constituents are combined at macroscopic level and are not soluble in each other. One constituent is called as Matrix phase and the other is called Reinforcing phase. When designed properly, the new combined material exhibits better strength than would each individual material. The composites can be classified based on the reinforcing and the matrix materials. They strength of these natural fiber reinforced composites are also influenced by the resin and secondary reinforcing phase used.

1.1 Reinforcing Phase

Reinforcing phase may be in form of fibers or flakes or particulates. Considering fiber reinforcement, natural fibers and synthetic fibers are one of the divisions of the reinforcing phase of the composites. As the name indicates that these natural fibers are available in nature either from plant or animals (EX: bark of a tree or wool from sheep).They have good specific properties than synthetic fibers thus making it very good competitors for the synthetic fibers. Further they are bio degradable and can easily be disposed. India and Bangladesh are one of the larger producers of Jute. They are peeled from the bark of the plant and then washed and dried in air; jute is one of the major plant fibers which can be used for various applications when used as composite material.

1.2 Matrix

This is one of the important parts of FRP composites. It is used to hold the fibers together and form a strong bond with each other. The matrix phase used is mostly thermosetting in nature. Matrix phase consists of a resin and a hardener, addition of this hardener causes the resin to cure and become hard thus making it a rigid material. The curing of the composites depends on the hardener used (High temperature curing or room temperature curing)

1.3 Secondary Reinforcing Phase

These are also called as filler materials used to improve the strength in the composite materials. They improve the mechanical properties of the composite material, thus obtaining a material required for a particular application.

1.4 Dynamic Behavior

Dynamic behavior of the material is defined by 3 parameters natural frequency, mode shapes and damping factor. Natural frequency is the frequency at which a system tends to oscillate in the absence of any driving or damping force. At a particular frequency the dynamic

response of the plates or the structure is high and then it decreases, again at some particular higher frequency the same response is obtained, these keeps on continuing. The frequencies at which dynamic response of the structures are maximum are called as the natural frequencies and these different natural frequencies of the same material represent different modes of vibration.

Damping is the property of the material to resist oscillations or vibrations.

2. LITERATURE REVIEW

The use of natural fibers is increasing due to its unique properties. They are easily available and can easily be used as the reinforcing phase without much processing compared to synthetic fibers and have good specific properties.

Reliability of the composites were investigated by Manuel Chiachio, et al,[1] wherein they focused on reliability based design and safety factor calibration, where reliability calculations are crucial. Thus, a composite can be used for wide range of applications.

A research has been carried by P. Parandaman et al,.[2] and has analyzed the effect of the retrofitted FRP composites structures with concrete beams to provide good performance. The thickness of the FRP material used is 6mm thick. FRP materials used are GFRP, CFRP and KFRP. The performance of the retrofitted beam with FRP increases than without retrofitting.

Dipl. Phys. Michael Karus, et al.,[3] has surveyed the use of natural fibers in automotive sectors and have found that demand is increasing day by day. We can also see the importance of compression molded parts. Major automotive suppliers make the most substantial contribution to the use of natural fibers for composites. For the future, one can expect other models in other vehicle segments and means of transport (e.g. small cars, trucks, trains), as well as in other European countries, to be fitted with natural fiber press-molded parts.

Anin Memon,et al.,[4] has carried out experimental work on fabrication of jute reinforced composite using compression molding. Impregnation quality and dispersion of fiber bundle were increased with increasing the molding temperature, as molding temperature increased the tensile strength reduced due to the deterioration of jute fiber. Thus, molding temperature affects the mechanical properties of the jute fibers. It also depends on the resin used.

Md. Rashnal Hossain.et al.,[5] has studied behavior of environment friendly jute epoxy laminated composite due to its superior specific properties compared to manmade synthetic fibers like glass, Kevlar, asbestos, etc. The developed composites were characterized by tensile and three point bend tests. Experimental results revealed that the tensile properties of the developed composites are strongly dependent on the tensile strength of jute fibers.

Another research conducted by A. Ticoalu, et al,[6] has highlighted that natural fibers are suitable for load bearing materials such as roofs and beams. If the materials have tensile strength more than 50Mpa they can be used in roofs. Furthermore, for infrastructure applications where the use of synthetic fibers is not suitable, natural fibers can be a suitable substitute. Jute mats reinforced composites have been used for trenchless rehabilitation of underground drain pipes and water pipes. Availability of fibers is also an important parameter for mass production.

G.M. Arifuzzaman Khan, et al.,[7] has conducted mechanical properties of woven jute fabric reinforced poly(L-lactic acid) composites. Woven jute composites in warp and weft directions presented superior mechanical properties than non-woven jute fabric (NWJF) composites. The influence of woven structure and direction on the properties such as tensile, flexural and impact properties was investigated. Finally, it can be concluded that PLLA based woven jute fabric composites might be a good alternate of synthetic fiber composites and are suitable for high load bearing applications.

Vivek Mishra et al,.[8] has carried out an investigation on bi directional jute fiber, a natural fiber abundantly available in India. The minimum and maximum void content are in neat epoxy and 12 wt. % fiber loading specimens respectively. It is also found from the study that the void content decreases with the increase in fiber loading. The hardness, tensile properties and impact strength of the jute-epoxy composites increases with the increase in fiber loading. Flexural strength and inter-laminar shear strength are greatly influenced by the void content.

Ajith Gopinath et al, [9] has investigated and compared the mechanical properties of woven jute fiber with both epoxy and polyster resin. The prepared composites were tested to study the mechanical properties of the composite such as tensile, flexural, impact strength and hardness. The jute reinforced epoxy composite exhibited better mechanical properties than Jute-polyester composite.

Darshil U. Shah et al,.[10] has investigated the use of flax fiber in rotor blade and has compared it with glass fiber rotor blade. Flax fibers are 10%lighter than the glass fiber. It is also concluded that flax is a potential structural replacement to E-glass for similar composite small wind turbine blade applications. However flax fibers are very expensive (almost 3 times than that of E-glass fibers).

Another research has been successfully carried out by S.Prabhakaran et al, [11] on vibrational behavior of natural fibers. When the composites are used in higher applications, dynamic loads acts on the composites causing vibrations, this further causes the micro cracks to grow and further leads to failure. Hence, vibrational behavior of the materials is of utmost importance. The vibrational behavior of the Flax and glass fibers are

compared and is found that flax fiber reinforced composites have 51.03% higher vibration damping than the glass fiber reinforced composites.

A study conducted by Andrzej K. Bledzki et al, [12] have tabulated the values of different plant fibers and compared it with glass fibers. The tensile strength and the Young's modulus of the synthetic fibers are visibly much higher than that of the natural fibers. However, the difference in the specific values of synthetic and natural fiber, most important with respect to applications, is not as great. Jute and flax have similar and better mechanical properties compared to other natural fibers .Further the jute fibers are less dense than flax.

In this work experimental investigation is carried out by K. Senthil Kumar, et al [13] on free vibration characteristics of short sisal fiber (SFPC) and short banana fiber (BFPC) polyester composites and is found that 50:50 ratio of resin and fiber volume fraction gives good result. Further length of the fibers is also considered. Damping nature of the fibers is also studied.

The investigation carried on mechanical properties, odor emission and structure properties of abacca, jute and flax fibers by A. K. Bledzki et al, [14] reveals that jute is found to have superior tensile and flexural modulus than the other two.

Nattakan Soykeabkaew et al,.[15] has successfully prepared starch-based batters incorporating jute, flax fibers inside a hot mold. Compared to flax, jute had more reinforcing effect (observed from the SEM photographs) than flax fibers.

Based on the survey carried out by government of India [16]. The availability of jute fiber is more than flax fibers (.5 million tons). Global production (2.5 million tons) of jute is more than any other natural fiber (except cotton).More importance of developing jute composites should be considered.

According to M.Sivapragash et al. [17] plant fiber (jute) has been found to be a versatile material for application in rural areas to high tech applications. Use of these fibers saves environment and also reduces the energy consumption which is required in processing man-made fibers. It is also coated that more research has to be carried out on the natural fibers to avoid any set back during the finalization from lab scale to commercial level.

Further modifying the resin by an appropriate modifier or filler can increase the mechanical properties of the composite materials. Ramesh K. Nayak, et al. [18] has modified the epoxy matrix by Al2O3, SiO2 and TiO2 micro particles in glass fiber/epoxy composite to improve the mechanical properties. It is observed that mechanical properties like inter lamina shear strength, flexural strength and modulus are more in case of SiO2 modified epoxy composite compare to other micro modifiers. Impact strength is more in case of Al2O3.

The addition of SiO2 increased the tensile, flexural strength and hardness of glass epoxy composite as investigated by Ramesh Chandra yadav, et al. [19]. Silicon Di Oxide is added to the composite based on the weight of the epoxy (0%, 5%, 10% etc.).As the filler content increased the Young's modulus also increased, even flexural modulus also increased up to 10%of the filler content and after 10% the flexural modulus decreased. Hence the filler percentage selected should be within 10% of the weight of the epoxy.

A research carried is out by Sharayu U. Ratnaparkhi, et al. [20] on dynamic behavior by fabricating a glass epoxy composite of thickness less than 7mm. The Resin: Fiber ratio is 50:50.The length of the specimen used is 25cm.

3. CONCLUSIONS

The reviews show that there is lot of research work going on in natural fibers due to the increasing demand of the environmental friendly composite materials and also for their dynamic behavior. The following may be concluded based on this review.

- Natural fibers have good specific properties than synthetic fibers which are used in applications
- Jute availabity is high in India and thus can be used for mass production.
- Woven jute fibers have good strength than non-woven jute fibers and can be used for load carrying applications. It can also be used in primary applications
- Epoxy resin is better choice of resin to be used.
- Usually when the materials are used for higher applications many dynamic loads acts on the structures these loads are very different from the static loads, thus various parameters are to be considered while analyzing these structures, and the important parameters are vibrational behavior, damping characteristics. The unwanted vibrations cause the micro cracks to grow within the material and thus leading to failure.
- As the Sio2 increases the tensile and flexural modulus, investigations have to be carried out to improve the dynamic behavior of the composites. Damping is also important parameter as it offers resistance to vibration. So, effect of SiO2 on damping is also important.
- Dynamic behavior of composites is very important when they are used in primary applications. However the research on effect of filler materials on Dynamic behavior is still at its beginning.
- Dynamic characteristics depend on many parameters such as fiber orientation, fiber volume fraction etc. it also depends on mechanical properties such as young's and flexural modulus.

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