A REVIEW OF STRUCTURAL AND VIBRATIONAL ANALYSIS OF NATURAL AND ARTIFICIAL COMPOSITES

Manoj S. Patil[1] , Prof. Dr. A. M. Vaidya[2]

[1]*Research Scholar, Gangamai College of Engineering, Nagaon, Dhule (M.S.), North Maharashtra University, Jalgaon, India.*

[2]*Research Guide and Principal, Gangamai College of Engineering, Nagaon, Dhule (M.S.), North Maharashtra University, Jalgaon,*

E-mail:- *mspatil.engg@yahoo.co.in*

ABSTRACT

The first part of the study focuses on the fabrication of the Natural fiber plates and synthetic fiber plates of glass and carbon. These plates are made with the different orientation and different curing temperature. Natural fiber has drawn attention of researchers as an environmentally-friendly alternative to synthetic fiber. Developing natural fiber reinforced bio-composites are a viable alternative to the problems of non-degrading and energy consuming synthetic composites. This study will focus on (i) the application of fiber as a potential reinforcement and, (ii) determining the structural and thermal properties of the randomly oriented short natural fiber composite both experimentally and numerically, also the nature of natural fiber plates is to be studied under various curing temperature rates. The fiber materials under consideration are Coconut fiber, Banana Fiber, Jute, Kenef Fiber. Fabrication is done on hand lay-up technique and vacuum bagging technique. Composite Natural fiber plates are compared with the synthetic plates of Glass Fiber, carbon fiber and mixed composition of glass and carbon fiber. The plates under consideration are having 00, 450, 900 orientation. The second part of the study consists of comparison of the natural fiber plate to the synthetic fiber plate. The comparison study includes the Tensile, impact and buckling of the composite plates. The third part of the study consist of Vibration testing of these plates experimentally with the help of FFT Analyser and the Numerically with the help of ANSYS ACP tool.

And attempt has been made to give best combination of fiber plates by making it laminated, while making it laminated plates these plates are made with the different layer combinations. These laminated plates are compared with the fiber reinforced plates. Also in case of Vibration occurring on the plates, these vibrations are reduced by providing the piezoelectric patch to the lowest vibrating and structurally sound plate. In this way the overall study of composite plates are to be done and a solution is provided to reduce the vibrations in real life applications such as automobile panels and aircraft wings etc

1.Heading

Composite structures, beam, plates, and shells are commonplace in many sectors of the automotive and aircraft industries. Use of such structures is now being considered for naval applications because of the potential for improved strength to weight ratio and resistance to harsh environments.

A composite is a structural material that consists of two or more combined constituents that are combined at a macroscopic level and are not soluble in each other. One constituent is called reinforcing phase and one in which it is embedded is called the matrix. The reinforcing phase material may be in the form of fibers, particles or flake. The matrix phase materials are generally continuous. The roles of matrix in composite materials are to give shape to the composite part, protect the reinforcements to the environment, transfer loads to reinforcements and toughness of material, together with reinforcements. Composite materials are used for Automobile, Ships, Aircraft, sports goods and so on.

Composite materials are hybrids consisting of two constituents at the nanometer or molecular level. Commonly one of these compounds is inorganic and the other one is organic in nature. Thus, they differ from traditional composites where the constituents are at the macroscopic (micrometer to millimeter level). Mixing at the microscopic scale leads to a more homogeneous material that either shows characteristics in between the two original phases or even new properties. Purpose of hybridization is to increase a resistance against the inter-laminar toughness that cannot be obtained with only conventional material. The use of composite materials in composite structural is becoming more nowadays, and the fibers can be arranged in various orientations during preparation of composite. However, there are other factors such as cost, weight, post-failure behavior leading the designer to use hybridization in order to tailor the material to exact needs under design. Epoxy resin is used in composite because it provides a unique balance of chemical and mechanical properties combined with extreme processing versatility. In all cases, thermo set resins may be tailored to some degree to satisfy particular requirements.

Composite laminates are prepared by stacking sheets of Glass/Carbon fibers to required orientation to form angle ply laminates, and fiber reinforced composite materials are prepared by hand lay up technique, the fibers are made up of banana, coconut, kenef, glass, carbon the angle of orientation of these fibers are dispersed i.e. not fixed in case of natural fibers plates and in case of synthetic fiber plates it is 0, 90 & 45 degree.

The composite material is processed from a mixture of two or more different materials in certain proportions. Generally speaking, composite comprises a fiber reinforcement embedded in a polymeric matrix. The motivation behind the invention of a composite material comes from the demand of low weight and high strength material for the aerospace industry. The major work in this area was carried out during 1960's and to date there are several types of composites being developed for various applications. Examples of some synthetic fibers are glass, carbon, boron, aramid and Kevlar. Commercially available polymer matrices include epoxy, polypropylene and polyethylene. Metals and ceramics are also used as matrix materials in composite processing. A wide range of these composite materials have been successfully used for structural applications in the aircraft, space, automotive, marine and infrastructure industries.

Generally, for structural applications, composite laminates are processed by stacking lamina with varying fiber orientations to achieve the desired structural behavior. Structural functionality includes high tensile load carrying members; low thermal expansion, thermal barriers etc; and sometimes discontinuous fiber composite as shown in Fig 1. The mechanical behavior of such laminates is anisotropic in nature, meaning it depends on the fiber and matrix properties, fiber orientation and volume fraction, the interface bond between fiber and matrix, and processing techniques. The choice of a particular composite processing technique depends on the type of matrix to be used for composite, either thermo set or thermoplastic. Techniques used for thermo set kind matrix include resin transfer molding, vacuum assisted resin transfer molding, compression resin transfer molding, and pultrusion process. Thermoplastic kind matrix includes compression molding, filament winding and injection molding. Application of these techniques depends on the type of structure (at or complex), rate of production and type of application.

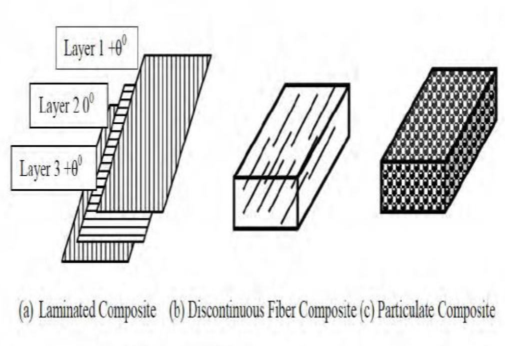

Fig:1. Various Types of Composites

Most of the existing composite materials (both fibers and polymers) are processed from petroleum based products and the previously mentioned processing techniques are power consuming. Consequently, some concerns associated with the commercially available composites are high energy consumption, non-recyclability, non-renewability and cost. There is a need for developing an alternate composite material or processing technique that is economical, low energy consuming and environmental friendly. In recent years, researchers explored the potential natural fibers (derived from plants and animals) as a replacement for synthetic fibers. An experimental investigation of some natural fibers conducted by S.V. Joshi et al. proved to be capable of replacing E-glass fibers. At this point, before proceeding into details, the following questions must be answered:

- What is the morphology of natural fibers?
- Do these fibers have enough benefits to replace existing commercial fibers?
- How does one process a natural fiber reinforced composite?
- What are the major advantages and applications of natural fiber composites?

Natural fibers in this context imply those derived or obtained from plants. These fiber scan be obtained from different parts of a plant, including the stem, leaf, root, core and fruit. The fibers obtained from the stem are called bast fibers and those obtained from thel eaf, root and fruit are called leaf fibers, root fibers and fruit fibers respectively. Examples of bast fibers are hemp, ax, and jute, leaf fibers are abaca, sisal and pineapple, and fruit fibers are cotton, coir and kapok. A summary of worldwide production of various natural fibers was given in. It was observed that the bast fibers are most commonly used, followed by leaf and fruit fibers, proving their abundance in nature. This is why past few years of research have focused on using bastfibers as a replacement for synthetic fibers. The potential of various bast fibers as a composite reinforcement is discussed in the subsequent sections. Once the source for fibers has been chosen, the next step is extracting fibers from the stem (known as retting). Various retting processes currently used in industry include dew-retting, water retting, chemical retting and physical methods. The effect of retting methods on the bast fiber properties was collectively discussed in a review article. Water retting results in good quality fiber but takes 2-3 weeks, whereas chemical retting is done quickly and results in decreased strength of the fibers. The process of retting isfollowed by decortication, carding and spinning into yarn. The full process of various fiber extractions is shown in Fig 1.2.

Table 1: Comparison of Natural and E-glass Fiber Properties

Properties	E-glass	Hemp	Jute	Ramie	Coir	Sisal	Flax	Cotton
Density (g/cm3)	2.55	1.48	1.46	1.5	1.25	1.33	1.4	1.51
E-modulus (GPa)	73	70	10-30	44	6	38	60-80	12
Specific modulus	29	47	7-21	29	5	29	26-46	8

Table 1: Comparison of Natural and E-glass Fiber Properties

The potential (specific modulus) of the natural fibers as a reinforcement was studied by Wambua et al. and shown in Table 1. Five different fibers; sisal, hemp, jute and coir were selected in and a polypropylene matrix based composite was processed. The mechanical properties of these composites were compared to that of E-glass fiber reinforced composites. Specific modulus of natural fiber reinforced and E-glass fiber reinforced composites were reported to be comparable except in the case of coir. Earlier research focused on ax, hemp, bamboo and jute fibers due to their abundant availability and extensive use in the textile industry. This study will focus on a similar common fiber source, the plant. Fiber secures third place in terms of worldwide production (870.103 ton per year) after jute. In addition to its availability, belongs to the same family as the jute plant and is likely to share jute's desirable properties. There is a need for research about fiber properties and its surface characteristics if it is to become a successful reinforcement for composite production.

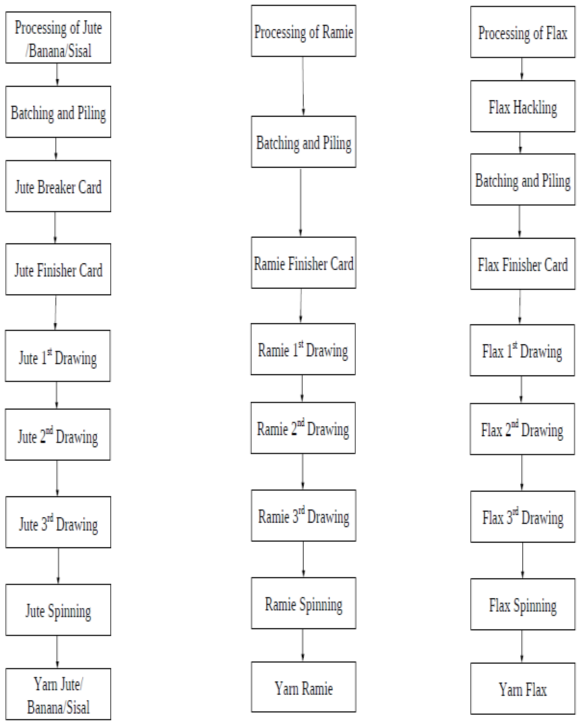

Fig.2. Processing Steps of Natural Fiber

Unlike artificial fibers, natural fibers show great variation in their mechanical properties due to: growth conditions, age of the plant, which part of the stem they are extracted from, varying constituent's fraction at the microscopic level, etc. Shinji Ochi [8] reported the variation of fiber modulus as a function of fiber location on the stem, where fibers obtained from the bottom part of a plant exhibited more tensile strength (about20% more). The tensile strength of a fiber determined experimentally at the macroscopic scale is governed by the structure and the chemical composition present at the microscopic scale. Most of the materials available in nature are composite in nature (i.e. the material is a mixture of different chemical constituents). Similarly, bast fibers also consist of constituents namely: cellulose, hemicellulose, lignin, pectin and waxes at the microscopic scale. Fibers obtained from different plants have variation of these constituents and consequently exhibit different properties. The volume fraction of each constituent in different fibers was reported in and is presented here in Table 1.

The major advantages of developing natural fiber based composites include low cost, low density, recyclability, low pollution, no health hazards and effective utilization of resources. To this point, natural fiber composites can be used for secondary structural application due to their lower tensile strength and mechanical properties compared to that of primary structural applications. Some applications were listed in that includes seat backs, dashboards, door panels, and sports goods. In order to expand the use of natural fiber based composites, further detailed investigations are required with a focus on strength improvement.

In this study the prediction of transient response and natural frequencies is to be done on the laminated composite materials. As composite materials are widely used in many fields, there is a need for accurate prediction of dynamic characteristics so that they can be designed against the failure due to various types of dynamic loads. In the past few years the problem of health monitoring and fault detection of structures has received considerable deliberation. The changes can be considered as an indication of the health of the structure. Subsequently, these methods of fault detection are based on the comparison of the vibrant response of the healthy structure with the active response of the deserted structure. The evaluation is carried out through some algorithm, which employs the modal data of the healthy and deserted structure. Therefore, the fault detection problem is in need of the modal data for the healthy structure, the modal data for the deserted structure and the algorithm that uses these data and provides information about the state of the structure. Each of these items has its own aspects and associated problems that affect the results of the fault detection. Due to the drawbacks of vibrations, it is important to eliminate or reduce the vibration i.e. provide damping, for this purpose the vibration analysis is to be done. In analysis of vibration we can derive the equations of motion of a vibratory system and find out the response of vibration in the forms of natural frequencies and displacements.

In our work in the area of vibration analysis we wish to develop an efficient model correction approach for resonant systems that are obtained from model analysis and approximate methods. Model correction for point-wise and spatial models of resonant systems would be considered. Also we have included the effect of damping in the resonant system which is assumed to be negligible in other approaches.

1.1 Objectives

- To develop the Natural Fiber Composite plate for various applications by using coconut, banana, and jute fiber at various curing temperature.
- To develop the synthetic fiber composite plate in comparison with the natural fiber plate at various fiber angle and various curing temperature.
- To determine the Young's modulus of natural fiber composite plate through tensile test by considering the appropriate fiber cross-sectional area after failure.
- To determine Young's modulus and Poisson's ratio of a short natural fiber reinforced composite plate.
- To determine Young's modulus and Poisson's ratio of a short synthetic fiber reinforced composite plate.
- To predict the structural behavior of carbon fiber composite when fiber angle is 0^0, 45^0, 90^0 respectively
- To predict the structural behavior of glass fiber composite when fiber angle is 0^0, 45^0, 90^0 respectively
- To study the Vibration characteristics of glass/carbon fiber composite when fiber angle is 0^0, 45^0, 90^0 respectively
- To structurally compare the results of natural fiber composite plate with the synthetic fiber composite plate.
- All the above process to be done numerically on ANSYS Software and Experimentally with the help of UTM and FFT analyser.
- To provide the best material to the automobile and aerospace industry which is lighter, stronger and less vibrating.

I. Measurement

The Natural Fiber reinforced composites plates are to be made up of hand lay up technique. Coconut, banana and jute fiber will be used. The dimensions of the plate will be 150x250x6 mm.Curing is different for every composite.In case of the synthetic fiber the Glass and carbon fibers will be used, these plates are also to be manufactured by hand lay up technique.The epoxy resin used in this study was, with its hardener (Epoxy 10) in ratio (3:1), and left at room temperature (23^0 C) to solidified after (24) hours, at (30^0C) & (40^0C) for 24 hours.Hand lay – up molding technique used to prepare:-a- epoxy composite reinforced with [chopped strand mat fibers with surface density 0.277 Kg/m2] from 12C Composites Pune.

Epoxy composite reinforced with [woven roven (0^0–90^o) with surface density 0.5 Kg/m2] from12C Composites Pune and chopped strand mat together as a sandwich composite.

Tensile Testing

Tensile testing is a fundamental mechanical testing method in which a sample is subjected to uniaxial tension until failure. The results from the test are commonly used to select a material for an application, for quality control, and to predict how a material will react under other types of forces. Properties such as ultimate tensile strength, maximum elongation and reduction in area can be determined. In this test specimen is loaded in a very controlled manner while measuring the applied load and the elongation of the specimen over some distance.

Specimens are prepared as per ASTM D3039 standard, which consist tabs at either ends. The universal testing machine (UTM) is used for testing with higher accuracy, the maximum capacity of machine 100 KN is used for testing, which operated on electronic control servo mechanism. Speed rate is 2 mm/min; the specimen is fixed between lower crosshead & intermediate cross head.

In the second phase, the composite structures consisting of aluminum, mild steel and FRP materials are to be constructed and compared with the reinforced composites, the stacking sequence is going to change.

Figure 3: Composite Structures

The natural frequencies for these composite materials are found out. In this stage, the Damping effect produced by these sandwich structures is measured.

Plan of Instrumentation

The complete experimental setup for vibration analysis is shown in following figure, In order to obtain natural frequencies of plates. The values of natural frequencies obtained by exciting the handle bar using Impact Hammer shown in following figure and measuring the response by an Accelerometer which was connected to FFT Analyzer.

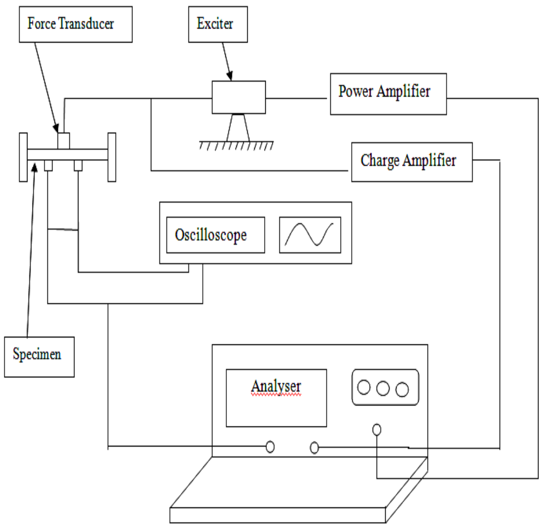

Figure 4 : Schematic Diagram of Experimental Setup

I. FUTURE SCOPE

Experiments were conducted on Glass fiber/Carbon fiber/Epoxy resin hybrid angle ply laminates with different fiber orientation to characterize the tensile properties. The following conclusions were drawn and recorded:

During specimen preparation angle ply hybrid composite for 0°/90° orientation, glass fiber is placed in 90° and carbon fiber placed in 0°, because the glass fiber is more ductile than carbon fiber.

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In tensile test load is acting in axial direction, since glass fiber is in the direction of load which carries maxi- mum load and also could be transferred to the carbon fiber. Carbon fiber is brittle in nature which fails first then glass fiber will fails.

In other types of specimen i.e. for 60°/30° and ± 45° orientation of hybrid composite degree of orientation for glass fiber is less, because the less the degree of orientation is, the less the strength and stiffness of materials will be.

From above we concluded that if we calculate mechanical properties for other orientations, the maximum properties can be obtained only in 0°/90° angle ply orientation.

Further research work needs to be carried out in the development of hybrid fiber-reinforced composites by the inclusion of filler material and fiber treatment for get- ting improved mechanical properties.

Comparatively the glass fiber materials provides more damping than that of other structures these plates can be used in the roofing of automobiles as well as the packaging purposes.

Nutural fibers are a good alternatives for the Automobile interior roof and other inerior panels of the automobile, these materials can act as a good shield to absorb the shock for the various machine parts.

In case of synthetic materials these materials can be used for the outer surfaces of automobile panels, aircraft panels to reduce the vibration in service on these panels we can provide the automatic actuator arrangement on these panels, so as the drag will be reduced and we get a good aerodynamic structure.

2. Conclusion

After performing the experiment for the validation of geometrical nonlinearity it is observed that, after 60 mm deflection actual effect of the nonlinearity is observed as it differs the linear and nonlinear results above 1 mm and the experimental results are matching with the software results.

So this concludes that Geometrical nonlinearity must have to take under consideration during whole analysis process. Research is in progress considering nonlinearity

Parameters of glass plate.

3.References

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4. Author Profile

Mr. Manoj S. Patil received his BE degree in Mechanical Engineering from S.S.G.B. College of Engineering Bhusawal, North Maharashtra University, Jalgaon in 2002. He has completed ME in Machine Design from SSBT`s College of Engineering Bambhori, North Maharashtra University, Jalgaon.Now he is a research scholar in North Maharashtra University, Jalgaon.