INTERNATIONAL JOURNAL OF RESEARCH IN MECHANICAL, MECHATRONICS AND AUTOMOBILE ENGINEERING (IJRMMAE)
ISSN: 2454-1435 (Print) | 2454-1443 (online)
Volume 7 Issue 4, Jan-March. 2022- www.ijrmmae.in – Pages 7 - 19

LIFE PREDICTION AND STATISTICAL ANALYSIS OF E-GLASS FABER WITH ALOEVERA IN COMPOSITE SPECIMEN

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ABSTRACT

Composite materials having major Applications in Aerospace industries and automobile industries. They have variability in their mechanical properties and also strength properties due to their internal structure. This leads to perform their safe utilization in design and manufacturing. In this study, the life prediction of the composite specimen is obtained by experimentally; the Experiments are carried according to standard ASTM D3039 in flexural and barcol Machine. The results are compared with the other specimen experimental results of the composite specimen.

Keywords: Life prediction, ASTM D3039

1. INTRODUCTION

In recent years conventional materials are replaced by composite materials due to their mechanical properties such as high specific strength, Elastic modulus, light weight and corrosion resistance. Aircraft and automobiles are examples of vehicles in which the application of fiber reinforced composite materials has been increasing. However, there are problems with fabrication of these composites, which require highly précised volume fraction methods like Resin transfer molding process (RTM), Vacuum Bag molding, compression molding. Whatever the method used for fabrication of composites, they are not isotropic and therefore have different mechanical properties in different directions. In addition to this, they present varying strengths due to their internal structure and to brittleness of the fibers and matrices, which means that there is no specific strength value to represent their mechanical behavior. This leads to the necessity of employing analyses for their safe utilization in design and manufacturing.

The Weibull distribution, which has recently been used for the determination of static and dynamic mechanical properties of ceramics and metal-matrix, ceramic- matrix, and polymer- matrix composites statistically. Weibull distribution is a practical method in the determination of 90% and 95% reliability values used in composite material mechanics. In this study, the life prediction of the carbon/epoxy and glass/polyester composite specimens was determined by both experimentally and probabilistically. For Experimental analysis, specimen is fabricated by Hand layup technique according to ASTM D3039 standard. Order to predict the exact strength for particular loading conditions of the composite specimen.

1.1 INTRODUCTION OF COMPOSITE MATERIALS

A composite material is made by combining two or more materials to give a unique combination of properties. The above definition is more general and can include metals alloys, plastic co-polymers, minerals, and wood. Fiber-reinforced composite materials differ from the above materials in that the constituent materials are different at the molecular level and are mechanically separable. In bulk form, the constituent materials work together but remain in their original forms. The final properties of composite materials are better than constituent material properties. The concept of composites was not invented by human beings; it is found in nature. An example is wood, which is a composite of cellulose fibers in a matrix of natural glue called lignin. The main concept of a composite is that it contains matrix materials. Typically, Composite material is formed by reinforcing fibers in a matrix resin as shown in Figure 1. The reinforcements can be fibers, particulates, or whiskers, and the matrix materials can be metals, plastics, or ceramics. The reinforcements can be made from polymers, ceramics, and metals. The fibers can be continuous, long, or short. Composites made with a polymer matrix have become more common and are widely used in various industries.

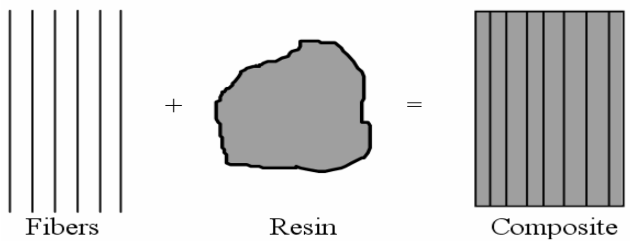

Fig: 1 Composition of Composite Material

1.1.1 CLASSIFICATION OF COMPOSITE MATERIALS

The first level of classification is usually made with respect to the matrix constituent. The major composite classes include Organic Matrix Composites (OMCs), Metal Matrix Composites (MMCs) and Ceramic Matrix Composites (CMCs). The term organic matrix composite is generally assumed to include two classes of composites, namely Polymer Matrix Composites (PMCs) and carbon matrix composites commonly referred to as carbon-carbon composites.

The second level of classification refers to the reinforcement form - fibre reinforced composites, laminar composites and particulate composites. Fibre reinforced composites can be further divided into those containing discontinuous or continuous.

Fibre Reinforced Composites are composed of fibers embedded in matrix material. Such a composite is considered to be a discontinuous fibre or short fibre composite if its properties vary with fibre length. On the other hand, fibres when the length of the fibre is such that any further increase in length does not further increase, the elastic modulus of the composite, the composite is considered to be continuous fibre reinforced. Fibres are small in diameter and when pushed axially, they bend easily although they have very good tensile properties. These fibres must be supported to keep individual fibers from bending and buckling.

Laminar Composites are composed of layers of materials held together by matrix. Sandwich structures fall under this category.

Particulate Composites are composed of particles distributed or embedded in a matrix body. The particles may be flakes or in powder form. Concrete and wood particle boards are examples of this category.

1.1.2 TYPES OF FIBERS

Glass, Carbon, Aramid, Polyethylene, Boron, Silicon Nitride, alumina and Silica are the fiber types. The available matrices are polymer, glass, carbon, ceramic and metal. Considering the economics of these materials i.e. performance vs. prices, availability, consistency, reliability and production capabilities with glass, carbon, and aramid fiber are the most commonly used composite material both for general purpose and for high performance applications. There are two types of polymer matrices namely

1.1.2.1 GLASS FIBER

Glass fibers are the most common of all reinforcing fibers for polymer matrix composite. The principal advantages are low cost, high tensile strength, high chemical strength and insulating properties. The disadvantages are low tensile modulus, relatively high specific gravity, sensitivity to abrasion with handling which frequently decreases tensile strength, relatively low fatigue resistance and high hardness .E (Electrical) and S (high content of silica) are commonly used. C (corrosion), D (Dielectrically), A (Appearance), R (structural reinforcement) are the other types.

1.1.2.2 ALOE VERA

Aloe Vera is a plant whose extracts have been used in herbal medicine and in alternative medicine for their rejuvenating, soothing and healing properties41. The aloeplant is the source of two herbal preparations: aloe gel and aloe latex. Aloegel is often called Aloe Vera and refers to the clear gel or mucilaginous substance produced by parenchymal cells located in the central region of the leaf. Diluted aloe gel is commonly referred to as Aloe Vera extract. The gel is composed mainly of water (99%) and mono- and polysaccharides (25% of the dry weight of the gel). The properties of aloevera in accelerating wound healing in burn victims have been studied extensively43. Aloevera promoted complete healing of burn wounds. Several studies and clinical trial have assessed the effectiveness of aloevera in the treatment of skin burns4. It was found that aloevera was found to exhibit anti-inflammatory effects and the histological examination showed with aloevera may be excellent new dressing for wound occlusion tissue repairing and could be used for effective treatment of all types of wound17,4 . The evidence suggests that the primary sites of action for aloevera are epithelial tissues and their action on surfaces and membranes, rather than solid organs, may account for some of the healing properties18-20. In the case of the immune system, aloevera exerts an effect on the cytokine system, resulting in immune modulation21-23. It was revealed that the mannose-6-phosphate, a major constituent of aloevera gel, either directly or indirectly stimulates fibroblast activation, an important factor in the wound healing process or plays a significant role in the biological activity of aloe vera18. It was revealed that a triple antibiotic ointment (containing polymixin B sulphate, bacitracinand neomycin sulphate) and an aloevera extract gel were evaluated for their effects on open wound healing of wounds created under anesthesia in 15 Beagle dogs. It was found that the primary difference between the two medications was noticed at 7 days when the aloe-treated wounds had a smaller unhealed area than did untreated control wounds and wounds treated.

1.1.3 TYPES OF POLYMER MATRIX

Polyester: The advantages are low cost and the ability to be made translucent; drawbacks include service temperatures below 170° F, brittleness, and high shrinkage of as much as 8% during curing.

Epoxies: The advantages are high mechanical strength and good adherence to metals and glasses; drawbacks are high cost and difficulty in processing.

Phenolics: The advantages are low cost and high mechanical strength; drawbacks include high void content.

1.2 FABRICATION PROCESSES

Manufacturing of composite materials involves distinct operations that may vary depending upon available technology, existing facilities and personnel skill.

The manufacturing process may also vary due to wide variety of composite materials and their application. Each of the fabrication processes has characteristics that define the type of products to be produced. This is advantageous because this expertise allows the manufacturer to provide the best solution for the customer. Factors considered for selection of most efficient manufacturing process are as follows:

- User needs
- Total production volume
- Performai1ce requirements
- Economic targets
- Size of the product

The goals of the composite manufacturing process are to:

- Achieve a consistent product by controlling
    - Fiber thickness
    - Fiber volume

1.2.1 FABRICATION METHODS

There are number of fabrication processes available for the production of fiber reinforced composites. Some of the fabrication processes which are commonly used are : a) Hand lay-up b) Vacuum bag molding c) Autoclave molding, d) Pultrusion e) Filament winding f) Resin transfer molding g) Resin infusion techniques h) Resin Injection techniques

Properties

Some of the factors that are responsible for the success of composites as engineering materials are

a) Low weight

b) High specific strength

c) High stiffness

d) Fatigue insensitivity

e) Corrosion Resistance

One of the most significant advantages of a composite over a conventional material is its ability to tailor a composite material. Tailoring of composite materials yields only the stiffness and strength required in a given direction. In contrast, an isotropic material is by definition constrained to have excess strength and stiffness in any direction other than that of the largest requirement. The special nature of composite material makes it essential for the design analyst to be aware of certain types of material defects that occur during manufacture or fabrication.

1.3 PREDICTION STRENGTH OF A UNIDIRECTIONAL LAMINA

The prediction of five ultimate strengths of a unidirectional lamina is far more difficult than the prediction of the four elastic constants and the hygro thermal parameters. This is because failure of a lamina is a very complex process. First, failure is likely to initiate in a local region, especially at where defects exist (void, cluster, etc.), which might be introduced during the manufacturing. Those defects are almost unavoidable and are difficult to predict. Secondly, except the two constituents, fiber and matrix, the interface between the fiber and matrix plays an important role in the failure mechanism. The property of interface is difficult to be identified. Thirdly, there exist many different failure modes (matrix cracking, interface debonding, fiber fracture, micro buckling of fibers, etc.). For the same laminar, the failure modes depend on the loading conditions and many other factors. Furthermore, the failure process may involve several different failure modes, one failure mode may evolve to another failure mode or several failure modes may exist simultaneously.

Because of the complexity of the failure process, the mathematical treatment of relationship between the ultimate strengths of a lamina and the properties of its constituents is considerably less developed. There are some theoretical or empirical models available for some strength parameters. But it must be with caution to use them. Therefore, experimental evaluation of these strengths becomes important. The experiments to determine the strengths of a unidirectional laminate subjected to a single principal stress component are relatively simple and have been standardized in the ASTM code.

1.3.1 PROBABILISTIC DESIGN SYSTEM

Probabilistic design offers tools for making reliable decisions with the consideration of uncertainty associated with design variables/parameters and simulation models. In spite of the benefits of probabilistic design is associated with the intensive computational demand of uncertainty analysis. To capture the probabilistic characteristics of system performance at a design point, we need to perform a number of deterministic analyses around the nominal point, either using a simulation approach (for instance, Monte carol simulation) or other probabilistic analysis methods (such as reliability analysis). Many researchers have been concentrating on developing practical means to make probabilistic design computationally feasible for complex engineering problems. In general, a finite element analysis program starts with a set of input data such as geometric parameters, material parameters, loads and boundary conditions. The program then generates some output data for the analysed component such as displacements, stresses and strains. As a matter of fact almost all of these input parameters are subjected to scatter due to either natural variability or inaccuracies during manufacturing or operation. In a probabilistic approach, these uncertainties on the input side are described by statistical distribution functions. A probabilistic analysis can be used to find the answer for the following situations.

In probabilistic design, statistical distribution functions are used to describe and quantity random input variable. The following information is typically used to characterize a statistical distribution. F (x) probability density function. The probability density function of a random input variable x is a measure for the relative frequency of which values of random input variables are expected to occur. F (x) cumulative distribution function.

The cumulative distribution function of a random input variable x is the probability that values for the random input variable remain below certain limit x, µ-mean value. The mean value of a random input variable x is identical to the arithmetic average. It is a measure for the location of the distribution of a random input variable. σ- Standard deviation. The standard deviation is a measure for the width of the distribution of a random input variable.

Variations

The analysis and design of mechanical or structural component is influenced by three factors namely

- Geometry
- Material strength
- Load
- Variations involved in each factor are given below

- **GEOMETRY**

Although the nominal or design dimensions are known precisely the actual dimensions will be random in nature. When dimensions are produced on a machine tool the limitations of the machine and the operator lead to variations in the dimensions in the form of tolerances. Similarly when the structural members are rolled in a mill the shaping rollers will gradually wear resulting in variations in the cross sectional dimensions of the rolled member. Since it is not possible to change the rollers frequently some variations in the dimensions of the rolled members are unavoidable. The errors in fabrication and assembly also cause variations in the overall dimensions of multi component mechanical and structural systems.

- **MATERIAL STRENGTH**

Variations occur in the properties of the, materials due to uncertainties in the chemistry and the geometric shapes as well as the manufacturing and the fabrication procedures used.

- **LOAD**

The mechanical strength is also influenced by the loading and the strain rates applied to the component. The load acting on a machine or structure is considered to be static if the magnitude of the load is constants or dynamic if the load is variable with respect to time. The static loads include dead loads due to self weights of the components and the live loads acting on the structure. These loads are subject to variability due to fluctuations in the specific weights of the materials as well as changes in the working loads acting on the structure. The dynamic loads include wind, snow, wave and earthquake induced loads. These loads are to be treated as random processes for the reliability analysis of the structures (singiresu s. Rao, 1991).

2. EXPERIMENTAL WORK

The experimental work consists of fabrication of composite specimens. There are two different composite sheets taken for conducting experiments.

2.1 Carbon/Epoxy composite sheet

The composite specimens used in the experiments were prepared from carbon/ epoxy sheets with (0^o) configuration, 0.89mm thickness and 295 g/m^2 weight. The material properties presented in Table 1 were obtained by means of the strain gauge method. The tests were carried out according to ASTM D3039 standard (ASTM D3039, 1976) on an Instran 8516+ universal testing centre. A crosshead speed of 1.33 mm/min was used and room temperature conditions were present during the tests. The dimensions of the specimens are shown in Figure 2 and the ultimate tensile strength values obtained are given in Table 2.

2.2 Glass &Aloevera/Polyester composite sheet

Set the molding board and the frame work with the required dimensions. First apply wax polish at the base of the molding board which acts as releasing agent. Next apply poly vinyl alcohol over the wax polish at the base of the molding board which also acts as releasing agent. Glass fiber mat &aloevera of 10 mm thickness and (0^o) configuration is used. Cut the fiber mat according to the required size (thickness) of the mould. Take the required amount of the polyester resin and mix it with cobalt napthanate and methyl ethyl ketene peroxide which acts as accelerator and catalyst respectively. The ratio of cobalt added is 3 ml per kg of polyester resin. The catalyst is used for the quick drying of the mixture. Place the fiber mat on the molding board. Apply the prepared mixture resin over the fiber mat. After 24 hours, the composite sheet is cured, and then it is removed and cut into required number of specimens according to ASTMD3039 standard.

Fig: 2 Test Composite Specimen E-Glasses, Aloevera &Polyster Resin

3.1 EXPERIMENTAL PROCEDURE

3.1.1 BARCOL HARDNESS

This test method covers the determination of indentation hardness of both reinforced and non reinforced rigid plastics using a Barcol Impresser, Model No. 934-1 and Model No.935 A material’s surface hardness is determined through the use of a Barcol Impresser. The relative depth of penetration of the impresser ’sindenter provides a comparative measure of the material’s hardness he Model No 934–1 and Model No. 935 Barcol Impressers are designated for use. Within the range of hardness measured by these Impressers the Model No. 934-1 is used for measuring harder materials and the Model No. 935 is used for measuring softer materials. The Barcol Impresser is portable and therefore suitable for testing the hardness of fabricated parts and individual test specimens for production control purposes.

Fig: 3Barcol Impresser

3.2 BARCOL HARDNESS TESTING

Before proceeding with this test method, reference should be made to the specification of the material being tested. Any test specimen preparation, conditioning, dimensions, or testing parameters or combination thereof covered in   conditioning, dimensions, or testing parameters or combination thereof covered in the relevant ASTM materials specification shall take precedence over those mentioned in this test method. If there are no relevant ASTM material specifications, then the default conditions apply.

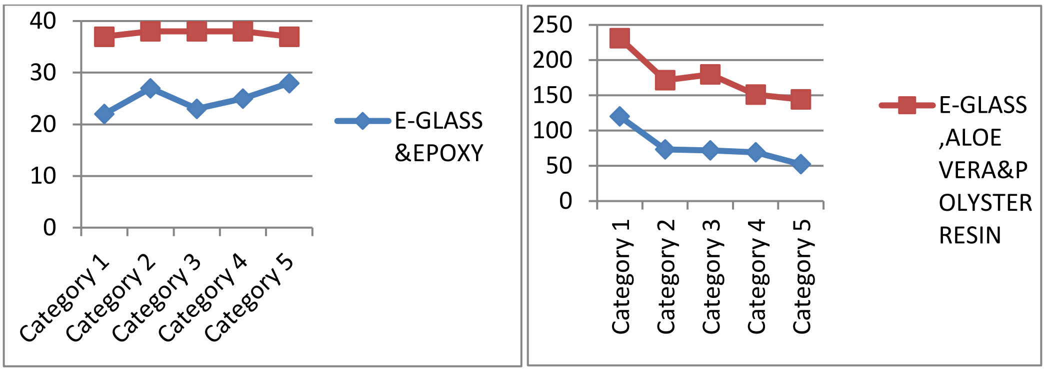

Fig: 4 Barcol Hardness variations

3.3 FLEXURAL STRENGTH

Flexural strength is an object’s ability to bend without obtaining any major deformities. A standard experiment called the three-point test can calculate an object’s flexural strength. For example, a rectangular slab of concrete is placed on two parallel platforms. Then another object applies load on the central part of the concrete, between the platforms, and gradually increases pressure until the concrete breaks. The flexural strength of concrete is estimated based on the weight of the load that collapses the concrete, the distance between the platforms and the width and thickness of the object being tested.

In occupational fields such as construction and engineering, knowing a material's flexural and tensile strengths is important in order to make sure that the material is strong enough to use in structures. Hard but brittle objects, such as wood concrete, alloys and plastic, are used more often in construction than elastic and ductile objects such as rubber, gold or silver, so it is more important to evaluate the former’s flexural and tensile strengths .In theory, an object’s flexural and tensile strengths would be in similar ranges if there is homogeneity in the materials used, meaning that the substances used are mixed in equally. If the substances are not uniformly mixed, then the flexure and tensile strengths might drastically vary in different areas of the object.

3.4 FLEXURAL STRENGTH TESTING

The specimen is prepared according to the ASTM D790 standard. Three point flexural testing method is followed. The testing is carried out in tensile testing machine with displacement velocity at 1.5 mm/min. The gauge length for testing specimen is 80 mm. Initially the breadth and width of specimen is observed and the area of cross section is calculated. The output result is a load Vs displacement curve, from this result the ultimate stress and break load is calculated. Five specimens are tested for each fiber resin composition ratio.

Sample No	E-glass Fiber & Epoxy Resin	E-glass Fiber, Aloevera & Polyester Resin
1	22	37
2	27	38
3	23	38
4	25	38
5	28	37

Fig: 5 Flexural Strength Testing

Table 1 Result of E Glass, fiber aloevera and polyester resin material

Sample No	E Glass Fiber & Epoxy Resin	E Glass Fiber, Aloevera & Polyester Resin
1	120.06	111.9
2	73.39	98.5
3	71.89	108.1
4	69.18	82
5	52.18	92

Table 2 Result of E-Glass Fiber with Aloevera in Composite Specimen

CONCLUSION

The strength variation of E-glass/epoxy and Glass/Polyester composite specimen experimental results are compared with other experimental results obtained by barcol and flexural testing machine. From the comparison, the numerical results give better agreement with the experimental results. This study questions and then rejects the assumptions that strength of composite materials is taken as an average of the experimental results. In this respect, the Weibull distribution allows researchers to describe the fracture strength of a composite material in terms of a reliability function. It also provides composite material manufacturers with a tool that will enable them to present the necessary mechanical properties with certain confidence to end users.

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