

A Study on Behavior and Mechanical Properties of Polyester Based Composite Materials

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Abstract— This review paper represents the study of different parameters, properties, behaviors and testing of Composite Materials. The studies of composite material can be done from different articles in the period of 2009 to 2019 and this paper reviewed from: Brief study on Mechanical Testing and their properties, fatigue behavior and its group properties like (Ultimate strength, Yield stress, and Elasticity Modulus) of prosthetic for partial foot amputation, Experimental analysis of unsaturated polyester reinforced by ceramic particles of alumina for implementation on human body, The process of occurring failure and solution to analysis the problem faced by drill twist of drilling operation on composite materials, The Design of Experiment is to evaluate effect of design parameter on dynamic response of laminated composite lattice cylinder shell, The Discussion of properties and geometric parameters on plastic zone size, The Investigation of fatigue Test can made on polymer composite material, The Technology in shielding can be discussed to improve better development in Fabrication process. In this paper the discussion reviews on basic study of composite materials.

Keywords— Composite materials, mechanical testing, fatigue behavior, radiation shielding, and acoustic emission.

I. INTRODUCTION

The composite materials are defined as the process of combining two or more constituent materials with Engineered or Naturally occurring materials. The composite material is to form a material capable of sustaining loads in microscopic scale. The composite material is widely used in many applications to increasingly have a high strength, durability, wear resistance, stiffness, low density while compared to heavy materials and loss in weight of material. Composites are also used to contain the physical, chemical and mechanical properties.

In historical, earliest period the composite materials are mixture of straw and mud is used to form bricks for building construction. In the year 1958, the metallic composites of SiO₂ and Al are used for Rolls Royce- England and glass fiber and plastic is used in motor cases for missile system. In the year 1960, the principle of fiber reinforcement system has been established. In the year 1938, the natural fibers and polymers are used in asbestos and phenol resins. The Engineered materials are evolved from the period of 10000 BC to 2020 as shown in fig.1.1.

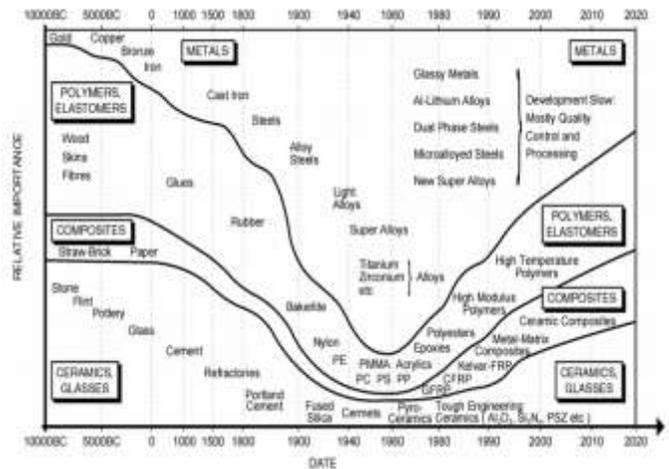


Fig.1.1. Evolutions of Engineered Materials

Classification of Composites:

The Fig.1.2 shows that the classification of composite materials and composites are mainly classified into following three categories are given below. They are,

- Particles-reinforced (large particles and strengthened)
- Fiber-reinforced (continuous and short fibers)
- Structural (laminated and sandwich panels)

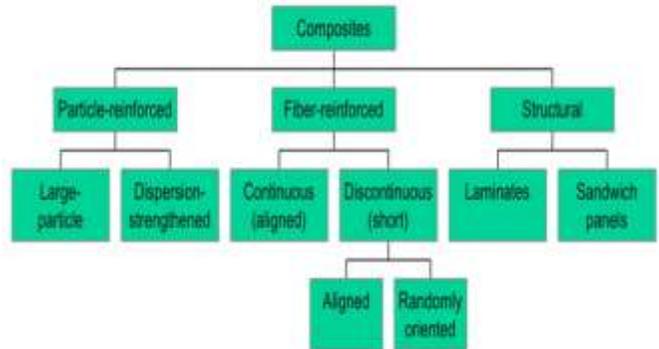


Fig.1.2. Classification of composite materials

Application of Composite Materials:

The different types of composite materials are used in Industrial application and it is described in Table.1.1 along with its properties.

Table.1.1. Application of Composite Material

INDUSTRIES	PROPERTIES
Automobile	Lightweight, High strength, Wear resistance, Rust free, Aesthetic.
Aerospace	Strength, Light weight, Temperature resistance, Smart structure and Wear resistance.
Sports	Lighter, Strength, Toughness, Better Aesthetic, Higher damping properties.
Transports and Infrastructure	Lighter, Stronger, Toughness and Damping.
Others:	<ul style="list-style-type: none"> ➤ Biomedical Industry ➤ Consumer goods ➤ Agricultural Equipment ➤ Heavy machinery ➤ Computers

Mechanical testing of composite materials:

The mechanical properties of polymer describe the development of the glass fiber reinforced polymers as composite parts. It is used for car body, boat hulls and radar domes. The design is directly evaluating the bulk mechanical properties of composites are preferred usually for tensile, compressive and shear tests. The fig.3 shows that the structure of mechanical properties along with ductile and brittle material. The properties of an isotropic and in homogeneous composite materials are used to demand the structural application and it requires wide range of mechanical test. The mechanical testing of composite materials involves a range of test types along with testing conditions in variety of different environment.

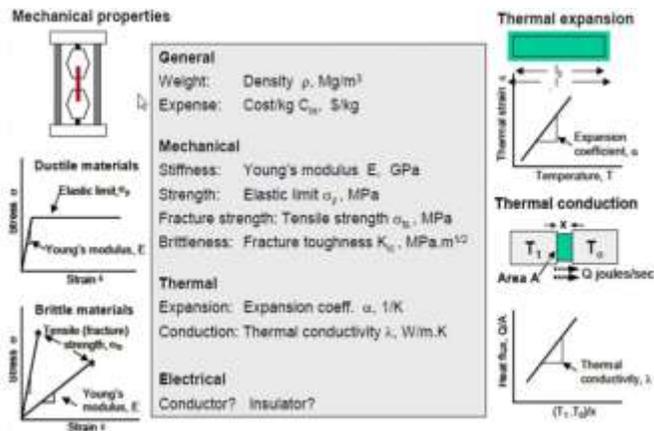


Fig. 3. Basic Materials Properties

Fatigue behavior of prosthetic for partial foot amputation:

The fatigue behavior is investigated with various composite laminate materials. The different types of composite materials are used to analysis fatigue test and tensile properties of partial foot prosthetic which laminated using vacuum system. The prosthetic is nothing but it is a substitute device of missing parts of body for amputee due to accidents and diseases.

Delaminating in drilling composite materials:

In the machining operation, the drilling operation using twists drill. It is most frequently applied for secondary machining of composite materials and used for structure joining. Nearly 40% of metal removal operation is carried out by drilling operation in automotive industries. Drill wear is necessary to prevent damages made on machine tools, cutting tools and work piece. Drill wear is caused due to the existence of critical speed. Tool wear is depending upon the type of tool using, cutting condition of work material and selection of lubrication. The failure of twist drill occurs in to two modes: 1) Fracture or chipping, 2) Excessive wear.

Modeling of polyester-alumina:

The modeling can be done on the possibility of manufacturing materials in composite particles of unsaturated polyester reinforced by ceramic particles of alumina. It is used in different industries because of having good physical and mechanical properties. Many years back, polyester fiber is used in different useful purpose as industrial applications such as garments clothes and home furnishing when unsaturated polyester acts as organic material.

Elastic-Plastic stress investigation for arc shaped interface crack:

The dissimilar constituents in composites are defects to produces micro cracks. The plastic zone size had investigated for curved interface crack between a circular inclusion and infinite matrix. The stresses of plastic deformation in plastic zone is satisfied with von mises yield criterion and also satisfied the condition of stress intensity factors induced by external load with distributed dislocation method.

Lattice cylindrical shell:

The cylindrical shells are manufactured by using composite materials because of light weight and good mechanical properties by lattice composites. It is widely used in aerospace engineering of different space area. The composites are designed to withstand in high temperature and generates undesirable thermal deformation. Composite lattice cylindrical shell presents wide range of positive, negative and thermal expansion.

II. LITERATURE SURVEY

N.Saba et. [1] Were studied on overview of mechanical and physical testing of composite materials. The study on mechanical testing is carried out to improve the properties of the composite materials. In this paper the mechanical testing, the polymer is used for development of glass fiber reinforced polymer as composite. The mechanical properties of strength and stiffness has characterized by using polymer. The different tests of tensile test, flexural test, impact test, compression test, bending test, shear test and fatigue test are taken as mechanical testing. This paper is concluded with good improvement.

Saif M. Abbas et. [2] Were experimented on mechanical and fatigue behaviors of prosthetic for partial foot amputation with various composite materials types effects. The experiment mainly considered the designing a part of human body which acts as a substitute device of missing parts of the body and it causes due to accident or disease. In that three types of composite materials are used for analysis of fatigue behavior and tensile properties of partial foot. This paper is concluded with safe design for partial foot composite material.

C. C. Tsao et. [3] Were experimented on effect of tool wear on de-lamination in drilling composite materials. The experiment considering the tool wears on de-lamination in drilling composite material. The machining of drilling operation is frequently applied for secondary machining of composite materials by using twist drill. The drill wear is necessary step taken to prevent damage of cutting tools, machine tools and work piece, it also concerned by hole making industry as a great impact. By industrial experience shows that work of drilling causes more de-lamination. After the experimental analysis, the result shows that twist drill has lower feed rate below which de-lamination damage can be avoided, while comparing to sharp drill. The conclusion has agreed with the industrial experience and extended to examine the wear effects of various drills.

Luiz Fernando Dos Santos Sauza et. [4] Were experimented and studied on dynamic response of laminated composite using design of experiments: An experimental and numerical study. The state study of composite plate by using vibration based method (VBM) has been determined. The VBM are simple and at low cost to detect damages and also detects fails in composite structure. Composite material places an important role in production process. The main strategy of Design of Experiment (DOE) is to reduce the no. of experiment and evaluate effect of design parameter. The output of research is done on a unidirectional laminate and on a laminate fiber. The two sets of laminated composite plates are analyzed numerically and experimentally. The final result has been concluded by consistent result by an experimental and numerical study.

Zainab S. Al. Khafaji et. [5] Were worked on preparation and modeling of composite materials (polyester- alumina) as implant in human body. The work prepared and modeled for composite to manufacturing composite particles of unsaturated polyester reinforced by ceramic particles of alumina. In this paper alumina is used for increase strength phase to unsaturated polyester resin. The different tests are conducted on the object and test includes bending, density, water absorption, hardness. The final statement has concluded with good improvement in unsaturated polyester resin and also shows that composite material have less density of al 10% and largest result for bending is 60% and also have less water absorbing is 0.6%.

Kai Wei, Yong Peng et. [6] Were worked on Light weight composite lattice cylindrical shells with novel character of tailorable thermal expansion. Composite lattice cylindrical

shells can present a wide range of negative, positive and especially zero co-efficient of thermal expansion. The tailorable thermal expansion ranges from -2200 to 2200ppm/°c. So heat can be easily achieved because of having high thermal expansion compared to available engineered materials. The result has concluded that light weight features enable composite lattice cylindrical shell to be potentially used in aerospace engineering.

M. Fan, D. K. Yi et. [7] Was studied Elastic-plastic stress investigation for arc shaped interface crack in composite material. The plastic zone size has been investigated for curved interface crack. Von mises yield criterion is satisfied the stress in plastic zones. The physical problem is formulated into a set of singular integrated equation by using Jacobi polynomials. The shear modulus ratio is very significant when the inclusion is softer than matrix. It plays dominant role when the inclusion is stiffer than matrix. The development produces great influence on the plastic deformation at crack tips. The result concluded that the maximum deboning angle is lower than 77° of under axial tension. It also shows that the inclusion has done partially deboned from matrix.

Tarek Merzouki et. [8] Were experimented on direct identification of non-linear damage behavior of composite material using the constructive equation gap method. The experiment on orthotropic material is consisted to improve the reliability of identification parameters that governed a non linear damage law. The main process is to minimize the constructive equation gap. Here Levenberg-marquard method is used to minimize the problem simulation, which is used for experimental process. The experiment has been concluded with good result.

D.D. Doan et. [9] Were worked on unsupervised pattern recognition approach for acoustic emission data originating from fatigue tests on polymer composite material. The work conducted on carbon reinforced polymer composite specimen to investigate acoustic emission generated during tension fatigue tests. The process describes the reduction in noise and separation in acoustic emission. The two types of signal screening and noise model –based filtering are the filtering methods used in the AE fatigue data pre-processing. The acoustic emission originated from outside the area of interest bounded by the sensors. The result has concluded by presenting different procedure insight into fatigue damage development in composites.

Beren R. Evans et. [10] Were worked on evaluation of shielding performance for newly developed composite materials. The work carried out in fabrication technology of shielding materials. The manufacturing consist the various radiation interaction properties and it is used for shielding materials. The different factors are occurred to develop the composite for shielding materials. The investigation has detailed the evaluation of various composite materials. The shielding performance concluded by using Monte Carlo simulation method.

III. CONCLUSION

This paper has concluded with the case study of different parameters and properties of the composite materials. The study can teach the development of various composite materials for the different applications by its physical and mechanical properties. The scope of composite material is obtained to improve the products by eco-friendly and biodegradable material to obtain clean and safe environment.

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