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Fabrication and Investigation of Mechanical Performance of Polymer Based Golf Shaft

[1]Krishnakumar.P [2]Dr B.Vijayaramanath [3]Dr C.Elanchezhian
[1] PG Student Scholar, Sri Sairam Engineering College, west-Tambaram, Chennai, India-600044.
[2 3] Professor, Department Of Mechanical Engineering, Sri Sairam Engineering College, west-Tambaram, Chennai, Tamil Nadu, India-600044.
Corresponding Email: krishnamechssiet@gmail.com

Abstract— **The Composite materials have found widespread applications in various fields of engineering such as aerospace, marine, automobile and mechanical applications. Polypropylene is most widely used polymer matrix composite (PMC) due to its unique strength and hardness. In sports application like golf shaft which is subjected to various deflection and torsion loads so that ordinary steel golf shaft is replaced to polypropylene plastics which may help the player for more comfort due to its weight reduction. The Composite structure of golf shaft made of polypropylene plastics is modeled and mechanical behavior is experimentally calculated. Experimentally deflection is measured by hanging a mass on the tip with the butt fixed. The degree of torsion is measured by applying the twisting moment, to the tip. The frequency of vibration is measured by adding a mass to the tip of a shaft and shaking it.Finite element results for deflection and torsion give satisfactory results with the experimental data. These results will be useful in designing polypropylene and sheet rolled golf shaft.**
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.Keywords— Nano composites; Polypropylene; calcium carbonate; scanning electronic microscope; wear.

1. Introduction

Composites are made up of individual materials referred to as constituent materials. There are two categories of constituent materials: matrix and reinforcement. At least one portion of each type is required. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcements impart their special mechanical and physical properties to enhance the matrix properties. A synergism produces material properties unavailable from the individual constituent materials, while the wide variety of matrix and strengthening materials allows the designer of the product or structure to choose an optimum combination. Engineered composite materials must be formed to shape. The matrix material can be introduced to the reinforcement before or after the reinforcement material is placed into the mould cavity or onto the mould surface. The matrix material experiences a melding event, after which the part Shape is essentially set. Depending upon the nature of the matrix material, this melding event can occur in various ways such as chemical polymerization or solidification from the melted state.

A variety of moulding methods can be used according to the end-item design requirements. The principal factors impacting the methodology are the natures of the chosen matrix and reinforcement materials. Another important factor is the gross quantity of material to be produced. Large quantities can be used to justify high capital expenditures for rapid and automated manufacturing technology. Small production quantities are accommodated with lower capital expenditures but higher labour and tooling costs at a correspondingly slower rate. Andrew Suttona and James Sherwood [1] found that Hollow non wood baseball bats have performance advantages over wooden bats. The hollow barrel bats act as a spring or trampoline during the bat-ball collision. De Morais [2] identified that a micromechanical model is presented for predicting the longitudinal tensile strength of polymer matrix composites. Rehman et al [3] used Stir casting process in his work about to analyze the suitability of aluminium alloy-silicon carbide MMC (Al-SiC). Slater et al [4] Fabricated and tested golf shafts. Composite materials have been selected as the material of choice for structural, mechanical and sporting applications for a number of years due to their high stiffness/weight ratio. Ranga and Strangwood [5] Finite element modeling (FEM) has been used to replicate the quasi-static and dynamic behavior of a solid sports ball (of a single material, extracted from a commercial hockey ball), by using experimentally determined viscoelastic, hyper elastic and mechanical material properties and data obtained from the ball material. Eric Ruggiero et al [6] investigated that Northern white ash had been the wood of choice for Major League Baseball (MLB) bats until the introduction of hard maple in the late 1990s Fareed Kaviani and Hamid Reza Mirdamadi [7] proposed that this article addresses wave propagation in carbon nano-tube (CNT) conveying fluid. CNT structure is modeled by using size-dependent strain/inertia gradient theory of continuum mechanics, CNT wall-fluid flow interaction by slip boundary condition and Knudsen number (Kn Kaufmann et al [8] observed that Floating sports equipment such as snowboards experience extreme loads during riding it during this maneuver the steel edge of a snowboard could easily hook into the handrail, researches

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worked out. Jeffrey Kensrud and Lloyd Smith [9] the spin of a batted ball is needed to describe the ensuing trajectory. The following considers experimental spin

Measurements collected by impacting a stationary ball with a swinging bat. Jean-Samuel Rancourt et al [10] conducted to assess Player testing was conducted to assess the effects of different golf shaft alignment methods on 5-iron golf club performance.

2. Materials and Methods

GLASS FIBRES:

Glass fibers are the most common of all reinforcing fibers for polymeric matrix composites (PMC). The principal advantage of glass fibers are low cost, high tensile strength, high chemical resistance, and excellent insulating properties. The disadvantages are relatively low tensile modulus and high density sensitivity to abrasion during handling (which frequently decreases its tensile strength), relatively low fatigue resistance, and high hardiness (which causes excessive wear on molding dies and cutting tools). Sample fiber glass tape is shown in the fig.1

Fig 1 shows fiber glass tape roll

POLYPROPYLENE SHAFT:

Polypropylene (PP), also known as **polypropene**, is a thermoplastic polymer used in a wide variety of applications including packaging and labeling, textiles (e.g., ropes, thermal underwear and carpets), stationery, plastic parts and reusable containers of various types, laboratory equipment, loudspeakers, automotive components, and polymer banknotes. An addition polymer made from the monomer propylene, it is rugged and unusually resistant to many chemical solvents, bases and acids. Polypropylene (PP), a polymer prepared catalytically from propylene which differs from HDPE by having an isostatic replacement of a hydrogen atom by a methyl group on alternate carbon atoms in the main chain. Although largely unreactive chemically the presence of the methyl groups makes Polypropylene slightly more susceptible to attack by strong oxidizing agents than HDPE. A major advantage is Polypropylene's higher temperature resistance, this makes PP particularly suitable for items such as trays, funnels, pails, bottles, carboys and instrument jars that have to be sterilized frequently for use in a clinical environment. Polypropylene is a translucent material with excellent mechanical properties and it has gradually replaced the polyethylenes for many purposes.

EPOXY MATRIX:

Starting materials for epoxy matrix are low molecular weight organic liquid resins containing a number of epoxy group which are three member rings are one oxygen atom and two carbon atoms. The polymerization reaction to transform the liquid resin to the solid state is initiated by adding a small amount of reactive cutting agent just before incorporating fiber into liquid mixture. The properties of a cured epoxy resin depend on principles on the cross link densities. In general the tensile modulus the glass transition temperature and thermal stability aweless chemical resistance are improved with cross link density.

Manufacturing Process of the Shafts

The shaft is completely cleaned with the water and then allowed to dry for sometimes until the water wipes out from the shaft. Then epoxy is mixed with the hardener in the ratio of 10:1. The resin and hardeners are finelly mixed and evenly applied to the shaft and fiber glass.

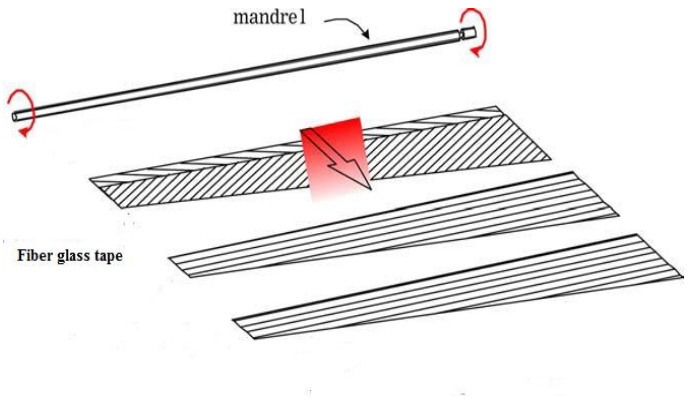

Fig 2 shows application of resin on mandrill

After the completion of laying-up, wrapping is required to maintain the pressure upon the shaft. Polypropylene tape is usually used for wrapping and the line pressure of the shaft is about 30–40 kgf/mm.

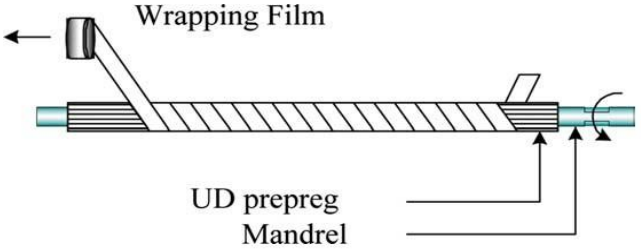

Fig. 3. Wrapping process of the shafts.

The curing process of the shaft in a hot-air oven. The hardening time in this process depends on the types of resin but the shaft used in this experiment was kept in an oven at 125 C for 90 min.

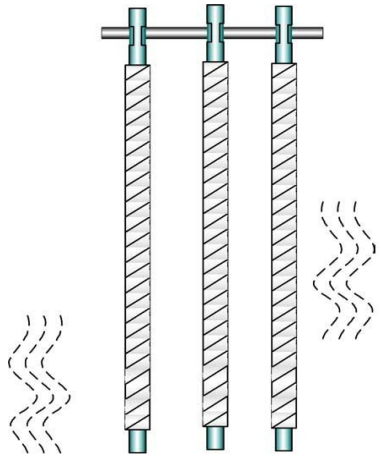

Fig. 4. Curing process of the shafts.

Fig 5 shows fiber glass wrapped shaft

III. Experimental Details

The characteristics of a golf shaft can be investigated using four different mechanical parameter tests.
These tests are as follows.

The torsional angle of golf shafts

The torsion of a golf shaft is a critical factor that determines the hitting point of a golf ball on the head face at the time of swing, and the degree of torsion also determines various styles of swing feeling. If the degree of the torsion of a golf shaft is not constant, it can vary the points of contact. it is true that the swing speed of an individual requires an adjustment of the range of torsional angle and that the golf shaft which becomes bent and distorted in the back swing should return to its original state to have a greater impact at the time of down-swing. However, if a player with a high swing speed uses a very flexible golf shaft, the head fails to reach the necessary speed and is consequently unable to make an accurate hit.

Deflection

Deflection is the degree of bend of a golf shaft at the moment of swing. This deflection board is used to Classify the grade of golf shafts by some manufacturers. It is highly advised to use a shaft with an appropriate deflection board to produce accurate swings. This is because the deflection is a crucial factor in determining the desired swing positions and the right impact points of the head. This is why the deflection board is utilized in the management of product quality.

About ANSYS

Finite element analysis, the core of computer aided engineering dictates the Modern mechanical industry and plays a decisive role in cost cutting technology. It is a technique to simulate loading conditions on a design and determine the Designs response to those conditions. The design is modeled using discrete Building blocks called elements; each element has extract equations that describe how it responds to certain load.
ANSYS the leading **FEA** simulation software, with its robust capabilities guides the Engineers to arrive at perfect design solution. ANSYS finite element analysis software enables engineer to perform the following tasks

3. Build computer models or transfer CAD models of structure, products, components or systems.
4. Apply operating loads or other design performance conditions.
5. Study physical responses, such as stress levels, temperature distributions, or electromagnetic fields.
6. Optimize a design early in the development process to reduce production costs.
7. To do prototype testing in environment otherwise would be undesirable or impossible.

ANSYS allows you to model composite materials with specialized elements called layered elements. Once you build your model using these elements, you can do any structural analysis
Composite are somewhat more difficult to model than an isotropic material such as iron or still. You need to take special care in defining the properties and orientations of the various layers since each layer may have the different orthotropic materials properties. In the section we will concentrate on the following aspects of building a composite model:

1. Choosing the proper element type.
2. Defining the layered configuration.
3. specifying failure criteria

Choosing the proper element type

The following element types are available are available to model layered composite materials: SHELL99, SHELL91, SHELL181, SOLID46, and SOLID191. Which element you choose depends on the application the type of results that need to be calculated

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and so on. Check the individual element descriptions to determine if a specific element can be used in your ansys product. All layered element allow failure criterion calculations.

SHELL99:

Used for layered applications of a structural shell model or for modeling thick sandwich structures. Up to 100 different layers are permitted for applications with the sandwich option turned off. Allows more layers. The element has six degrees of freedom at each node: translations in the nodal x, y, and z directions and rotations about the nodal x, y, and z-axes

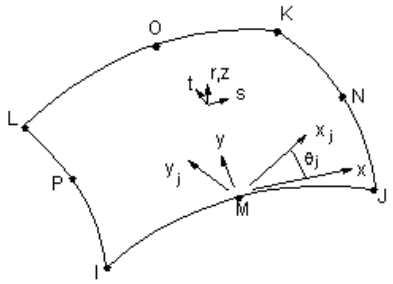

Figure.6

Shell 99 IS AN 8 N0DE 3D shell element with six degree of freedom at each node. It is designed to model thin to moderately thick plate and shell structure with a side to thickness ratio of roughly 10 or greater. For structure with smaller ratios, you consider using SOLID 46. The SHELL99 element allows a total of 250 uniform thickness layers.

IV. Results and Discussions

The ansys result shows the flexibility level of shaft. The composite materials is included in ansys by selecting layered shell. One end of the shaft is fixed and load 27.21 N load is applied to the other end. The deflection level is shown in the fig .8

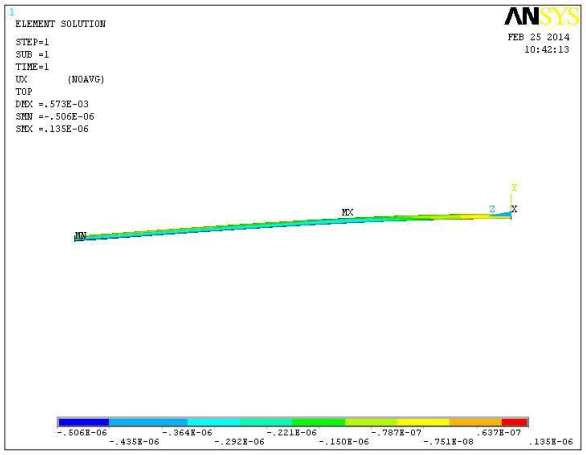

Fig 7 shows PP and fiber glass shaft

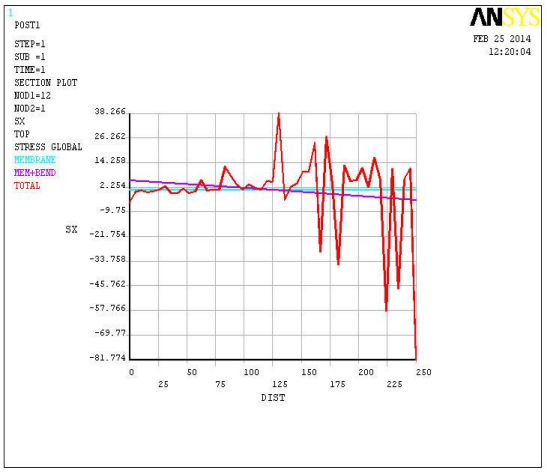

Fig 8 Shows deflection graph results

V. Conclusions

The evaluation of the mechanical properties of the golf shaft using the analysis of finite elements resulted in the following conclusions:

The composite shaft will perform better than that of steel shaft which gives more flexibility and grip for the player.

It has been proven efficient to apply the analysis of finite elements in the process of designing golf shafts.

The mechanical parameters are greatly influenced by the properties of the materials used and the fiber of layers.

It is possible to realize a database for the pattern designs based on the re-evaluation of current products.

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