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RESEARCH ARTICLE

ANALYSIS OF NATURAL FIBER REINFORCED COMPOSITE MATERIAL FOR THE HELMET OUTERSHELL - A REVIEW

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ABSTRACT

Composite materials with thermoplastic matrices and a reinforcement of natural fibers are increasingly regarded as an alternative to material replacement for various applications. The substitution of the traditionally used composite of natural fibers such as sisal, banana and Roselle can lead to a reduction of the component's weight and furthermore to a significant improvement of specific properties like impact strength, crash behavior. One of the major fields of application for such materials can be found in structural components manufacturing of helmets. The helmet manufacturing aspects are reviewed. Both the thermoplastic and the natural fiber composite shell manufacturing techniques are presented with specific mentioning of the advantages and disadvantages to each type from the manufacturing point of view. Then the properties such as stiffness, strength young's modules, and Poisson ratio of helmet from existing model is compared with the natural fiber composite material.

INTRODUCTION

A. Overview of Composite material

The advantage of composite materials over conventional materials stem largely from their higher specific strength, stiffness and fatigue characteristics, which enables structural design to be more versatile. By definition, composite materials consist of two or more constituents with physically separable phases. However, only when the composite phase materials have notably different physical properties it is recognized as being a composite material. Composites are materials that comprise strong load carrying material (known as reinforcement) imbedded in weaker material (known as matrix) Reinforcement provides strength and rigidity, helping to support structural load. The matrix or binder (organic or inorganic) maintains the position and orientation of the reinforcement. Significantly, constituents of the composites retain their individual, physical and chemical properties; yet together they produce a combination of qualities which individual constituents would be incapable of producing Long fibers that are oriented in the direction of loading offer the most efficient load transfer. This is becausethe stress transfer zone extends only over a small part of the fiber-matrix interface and perturbation effects at fiber ends may be neglected. In other words, the ineffective fiber length is small. Popular fibers available as continuous filaments for use in high performance composites are glass, carbon and aramid fibers

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B. NaturalFiberReinforcedComposites

The interest in natural fiber-reinforced polymer composite materials is rapidly growing both in terms of their industrial applications and fundamental research. They are renewable, cheap, completely or partially recyclable, and biodegradable. Plants, such as flax, cotton, hemp, jute, sisal, Roselle, kenaf, pineapple, ramie, bamboo, banana, etc., as well as wood, used from time immemorial as a source of lignocelluloses fibers, are more and more often applied as the reinforcement of composites. Their availability, renewability, low density, and price as well as satisfactory mechanical properties make them an attractive ecological alternative to glass, carbon and man-made fibers used for the manufacturing of composites. Fiber-reinforced polymer composites have played a dominant role for a long time in a variety of applications for their high specific strength and modulus. The manufacture, use and removal of traditional fiber–reinforced plastic, usually made of glass, carbon or aramid fibers–reinforced thermoplastic and thermoset resins are considered criticallybecause of environmental problems. By naturalfiber composites we mean a composite material that is reinforcedwith fibers, particles or platelets fromnaturalorrenewable resources, in contrast to for example carbon or aramidefibers that have to be synthesized..

C. Helmet

A helmet is a form of protective gear worn on the head to protect it from injuries. Most helmets are made fromresin or plastic, which may be reinforced with fibers such as aramids. All helmets attempt to protect the user's head by absorbing mechanical energy and protecting against penetration. Their structure and protective capacity are altered in high-energy impacts. Beside their energy-absorption capability, their volume and weight are also important issues, since higher volume and weight increase the injury risk for the user's head and neck. Anatomical helmets adapted to the inner head structure were invented by neurosurgeons at the end of the 20th century.

D. Materials

Most helmets are made from resin or plastic, which may be reinforced with synthetic fibers such as Aramid and Twaron.

LITERATURE**R**EVIEW

A. *Mechanical properties of natural fibers*

Shivnand *et al.* (2010) focused on Evaluation of tensile and flexural properties of hemp and polypropylene based natural fiber composites. They developed composites which then characterized by tensile test, flexural test and impact testing. The result shown by them is that tensile strength and flexural properties increases with increase in fibre percentage. However after a certain percentage the tensile strength decreases again. Malick *et al.* (2005) have reported the Development of Natural fiber composites in India. It has been stated that Natural fiber Composites can be very cost effective material for construction of building, packaging, automobile, railway industries, and it has been stated that plant based natural fibers can very well be used as reinforcement in polymeric composites, to replace more expensive, synthetic fibers such as glass. Chandramohan *et al.* (2011) has published a paper on tensile and hardness of a natural fiber hybrid composite materials and has stated that natural fibers like Sisal, Banana & Roselle, Sisal and banana , Roselle and banana and Roselle and sisal are fabricated with bio epoxy resin using molding method. In this work, flexural rigidity and hardness of Sisal and banana (hybrid), Roselle and banana (hybridand Roselle and sisal (hybrid) composite at dry and wet conditions were studied. Hardness test were conducted using Brinell hardness testing machine. In this work micro structure of the specimens are scanned by the Scanning Electron Microscope.

B. *Materialpropertiesofnaturalfibers*

Chandramohan *et al.* (2011) has published a paper proposed on fabrication of natural fiber powdered (Particle) material [like Sisal (*Agave sisalana*), Banana (*Musa sapientum*) and Roselle (*Hibiscus sabdariffa1*)] reinforced polymer [NFRP] composite plate material with bio epoxy resin Grade 3554A and Hardener 3554B.Instead of orthopaedics alloys such as titanium, cobalt chrome, stainless steel, and zirconium, this plate material can be used for internal and external fixation on human body for fractured bone. The objective was to utilize the advantages offered by renewable resources for the development of biocomposite materials based on biopolymers and natural fibers. The application of biocomposite materials in the field of orthopaedics for bone graft substitutes is promising. In this work, the variation of mechanical properties such as tensile, flexural, and impact strengths of Sisal and banana (hybrid) at a ratio of 1:1, Roselle and banana (hybrid) at a ratio of 1:1 and Roselle and sisal (hybrid) at a ratio of 1:1 composite at dry and wet conditions was studied. Also this present work focuses on the prediction of thrust force and torque of the natural fiber reinforced polymer composite materials, and the values, compared with the Regression model and the Scheme of Delamination factor / zone using machine vision system. Malick (2005) this book explains the basic principle different types of the composite materials , and its direct and indirect effect of material factors such as length of fiber and weight% of fiber, filler materials, etc. the practical application of the fiber-reinforced polymer composite solution for different types of problems are discussed. Chandramohan et al. (2011) has published a paper about worldwide review report on natural fibers and its applications. Also, this paper concentrates on biomaterials progress in the field of orthopaedics. An effort to utilize the advantages offered by renewable resources for the development of biocomposite materials based on bio epoxy resin and natural fibers such as Agave sisalana; Musa sepientum; Hibiscus sabdariffa and its application in bone grafting substitutes. Kuruvilla Joseph *et al.* (1999) presented a review on sisal fiber reinforced polymer composites. The global demand for wood as building material is steadily growing, while the availability of this natural resource is diminishing. This has led to the development of alternative materials. Of the various synthetic materials that have been explored ie polymer composites in particular natural fibers reinforced polymer composites are widely used. Among the various natural fibers sisal fiber is the most commonly used due to the following advantages

Herrera-Franco and Valadez-Gonza´lez (2005) studied mechanical properties of short glass-fiber reinforced composites. The fiber-matrix interface shear strength was used as an indicator of the fiber-matrix adhesion improvement, and also to determine a suitable value of fiber length in order to process the composite with relative ease. The comparison of tensile properties of the composites showed that the silane treatment and the matrix-resin pre-impregnation process of the fiberproduced a significant increase in tensile strength. Due to the treatment using silane coupling agent the tensile strength, flexural strength and shear properties are improved and there is no change in tensile modulus, and shear modulus. The shear properties of the composites also increased significantly. Ke.han *et al*. (2007) has published a report on cobalt multiphase alloy, MP35N, is studied as one of the reinforcement materials for pulsed magnets. The mechanical properties of this alloy at room temperature and 77 K are examined. The cold-rolled and aged MP35N produces a hardness of 5650 MPa and yield strength of 2125MPa at room temperature. At 77 K, the yield strength reached 2500 MPa and the work hardening rate was higher than that at room temperature. The Young’s modulus increases about 6% upon cooling from 300 to 5 K. Therefore, the increase of the strength at low temperatures is attributed mainly to the increase of the work hardening rate rather than modulus. The potential for further increasing of the strength of this alloy is discussed

C. *Resin and Reinforcement fibers*

Roger M. Rowell has reported that the glass fibers are a viable alternative to inorganic/material based reinforcing fibers in commodity fiber-thermo plastic Composite materials as long as the right processing conditions are used. These renewable fibers have low densities and high specific properties. E-glass fibers, for example, have excellent specific properties and have potential to be outstanding reinforcing fillers in plastics. Liliana Manfredi, *et al.* (2006) reported on Thermal Degradation and Fire Resistance of Unsaturated polyester, modified acrylic resins and their composites with Natural Fibers. It is stated that Unsaturated polyester matrix composites have been used for many years, unsaturated Polyester isan economical thermoset Material that is widely used due to its excellent process ability and good cross linking tendency as well as Mechanical properties when cured, particularly natural fiber reinforced polymers are used in the Automotive and Construction Industry.

***D.** Medicalproperties*

Chandramohan *et al.* (2005) has discussed about Mechanical Engineering based research directed safety systems which can be successfully implemented in the field of orthopaedics. It includes the development of tool which helps in preventing the fractures usually occur after the fixation of plates over the humerus bone. Fractures mostly occur on femur bones and humerus bones. This project mainly focuses on injury to the shaft of humerus bone. So this project mainly deals with the stress analysis of bone particularly on the humerus bone during the fixation of plate. The deflection of the bone is calculated manually and the value is compared with the ANSYS solution and the aid of rehabilitation of patients having acute pain on upper limp and vertebrae is effected by calculating the load on the spine Chandramohan et al. (2005) has focused on a research was an effort to utilize the advantages offered by renewable resources for the development of biocomposite materials based on biopolymers and natural fibers and in future this plate material externally coated by calcium phosphate calcium sulphate, hen eggshell powered material and Hydroxy Apatite (hybrid) composite and it can be used for inside fixation on human body for fractured bone. The most important thing that the researchers have to take into account is that these step taken now, will help the mankind to develop and to have a more pleasant life. Chandramohan et al. (2005) has reviewed a worldwide patent report on microstructure of the natural fiber reinforced composite fiberspecimens and it was scanned by the scanning electron microscope, and composition isanalyzed by the electron dispersive thermodetector. In the future, this NFRP composite material coated by calcium phosphate and hydroxyapatite (hybrid) composite can be used for both internal and external fixation on the human body for fractured bone

***E.** ApplicationsofNaturalFiber*

Chandramohan et al. (2005) has focused a new method of using data obtained from CT images combined with digital CAD and rapid prototyping model for the surgical planning of difficult corrective and this new application enables the surgeon to choose the proper configuration and location of internal fixation of plate on humerus bone in the field of orthopaedics. This paper presents the procedure for making model of humerus bone using rapid prototyping technologies [RPT]. Production of prototypes for medical modeling (orthopaedics) in general can be classified into two broad categories based on manufacturing process route and type of data available, i.e. designed data and scanned/digitized data. Designed data is data that is created according to a person's idea on computer aided design (CAD) system. For this type of data, the designer has total control to modify, adjust and manipulate his design ideas to serve the functional purpose of his design. Producing models with this type of data is very straightforward and no further data treatment is required. CAD solid model can be directly converted to STL format for use in subsequent rapid prototyping process. For this type of data, the user has limited capability to modify and manipulate the geometry and further processing is required before they can be readily used by rapid prototyping system. For example, further data treatment is needed for Scanned data from computed tomography (CT) and agnatic resonance imaging (MRI) scanners which capture soft and hard tissue information based on density threshold value. The undesired soft tissue data is removed before it is sent to rapid prototyping machine for fabrication. This procedure can be a daunting task for complex structure and one has to repeat the procedure many times until satisfactory result is achieved. There are a number of commercial software's such as MIMICS, and Go-build which translate this data to the format required by RP systems. Also , this paper describes rapid tooling methods. Shao-Yun *et al.* (2008) has discussed in Motorcycle helmet safety design researchby analyzing market research results of motorcycle helmets, this article proposes the improved motorcycle helmet safety design after discussing helmets' function, structure, materials, ergonomics, color, and many other characteristics. The design makes use of "honeycomb" structure, solar panels and other methods to improve the safety performance of protective helmets, accomplishes motorcycle helmets safety innovation design. The theory of enhancing the safety performance of motorcycle helmets are primarily from the structure, materials. This paper discusses the "honeycomb" structure and carbon fiber'sapplication. Afteranalysis of motorcycle helmets' function, structure, material, and ergonomics, this paper proposes a new appropriate high safety motorcycle helmets' design. Thomas et al. (2009) presented a paper on renewable materials for automotive applications. For the past sixty years synthetic fibers were used in automobile industries. Now, natural fiber composites are regaining ground in automotive industries. One of the major reasons for this renewed growth is an increased awareness for our environment, the use of plant fibers as insulating materials or reinforcement in polymeric materials plays an important role in automotive industries. Mathur *et al.* (2006) have reported in their study on Composite Materials from local Resources , Natural Fiber composites present immense opportunities as alternative materials for Wood. They have Special relevance to countries like India in view of their low cost, saving in energy, and applications as substitute materials. Development of natural fiber reinforced composites as alternative building materials must be thoroughly researched for their durability and cost effectiveness in order to obtain consistent performance under user conditions.

Wenbin Yao *et al.* (2011) Research on manufacturing Technology and Application of Natural Bamboo Fibre,This article focused on the natural bamboo fiber manufacturing methods, processes and supporting equipment. The preparation mechanism and research progress of bamboo fibre are analysis. The future-application areas and new products that can be developed are investigated. The main problems to be solved in the bamboo fibre preparation and the main direction of the future are pointed out. In addition, compared with other fibres, the unique advantages and higher economic value-added of the fibre are expounded and broad application prospects are pointed.

MATERIAL AND METHODS

A. Manufacturing process

1) Chemical Treatment

The fibers are powdered**.** Then the fibers are cleaned normally in clean running water and dried. A glass beaker is taken and 6% NaOH is added and 80% of distilled water is added and a solution is made. After adequate drying of the fibers in normal shading for 2 to 3 hours, the fibers are taken and soaked in the prepared NaOH solution. Soaking is carried out for different time intervals depending upon the strength of fiber required. In this study, the fibers are soaked in the solution for three hours..

B. Moisture Absorption Test Procedure

Tensile, flexural and impact specimens as per ASTM standards were cut from the fabricated plate. Edges of the samples were sealed with polyester resin and subjected to moisture absorption. The composite specimens to be used for moisture absorption test were first dried in an air oven at 50 ◦C. Then these conditioned composite specimens were immersed in distilled water at 30 ◦C for about 5 days. At regular intervals, the specimens were removed from water and wiped with filter paper to remove surface water and weighed using a digital balance of 0.01mg resolution. The samples were immersed in water to permit the continuation of sorption until saturation limit was reached. The weighing was done within 30 s, in order to avoid any errors due to evaporation. The test was carried out according to ASTM D570 to find out the swelling of specimen. After 5 days, the test specimens were again taken out of the water bath and weighed.

C. *Mechanicaltesting**:***

After moisture absorption tests, the tensile strength of the composites was measured with a universal testing machine in accordance with the ASTM D638 procedure at a crosshead speed of 2mm/min. Flexural tests were performed on the same machine, using the 3-point bending fixture according to ASTMD790 with the cross-head speed of 2 mm/min. In the impact test, the strength of the samples was measured using an Izod impact test machine. All test samples were notched. The procedure used for impact testing was ISO 180. The test specimen was supported as a vertical cantilever beam and broken by a single swing of a pendulum.

D. Cadd Modelling and Analysis

The helmet model is generated using catia v5 modelling software using the medium size of motor cycle safety helmet. The file is later transferred to the intial graphics exchange system file format that can be transfer to the Ansys software and crash flow analysis is performed using dynamic loading procedure in Ansys

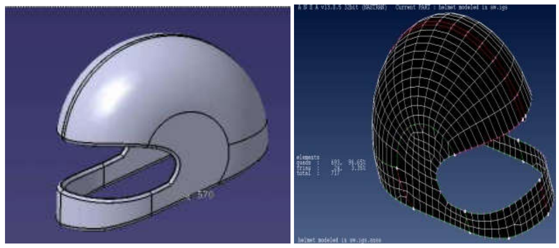

Fig. 1. Helmet outer shell model generated in Catia V5 and meshed using Ansa meshing softwares

RESULT AND DISSCUSSION

The prepared hybrid material that under goes different testing methods and

Table 1: Properties Of Helmet Outer Shell Material And Hybrid Natural Fibers

Parameters	AS4/polyphonylene sulfide	Banana+ Roselle	Sisal + Roselle	Sisal + banana
Density (Kg/m^3)	$1.4x10^3$	$1.5x10^3$	$1.4x10^3$	$1.3x10^3$
Young's modules [Gpa]	15	25.06	20.85	30.77
Poisson ratio	0.35	0.32	0.33	0.30

CONCLUSION

Finally it has conclused from the previous researches and experimental analysis the natural fiber reinforced composite material of hybrid combinations is analysed and a cad model of helmet is generated and impact analysis is performed in ansys. Thus the best hybrid combination of natural fiber composite material is suggest as replacement for plastic in helmet outer shell manufacturing.

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