Ain Shams University

Faculty of Engineering

Design and Production Engineering Department

Mechanical Behavior of Hybrid Composites

A Thesis Submitted in Partial Fulfillment for the Requirements of the Degree of Master of Science in Mechanical Engineering

by

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Bachelor of Science in Mechanical Engineering

Design and Production Engineering

Faculty of Engineering, Ain Shams University, June 2011

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Statement

This thesis is submitted in partial fulfillment for the degree of Master of Science in Mechanical Engineering, to Faculty of Engineering, Ain Shams University. The author carried out the work included in this thesis at the laboratories of the Design and Production Engineering department, Faculty of Engineering, Ain Shams University. No part of this thesis has been submitted for a degree or qualification at any other university.

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Thesis Summary

Natural Fibers (NF) are widely used as reinforcement in polymer based composites. Their main advantages lie in their availability from renewable resources at low prices, in addition to the relatively low density and high specific properties in contrast to synthetic fibers. Natural fiber composites have been found to exhibit suitable mechanical properties for nonstructural applications. However, when it comes to high strength (structural) applications, the specific properties of natural fibers are typically not sufficient. One potential method for solving some of the drawbacks related to natural fibers is to hybridize them with synthetic reinforcements with the goal of improving overall composite mechanical properties.

In this respect, this research aims to investigate the potential improvement in mechanical and erosion characteristics of jute fiber reinforced epoxy composites through the hybridization with SiC particles using the VARI technique.

In order to achieve this aim, physical and mechanical properties of jute fabric were characterized. As a preparation for the reinforcement of epoxy matrix, fibers were treated with sodium hydroxide. A number of conditions were examined to find the optimum alkali treatment conditions that result in best mechanical behavior of the jute-epoxy composites. In a second stage, this optimum fiber treatment was further adopted for the preparation of the hybrid jute-SiC epoxy composites. Different volume fractions of 2, 4, 6 and 8 % SiC were incorporated into the composite to investigate the effect on mechanical and physical properties. Further, the erosion wear of the prepared hybrid composites was investigated.

The homogeneity of SiC particle distribution was also investigated. It is anticipated that the homogeneous distribution of the particles within the textile reinforcement is a function of woven fabric mesh and particle size as well as the infiltration length in the VARI process. This is validated through the alteration of fabric type and particle size, and was examined through a number of characterization methods.

Generally, analysis of variance (ANOVA) techniques were applied to make statements about the statistical significance of the measured characteristics. Proof

of concept is provided through the manufacture of a small scale wind turbine blade from optimum composite compositions that were considered.

These topics are described in the various chapters of the thesis, as follows:

Chapter 1 introduces an overview for the recent works in the field of natural fiber composites.

Chapter 2 presents a literature review that is the base of knowledge already available in the field of natural fibers, their composite and hybrid materials.

Chapter 3 presents the main objective of this research and summarizes the work plan that has been followed to achieve the aim of the research.

Chapter 4 provides a detailed description of the experimental procedures used in the present study. First, a description of the used materials and their main properties is presented. Further, details about the experimental procedures for the characterization of jute properties and the chemical treatment are described. Finally, details of composite and hybrid composite fabrication as well as the characterization methods are depicted.

Chapter 5 presents and discusses the results of fiber and composite behavior and relates them to literature findings.

Finally, chapter 6 summarizes the main outcomes and conclusions of this study and presents future recommendations for subsequent studies.

Keywords: Natural fibers, Jute Fabric, Alkali treatment, Epoxy resin, SiC particles, Hybrid composites, Vacuum Assisted Resin infusion (VARI).

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List of abbreviations

Al_2O_3	Aluminum oxide
ANOVA	Analysis of variance
DF	Degree of freedom
DP	Degree of polymerization
EFB	Empty fruit bunches
EP	Epoxy
FRPC	Fiber reinforced polymer composites
JE	Jute epoxy
JF	Jute fabric
MSB	Mean square between
MSE	Mean square error
NF	Natural fibers
-OH	Hydroxyl group
PFPC	Particle filled polymer composites
PMCs	Polymeric matrix composites
SEM	Scanning electron microscope
SiC	Silicon carbide
UV	Ultraviolet
VARI	Vacuum assisted resin infusion

List of symbols

d	Fiber diameter	[μm]
K	Yarn count constant	[m/g]
L	Yarn length	[m]
l/d	Aspect ratio	--
l_c	Critical length	[μm]
m	mass	[g]
S1, S2, S3	Secondary wall	--
σ	Ultimate tensile strength	[MPa]
τ_c	Fiber –matrix bond strength	[MPa]

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