Dissertation Report

on

"Processing, Characterization and Evolution of Epoxy and E-Glass Fibre Composite Filled with Zinc Sulphide for Automobile Body Panel Application"

Submitted in partial fulfillment of the requirements for the obtainment of degree of

Master of Technology

In

Production Engineering

by

Prabhat Kumar
2013PPE5149

Under the Supervision of

Mr. Mukesh Kumar

DEPARTMENT OF MECHANICAL ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR-302017

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF MECHANICAL ENGINEERING
Jawahar Lal Nehru Marg, Jaipur-302017(Rajasthan)

CERTIFICATE

This is to certify that the Dissertation titled **"Processing, Characterization and Evolution of Epoxy and E-Glass Fibre Composite Filled with Zinc Sulphide for Automobile Body Panel Application"** that is being submitted by **PRABHAT KUMAR,** M.Tech (2013PPE5149) requirement for partial fulfillment of award of the degree of **Master of Technology, Production Engineering,** Malaviya National Institute of Technology Jaipur is found to be satisfactory and is hereby approved for submission.

Place: Jaipur
Date:

Mr. Mukesh Kumar
Asst. Professor Mechanical Engineering Department
MNIT Jaipur

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF MECHANICAL ENGINEERING
Jawahar Lal Nehru Marg, Jaipur-302017(Rajasthan)

CANDIDATE'S DECLARATION

I hereby certify that following work which is being presented in the dissertation entitled **"Processing, Characterization and Evolution of Epoxy resin and E-Glass Fibre Composite Filled with Zinc Sulphide for Automobile Body Panel Application**" in the partial fulfillment of requirement for award of the degree of Master of technology (M.Tech.) and submitted in **Department of Mechanical Engineering** of Malaviya National Institute of Technology Jaipur is an authentic record of my own work carried out by me during a period from July 2014 to June 2015 under the supervision of **Mr. Mukesh Kumar,** Assistant Professor, Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur.

The matter presented in this dissertation embodies the result my own work and studies carried out and has not been submitted anywhere else.

Date: **Prabhat Kumar**

2013PPE5149

ACKNOWLEDGEMENT

It gives me immense pleasure to express my deep sense of gratitude and indebtedness to my supervisor **Mr. Mukesh Kumar** for his constant encouragement and guidance from inception to completion of this dissertation work by taking interest and giving personal attention to the same. His valuable feedback and moral support have been a great source of inspiration for broadening my horizons in this area of research.

I am grateful to **Professor G.S. Dangayach, H.O.D. Mechanical Engineering Department** for providing me a healthy and supportive environment for my research work.

I would like to extend my sincere thanks to **Dr. Amar Patnaik** for his invaluable support throughout the research work and **Professor Upender Pandel**, HOD. Metallurgical & Material Engineering for his help and cooperation.

I would also like to thanks all Technical and Non-Technical Staff of the office of Mechanical Engineering department, MNIT Jaipur and Staff of Material Research Centre for their support.

I sincerely thank to my family members and friends for encouraging me and giving me support though all my works.

Prabhat Kumar

(2013PPE5149)

ABSTRACT

Fibre reinforced Polymers (FRPs) are widely used in industries like automobiles, aerospace, marine and many others. They are preferred for their light weight, durability and design flexibility. Automobile body panels are also made of fibre glass, carbon fibres, or fibre-reinforced plastic. In some light commercial vehicles, these reinforced plastics may be used to ensure its potential benefits as per requirements. In the present work the polymer matrix composites (PMC) uses E-glass fibres as reinforcement and Epoxy resin as matrix component. The variation of properties of composites is studied under different fillers (particulates) contents, particulate being Zinc sulphide (ZnS) in this case. The present research work deals with the mechanical, thermal, thermo-mechanical and erosive wear behavior of E-glass fibre reinforced epoxy based composites and its properties variations with variation in the filler contents. The effect of filler content on mechanical properties like tensile strength, flexural strength, hardness and impact strength are investigated. The thermo gravimetric analysis is done to study the effect of thermal degradation of the polymer matrix composites. The dynamic mechanical analysis is also performed on the Visco-elastic materials to study Storage modulus, loss modulus and tan delta variations with temperature. Solid particle erosion behavior is provided in great details for glass fibre reinforced polymers. A robust design technique called Taguchi method is also used to determine the optimal condition for erosion wear rate by considering different parameters associated with it. The morphology of eroded surfaces is examined by using scanning electron microscopy (SEM) and possible erosion mechanisms are discussed.

CONTENT

CERTIFICATE II

CANDIDATE'S DECLARATION III

ACKNOWLEDGEMENT IV

ABSTRACT V

CONTENT VI-VII

LIST OF FIGURES VIII-IX

LIST OF TABLES X

ABBREVIATION XI

1. INTRODUCTION 1

1.1 Background 1

1.2 Classification of Composite materials 1

1.2.1 Classifications based upon the Matrix Phase 1

1.2.2 Classification of Composites based on the type of Reinforcements 4

1.3 Types of polymer matrix composites 5

1.4 Types of Fibre Reinforcements 6

1.5 PMC for Automobile body panel applications 7

1.6 Thesis Outline 8

2. LITERATURE REVIEW 9

2.1 On mechanical properties of E-glass reinforced epoxy composites 9

2.2 On thermal and thermo-mechanical characterization of PMC 10

2.3 On the basis of solid particle erosion of polymer composites 11

2.4 On implementation of DOE (Design of Experiments) and optimization techniques 13

2.5 Research Gap 13

2.6 Objectives of present study 14

3. MATERIALS AND METHODS 15

3.1 Materials 15

3.2 Fabrication of composites 16

3.3 Physical and Mechanical Characterization 17

3.4 Thermal and Thermo-mechanical characterization 20
3.5 Scanning electron microscopy (SEM) 21
3.6 Erosion wear test rig 22
3.7 Taguchi Method 23
4. RESULTS AND DISCUSSION 26
4.1 Physical and Mechanical Characterization of composites 26
4.2 Thermal and Thermo-Mechanical Characterization of composites 31
4.2.1 Thermo-gravimetric analysis (TGA) 31
4.2.2 Dynamic Mechanical Analysis (DMA) 32
4.3 Erosion Wear Characteristics 36
4.3.1 Taguchi Experimental Analysis 37
4.3.2 ANOVA and the effects of factors 39
4.4 Surface Morphology 39
5. CONCLUSION 42
REFERENCES

LIST OF FIGURES

Figure 1.1 Classification of composite based on the type of matrix phases

Figure 1.2 Classification of Composites based on the type of Reinforcements

Figure 3.1 Unmodified epoxy resin chain

Figure 3.2 Fabricated Samples

Figure 3.3 Rockwell Hardness Testers

Figure 3.4 Electronic Tensometer for Tensile test

Figure 3.5 Impact Tester

Figure3.6 Thermo-gravimetric analyzer

Figure3.7 Dynamic Mechanical Analyzer

Figure3.8 Scanning Electron Microscopy (SEM)

Figure 3.9 Air Jet Erosion Tester

Figure 4.1 Variations of Density and Void Fraction with Filler Content

Figure 4.2 Rockwell Hardness (HRB) variations with Filler content

Figure 4.3 Tensile Strength Variations with Filler Content

Figure 4.4 Flexural Strength Variations with Filler Content

Figure 4.5 Impact Energy Variations with Filler Content

Figure 4.6 TGA behavior of unfilled and ZnS filled GFRP composite

Figure4.7 Storage Modulus (E') vs. Temperature

Figure 4.8 Loss Modulus (E'') Vs Temperature

Figure 4.9 Tan Delta (tan δ) Vs Temperature

Figure 4.10 Effect of control factors on erosion rate

Figure 4.11 SEM graph of glass fiber reinforced epoxy composites

Figure 4.12 SEM micrographs of the eroded epoxy composites filled with ZnS

LIST OF TABLES

Table 1.1 Composition of glass fibres

Table 3.1 Properties of Epoxy resin used

Table 3.2 Properties of E- Glass Fibre used

Table 3.3 Properties of Zinc Sulphide used

Table 3.4 Designations and detailed compositions of the composites

Table 3.5 Parameter settings for erosion test

Table 3.6 Levels for various control factors

Table 3.7 Taguchi orthogonal array design (L_{16}) for solid particle erosion test

Table 4.1 Densities of the composites

Table 4.2 Rockwell Hardness Values

Table 4.3 Tensile strength values (MPa)

Table 4.4 Flexural Strength values (MPa)

Table 4.5 Impact Energy values (Joule)

Table 4.6 Experimental design using L16 orthogonal array

Table 4.7 Response Table for Signal to Noise Ratios

Table 4.8 ANOVA table for erosion rate

ABBREVIATION

PMC:	Polymer matrix Composites
FRP:	Fibre reinforced polymers
GF:	Glass fibre
GFRP:	Glass fibre reinforced polymers
CF:	Carbon Fibre
DGEBA:	Bisphenol-A-Diglycidyl-Ether
TETA:	Tri-ethylene-tetramine
TGA :	Thermo-gravimetric analysis
DMA :	Dynamic Mechanical Analysis
SEM :	Scanning electron microscopy
S/N :	Signal-To-Noise
HRB:	Rockwell Hardness B-Scale
DOE:	Design of Experiments
ANOVA:	Analysis of variance