Chapter 1

INTRODUCTION

1.0 INTRODUCTION TO COMPOSITES

Composites are one of the most widely used materials because of their adaptability to different situations and the relative ease of combination with other materials to serve specific purposes and exhibit desirable properties. Composites materials offer higher specific strength and stiffness than other conventional materials as stated by Adanur,1997 [1]. Day by day, composite materials are replacing the conventional metallic materials due to their light weight, high strength, design flexibility and long life.

Since the 1970s, due to development of new high-performance fibres such as carbon, boron, and aramids, application of composites has widely increased. By developing the use of thermosetting polymers such as epoxy, polyester, and urethane resins as matrices the uses of advanced composites have widened.

1.1 TEXTILE COMPOSITES

Textile composite structure has emerged as enormous category of composite materials due to its outstanding properties in terms of easy handling, shapability, adaptability, reproducibility and structural complexity. Fibre-reinforced composite (FRC) materials differ from common materials in that the constituent materials of the composite (two or more phases) are macroscopically distinguishable and mechanically separable (Encyclopedia). It means the constituent materials of composite work together but remain fundamentally in their original bulk form. Researchers (Haleh et al., 2014; Hochard 2006; and Shembekar, 1992) [2-4] have described that woven-fabric composite laminates deliver a number of functional properties compared to unidirectional-tape such as lower production costs, better drapability, good resistance to fracture and transverse rupture due to weaving resistance, and high impact strength.

Moreover, the Fibre-reinforced plastics (FRP) are anisotropic. The anisotropicity is dependent on the Fibre orientation as well as the lay-up sequence in the laminate (x, y, z direction). Due to this property, composites can be engineered to produce specific composite for specific application. Some of the applications required strength in only one direction, need not be strong in another direction. Composite for such application can be manipulated by varying angle of orientation of fibre, layering sequence, weave structure and type of reinforced fibre etc. That means cost effective product can be prepared by using suitable composite. Hybridisation will also help to fulfil such requirements. Hybrid composites combine two or more reinforcing materials in a matrix. Studies have shown that hybrid composites made of two or more types of reinforcement material may lead to a better solution to obtain a product with desired properties.

The mechanical performance of composites depends mostly on the properties of matrix, reinforcement materials, and their interface. So, fabricating hybrid composites lead to better mechanical properties and reduced material costs compared to the conventional composites. In published literature very scanty references are available about the study of effect of fibre orientation, layering sequence, hybridisation, weaving pattern and type of reinforcement on properties of composites such as; the orientation and density of fibres directly influences the permeability of reinforcement and becomes crucial in predicting the mechanical behaviour of the final part (Rajanish et al. 2014 and Loix et al., 2008)[5-6]. It is being stated by Sevkat [7] that cautious assortment of stacking sequence can give high strength. It has also been observed that the formation of the fabric structure and weave structure influences the tensile strength of the composite for high strength application by Karahan et al., 2014 and Saiman, 2014 [8-9].

Though composites having specific properties are available but most of them are proprietary knowledge. Moreover, there is a lack of comprehensive single study which covers effects of angle of layering sequence (skew angle), weave structure and type of reinforcement etc. Hence, for this research work, it was decided to study effect of orientation of layer on mechanical and physical properties of the composites. In addition to this, laying the layers differently in terms of type of reinforcement yarn like Carbon, Kevlar and HDPE and different weave structure like plain, twill and sateen is considered. Here in this work, HDPE is studied to reduce the cost and improve ductility of the product. Optical and microscopic graphs are further practiced on the specimens to determine failure modes.

The parameters such as fibre architecture, fibre properties and matric properties which affects the mechanical behaviour of composites put ahead a challenging task for researchers to perform the modelling of textile composites. The numerous assumptions made during this modelling procedure were applied only to simple structure and not to the complex. Here, FEM analysis with ANSYS software is used to achieve this aim.

Present thesis consists of **Six Chapters.**

Chapter One covers introductory part.

Chapter Two deals with literature survey for the present work.

This chapter includes broad review of the published work about composite, textile reinforced composite, classification of composite materials based on their matrices, laminates, lay-up sequences, importance of lay-up sequences. Literatures based on different testing methods for mechanical properties like tensile, flexural, impact and damage resistance and physical properties like density and fibre volume fraction. Literature about the different parameters that affect these mechanical and physical properties. It also deals with literature review of importance of Scanning electronic microscope (SEM) and its method of testing. Lastly it gives insight about the applications of composite materials. It also reviews the past and recent modelling techniques relating to the mechanical behaviour of polymer textile composite laminates with focus on woven fabric textile reinforcement.

Chapter Three describes the methodology of experiment which is adopted in this work. It is described in three sections:

Section I: This section deals with the preparation of woven fabric on sample loom. It is devoted to modifications done on CCI sample loom to successively weave different hybrid fabrics (Carbon-Carbon; Carbon-HDPE (plain, twill and sateen); Kevlar-HDPE). It also deals with the changes made on single end warping machine for proper unwinding of the tow.

Section II: This section deals with the preparation of textile composites using hand lay-up technique, by stacking the layers of hybrid fabrics differently at varied skew angles, weave structure and reinforcing yarn.

Section III: This section deals with the testing and analysis of prepared hybridised composites for physical and mechanical properties such as tensile, flexural, impact and damage resistance were done. It also describes SEM analysis.

Chapter Four deals with tabulation of the results and their analysis. It presents an elaborate discussion on physical properties and mechanical properties of all developed samples like tensile strength, flexural strength impact strength and damage resistance strength. A comparative analysis of mechanical properties between each sample was addressed. The chapter also presents the microstructural defects and enhancement of those defects in the selected samples.

Chapter Five deals with numerical simulation of tensile properties of textile polymer composite laminates using FEM and ANSYS software.

Chapter Six deals with the conclusion about this research work. It consists of detailed conclusion of the results obtained from this study. It also includes suggestions for the future scope of the work.

Appendices and references are given at the end.

1.2 AIM OF THE STUDY

The main purpose of this work is to study the physical and mechanical behaviour in the textile polymer composite laminates (TPCL) which are prepared by incorporating hybrid laminates and polymer matrix. For manufacture of hybrid composite Carbon-Kevlar and HDPE yarn was used. These yarns were utilised to produce fabrics with different weave structure. The prepared fabrics were laid differently to manufacture TPCL. The work is focused to develop composites having their laying of layers at different skew angle (laying angles).

The composite material was analysed in terms of their physical and mechanical properties. The mechanical properties were evaluated by using standard techniques in terms of tensile, flexural, impact and damage resistance properties. The fractured specimens were examined and analysed by using SEM. To understand the effect of laying angle on the tensile property of the composite, numerical simulation was done using FEA (finite element analysis) and Ansys software.

By laying the fabric layers in different angles the anisotropy of the mechanical properties was observed clearly. It was also possible to get improved mechanical properties at certain angles. By incorporating the HDPE yarn in the composite fabric preparation, the cost effectiveness of the composite was improved as HDPE is cheap. Also, Carbon-HDPE combination gave improved mechanical properties in various hybrid composite. This leads to preparation of better and cheaper products for their applications to various fields of technical textiles.