DAMAGE INITIATION AND PROPAGATION IN COMPOSITE MATERIALS SUBJECTED TO TENSILE AND COMPRESSION LOADING

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This report is submitted as partial fulfillment of the requirements for the award of Bachelor of Mechanical Engineering (Thermal Fluid)

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APRIL 2009

"I admit that had read this dissertation and in my opinion this dissertation is satisfactory in the aspect of scope and quality for the bestowal of Bachelor of Mechanical Engineering (Thermal Fluid)"

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For my beloved parent and siblings

ACKNOWLEDGEMENT

I would like to thank my supervisor, Pn Siti Hajar bt Sheikh Md Fadzullah for her support, guidance and encouragement during completion of this final year project.

I would like to dedicate this project to my parents, friends and anyone that helped me in finishing my project. I hope this report would be beneficial for future student as a reference.

ABSTRACT

Today, composite materials are useful in reticular structures, however their structure performance related to damage of fresh composite material. This research investigates the damage initiation and propagation for laminated composite under low and high velocity subjected to tensile and compression test. Three types of composite material are used, which include the uni-directional carbon fibre, woven carbon fibre and woven glass fibre. Tensile test as per ASTM D3039 was carried out at different velocity ranging from 0.6mm/min to 1.0mm/min and Compression tests as per ASTM D695 was carried out velocity of 0.2mm/min to 0.6mm/min. The effect of this tensile and compression test at on the specimen were analyzed by using scanning electron micrograph (SEM).The damage modes considered are initial matrix cracking, saturation of matrix cracking, kind band, damage propagation and fiber breakage. The progressive failure is expressed by reducing stiffness of the material at all failed points. The lowest stiffness drop occurred in the laminates with the lowest edge crack density. The orientations of fibre affected the crack density of composite material. To get a clear observation on damage initiation and propagation of composite material, analyses of failure for three of type material were compared by discussing their different damage mechanism. For comparison, the data of mechanical testing was simulated using Finite Element Analysis (FEA), by Cosmos Xpress.

ABSTRAK

Kini, komponen bahan komposit sering digunakan dalam penyatuan strukturnya, walau bagaimanapun prestasi struktur bahan komposit sering dikaitkan dengan kemusnahan bahan mentah. Penyelidikan ini mengkaji tentang kerosakan permulaan dan perambatan bahan komposit yang berlapis pada halaju yang tinggi dan rendah di bawah beban tegasan dan mampatan. Kajian ini terdiri daripada tiga jenis bahan komposit iaitu gentian karbon jenis ekaarah, gentian karbon jenis fabrik tenun dan gentian kaca jenis fabrik tenun. Dalam kajian ini, ujian tegasan dijalankan pada halaju 0.6mm/min hingga 1.0mm/min dengan merujuk pada ASTM D3039, manakala ujian mampatan dijalankan pada halaju 0.2mm/min hingga 0.6mm/min dengan merujuk pada ASTM D695. Kesan daripada ujian beban tegasan dan mampatan ini, spesimen dianalisa dengan menggunakan SEM. Terdapat beberapa jenis kerosakan bahan dikaji, antaranya retakan permulaan matrik, retakan ketepuan matrik, patah jalur punding, kerosakan perambatan bahan dan pecahan bahan karbon. Penambahan kegagalan bahan komposit dapat dilihat dengan mengurangkan pengukuhan stuktur bahan di titik kegagalan bahan komposit. Apabila berlaku pengurangan keretakan tepi pada bahan komposit berlapis, pengukuhan ketumpatan bahan akan menurun dan mengakibatkan kemusnahan bahan. Arah pada struktur bahan gentian mempengaruhi ketumpatan keretakan pada bahan komposit. Untuk melihat lebih dekat kerosakan permulaan dan perambatan bahan, analisis kegagalan dan kemusnahan bagi ketiga-tiga jenis bahan komposit dikaji dengan membuat perbandingan dan perbincangan kerosakan setiap bahan. Di akhir kajian, data yang diperolehi melalui kaedah kajian digunakan untuk perbandingan menggunakan perisian analisis unsur terhingga iaitu 'Cosmos Xpress'.

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σ	= Engineering stress
Δl	= Elongation
ε.	= Engineering strain
lo	= initial length
Ao	= cross section area
F	= uniaxial tensile force
°C	= Degree celcius

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CHAPTER I

INTRODUCTION

1.0 Introduction

Damage of material means the progressive or sudden deterioration of their mechanical strength because of loadings or thermal or chemical effect. It covers all related phenomena that occur from the virgin or reference state up to a micro crack initiation. The phenomenon happens after two phases. In the first step, the micro-voids and micro-cracks growth is nearly uniform: it is the initiation stage. From the critical point the strain and also the damage become more and more localized. In second stage, the load/displacement curves are very different. It becomes instabilities as localized necking.

In basic, composite materials is a structural material which consists of combining two or more constituents. It is fail by the (statistical) accumulation of damage in a progressive process that reduces stiffness and strength and defines the life of the material or components. In general, the early stages of life, damage initiation dominate the damage development process. For fiber-dominated composites, fiber fracture and matrix cracking are common result of the process. Then, damage accumulates and begins to interact over a portion of the life that is often a major fraction of the total. In the final stages, damage interaction creates locally intense concentration that ultimate cause failure.

In this research, two testing mode which include tensile testing and compression testing are utilized use to discuss the effect on the damage initiation and propagation of composite material. In tensile test, the normal stresses are initiated due to force directed away from the plane on the other compression hand in maximum compressive stress that a material is capable of sustaining is measured.

1.1 Objectives

The objectives of this research are to study and discuss the effects of different testing mode (compression and tensile) on the damage initiation and propagation of advanced composite materials.

1.2 Problem Statement

This research has been carried out due to the problem with CRFP. CRFP laminate tend to suffer from internal damage such as ply cracks and delaminating between the plies even under a much lower load. Therefore it is crucial to study the initiation and propagation of the material under tensile and compression loading.

1.3 Scope of the Research

This research comprises of the following scope:-

a) To do literature study on composite materials.
b) To carry out compression test and tensile test.
c) To carry out surface analysis after compression and tensile test via scanning electron microscope (SEM).
d) To compare the data using 'Finite Element Analysis