UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Design and Analysis of Autoclave Mould for Carbon Reinforced Spoiler

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Design) with Honours.

by

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This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Design) with Honours. The member of the supervisory committee is as follow:

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ABSTRACT

Aerospace part is very important and considered as critical because it carries a massive responsibility of human life and tiny mistake can cost hundreds of life and thousands of dollars. Therefore, the process of manufacturing the part is crucial in order to avoid air crash from happening. This report describes the mould design and the analysis of the carbon fiber reinforced spoiler for small aircraft. The objective of this project is to design mould of the carbon fiber reinforced spoiler for small aircraft, to predict the thermal expansion of the mould billet and support frame and to investigate the stress analysis of the autoclave mould due to nature of autoclave process. The structural model of the autoclave mould was developed by using the 3D design software and also converted into the computer aided design software for the analysis. The finite element modeling is performed utilizing finite element analysis code. By performing the analysis, the expansion of the spoiler can be identified and massive expansion that could reject the spoiler can be avoided.

ABSTRAK

Bahagian aeroangkasa sangat penting and diangap kritikal kerana ia memegang tanggungjawab yang besar terhadap kehidupan manusia kerana kesilapan kecil boleh menyebabkan kehilanggan ratusan nyawa dan ribuan ringgit. Oleh kerna itu, proses pembuatan bahagian aeroangkasa sangat penting untuk mengelakkan kemalangan berlaku. Laporan ini menerangkan tentang rekabentuk dan analisis acuan spoiler daripada gentian karbon untuk pesawat kecil. Objektif projek ini adalah merekabentuk acuan atau mold untuk spoiler pesawat kecil, meramalkan mengembangan bilet mold dan struktur mold, dan mengkaji dan menganalisis stres dan terma stres sementara akibat daripada proses autoclave. Struktur model untuk mold autoclave dibina dengan menggunakan software rekabentuk 3 dimensi dan ditukarkan ke dalam software design berbantu computer untuk analisis. Model finite elemen direka dengan menggunakan kod analisis finite elemen. Dengan menjalankan analisis, pengembangan spoiler dapat dikenal pasti dan ekpansi yang terlalu besar yang boleh menyebabkan spoiler ditolak dapat dieleakkan.

DEDICATION

Dedicated to my beloved mother, father, siblings and friends
for their love and support

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THANK YOU

TABLE OF CONTENT

LIST OF TABLE

LIST OF FIGURE

LIST ABBREVIATIONS

FEM	-	Finite Element Modeling
RFI	-	Resin Film Infusion
FEA	-	Finite Element Analysis
CAE	-	Computer Aided Engineering
FRF	-	Frequency Response Function
TPA	-	Transfer Path Analysis
CAD	-	Computer Aided Design
EMC	-	Epoxy Molding Compound
DRBEM	-	Dual Reciprocity Boundary Element Method

CHAPTER 1

INTRODUCTION

1.1 Background

Autoclave molding is an adjustment of pressure bag and vacuum bag molding. This advance composite process produces denser, void free molding because higher heat and pressure are used for curing. Autoclaves are essentially heated pressure vessels usually equipped with vacuum systems into which the bagged lay-up on the mold is taken for the cure cycle. It is widely used in the aerospace industry to manufacture high strength or weight ratio parts from pre impregnated high strength fibers for aircraft, spacecraft and missiles. In this paper, the project will focus on the mould design of the carbon fiber reinforced spoiler for small craft.

The desire to create load bearing structure that are lighter and stronger has been known in the industries for some time. Carbon fiber reinforced polymer is a very strong, light and expensive composite material. The advantages of composites in aircraft design are their high strength-to-weight ratio, excellent fatigue endurance, corrosion resistance and a malleability that allows tailoring them to meet design requirements. Composites can be more easily formed into complex shapes (such as spheres) than their metallic counterparts. This not only reduces the number of parts

making up a given component, but also reduces the need for fasteners and joints, often the weakest points of a structure.

The choice of matrix can have a profound effect on the properties of the finished composite. One method of producing graphite-epoxy parts is by layering sheets of carbon fiber cloth into a mould in the shape of the final product. The alignment and weave of the cloth fibers is chosen to optimize the strength and stiffness properties of the resulting material. The mold is then filled with epoxy and is heated or air cured. The resulting part is very corrosion-resistant, stiff, and strong for its weight. Parts used in less critical areas are manufactured by draping cloth over a mold, with epoxy either pre impregnated into the fibers or "painted" over it. High performance parts using single molds are often autoclave cured, because even small air bubbles in the material will reduce strength.

1.2 Problem Statement

An autoclave molding process to mould part having a certain coefficient of thermal expansion, wherein the mold involves a sufficiently gas permeable material that serves as a mould foundation and that has a sufficiently matching coefficient of thermal expansion, in combination with part molding element that also has a sufficient matching coefficient of thermal expansion and that is made from short reinforced fiber material, with the intended effect that risk of unacceptable deformation such as breaking of the material to be mould is sufficiently abated. Therefore, the analysis is done to observe the result of the thermal distribution and calculated the possibility of the mould expansion and effect to the carbon reinforced spoiler. Hence the risk of the carbon reinforced spoiler will be rejected can be minimized.

1.3 Objective

This project is focused on the finite element method based on the thermal analysis of the mould while the autoclave process occurs.

The overall objectives of this project are:

1. To design mould of the carbon fiber reinforced spoiler for small aircraft.
2. To analyze the thermal expansion of the mould billet.
3. To analyze the structural stress analysis and the thermal stress analysis of the autoclave mould due to nature of autoclave process.

1.4 Scope

This study concentrates on the design and analysis of the autoclave mould while the autoclave process occurs. The scopes of study are briefly as follows:

1. Structural modeling
2. Finite element modeling (FEM)
3. Structural stress and thermal stress analysis of the autoclave mould excluded the carbon reinforced spoiler and others part such as clampers, pins, hook and support plate.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In order to accomplish this project, the knowledge about the tools and methods that will be used should be identified. This chapter explains in detail of the spoiler, autoclave moulding and fibers reinforced composite. Other than that, the design software used and the analysis that need to be done are also discussed.

2.1 Definition of Spoiler

Spoiler is a small, narrow, long and movable plate attached on top of the aircraft wing. It is used to decrease the lift, so that the air flow over the wing will be disturbed and the amount of force will changed. It is also used to slow down the aircraft and to counteract the flaps during the landing. In other words, spoilers are employed on airplanes wing to disturb the airflow over the wing. When spoiler is not in use, it is disposed within the wing (George Xenakis, 1958). According to Walter Anthon Stephan (2001), the term spoiler serves to donate a deflector provided on the rear upper side of a wing, which, on the one hand, serves as an air brake during landing and, on the other hand, also assists the aileron by asymmetrical use. The English term "spoiler" goes back to the fact that it creates a resistance, thereby annihilating part of the lift.