UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND ANALYSIS OF RESIN TRANSFER MOULD FOR COMPOSITE PART

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

By

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TAJUK: **Design and Analysis of Resin Transfer Mould for Composite Part**

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I hereby, declared this report entitled "Design and Analysis of Resin Transfer Mould for Composite Part" is the results of my own research except as cited in the references.

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Date	:	JUNE 2013

APPROVAL

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) (Hons.). The member of the supervisory is as follows:

……

(DR. ROSIDAH BINTI JAAFAR)

ABSTRACT

The composites manufacturing process is available to process various types of reinforcement and resin system. Resin Transfer Mould (RTM) is one of the processes for making the composite part. Meanwhile, Hand Lay Up process is used for making the mould for the Resin Transfer Mould part. The final year project' s aims to design the composite part of Resin Transfer Mold, design the mould for the Resin Transfer Mold process and to perform the analysis which consists of fluid flow analysis for RTM mould and stress analysis of the Resin Transfer Mold part. The 3D model was designed by using SolidWorks Premium 2012 software. The fluid flow analysis was simulated by using SolidWorks FloXpress Wizard Analysis and the stress analysis was being simulated by using SolidWorks Simulation Xpress. The stress analysis results show that the Von Mises Stress and Resultant Displacement is directly proportional to the pressure applied. Meanwhile, the Factor of Safety value is indirectly proportional to the pressure applied. The yield strength value plays important role in stress analysis. By doing the fluid flow simulation, the result shows that the maximum velocity of fluid flow is 0.119 m/s. The Reynolds number is less than 1 show that the flow of fluid is laminar.

ABSTRAK

Proses pembuatan komposit merupakan proses yang digunakan untuk memproses pelbagai jenis sistem pengukuhan damar. 'Resin Transfer Mold' adalah salah satu proses untuk membuat bahagian-bahagian komposit. Manakala, acuan pada bahagian komposit dihasilkan melalui proses 'Hand Lay Up'. Projek Sarjana Muda bertujuan untuk merekabentuk produk komposit untuk 'Resin Transfer Mold' proses, rekabentuk acuan untuk 'Resin transfer Mold' process dan membuat analisis iaitu analisis aliran cecair untuk acuan produk yang dihasilkan melalui proses Resin Transfer Mold dan analisis tekanan untuk produk komposit yang dihasilkan melalui proses Resin Transfer Mold. Model 3 Dimensi direka dengan menggunakan perisian SolidWorks Premium 2012. Aliran cecair dianalisa menggunakan perisian SolidWorks FloXpress Wizard Analysis dan tekanan pada produk komposit dianalisa dengan menggunakan perisian SolidWorks Simulation Xpress. Keputusan analisa menunjukkan bahawa tekanan Von Mises dan anjakan terhasil adalah berkadar terus dengan tekanan yang dikenakan. Sementara itu, nilai Faktor Keselamatan adalah berkadar langsung kepada tekanan yang dikenakan. Kekuatan nilai 'Yield Strength' memainkan peranan yang penting dalam analisis tekanan. Dengan melakukan simulasi aliran bendalir, hasilnya menunjukkan bahawa halaju maksimum aliran bendalir adalah 0.119 m / s. Nombor Reynolds adalah kurang daripada 1 menunjukkan bahawa aliran cecair adalah lamina.

DEDICATION

Dedicated to my beloved father and mother, En Bharum bin Hassan and Pn Hanifah binti Md. Yusof, my dear siblings, my respected supervisor, Dr. Rosidah binti Jaafar, and my beloved friends. I have been inspired and encouraged by them.

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Thank You.

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LIST OF ABBREVIATIONS, SYMBOLS AN NOMENCLATURE

RTM	-	Resin Transfer Mould
FRP	-	Fibre Reinforcement Plastic
km	-	kilometre
h	-	Hour
FYP	-	Final Year Project
PEEK	-	Polyether ether ketone
PPS	-	Polyphenylene Sulphide
SRIM	-	Structural Reaction Injection Moulding
GMT	-	Glass Fibre Mat reinforced Thermoplastic
GRP	-	Glass Reinforced Plastic
CSM	-	Chopped Strand Mat
UV	-	Ultraviolet Light
MEKP	-	Methyl Ethyl Ketone Peroxide
k	-	Kilo
Pa	-	Pascal
℃	-	Degree Celsius
s	-	Second
SI	-	System International
mm	-	millimetres
N	-	Newton
FEA	-	Finite Element Analysis
3D	-	Three Dimension
2D	-	Two Dimension
CAD	-	Computer Aided Design
BOM	-	Bill of Material
DOF	-	Degree of Freedom

CHAPTER 1
INTRODUCTION

The introductory chapter comprises a brief explanation about the Final Year Project, and the background of the project title "Design and Analysis of Resin Transfer Mould for Composite Part". The Chapter 1 also covers on Problem Statement, Objective of the project, Scope and Limitation of Project, Report Organization and Planning Flow Process.

1.1 Background

The composites manufacturing process is available to process various types of reinforcement and resin system. Resin Transfer Mould (RTM) is the process for making composites parts and Hand Lay Up as the process in making its mould. Resin transfer moulding is a closed mould pressure injection process to manufacture fibreglass composites. The use of RTM as an economic and efficient means of producing high performance fibre-reinforced composites are critical limited by the permeability of the fabrics employed. This parameter relates the fluid flow rate to the pressure gradient, the fluid viscosity and the dimensions of the bed of porous medium. Resin is introduced through a central injection port in the mould base. Most other composite manufacturing process involves only a short range flow of the resin into the fibre tow or through the layer thickness. RTM differs from other composite manufacturing processes as it involves the long-range flow of resin, parallel to the lamina, through the pore space between the reinforcing fibres.

The advantages of this process include faster gel time; faster cure times, less waste, less environmental impact, and more constant part size or material usage as compared to alternative types of moulding. Resin Transfer Moulding (RTM) is a high performance composite manufacturing technique of liquid injection moulding for fabricating parts with tight dimensional and strength requirements which is gaining popularity in the composite industry. The RTM process is a closed mould operation in which a dry fibre performs is placed in a mould and then the thermo set resin is injected through an inlet port until the mould is fully filled with resin. The resin is then cured and the part is removed from the mould.

Hand Lay Up is a shaping method in which successive layers of resin and reinforcement manually applied to an open mould to build the laminated FRP composite structure. Hand Lay Up processes are not required higher labour intensive process so; it does not require large capital investments. The material used for RTM parts are Rovicore, Butanox M-50 and Polyplex as a resin. Meanwhile, the material used for making moulds of the RTM part are Thai epoxy resins, Vinyl ester resin, Nylon peel ply, breather, perforated foil, vacuum foil and Butanox M-50. The design requirements for the RTM part and mould for RTM parts are injection pressure which are full and half pressure, mould temperature, curing temperature, resin viscosity, fluid flow through porous media in RTM and stress analysis. The analysis will be done by using SolidWorks Simulation Xpress and SolidWorks FloXpress Analysis Wizard.

1.2 Problem Statement

Resin Transfer Mould processes make use of a closed mould and unlike in hand lay-up process, RTM gives better control on product thickness and good surface finish. RTM process can be used for the part because the medium reactive resins that cure at much faster cycles than used in hand lay-up which a productive cycle of RTM is about 20 minutes compared to the 3 to 4 hour cure in hand lay-up.

The major problems of this project are the part that is designed to have a complex shape. The RTM process is used for making the part because it requires low tooling cost; it is high in production rate and easier to use. Moreover, the RTM process is the most suitable process for making parts with complex shape. The analysis should be on fluid flow analysis and stress analysis because the sandstorm speed can reach more than 70 psi so; the part must be strong enough in the sand storm. The fluid flow distribution must be in uniform to produce a better surface finish.

1.3 Objective

The objectives of this project are:

1. To design the composite part of the Resin Transfer Mould process.
2. To design the mould for the Resin Transfer Mould process.
3. To perform the analysis which consists of fluid flow analysis for RTM mould and stress analysis of the Resin Transfer Mould part.

1.4 Scope/Limitation

This project is focusing on the Resin Transfer Mould composite part and its mould. The analysis is focused more on the fluid flow of resin of RTM process and stress analysis of the part.

1.5 Report Organization

This report contains five major chapters which are Introduction, Literature Review, Methodology, Discussion and Conclusion.

a) Chapter 1: Introduction

Chapter 1 will explain on Background, Problem Statement, and Objective of the project, Scope and limitation of the project, Report Organization and Final Year Project Planning Flow Progress.

b) Chapter 2: Literature Review

Chapter 2 will explain in the literature review. The information which is related to the project was studied and summarized. The literature review is based on journal, magazines, conference, books and studies past course. The literature will be a guide for the project in the future including the design of parts and mould for the most part, software used for designing the part and mould, software used for design analysis, the process involved and the material used for the project.

c) Chapter 3: Methodology

Chapter 3 will explain on methodology. This chapter will explain and elaborate more on research method, and the process flow on how to conduct the research method. This chapter shows the project flow from beginning until it's finished.

d) Chapter 4: Discussion

Chapter 4 will discuss more on the design analysis result that have been conducted. The discussion of design analysis will focus more on flow analysis and stress analysis.

e) Chapter 5: Conclusion

Chapter 5 will conclude on the project findings and research. This chapter includes the recommendation or suggestion for the project in the future development.

1.6 Final Year Project Planning Flow Process

In order to accomplish the project within the time provided, a Gantt chart is designed to show the schedule of the project. The Gantt chart is very important as a guide that used to monitor the entire project progress. The Gantt chart for FYP 1 and FYP 2 is shown below.