NEW TECHNIQUE OF PLASTIC MOULD FOR THERMOSET COMPOSITE FABRICATION

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NEW TECHNIQUE OF PLASTIC MOULD FOR THERMOSET COMPOSITE FABRICATION

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

by

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FACULTY OF MANUFACTURING ENGINEERING

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I hereby, declared this report entitled "New Technique of Plastic Mould For Thermoset Composite Fabrication" is the results of my own research except as cited in references.

Signature	:	……
Author's Name	:	MOHAMAD MUSTAQIIM B. CHE HASSAN
Date	:	20 APRIL 2010

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APPROVAL

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

.....

(Principal Supervisor)

(Mohd Yuhazri Bin Yaakob)

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ABSTRACT

This research relates to a new technique of plastic mould for thermoset composite fabrication. Currently mild steel, wood and aluminium are as the moulds for moulding the plastic products as they hard and tough. However these moulds require high tooling cost and some complex shapes cannot be produced. Thus, this research is a development of new technique that used plastic as the moulds. The plastic that was used is PVC film from thermoplastic material. For manufacturing the thermoset composite, a new technique was developed from Vacuum Assisted Resin Infusion Moulding (VARIM) process but different from the moulds. Both of the upper and bottom mould used were flexible moulds from PVC film. A polyester resin was used as the matrices and fibreglass was used as the reinforcement for manufacture the thermoset composite. Lastly, after the composite were produced they had been inspected for quality assurance to measure the successful of this new technique of plastic mould. These involved mould capability, surface quality of the resulted composite and manufacturing complexity based on three experimental product designs that had been decided which are simple design, medium design and complex design. In general, the results showed that this new technique of plastic mould for thermoset composite fabrication was successfully produced and feasible for fabrication trial products or a small quantity of productions with reducing the manufacturing costs. The new technique of plastic mould also increases most of the mechanical properties of the thermoset composite than if they were produced by hand lay up technique or vacuum infusion technique. In addition, the plastic mould can also be repeated for almost 8 times. Due to that this technique significantly reduced the tooling cost and time for making the mould.

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ABSTRAK

Kajian ini melibatkan pembangunan teknik menghasilkan komposit termoset di mana acuan yang digunakan ialah daripada bahan plastik. Kebiasaannya, bahan acuan mestilah lebih kuat dan keras dari bahan yang akan dihasilkan seperti acuan dari besi, kayu dan aluminium. Akan tetapi, bahan acuan tersebut memerlukan kos yang tinggi dan tidak sesuai dalam menghasilkan produk yang mempunyai bentuk yang kompleks. Berdasarkan masalah tersebut, kajian ini merupakan pembangunan teknik baru yang akan menggunakan plastik sebagai bahan acuan. Plastik yang akan digunakan adalah filem PVC daripada bahan termoplastik. Untuk menghasilkan komposit termoset, proses yang akan digunakan mirip dengan proses *Vacuum Assisted Resin Infusion Moulding* (VARIM) tetapi berbeza daripada segi bahan acuan. Bahan acuan yang fleksibel iaitu filem PVC dan resin poliester digunakan sebagai bahan pengikat untuk menghasilkan termoset komposit. Akhir sekali, setelah komposit dihasilkan, ianya akan diperiksa untuk mengukur kejayaan teknik baru ini. Ianya melibatkan keupayaan bahan acuan ini, kualiti permukaan termoset yang dihasilkan dan kesukaran penghasilan berdasarkan pada tiga jenis model eksperimen yang telah diputuskan iaitu reka bentuk mudah, reka bentuk sederhana dan reka bentuk kompleks. Secara umum, hasil yang diperolehi membuktikan bahawa teknik baru ini yang menggunakan bahan acuan daripada plastik untuk menghasilkan komposit termoset berjaya dibangunkan dan sesuai untuk pembuatan produk percubaan dan sejumlah kecil produk dengan mengurangkan kos pengeluaran. Komposit termoset yang dihasilkan melalui teknik ini menunjukkan peningkatan bagi sifat mekanikal komposit tersebut dan cuan plastik yang digunakan dapat diguna pakai sehingga 8 kali. Oleh itu, ianya dapat menjimatkan kos peralatan dan masa yang diperlukan untuk menghasilkan acuan.

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DEDICATION

To my family; Hassan Ishak, Aini Hamzah, Zureen Hassan and Jannah Hassan

who is always there when it matters,

to all my friends,

for the big things and little ones.

every hour, every moment of every day,

I will always love you all with my heart and love...

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Alhamdulillah, thankful to Allah S.W.T and the prophet Nabi Muhammad S.A.W. with the power and permission from Allah I have finished my research proposal on the specified deadline.

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LIST OF ABBREVIATIONS

ABS	-	Acrylonitrile Butadiene Styrene
BMC	-	Bulk Moulding Compound
C	-	Carbon
C	-	Celsius
CAL	-	Calibration
FRP	-	Fibre Reinforced Plastic
g	-	Gram
GPa	-	Giga Pascal
H	-	Hydrogen
Hg	-	Mercury
I	-	International
J	-	Joule
K	-	Kelvin
kg	-	Kilogram
kN	-	Kilo Newton
lb	-	Pound
m	-	Metre
MEKP	-	Methyl Ethyl Ketone Peroxide
mm	-	Millimetre
MPa	-	Mega Pascal
NDT	-	Non Destructive Testing
NR	-	Non Repeated
PBT	-	Polybutylene terephthalate
PET	-	Polyethylentherephthalate
PC	-	Polycarbonate
Psi	-	Pound per square inch
PU	-	Polyurethane

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PVC	-	Polyvinyl Chloride
R	-	Repeated
Ra	-	Arithmetic mean value
Rq	-	Root-mean-square average
Ry	-	Maximum roughness height
Rz	-	Ten-point height of irregularities
RTM	-	Resin Transfer Moulding
S.D.D	-	Shore Durometer Type D
SCRIMP	-	Seemann Composites Resin Infusion Moulding Process
SI	-	International System
SMC	-	Sheet Moulding Compound
UV	-	Ultraviolet
VARI	-	Vacuum Assisted Resin Infusion
VARIM	-	Vacuum Assisted Resin Infusion Moulding
VARTM	-	Vacuum Assisted Resin Transfer Moulding
VBRTM	-	Vacuum Bag Resin Transfer Moulding

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LIST OF SYMBOLS

%	-	Percent
μ	-	Micro
º	-	Degree

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CHAPTER 1
INTRODUCTION

1.1 Background

Within a decade, fibre reinforced plastic (FRP) materials composites were being used by several industries, for example in the automobile industry. Manufacturing of composite materials is very different from metals. This is because when making a metal part, the properties of the virgin material and the finished part are fundamentally unchanged. However for composites, their manufacturing process plays a key role. During composite processing, manufacturer makes not only the part of the desired shape, but also the material itself with specific properties as Coleman, D., *et al*. (2006) stated that the properties of composite can be changed by varying the type and quantity of its ingredients. Fibre type, length, and mix proportion help determine properties such as strength and rigidity. In addition, resin characteristics can be changed to provide the desired process ability, durability, heat, and corrosion resistance.

However, the lacked of automated and repeatable manufacturing processes drive the cost of composite parts up and limited the number of potential uses. The majority of the manufacturing composite was very labour intensive and not very cost effective. According to the study by Foster, N.G., (1998), in early stages of development, the cost of composite materials was very high and only selected industries involved. They took advantages because of their properties such as light weight and the high strength which outweighed the cost factor.

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Many different processes are used to manufacture composite into final products such as sheet, rods, extruded sections, pipe, or finished mould parts. The process used depends to a certain extent on whether the plastic is a thermoplastic or thermoset one. Thermoplastic are usually heated to a soft condition and then reshaped before cooling. On the other hand, thermoset materials not having been completely polymerized before processing to the finished shape use a process by which a chemical reaction occurs to cross link polymer chains into a network polymeric material. The final polymerization can take place by the application of heat and pressure or by catalytic action at room temperature or higher temperatures.

1.2 Problem Statement

This research is focused on new technique of plastic mould for thermoset composite fabrication which it involves development for mould that made from plastic. Then, the mould is used to make the composite products where polyester as the matrix and fibreglass as the reinforcement.

There are generally used a mild steel, tool steel, wood, and aluminium mould for moulding plastic products as they hard and tough. However these moulds require high tooling cost and some complex shapes cannot be produced. The choice of material to build a mould from plastic is primarily one of economics than the steel mould which is generally cost more to construct. Due to intrinsic limitations of steel, a thermoplastic material was selected as replacement material for making the mould. Thermoplastic material provides more strength, dimensional stability, and corrosion resistance than steel, while increasing design flexibility and manufacturing efficiency.

Manufacture of thermoset composite generally using the physics of flows through porous media as the resin viscosity is low enough to move relative to the network of fibre performs which the impregnation of a molten resin into a fibre bundle is easy (Grimsley, B.W., *et al*., 2001). The apparatus and processes used to make these

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structures therefore vary considerably depending upon the specific shape and form of the structure to be produced.

1.3 Objectives

This research focuses to a new technique of plastic mould for thermoset composite fabrication. It involves development for mould made from plastic which is fast, uses inexpensive tooling and provides a wide variety of curved and contour shaping in the moulded article. On the other hand, the objectives also to invent new technique that can reduce costs and efficient for moulding trial products or a small quantity of productions.

1.4 Scope

The research had been conducted within the following scope:

(a) PVC film from thermoplastic material as the plastic mould.
(b) Polyester resin from thermoset material as the matrices for composite material.
(c) The development from vacuum assisted resin infusion moulding process was approached in this research for thermoset composite fabrication.
(d) Limits on the strength and toughness analysis of the mould.
(e) Limits on the strength and toughness analysis of the composite product.
(f) Study the quality of the final composite products.

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1.5 Rational of Research

Composite materials containing fibre bundles or flakes as reinforcements in a thermoset resin matrix. Thermoset composites provide more strength, dimensional stability, and corrosion resistance than metals, while increasing design flexibility and manufacturing efficiency. In addition Coleman, D., *et al*. (2006) highlighted that thermoset composite structures have long life spans and low maintenance requirements. Due to the intrinsic limitations of metals many design engineers utilize thermoset composites as a metal replacement material for high performance applications.

Manufacture of thermoset composite generally requires high strength precision but it is well known that the impregnation of a molten resin into a fibre bundle is easy. The apparatus and processes used to make these structures therefore vary considerably depending upon the specific shape and form of the structure to be produced. A technique that was developed from Vacuum Assisted Resin Infusion Moulding (VARIM) process had been used to form fibre reinforced plastic structures. In this technique, flexible moulds are used to cover the pattern and vacuum serves to shape the mould, to draw the resin through the fibreglass and to remove any air. Traditionally, moulds have been expensive to manufacture. They were usually only used in mass production where thousands of parts were being produced. There are generally used a mild steel, tool steel, wood, and aluminium mould for moulding plastic products as they hard and tough. However this type of mould requires high tooling cost and some complex shapes cannot be produced.

The choice of material to build a mould from plastic is primarily one of economics and easy for processing. With the advantage and limitations of the thermoplastic and thermoset material, they offer the composite industry a spectrum of choice which gives the opportunity for further expansion of the industry as a whole (Munirah, M., 1995). Thus, the objective of the research is to provide plastic moulds having good in durability to be used for thermoset composite fabrication.

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1.6 Research Methodology

Figure 1.1 shows the flowchart of the research. The flow is summarized by defining the steps taken in order to fulfil the objectives for this research. There are generally five major steps need to be concentrated at in ensuring the research run smoothly.

As shown in the Figure 1.1, the steps need to be put in order where it consists of material selection, parameter selection, processing, testing, and analysis of data collected.

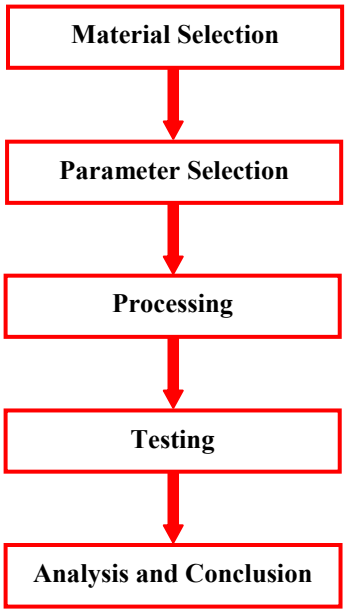

Figure 1.1: Research methodology flowchart.

In material selection steps, plastic material had been identified in this research. Plastic are a large and varied group of synthetic materials that are processed by forming or moulding into shape. Plastics can be divided into two classes, thermoplastics and thermoset materials, depending on how they are structurally chemically bonded. In this research, PVC film from thermoplastic material will be used as the material for moulds and polyester from thermoset material will be used as the matrices in the composite.

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