UNIVERSITI TEKNIKAL MALAYSIA MELAKA

A QUALITY STUDY OF PARTS PRODUCED BY SILICONE RUBBER MOULD USING VACUUM CASTING PROCESS

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

by

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I hereby declare that this report entitled "A Quality Study of Parts Produced by Silicon Rubber Mould using Vacuum Casting Process" is the result of my own project except as cited in the references.

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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). The members of the supervisory committee are as follow:

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ABSTRACT

This project is about a study on the parts produce using silicon rubber mould. This study based on Rapid Prototyping (RP) concept where RP model named Master Pattern is designed. Design is done using (CAD/ CAM) modeling software system for 3D modeling and analysis. The Master Pattern consists of shape and features of triangular and circular protrusion as well as triangular and circular hollow cavity and the part features consists of sections with draft angle were designed using CAD software. This study investigates the surface roughness, dimensional accuracy, flatness and straightness of the products produced from the mould. Appropriate measuring equipment is later used for quality testing. Method used to obtain quality is study at metrology laboratory. The dimensional accuracy of the products was measured using a Digital Vernier Calliper. The Coordinate Measuring Machine (CMM) is used to measure the flatness and straightness. The Mitutoyo CV 500 Contour Measuring Instrument is used so measured the surface finish of the products show. There are significant effect on surface finish, dimensional accuracy and flatness as more products were produced using the silicone mould.

ABSTRAK

Projek ini mengenai “Satu kajian mengkaji kualiti objek yang dihasilkan oleh acuan silikon menggunakan mesin *Vacuum Casting*. Kajian yang dilakukan ini berdasarkan konsep *Rapid Prototyping (RP)* di mana konsep ini direka atau dilukis dahulu menggunakan perisian *CAD CAM*. Perisian yang digunakan adalah untuk 3D peragaan dan menonton. Dalam perisian ini mengandungi bentuk dan bulat serta rongga kosong segiempat tepat dan bulat dan ciri-ciri bahagian mengandungi seksyen-seksyen dengan sudut draf telah direkabentuk dengan menggunakan perisian *CAD.* Kajian ini dilakukan adalah untuk menyelidik permukaan produk, dari segi dimensi ketepatan, rata dan kejujuran pola induk bahagian-bahagian contoh-contoh dihasilkan menggunakan penuangan vakum sesuai untuk kualiti alat pengukuran ujian. Kaedah atau kajian hendak dilakukan untuk memperoleh kualiti dilakukan di Makmal Metrologi. Ketepatan produk diukur menggunakan alat pengukuran iaitu *Digital Vernier Calliper*. Penyukatan Koordinat Mesin (CMM) diukur pada permukaan rata dan bahagian lurus pada produk. *CV Mitutoyo 500 Contour Measuring Instrument* diukur padabahagian kemasan permukaan produk. Ujian ini amat penting dilakukan kerana untuk mendapatkan aspek kualiti sesuatu produk. Apa yang pengting adalah kesan ke atas kemasan permukaan, dimensi ketepatan dan rata sebagai lebihan bahagian apabila produk dikeluarkan daripada acuan silikon.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVATIONS

CAD	–	Computer Aided Design
CMM	–	Coordinate Measuring Machine
3D	–	Three Dimensional
HDPE	–	High Density Polyethylene
LDPE	–	Low Density Polyethylene
MJS	–	Multiphase Jet Solidification
PP	–	Polypropylene
R_a	–	Arithmetic Mean Value
RP	–	Rapid Prototyping
RT	–	Rapid Tooling
RTV	–	Room Temperature Vulcanizing Rubber
R_y	–	Maximum Roughness Height
Rz	–	Ten-Point Height of Irregularities
SGC	–	Solid Ground Curing
SLA	–	Stereolithography
SLS	–	Selective Laser Sintering
UV	–	Ultra-Violet
CMM	–	Coordinate Measuring Machine

CHAPTER 1
INTRODUCTION

This report is about a project on "A Quality Study of Parts Produced by Silicon Rubber Mould using Vacuum Casting Process". In this chapter, the background of the project, problem statement, objectives, scope, and report outline are explained.

1.1 Background Project

There are many types of products made from machines nowadays. It follows the design made beforehand before they are produced. Rapid Tooling (RT) is a new technique driven by Rapid Prototyping. In the development Rapid Tooling processes, there is a need for faster, better, and less expensive tooling solutions. The term Rapid Tooling typically used to describe a process that either uses a Rapid Prototyping process directly to fabricate tools for a limited volume of prototypes. There is tremendous interest in Rapid Tooling solutions these days for product design and manufacturing. In the indirect method, Rapid Tooling masters patterns to produce a mould such as silicone rubber mould. To make it more accurate, tooling solutions has resulted in the development of many Rapid Tooling methods such as vacuum casting process. The accuracy of these processes depends in part on the accuracy of the Rapid Tooling process used to create the pattern. (Noraini.R, 2006) Materials also affect the choice of the most suitable Rapid Tooling techniques, which appropriate for each application, i.e. indirect tooling or direct tooling. (Dr Rennie *et al*, 2002) To make a mould, one must know which materials to use, calculation in mould making and its properties. To produce the parts by using vacuum casting process was into consideration.

In this project, the qualities of the parts produced were visually observed and measured. These include the following features, dimensional accuracy, surface roughness, flatness roundness, and straightness. Therefore, to take into account all the meaning above, the project taken is regarding the quality study of the parts produced using silicone rubber mould via vacuum casting process and its development. In addition, it is also to produce a high quality mould for good percentage accuracy and repeatability, or consistency, in producing products that are of high quality at any time and within the dimensional zone.

1.2 Problem Statement

This research is about a quality study of parts produced by silicon rubber mould using vacuum casting process. Most of the current focus is in increasing the quality of part produced by using the silicone mould. By accomplishing these facts, the parts produced, a 13-Ampere plug, can be produced at a consistent rate in term of its quality of dimensions. To reduce the problem of current silicone rubber mould, such as reducing the time and cost in the installation and production, prototypes are also useful for testing a design, to see if it performs as desired or needs improvement. It is because to get the highest achievable quality. The method used is by casting silicone moulds, made in the shape of a 13-Ampere plug is carefully prepared, to ensure a high quality finish to the surface and the definition of the parting planes.

Vacuum casting is a process to evaluate molding designs without committing to the delays and expense of production tooling. The system is capable of reproducing intricate designs with complex internal detail and surface finish comparable to injection-molded components and is suitable for producing a limited quantity of working prototypes or production parts. Standard lead-time is six (6) working days from receipt of masters or CAD data to production. (Kunstmaan, 2008) So, by ensuring the quality is maintained and improved, the installation and production of the mould can be optimized in a certain period.

1.3 Project Objective

The purposes of this project are:

(a) To understand about the quality of the parts produced using silicone rubber mould via vacuum casting process in term of dimensional accuracy, surface roughness, flatness, and straightness of the resulting parts.

(b) To investigate the factors that effect and defect of the parts produced using silicone rubber mould via vacuum casting.

(c) To understand operation produce parts using vacuum casting process.

1.4 Scope of Study

The scope project will focus on:

(a) Produce the parts using silicone rubber mould.

(b) Study the quality product when using silicon rubber mould.

(c) Analyzed the results of parts produced in term of dimensional accuracy, surface roughness, flatness, and straightness.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

A literature review is a body of text that aims to review the critical points of current knowledge on a particular topic. The literature review usually precedes a research proposal, methodology and results section. The literature reviews is the analysis the scientist at the past years ago about the project or produce the product.

In a way, literature review is important to find out about the information and uses to explain a product. It also gives some idea about the current project. Literature review is also important since it can be as references in built up for a new product. Besides that, the background of the project will be reviewed and can determine the best alternative to upgrade the current project. Literature review is defined as evaluative report of information found in the literature related to selected area of study. The review should describe, summarize, evaluate, and clarify this literature. It should give a theoretical base for the research and help to determine the nature of the research. Therefore, for his project, the literatures review by source such as from journal, book, internet, and others.

In this project, the focus about a quality study of parts produced by silicone rubber using silicone rubber mould via vacuum casting process in term of dimensional accuracy, surface roughness, flatness, and straightness.

2.2 What is Stereolithography?

Stereolithography (SLA) is a "Rapid Prototyping" process that produces physical, three-dimensional objects, a "conceptual model," or "master pattern". Most produced the parts from computer solid model are "3D CAD file", and "Master Model". A stereolithography machine uses a computer-controlled laser to cure a photosensitive resin, layer by layer, to create the 3D part. Producing a pre-production SLA prototype of a part can greatly added the geometric visualization of a product, as well as communication between project team members. Stereolithography is fast, allowing prototypes to make in a matter of days, and the complexity of the model is seldom a factor. (Jacobs, P.J.*et. al*, 1998).

2.2.1 Benefits of Stereolithography.

Below show the benefits of stereolithography. They are:

(a) Crisp, highly-detailed pieces
(b) Speed of delivery (usually 2-3 days)
(c) Tolerances within .004"/inch

2.2.2 Applications of SLA Technology

(a) Aesthetic and conceptual models
(b) Parts requiring detail & accuracy
(c) Master patterns for castings and secondary processes
(d) Medical models

Stereolithography is a master models that can be used for "master patterns" when it is time for metal castings. There is easy modifying to accommodate any last minute changes. Additionally, SLA models can be used for photo-optic stress analysis as well as dynamic vibration analysis, which further extend engineering design capabilities. SLA is really "Rapid Modeling" since the objects generated from existing photosensitive resins or photo polymers do not have the physical, mechanical, or thermal properties typically required of end use production material. There is much ongoing research and development in the area of durable materials. (Jacobs, P.J.*et. al*, 1998).

2.3 Rapid Prototyping

2.3.1 Introduction Rapid Prototyping

Over the last several years, Rapid Prototyping techniques have grown seriously. They reduce in a considerable manner for the manufacturing time for parts, and lead to a faster production phase-shift. The processes associated with Rapid Prototyping techniques make to obtain viable plastic injection moulds in one day. This induces a great reduction of implementation time for production. (Augustian, 1999)

The classification of technologies, Rapid Prototyping (RP) can automatically construct physical models from Computer-Aided Design (CAD) data. These "three dimensional printers" allow designers to quickly create tangible prototypes of their designs, rather than just two-dimensional pictures. Such models have numerous uses. They make excellent visual aids for communicating ideas with co-workers or customers. In addition, prototypes can use for design testing. In addition to prototypes, RP techniques can also used to make tooling (referred to as rapid tooling) and even production-quality parts (rapid manufacturing). (Jacobs, P.J.et. al, 1998) Rapid prototyping technologies provide prototypes of very complex part geometry and it is directly from three-dimensional computer aided design (CAD) software. The processes build prototypes in a wide variety

of materials such as polymer, wax, and paper. In the contrast to traditional machining methods, the majority of rapid prototyping systems tend to fabricate parts using a process of addition and removal of material. (King, and Tansey, 2002)

Type of fabrication is unconstrained by the limitations attributed to conventional machining approaches. These types are no problems of tool clash at the any shape of geometry can essentially to reproduce at the high degree of accuracy. Rapid prototyping techniques can be produce high quality three-dimensional parts, of varying degrees of complexity, size and shape because it is various photochemical, lasers sintering, guided deposition, extrusion layering, or sculpting processes. Rapid prototyping (RP) has emerged as a key enabling technology with its ability to shorten product development and manufacturing time. (Tansey, 1995)

Rapid Prototyping is a new technology that has profound effect on the product development process of design and manufacturing industries. It is called prototyping because it can prototype parts rapidly in cases, in hours in days or weeks. So rapid prototyping, tooling and manufacturing (RPTM) is term used these days. (Ashley, 1995) To created technologies the Rapid Prototyping industries in the late 1980s. Rapid Prototyping (RP) technique generated the replacing traditionally made patterns but the Rapid Prototyping not only reduces lead-time but allows for comprehensive design evaluations to be early in the development stage for improved design quality in a fraction of the time for traditional prototyping. The application of Rapid Prototyping to the product development process has shown a sixty percent decrease in lead-time over traditional methods. (Choi and Samavedam, 2001)