UNIVERSITI TEKNIKAL MALAYSIA MELAKA

THE EFFECT OF PROCESS CONDITIONS IN VACUUM CASTING PROCESS

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

by

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TAJUK: **THE EFFECT OF PROCESS CONDITIONS IN VACUUM CASTING PROCESS.**

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

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ABSTRAK

Projek ini bertujuan untuk mengkaji kesan daripada keadaan proses penuangan vacuum. Projek kajian ini dilakukan dengan membuat satu rekabentuk produk berdasarkan langkah-langkah rekabentuk dan pilih rekabentuk yang terbaik untuk membina dengan menggunakan Mesin (Fused Deposition modeling). Sebelum itu, produk terlebih dahulu direka dalam bentuk 3D model dengan menggunakan perisian "solidwork" dan kemudianya rekabentuk tersebut boleh dipindahkan kedalam mesin prototaip. Dengan hasil produk prototaip tersebut, acuan getah boleh dihasilakan mengikut bentuk prototaip tersebut untuk proses tuangan vakum. Sebelum membentuk acuan getah, pengiraan jumlah bahan yang perlu digunakan haruslah dikira untuk mengelakan pembaziran semasa proses. Dengan menggunakan rangka kayu dan model prototaip kedalamnya cetakan silikon dihasilkan, kemudian cetakan harus dipotong sepanjang garis perpisahan dan mengeluarkan produk prototaip. Pastikan laluan spru bersih bagi memudahkan pengaliran bahan memasuki kedalam cetakan semasa proses tungan dijalankan. Letakkan cetakan yang telah siap ke dalam ketuhar untuk melengkapkan pembekuanya. Polymer pelastik dipilih sebagai bahan untuk dijadikan produk akhir. Selama proses tersebut, parameter boleh disesuaikan dengan merujuk pada helaian data pada mesin MCP. Tetapan parameter akan mempengaruhi produk akhir. Setelah itu, tiga produk akhir dihasilkan dengan parameter yang berbeza dan struktur produk akan dibandingkan. Kesan yang diperolihi akan dinilai untuk setiap produk semasa percubaan dilakukan. Dengan menggunakan cubaan kekasaran permukaan, permukaan produk dapat dianalisa mengikut tahap kekasaran dan kesan lain yang boleh menganalisis dengan cara perbandingan. Dengan menjalankan projek ini hasil yang berbeza pada produk akan dijumpai mengikt parameter yang optimum diperolehi. Dalam projek ini juga menerangkan pengiraan bahan resin untuk mencegah pembaziran. Dengan lembaran pengiraan bahan boleh diketahui untuk menghasilkan sesuatu produk.

ABSTRACT

The purpose of this project is to analyze the behaviour of the effect of process conditions in vacuum casting process. This research project was done by create the design product based on the step design and chose the best design product to fabricate by using the Fused Deposition Machine. Before that, the design product 3D modeling of prototype product was prepared by using Solidwork software and will transfer in the fused deposition machine. With the prototype product, the mould will be produces by silicon rubber mould for vacuum casting process. To produce the silicon mould, the size of mould and type material are used must be determine with the calculation of volume material to use. Assemble the wood frame and enter the model participate by setting the position sprue and gate. After silicon mould finish, mould should cut along the parting line and remove the model product, suspension rod completely and cleaning the mold. Place the mould in the oven to complete the solidification. The resin polypropylenes are selected as material of final product. During the process, the parameter can be adjusted by referring the data sheet MCP machine. The parameters setting will affect the final product. After that, several products will produce with different parameter and compare the structure product. The effect can be detected for each product when experiment conducted. With using the surface roughness tester, the surface product can analyze the level of roughness and other effect can analyze by comparison. By this project the result of product will be found out and optimum parameter can be obtained. In this project also to calculate the volume material resin for prevent the wastage during process. With the spreadsheet the volume material can calculate the how many materials used to produce the product.

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With honest, special thanks dedicated to my beloved parents and my fellow friends and also to every single person who has provide the opportunities with all your love, patience and understanding.

All your blessing will be granted.

Thank You.

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LIST OF ABBREVIATIONS

PSM	-	Projek Sarjana Muda
CAD	-	Computer Aided Design
RP	-	Rapid Prototyping
FDM	-	Fused Deposition Modeling
ABS	-	Acrylonitrile Butadiene Styrene
LDPE	-	Low Density Polyethylene
HDPE	-	Height Density Polyethylene
AA	-	Arithmetic Average
CLA	-	Centerline Average
DOE	-	Design of Experiment
CMM	-	Coordinate Measurement Machine
R_a	-	Arithmetic Average Roughness

CHAPTER 1

INTRODUCTION

1.1 Introduction

Vacuum casting is the most importance of the prototype production process. The processes are familiar using the plastic method to produce product. Material polymer resin as material to produce the product because extremely versatile plastic and is available in many grades. The lowest density of all thermoplastics and this combine with strength, stiffness and excellent fatigue and chemical resistance make it attractive in many situations. For running the process is fabricate the silicon mould casting as far as the mould making process concerned. The model is cast in silicone angles and the mould will cutting into two halves so that the model can be take out easily. Then the mould is prepared with feeding tubes and vents for use in a vacuum casting machine. The mould is evacuated under predefined condition (pressure, temperature, time) depend on the material and after wards filled with the appropriate vacuum casting resin. The advantage of vacuum casting is that the moulds are evenly filled and the resin degassed. Significantly better model properties result. Today a vast number of commercial plastic materials can be used as vacuum casting material and the resulting models are comparable with the later injection cast mass production parts, at least with regarding to certain selected properties depend on the vacuum casting material and the complexity of the mould.

1.2 Background of Problem

Since the components in the plastic industry are becoming smaller, the need for a thorough impregnation and a perfect encapsulation of loaded components (parameter or by environmental influences) of vital importance. To meet this requirement, vacuum casting processes are important to develop.

However, the quality of the final products also determine by other factors. The following process is an attempt to give a general but not complete, survey of the basic interrelations between different parameters, which when interacting have an influence on the component quality. In the special attention is given to the influences which are in direct connection with vacuum casting. To overcome this problem, vacuum casting process methods are being investigated for rapid prototyping and even for rapid tooling applications. As contribution to this development, a fundamental study on a process to decrease the rate defect during process. So the parameter must have stable with vacuum casting process.

1.3 Problem Statement

Based on this study, several main points need to be focused and questions need to be answered at the end of the topic:

i. How different vacuum parameters affected polymer plastic material?
ii. How different vacuum parameters affected mechanical properties polymer plastic material with final product?

1.3.1 Objectives

Objectives of this study are as follows:

i. To design the product using the solidwork software.
ii. To investigate how different vacuum parameters affected macrostructure polymer plastic material.

iii. To produce the pattern using Fused Deposition Modeling machine.
iv. To fabricate silicon mould in polymer plastic for vacuum casting process.
v. To calculate volumes of material for produce a polymer plastic by using vacuum casting.
vi. To investigate how different vacuum parameters affected mechanical properties polymer plastic material using the surface roughness testing.

1.3.2 Important of Study

This project involves experimentation by using the MCP 5/01 vacuum casting machine in laboratory UTeM. The machine parameter factors involved in this project are speed, mixture ratio, stirring and temperatures machine. The data sheet report the result of vacuum casting process with surface roughness following the mixing ratio, volume, pressure and temperature. The report also involves the result and discussion of the result. These studies are established on the mechanical properties and surface roughness of the specimen. The focused samples were analyzed using the surface roughness testing Model Surftest SJ – 301 at UTeM laboratory. The methods used to analyze the surface products with different parameters. The projects were managed by Design of Experiment method where the types of design are trial and error. The designs of experiment method are used to develop the method equation where it can used to improve the manufacturing process.

1.4 The Structure of Report

Summary of each chapter was described in the structure of report. The structure of report include from Chapter 1 to Chapter 5 of this project which contain PSM 1 and PSM 2.

Chapter 1 includes the introduction of the vacuum casting process, the problems statement that related in the industry, the objectives of the project that involved on the parameters setting, and the scopes of the project. This chapter will be use as a guideline of this project that decide all of project imagination.

Chapter 2 reviews on the literature from journal, books, and internet. The area covered including mechanical properties material, machining parameters, mathematical equation of DOE method etc. All of the information or method is found out from this chapter as a reference to run the project. The information that find out basically involve from scope of the project.

Chapter 3 describes the methodology to develop the experiment. The requirement is to ensure this experiment completely and systematically run. In this chapter that indicate the planning to run the project by following the terms or steps of project. All of the aspect that engages to run the operation contains from the beginning until the final action of the project.

Chapter 4 describes the result and discussions of the trial and error based on vacuum casting process. The result of the product that had been measured will be discussing letter in this chapter. Interpretation on some result and finding of this research also stated in this chapter.

Chapter 5 describes a conclusion of this research including interpretation of overall research flow. The overall research objectives, scope, findings and discussions also conclude in this chapter. Finally, this chapter provides recommendation of future works.

1.5 Activity Planning

The Gantt charts are used as tool for planning and scheduling operations involving at least a relationship of dependency and experimental research. On the other hand, charts are easy to construct and understand, although they may contain large amounts of information. In general, the charts are easily maintained provided the task requirements are somewhat static. Updating of a Gantt chart will reveal difficulties encountered in the conduct of this experimental project. Gantt chart of PSM 1 and PSM 2 is provided in appendix A.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of the literature about design the prototyping product and select the best design to product in vacuum casting process .Other than that, study the effect condition during the process including the material, heat temperature, condition mould and solidification material. Beside, the literature about vacuum casting effect and process also review in this chapter. The background knowledge about type of plastics (resin) is also provided in relation to its process parameter, macrostructures properties and mechanical properties. Summary of literature review is provided at the end of this chapter.

2.2 Design

Ulrich, et al, (2008) specified the design refers to those activities involved in creating the styling, look and feel of the product, deciding on the products mechanical architecture, selecting materials and processes, and engineering the various components necessary to make the product work.

2.2.1 Product Steps Design

According to Ulrich, et al, (2008) there are stages that should be followed in order to design products. This level is a guide for designers to produce the best design of the product. The four levels are: concept design, system-level development, detail design, and testing. If the plan involves the total mass of product, there must be another step called 'production ramp-up' like, which is the last stage of all. But in this project, the final phase will focus on because there is only a product to be produced. There are steps to guide the design:-

a) Concept development

To design the product activity is often to identify before start the design. This stage explains why the designer will prepare all concepts for the designation of the product. The concept covers all concept products to relate the industrial design concept. The Geometry is not the subject of focus for the product in this phase. To develop preliminary concepts for the architecture of the product, and industrial designers develop renderings to show styling and layout alternatives. After narrowing the selection, non-functional appearance models are built of candidate designs. The concepts of a product are the ones who will be focused on the design and image of the product will be done in stages and according to all the concepts that have been prepared.

b) System-Level Design

System-level design, or the task of designing the architecture of the product, is the subject of this stage. In prior stages, the team was focused on the core product idea, and the prospective design was largely based on overviews rather than in-depth design and engineering. Several alternatives of shape and geometry will be prepared first before choosing the best which will be brought to the later stage. The best product architecture which has been chose is the one which is the best in optimizing all the concepts prepared in the early stage.

c) Detail Design

Detail design or design-for-manufacture, is the stage wherein the necessary engineering is done for every component of the product. During this phase, each part is identified and engineered. More detailed design drawings of products made during this phase. Tolerance was assigned to prepare the image. Also, at this stage, all the manufacturing processes involved developing a product design and quality assurance processes are defined.

d) Product Testing

After the stage detailed design, this product is produced and the work of designing a product is now entering the testing phase. Products that have been made will be tested in accordance with all aspects of quality that has been designed in the early stages. If an error is detected, it means that the product needs to investigate all the latest on the steps of product design. An error has occurred means there is an offense for one of the early stages. Design refinement need to be done after detecting the mistake which had to be corrected. One example of the quality of products is surface roughness. If the surface roughness value products out of tolerance, it means that there is something wrong with the manufacturing process, and now, the repair design is essential.

2.3 Technical Drawing

The drawings are very important for design the product and simplify to create the design. With have the Technical drawing can helps the designer to assemble the part and produce the product. The drawing shows the dimensions each part and tolerance to identify the actual dimensions. A drawing is a graphic representation of an idea, a concept an entity that actually or potential exist in life. The drawing itself is:-

- A way of communicated all necessary information about an abstraction, such as an idea or a concept.
- A graphic represent of some real entity such as a machine part and part product.

2.4 Rapid Prototyping

Rapid prototyping can be define as a group of techniques used to fabricate a scale model of a part or assembly using three dimensional computer aided design (CAD) data. Ulrich, et al, (2008) classify the Rapid Prototyping referred to as solid free form manufacturing and computer automated manufacturing, and layered manufacturing. Rapid Prototyping has real use as a vehicle for visualization. In addition, Rapid Prototyping models can be used for testing, such as when an airfoil shape is put into a wind tunnel. RP models can be used to create male models for tooling, such as silicone rubber mould and investment casts. In some cases, the RP part can be the final part, but typically the RP material is not strong or accurate enough. When the Rapid Prototyping material is suitable, highly convoluted shapes (including parts nested within parts) can be produced because of the nature of rapid prototyping.

2.4.1 Planning for Prototype

According to Ulrich, et al, (2008), the potential pitfall in product development is hardware swamp. The swamp is cause by misguide prototyping effectors, that this, the building and debugging of prototype (physical or analytical) that do not substantially contribute to the goals of the overall product development. One way to avoid the swamp is to carefully define each prototype before embarking on an effort to build and test. Below describe four step methods for planning each prototype during product development.

Step 1 : Design the purpose of the prototype

Recall the four purposes of prototypes learning, communication, integration and milestone. In defining the purpose of a prototype, team list its specific learning and communication needs. Team also list any integration needs and whether or not prototype is intended to be one the major milestones of the overall product development.

Table 2.1 : Example planning template for the project geometry/ impact test prototype (Ulrich, et al, 2008)

Name of prototype	Geometry / impact test
Purpose	• Select final product geometry and materials based on strength and shock absorption characteristic • Confirm that product absorb shock to withstand impact and protect the packbot and its payload
Level of approximation	• Correct wheel spoke geometry, materials and platform loads.
Experiment plan	• Build 12 test wheel using six different materials each with two spoke shapes • Mount the wheels to the best fixture. Conduct impact test at a range of drop height.
schedules	• 1 august select wheel design and materials • 7 august complete design of test fixture • 14 august wheels and test fixture constructed • 15 august assembly complete • 23 august testing complete • 25 august analysis of test results complete.

Step 2 : Establish the level of approximation of the prototype

Planning a prototyping requires definition of the degree to which the final product is to be approximated. The team should consider whether a psychical prototype is necessary or whether an analytical prototype would best meet its needs. In most cases, the best prototype is the simplest prototype that will serve the purpose establish in step 1. For other cases, an earlier model serves as a test bed and may be modified for the purpose of the prototype. In other cases, an existing prototype or a prototype being built for another purpose can be utilized.