UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Development of Housing Pattern Using Rapid Prototype

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

By

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APPROVAL

This thesis submitted to the senate of UTeM and has been accepted as fulfillment of the requirement for the degree of Bachelor of Manufacturing Engineering (*Design*). The members of the supervisory committee are as follows:

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ABSTRACT

Nowadays, the rapid prototype engineering term is very familiar in the rapid technology development. Most of the product existing in the industry used this technology as their main roots. The product that been developed by using this technology has higher quality and most commercialized by many company. In this project, a pattern for housing of 'Air Pressure Plug' is going to be developed. A pattern is a form template or model which can be used to make or to generate another objects or parts of an object. The product produced by the rapid prototype machine used a sketch as a guide to develop the shape. The 3D sketches in .stl format existed being the guided to make the housing. The design begins with identifying the product (air pressure plug) specification and functions, followed by some sketches of the housing. The next step was analyzing the sketching and draws the exact dimension. The drawing will be drawn in CAD software (Solidworks). After the drawing finished, the file was converted into .stl format to slice the drawing to easy the machine doing the process. After completely done the prototype, it will through some analyze before casting process will take place. Finally, design and process guidelines and procedures to produce the housing pattern were documented.

ABSTRAK

Pada masa kini, kaedah ‘rapid prototype engineering’ lebih dikenali dalam teknologi pemprosesan secara berterusan dan cepat. Hampir semua produk dalam industri perkilangan mengguanakan kaedah ini sebagai kaedah utama untuk penghasilan produk. Produk yang di hasilkan melalui teknologi ini lebih berkualiti dan lebih komersil. Untuk tugasan ini, satu paten untuk perumah ’air pressure plug’ akan dihasilkan. Paten adalah bentuk atau model yang digunakan untuk menghasilkan sesuatu objek yang lain. Produk yang dihasilkan melalui kaedah ini menggunakan lakaran untuk membantu mendapatkan bentuk yang dikehendaki. Merekabentuk bermula dengan mengenalpasti spesifikasi dan kegunaan produk (air pressure plug) diikuti dengan lakaran beberapa perumah. Kaedah seterusnya ialah menganalisa lakaran dan melukis produk mengikut ukuran sebenar. Lukisan ini akan dilukis dalam program CAD (Solidworks). Setelah selesai, lukisan ini akan disimpan dalam format .stl. Setelah selesai semuanya, proses penuangan akan dijalankan selepas ujikaji dijalankan. Akhirnya, panduan untuk merekabentuk, proses dan juga prosedur untuk menghasilkan paten akan didokumentasikan.

DEDICATION

Specially dedicated to; My beloved father, **Mokhtar Zaid** and my mother, **Jauriah Kasim** who are very concern, understanding, patient and supporting me. Thanks for everything. To my respectful supervisor, **Mr. Nik Mohd Farid Bin Che Zainal Abidin** for his constructive guidance, encouragement and patience in fulfilling my aspiration in completing this project. To all my siblings and my friends, I also would like to say thank you. The work and success will never be achieved without all of you.

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CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION OF THE PROJECT

Rapid prototyping (RP) is a technology used to fabricate physical objects by using direct CAD data sources and is the most common name in these technologies. In order to form the objects, they add and bond the materials in layers thus making them a unique method. These systems are also recognized as additive fabrication, three dimensional printing, solid freeform fabrication (SFF) and layered manufacturing. RP has the potential to introduce new products more frequent and responds to the demands of niche markets by reducing the progress times. Once it is certain that RP route is going to be practiced, then the RP method to be adopted will be chose. The RP method depends on the amount of product concerned, the complexity, and the use of the RP model. Other than that, RP method also depends on the purpose of utilization of the model. The examples are as stated below:

- Patterns for castings
- Electrodes for electrodischarge machining (EDM) of dies
- Marketing models

For models that are used to manufacture castings in the finished product, it is vital to keep in mind that the testing applied are limited and is only used to ensure that the components do fit together.

In this project, the application of rapid prototype will be use in producing a housing pattern of air pressure plug. This project will focus on the usage of Rapid Prototype Technology in real situation by developing a product rapidly and fabricating the functional product by casting processes. The methodologies for this research involve the designation part and the material selection for casting process.

The machine used to construct the prototype in this project is 3D-printer machine. The 3D-printer machine used is a Zprinter 310 Plus model which has been manufactured by Z Corporation (according to Massachusetts Institute of Technology). This 3D-printer consists of an inkjet printing systems; where layer of powder are selectively bonded by 'laying' a water-based adhesive from inkjet print head. The print head actually is capable to print the shape for each cross-section of the prototype as determined by a CAD file. The material to be used is called zp130 powder-based and it is specially made for Zprinter 310 Plus printer.

The casting process involved in this fabrication of a functional product is casting process with core. A core is a full-scale model of the interior surfaces of the part. It is inserted into the mold cavity prior to pouring, so that the molten metal will flow and solidify between the mold cavity and the core to form the casting's external and internal surfaces. The core is usually made of sand and compacted into the desired shape. One of the important factor that must be considered in casting is the actual size of the core must include allowances for shrinkage of the solidifying material. As for this project, the material used to fabricate the housing of Air Pressure Plug is aluminum due to its high strength-to-weight ratio and lightweight properties.

Finally, the housing of air pressure plug will be produced by determining the right properties of the product such as the shape and dimensions. Therefore, the process of rapid prototype and casting with core is applied and the application of producing the housing product will be studied further in this research.

1.2 OBJECTIVES OF THE PROJECT

The three main objectives that have to be considered in this research are as stated below:

I. To model a housing of air pressure plug using SolidWorks software
II. To apply the rapid prototype engineering method
III. To produce the housing of air pressure plug with casting process.

1.2.1 AIM OF STUDY

The aim of this project is to develop a functioning housing pattern of air pressure plug by using rapid prototype, analyze the product and try to fabricate the product using casting process. The air pressure plug is a combination of several parts and the housing is one of the components combined in an Air Pressure Plug. So, by using rapid prototype, the combination created would function as a die in the process of producing a mould for casting. Some analysis and investigation have to be taken to choose the right material for casting process that suits the characteristics of the housing of Air Pressure Plug.

1.2.2 PROBLEM STATEMENT

The existing product of the housing of Air Pressure Plug is only a visual prototype and it is not functioning. Therefore in this project, a functioning product of the housing of the Air Pressure Plug need to be develops. The manufacturing process involves in developing a functional product is rapid prototype that uses a 3D-Printer Machine and casting process that uses core to produce hollow parts with internal cavities or passages; one of the physical characteristic of the housing of the Air Pressure Plug. A die model needs to be designed and manufactured to enable the production of the housing of Air Pressure Plug in casting process. The model has to be manufactured in a short period of time but with low cost. Therefore, Rapid Prototyping (RP) is the technology chose to provide the ability to build or fabricate prototypes for initial design of this product and the suitable process for this research is by using 3D-Printer Machine. In producing the prototypes needed, the material used depends on the RP machine itself. However in this project, the

materials being used are Zp130 powder-based that is specially made for Zprinter 310 Plus printer. One of the properties of the metal used in fabricating the housing of air pressure plug is that it must be able to endure high temperature but lightweight as a characteristic of mobile product, therefore aluminum is chose as the suitable material. The housing of Air Pressure Plug has hollow parts with internal surface; therefore the casting process with core is used in manufacturing it.

1.3 SCOPE OF THE PROJECT

The scopes of this research involve designing a mold cavity and any prototype in automotive field and fabricating functional product with internal and external surfaces. The sketches by 2D and 3D can be use as a guide to select and then produce a new prototype to analyze before proceed to produce the real product. If the product resulting fails the specification needed, it can always be redesigned and another new prototype can be reproduced, following the analyzing and testing procedure. By implementing this approach, material, manufacturing cost and labor cost can be decreased. Other than that, the cycle time can also be decreased and this allows the right product to be manufactured after each failure by correcting the parameters used. This will ease the manufacturer in changing the design and parameters before preceding the process of manufacturing the product. Thus, the manufacturer can changes the design and do some correction before the real product is produced.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter describes about the precedent studies related to the research which had been done by the previous researcher in rapid prototyping engineering field. This chapter will include some of their ideas in applications and the methods that are used in this study. In this chapter, several types of rapid prototyping engineering and casting process are summarized and their application on the related fields is stated.

2.2 RAPID MANUFACTURING

Rapid manufacturing is defined as the use of a computer aided design (CAD)-based automated additive manufacturing process to construct parts that are used directly as finished product or component. The additive manufactured parts may be post-processed in some way by techniques such as infiltration, bead blasting, painting and plating. The term additive manufacturing is used in preference to layer manufacturing as it is likely that some future rapid manufacturing systems will operate in a multi-axis fashion. Rapid prototyping process can be classified into three major groups; subtractive, additives and virtual. As the name imply, subtractive processes involve material removal from a workpiece that is larger than the final part. Additive processes build up a part by adding material incrementally to produce the part. Virtual processes use advanced computer-based visualization technologies [Kalpakjian, 2006].

There are many advantages in being able to produce a physical model quickly and relatively cheaply using rapid prototyping such as:

- produces visual models for market research, publicity and packaging
- reduces 'time to market' for a new product
- generates customer goodwill through improved quality
- expands the product range
- reduces the cost and fear of failure
- improves design communication and helps eliminate design mistakes

However, rapid prototyping also has its own disadvantages as stated below:

- Rapid prototyping is not solution every fabrication problem. Even it is so easy way, but the CNC is more economical, widely understood and available. However it can't do the complex geometry shape
- The materials used in rapid prototyping are limited and depend on the method chosen. However the range and properties are available and growing quickly now
- The names of specific process themselves are also often used as synonyms for the entire field. Among these are stereolithography (SLA apparatus), selective laser

sintering (SLS), fused deposition manufacturing (FDM). Each these technologies has its singular strength and weaknesses

- In aspect of accuracy, the FDM machine usually is lower than SLS and CNC. The accuracy and the surface finish are shown better dimensional tolerance although ABS material properties are superior

2.3 RAPID PROTOTYPE TECHNOLOGIES

Rapid prototyping device can be classified into three major groups: subtractive, additive and virtual. As the names imply, subtractive is a process where material is remove from the workpiece. Additive process involves adding material incrementally as a process of building up a part while virtual process used advanced computer-based visualizations. [Kalpakjian, 2006]

2.3.1 SUBTRACTIVE RAPID PROTOTYPE

Subtractive rapid prototyping technology involves material removal from a workpiece that is larger than the final part. Making a prototype traditionally has involved a series of processes using a variety of tooling and machines, and it usually takes anywhere from weeks to month depending on part complexity and size. This approach requires skilled operators using material removal by machining and finishing operations, one by one until the prototype is completed. To speed this process, subtractive processes increasingly use computer-based technologies such as: [Kalpakjian, 2006]

- Computer-based drafting packages, which can produce three-dimensional representations of parts.
- Interpretation software, which can translate the CAD file into a format usable by manufacturing software.
- Manufacturing software, which is capable of planning the operations required to produce the desired shape.
- Computer-numerical-control machinery with the capabilities necessary to produce the parts.

When a prototype is required only for the purpose of shape verification, a soft material is used as the workpiece in order to reduce or avoid any machining difficulties. The material intended for use in the actual application also can be machined, but this operation maybe more time consuming, depending on the machinability of the material. Depending on part complexity and machining capabilities, prototypes can be produced in a matter of from a few days to a few weeks. Subtractive systems can take many forms; they are similar in approach to the manufacturing cells [Kalpakjian, 2006].

Application of subtractive rapid prototyping provides many benefits. Some of them are as follows:

- Increase productivity and save cost
- Finished product in short period of time
- No more waste internal resources and man-hours
- Wide variety of materials can be machined
- High tolerance machining

2.3.2 ADDITIVE RAPID PROTOTYPE

Additive rapid prototyping operations all build parts in layers; consist of stereolithography, fused-deposition modeling, ballistic-particle manufacturing, three-dimensional printing, selective laser sintering and laminated-object manufacturing. In order to visualize the methodology used, it is beneficial to think of constructing a loaf of bread by stacking and bonding individual slices on top of each other. All of the processes described in this section build parts slice-by-slice. The main difference between the various additive processes lies in the method of producing the individual slices, which are typically 0.1 to 0.5 mm thick and can be thicker for some systems. [Kalpakjian, 2006]
All additive operations require elaborate software. The first step is to obtain a CAD file description of the part. The computer then constructs slices of the three-dimensional part. Each slice is analyzed separately and a set of instructions is compiled in order to provide the rapid prototyping machine with detailed information regarding the manufacturer of the part. It should be recognized that the setup and finishing operations are very labor