UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND SIMULATION OF INVESTMENT CASTING MOLD FOR OBSOLETE AUTOMOTIVE PART

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Manufacturing Engineering Technology (Product Design) (Hons.)

by

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FACULTY OF ENGINEERING TECHNOLOGY
2015

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TAJUK: **Design and Simulation of Investment Casting Mold for Obsolete Automotive Part**

SESI PENGAJIAN: **2014/15 Semester 1**

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor's Degree in Manufacturing Engineering Technology (Product Design) (Hons.). The member of the supervisory is as follow:

……

(Project Supervisor)

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ABSTRAK

Projek ini menerangkan mengenai reka bentuk dan simulasi acuan tuangan pelaburan untuk bahagian automotif yang sudah dihentikan pengeluarannya menggunakan perisian SolidWorks dan AnyCasting. Skop projek ini adalah untuk menghasilkan data 3D CAD untuk bahagian automotif tersebut serta menghasilkan reka bentuk dan analisis dari acuan tersebut. Tuangan pelaburan menghasilkan pengeluaran bahagian-bahagian dengan ketepatan yang lebih baik , kebolehulangan, fleksibiliti dan integriti dalam pelbagai logam yang tinggi aloi. Tuangan pelaburan juga boleh mengeluarkan bentuk rumit yang sukar atau mustahil dihasilkan, tetapi ia tetap memerlukan kemasan permukaan bagi bahagian tersebut. Projek ini fokus kepada mereka bentuk acuan menggunakan perisian SolidWorks dan analisis masa isian, masa pemejalan dan kecacatan pada reka bentuk acuan tuangan pelaburan menggunakan perisian simulasi AnyCasting. Daripada keputusan simulasi, masa isian untuk reka bentuk 1, 2 dan 3 ialah 12.4122, 5.2307 dan 6.6537 saat mengikut turutan. Daripada keputusan simulasi tersebut, kecacatan yang berlaku pada reka bentuk yang telah dibuat terdapat di kedua-dua produk dan acuan untuk reka bentuk 1 dan 3, manakala kecacatan yang berlaku pada reka bentuk 2 hanya pada acuan. Reka bentuk terbaik yang dipilih untuk projek ini ialah reka bentuk 2 kerana masa untuk acuan penuh untuk reka bentuk tersebut paling cepat dan kecacatan yang berlaku hanya pada acuan dan bukan pada produk walaupun masa untuk memejal untuk reka bentuk tersebut paling lambat.

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ABSTRACT

This project describes about the design and simulation of investment casting mold for obsolete automotive part using SolidWorks and AnyCasting software. The scope of this project is to generate the 3D CAD data of obsolete automotive part as well as generating investment casting mold design analysis and simulation of the mold design. Investment casting here allocates the production of parts with better accuracy, repeatability, versatility and integrity in a variety of metals and high-performances alloys. Investment casting can manufacture complicated shapes that would be difficult or impossible with die casting, yet like that process, it needs little surface finishing and only minor machining. This project is focusing on designing the mold design using SolidWorks software and the analysis of the filling time, solidification time and defects on the mold design of the investment casting using AnyCasting software simulation. Based on the results that are obtained from the simulation, it found out that the filling time of Design 1, Design 2 and Design 3 are 12.4122, 5.2307 and 6.6537 seconds respectively. From the simulation results, it also found out the defects presence on the product and mold of the Design 1 and Design 3 while Design 2 had only defects on the mold. The best design for this project is Design 2 because the filling time for the mold design fastest compared to other two design and the defects presence only on the mold not on the product although the solidification time for the mold design slowest.

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DEDICATION

To my beloved parents, siblings and fellow friends

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ACKNOWLEDGEMENT

First and foremost, I would like to take this opportunity to express my sincere acknowledgement and gratitude to my supervisor Mr. Mohamad Ridzuan Bin Mohamad Kamal from the Faculty of Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) for his necessary supervision, support and encouragement towards the completion of this thesis.

I would also like to express my greatest gratitude to Mr. Ismail Bin Abu Shah and Mr. Mohd. Qadafie Bin Ibrahim for this project for their advices and suggestions in evaluation of this project. Special thanks to UTeM short term grant funding for the financial support throughout this project.

Special thanks to all my friends, my beloved mother and father, my supportive siblings for their moral support in completing this degree. Lastly, thank you to everyone who had been to the crucial parts of realization of this project.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

Al	-	Aluminium
Si	-	Silicon
C	-	Carbon
CAD	-	Computer Aided Drawing
CAM	-	Computer Aided Manufacture
RE	-	Reverse Engineering
CNC	-	Computer Numerical Control
HSM	-	High Speed Machining
FEA	-	Finite Element Analysis
CFD	-	Computational Fluid Dynamics
CAE	-	Computer Aided Engineering
UTeM	-	Universiti Teknikal Malaysia Melaka

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CHAPTER 1
INTRODUCTION

1.1 Background

On 28th December 2013, the well-known Honda EX5 Dream 100 has roll out for its final production since its appearance in 1987. This motorcycles is also known with the code C100B and C100MB, and has been a very famous bike for the people whether young or old, rich or not, for 26 exhilarating years. Since then, 2,051,530 units been sold and make its way to Malaysian roads. This motorcycle has been lovable reliable bike that known for its toughness, low maintenance and easy to ride and become favourite to the people until now.

Due to this event, the demand for the automotive parts of this motorcycle peaked as the production of this motorcycle stopped. Most of the people look up for the spare parts of this motorcycle when they were having problems with this type of motorcycle. Because of the production of this motorcycle was no longer produced or done in mass production, the motorcycle workshop cannot provide sufficient spare parts for their customers to repair their beloved motorcycles.

Most of the automotive parts for this motorcycle made from casting process. The making of automotive parts in huge and mass production for this motorcycle usually uses investment-casting method. Investment casting is an industrial method and was also known as lost-wax casting. Investment casting allocates the production of parts with better accuracy, repeatability, versatility and integrity in a variety of metals and high-performances alloys. Investment casting can manufacture complicated shapes

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that would be difficult or impossible with die casting, yet like that process, it needs little surface finishing and only minor machining.

1.2 Problem Statement

Several problems might occur in producing automotive parts that no longer produced in mass production. First, the generation of the 3D CAD data of obsolete automotive part for this motorcycle might be difficult to be done. The full dimensions of the part will be hard to obtain, as the part is hard to get nowadays. To create this obsolete automotive part for this motorcycle using investment casting, the full dimensions for the generation of 3D CAD data must obtained precisely. Apart from that, the best precision and tolerance from investment casting product will be hard to obtain if the simulation for the investment casting mold does not take places before the investment casting processes are done. Without the analysis from the simulation, the presence of several types of defects on the investment casting product will occur. Therefore, the analysis from the simulation for the investment casting mold must be done before going through with the production of the product to make sure the best product from the investment casting can be made.

1.3 Objectives

The objectives for design and simulation of investment casting mold for obsolete automotive part that wants to be achieve are:

i. To design an obsolete automotive component of intake manifold.
ii. To simulate investment casting mold designs for obsolete automotive part.
iii. To achieve optimum parameter of filling time, solidification time and defects for investment casting product.

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1.4 Work Scope

To make sure the project that was carried out will achieve the objectives stated, which was to design and simulate the investment casting mold of obsolete automotive part, therefore the scope of work for the study proposed in this project will be simple, clear and efficiently organized. The work scopes of this project are:

i. Generating 3D CAD data for intake manifold of Honda EX-5 Dream motorcycle.
ii. Optimizing and improving the current mold design of investment casting by generating several 3D CAD data of mold designs based on selected part.
iii. Simulation of the mold design of investment casting using AnyCasting software.
iv. Obtaining the best mold design of investment casting based on 3 parameters that are filling time, solidification time and defects.

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CHAPTER 2
LITERATURE REVIEW

A literature review is a process of evaluating text written or published information to reflect on the critical points of current knowledge including substantive result, as well as theoretical and methodological contributions to a particular topic. Literature review may considered by research through books, journal, article, thesis, website or any other resources. In this project, the literature review will be focusing on the several topics that related to this project.

2.1 Reverse Engineering

Reverse engineering (RE), is defined as legally authorized technique of copying a technology which begins with an existing product and works backward to figure out how it does and what it does in order to duplicate or enhance the project. (Hambali Bin Boejang, 2013) In other word, reverse engineering is a method that consists of discovering the technological principles of a device, object or system through analysis of its structure, function and operation.

RE regularly occupies disassembling something that is a mechanical device, electronic component, computer program, or biological, chemical or organic matter and analyzing its components and working in detail. This is either purposes of maintenance or to support creation of a new product or program that does the same thing, without simply duplicating or using the original. The RE process is consisting of:

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i. Digitization of the object, data capturing.
ii. Processing of measured data.
iii. Creation of CAD model.
iv. Prototype.

2.1.1 Point Cloud Data and Digitizing

The RE method begins with digitizing or scanning of an object or part for the creation of digital illustration of the object itself. This illustration known as point cloud as follows:

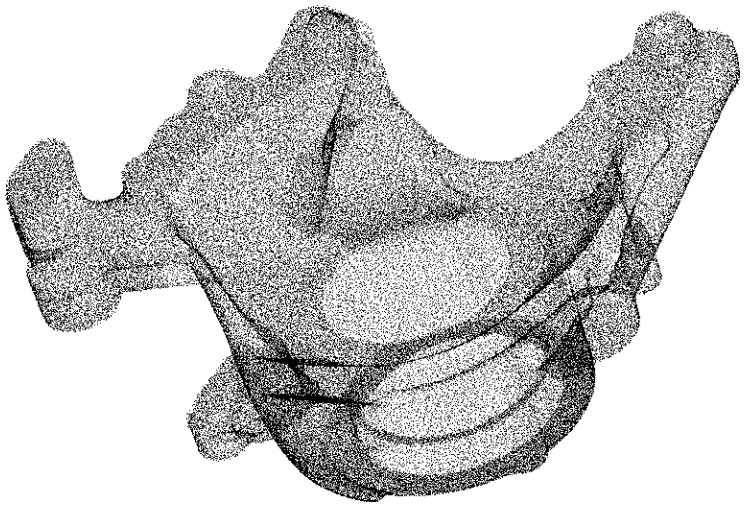

Figure 2.1 - Point cloud data of water pump.

Digitizing refers to the process of picking off an individual point's information, and scanning on the other hand refers to the method of collecting surface data i.e. through analogue probe or laser sintering. Both of digitizing and scanning are used interchangeably, and used to define data acquirement process through RE.

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2.1.2 Reverse Engineering Process Chain

The development of the product starts with a physical mock-up made out of clay or wood. The early stage of RE started with digitizing of an object for data or information acquirement. The comprehensive RE process chain illustrated as follows:

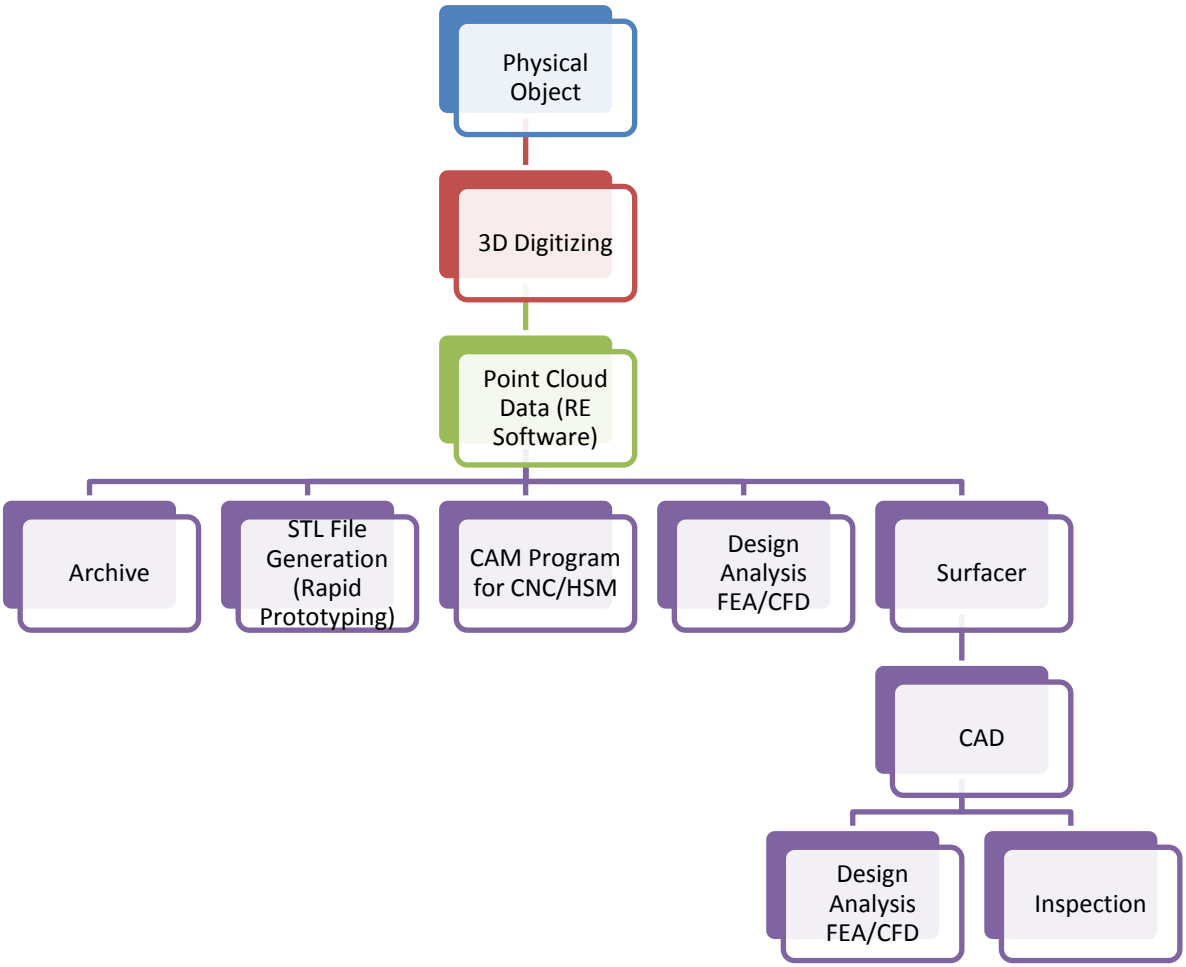

Figure 2.2 - Comprehensive RE process chain.

Once the object is scanned, the point cloud data can be altered via RE software (i.e. Rapidform, CopyCAD, Geomagic, etc) accordingly with respect to a particular application. The scanned data can be directly used for RP, CAM and analysis from the RE software. A solid model also can be generated from the surface data as well. Inspection and analysis together with simulation can be finished afterward for design optimization, visualization and verification.

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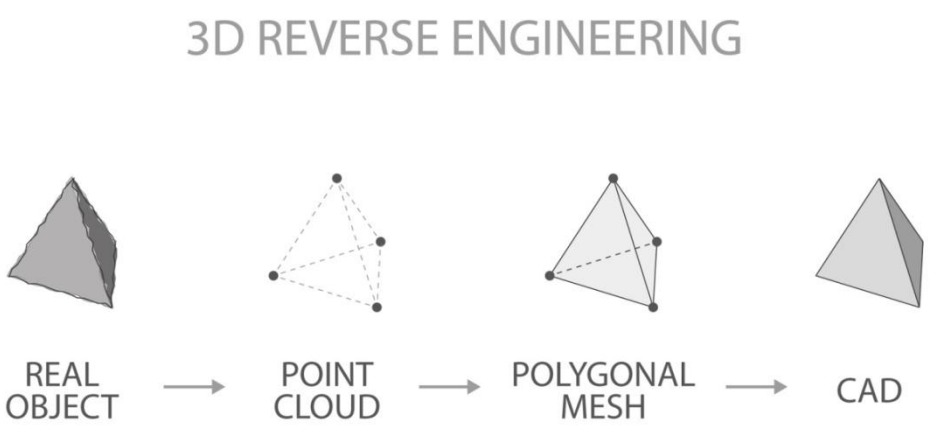

Figure 2.3 - 3D reverse engineering file conversion.

2.1.3 Application of Reverse Engineering

There are many applications of reverse engineering that important nowadays. Most of them are focused on the design of a new product, reproduction of an existing product and improving quality and efficiency of existing product or parts. These are some major applications of reverse engineering according to different field:

- Manufacturing engineering.
    i. To create 3D virtual model of an existing physical part for use in 3D CAD, CAM, CAE or other software.
    ii. To make a digital 3D record of own products.
    iii. To assess competitors' products.
    iv. To analyze the working of a product.
    v. To identify potential patent infringement.
- Software engineering.
    i. To extract design and implementation information.
    ii. To detect and neutralize virus and malware.

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- Chemical engineering.
    i. To determine chemical composition.
    ii. To substitute or improve recipes to stimulate or improve the products performance.
- Film-Entertainment industry.
    i. Animated objects are imparted motion using the reverse engineered human skeletons.
- Medical field.
    i. Applications in orthopaedic, dental and reconstructive surgery.
    ii. Imaging, modelling and replication of patient's bone structure.
    iii. Models can be viewed and physically handled before surgery, benefiting in evaluation of the procedure and implant fit in difficult cases.
    iv. Less risk to the patient and reduced cost through saving in theatre time.

2.2 CAD/CAM

Computer Aided Design (CAD) includes the use of computer hardware and graphics software to create design drawings. Modern CAD tools allow the designer to easily produce very precise, accurate and realistic images of products to be manufactured.

Computer Aided Manufacturing (CAM) is a system that used computer controlled production machines to produce finished products automatically. CAD and CAM work together in that the digital model generated in CAD is converted to the CAM software package. The CAM software needs to identify the physical shape of the product (CAD model) before it can create a proper set of fabrication commands to a production machine.

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2.2.1 SolidWorks Software

The SolidWorks CAD software is a mechanical design automation application that lets designers quickly sketch out ideas, test with features and dimensions, and generate models and detailed drawings.

2.2.1.1 SolidWorks Fundamentals

A SolidWorks model consists of 3D geometry that describes its edges, faces, and surfaces. The SolidWorks software helps to design models quickly and precisely. SolidWorks models are defined by 3D design and also based on components.

SolidWorks employs a 3D design approach as when a part was designed, a 3D model is created from the initial sketches to the final result. 2D drawings can also be generated or mate components consisting of parts or subassemblies to create 3D assemblies from this model. 2D drawings of 3D assemblies can also be created from the models.

One of the most powerful features in the SolidWorks application is that any modification made to a part was reflected in all associated drawings or assemblies.

2.2.1.2 Parts

Parts are the building blocks of every SolidWorks model. Each assembly and drawing created was made from parts.

There were many tools for making parts in SolidWorks software and used for many parts such as Extrude, Extrude Cut, Sweep and more. Each section started with the design approach for each part, including a high-level overview of the tools that create the part.

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