



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**REVERSE ENGINEERING ON 3D SCANNED DATA FOR  
CAD/CAM PROGRAMMING USING DELCAM AND CATIA V5  
SOFTWARE**

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

by

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## BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

**TAJUK: Reverse Engineering On 3D Scanned Data For CAD/CAM Programming Using Delcam And Catia V5 Software**

**SESI PENGAJIAN: 2015/16 Semester 1**

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I hereby, declared this report entitled “Reverse Engineering On 3D Scanned Data for CAD/CAM Programming Using Delcam and Catia V5 Software” is the results of my own research except as cited in references.

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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 of Engineering Technology (Technology of Manufacturing Engineering Process and Technology) (Hons.). The member of the supervisory is as follow:

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Mr. Muhammad Syafik Bin Jumali  
(Project Supervisor)

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Mr. Syahrul Azwan Bin Sundi @ Suandi  
(Project Co-Supervisor)

## ABSTRACT

Reverse engineering (RE) is a very important branch of geometrically design and manufacture application area, and this technique are an important step in the product development cycle. The use of reverse engineering (RE) will reduce the manufacturing time and costs. Reverse engineering (RE) is the process of producing design details in the form of CAD model from the physical part in the process of the product design. After that, CAD models are used for manufacturing applications. The objective of this project is to make a comparison between both CAD/CAM programming namely DELCAM and CATIA V5 and to investigate the machining result for both software by focusing on surface roughness. Reverse engineering method is a best way to produce the form of CAD model from a physical part by using the 3D scanner. It is a rapid process to copy from physical part. To get a complete CAD model, the CAD model must be edited using Geomagic Studio software. Then, do the CAD/CAM programming by using Catia V5 and Delcam Software. Afterward, does the machining process using 3-Axis CNC Milling Machine and the result of the machining part will be analyzed based on surface roughness using surface roughness tester. Seven point location areas has been choose for surface roughness test, every each point take at least five reading. Refer to the result of surface roughness for both sample, the delcam sample is better compared to Catia V5 sample. For future work, while do the CAM/CAD programming the position of stock must be same for both software because it will affect the surface roughness of the sample during machining process. Uses are newest technology of 3D scanner, easy for user to used, multifunction and the scanning process time is short.

## ABSTRAK

Sistem Kejuruteraan Undur (RE) adalah satu cabang yang sangat penting dalam reka bentuk geometri dan tempat pungguaa pengeluar dan teknik ini adalah satu langkah yang penting dalam kitaran pembangunan produk. Penggunaan kejuruteraan Undur (RE) akan mengurangkan masa pembuatan dan kos. Kejuruteraan Undur (RE) adalah proses menghasilkan butiran reka bentuk dalam bentuk CAD model dari bahagian fizikal dalam proses reka bentuk produk. Selepas itu, CAD model digunakan untuk aplikasi pembuatan. Objektif projek ini adalah untuk membuat perbandingan di antara kedua-dua program CAD / CAM iaitu Delcam dan CATIA V5 dan untuk menyiasat hasil pemesinan untuk kedua-dua keputusan permesinan dengan memberi tumpuan kepada kekasaran permukaan. Kaedah kejuruteraan undur adalah cara yang terbaik untuk menghasilkan bentuk model CAD dari bahagian fizikal dengan menggunakan pengimbas 3D. Ia adalah satu proses yang cepat untuk menyalin dari bahagian fizikal. Untuk mendapatkan CAD model lengkap, CAD model mesti diubahsuai menggunakan perisian Geomagic Studio. Selepas itu, lakukan pengaturcaraan CAD / CAM dengan menggunakan perisian Catia V5 dan Delcam . Selepas itu, lakukan proses pemesinan menggunakan 3-paksi CNC Mesin milling dan hasil daripada bahagian pemesinan akan dianalisis berdasarkan kekasaran permukaan menggunakan penguji kekasaran permukaan. Tujuh mata kawasan lokasi telah dipilih untuk ujian kekasaran permukaan, setiap titik mengambil sekurang-kurangnya lima bacaan. Merujuk kepada hasil kekasaran permukaan untuk kedua-dua sampel, sampel Delcam adalah lebih baik berbanding dengan sampel Catia V5. Untuk kerja-kerja masa depan, semasa melakukan pengaturcaraan CAM / CAD kedudukan stock mestilah sama bagi kedua-dua perisian kerana ia akan memberi kesan kepada kekasaran permukaan sampel semasa melakukan proses pemesinan. Guna teknologi pengimbas 3D yang terbaru supaya mudah kepada pengguna untuk pengguna, pelbagai fungsi dan masa proses pengimbas 3D yang singkat dan cepat.

## **DEDICATIONS**

Special dedication to my beloved parents,

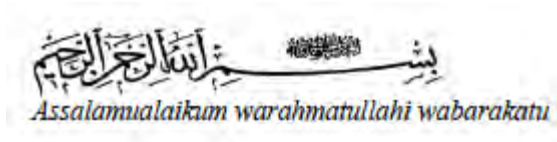
Mr. Rafeek Ahmad bin Mohamed Sidek and Mrs. Rosni binti Sidik

Also for my kind hearted supervisor and co-supervisor,

Mr. Muhammad Syafik Bin Jumali and Mr. Syahrul Azwan Bin Sundi @ Suandi

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# CHAPTER 1

## INTRODUCTION

### 1.1 Background of Study

Nowadays, competitive pressure reaches the point, where rapid product design and optimization need to be embraced within the product development cycle. A short lead-time in product development is strongly demanded to satisfy needs, resulting from the globalization of manufacturing activities and the changes in market requirements. In engineering areas such as aerospace, automotives, shipbuilding and medicine, it is difficult to create a CAD model of an existing product that has a free-form surface or a sculptured surface. In these cases, reverse engineering (RE) is an efficient approach to significantly reduce the product development cycle (Yu Zhang, 2013). Reverse Engineering (RE) is the decompilation of any application, regardless of the programming language that was used to create it, so that one can acquire its source code or any part of it. In Reverse Engineering (RE) have many tools and method. 3D scanner is one of the tools that uses in Reverse Engineering (RE). 3D Scanners are a device that analyses a real-world object or environment to collect data on its shape and possibly its appearance. VX Element is 3D scanner software to preview the CAD model after done scanning process.



Geomagic Studio Software is software to edit the CAD model to get a complete and better shape. Geomagic Studio is an easy-to-use software system designed to help you take advantage of generating CAD models directly from free-form scan data. You will see the most benefit with Geomagic Studio if projects involve generating CAD data of free form shapes, non-parametric models and quick conversion of scan to CAD ([www.3dscanco.com](http://www.3dscanco.com), accessed on 20 Mei 2015).

CAD/CAM Programming is a computer software use for technical data from a database in the design and production stages. Information on parts, material, tools and machine is integrated. Computer-Aided Design (CAD) allows the design in a computer environment, and Computer-Aided Manufacturing (CAM) is used to manage program and production stages on a computer. Catia V5 and Delcam is one of the software contained in the CAD/CAM programming. CATIA (Computer Aided Three-dimensional Interactive Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Dassault Systems and marketed worldwide by IBM. CATIA is the cornerstone of the Dassault Systemes product lifecycle management (PLM) software suite ([www.firstratemold.com](http://www.firstratemold.com), accessed on 20 April 2015). DELCAM software is one of the world's leading suppliers of advanced CAD/CAM solutions for the manufacturing industry. Delcam's range of design, manufacturing and inspection software provides complete, automated CAD/CAM solutions, to take complex-shaped products from concept to reality. It is now the largest developer of product design and manufacturing software in the UK, with subsidiaries in North America, Europe and Asia. Delcam's software is used by more than 50,000 organisations in over 80 countries ([www.delcam.com](http://www.delcam.com), accessed on 20 April 2015).

Computerized numerical control (CNC) is the term used when the control system utilizes an internal computer. The internal computer allows for the following: storage of additional programs, program editing, running of program from memory, machine and control diagnostics, special routines, and inch/metric-incremental/absolute switch ability. CNC Machine have three, four and five-axis, but in this project only focus on three-axis only. accomplished in two-axis combinations by y feeding the table or cross-slide in the XY, XZ or YZ planes in a predetermined path and distance from the machine spindle or headstock. The CAD model will be machine using 3-Axis CNC Milling Machine and will be analyze on surface roughness and dimensional accuracy (Thomas M. Crandell, 2003).

Coordinate Measuring Machine (CMM) is use to verify the dimensional accuracy of machining part. Coordinate measuring Machine (CMM) are extremely powerful metrological instruments, enable to locate point coordinates on three-dimensional structures at the same time that they integrate both dimensions and the orthogonal relationships. Surface roughness tester is to verify a condition surface roughness of machining part after done by using CNC Milling Machine. The evaluation of surface roughness of machined parts using a direct contact method has limited flexibility in handling the different geometrical parts to be measured. Surface roughness also affects several functional attributes of parts, such as friction, wear and tear, light reflection, heat transmission, ability of distributing and holding a lubricant, coating etc.

## **1.2 Problem Statement**

When a manufacturing company designing a product, engineers usually using standard geometric shapes such as lines, circles and arcs. These features are combined to shaping parallel faces, perpendicular intersections, and symmetrical surfaces. An existing part, however, has been subjected to forces introduced in the process used to manufacture the part which formed slight to major deviations from the design.

In the automotive company, they have to update especially design and technology of their newest car like shape, system, material and other. So the engineer hard to have a drawing, tough to get the part that their need in a CAD model and need a part from other automotive companies to modify. So they need a technology that can copy in actual part quickly, can preview the part in a CAD model, can modify a part in CAD model, and it is the rapid process.

In reverse engineering applications it is not desirable to copy these deviations. The goal of reverse engineering in these applications is to capture the engineering principles used in the design of the part, for modification of the part and not to make an exact copy of the physical part. To successfully use reverse engineering in these applications, specialized software and engineering analysis is required in this project.

### **1.3 Project Objective**

The object of the project is:

1. To make a comparison between both CAD/CAM programming namely DELCAM and CATIA V5.
2. To investigate the machining result for both software process focusing on surface roughness.

### **1.4 Project Scope**

The scope of project will be focused on:

1. This project will be focusing on two types of CAD / CAM programming which are CATIA V5 and DELCAM Software.
2. The part which is used in the research is an actual part that has been scanned using a 3D scanner.
3. Using CNC 3-axis machine to produce the part that have been scanned and prepare the CAD/CAM programming using CATIA V5 and DELCAM.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Reverse Engineering**

##### **2.1.1 What is Reverse Engineering**

Engineering is the process of designing, manufacturing, assembling, and maintaining products and systems. There are two types of engineering, forward engineering and reverse engineering. Forward engineering is the traditional process of moving from high-level abstractions and logical designs to the physical implementation of a system. In some situations, there may be a physical part/ product without any technical details, such as drawings, bills-of-material, or without engineering data. The process of duplicating an existing part, subassembly, or product, without drawings, documentation, or a computer model is known as reverse engineering. Reverse engineering is also defined as the process of obtaining a geometric CAD model from 3-D points acquired by scanning/ digitizing existing parts/products.

Reverse engineering provides a solution to this problem because the physical model is the source of information for the CAD model. This is also referred to as the physical-to-digital process depicted in Figure 2.1. Another reason for reverse engineering is to compress product development cycle times. In the intensely competitive global market, manufacturers are constantly seeking new ways to shorten lead times to market a new product. For example, automotive company need to design a part for a new car in short time. By using reverse engineering, a three-dimensional physical product or clay mock-up can be quickly captured in the digital form, remodeled, and exported for rapid manufacturing using multi-axis CNC machining techniques (Vinesh Raja, 2008).

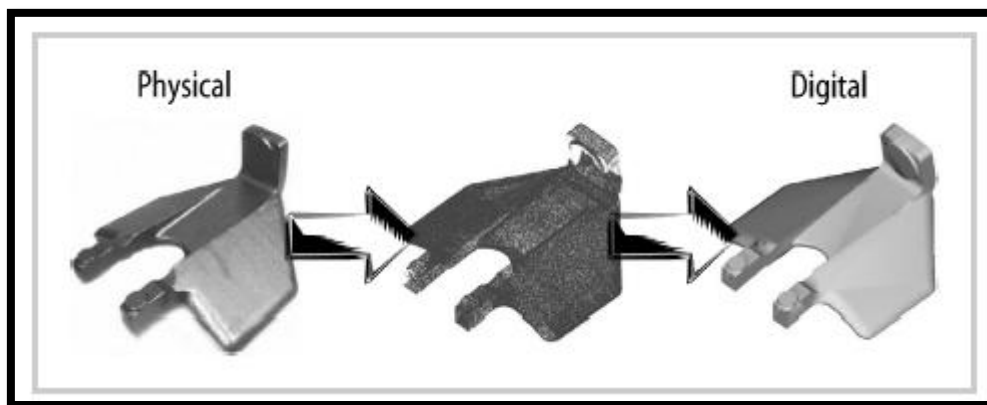


Figure 2.1 : Physical to digital process

Source: Vinesh Raja, 2008

### 2.1.2 Forward Engineering and Reverse Engineering Process

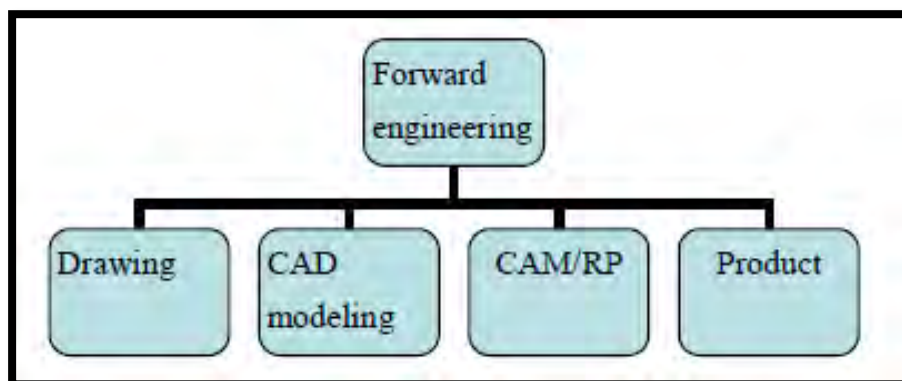


Figure 2.2: Forward engineering process

Source: Zhiliang Xia, 2014

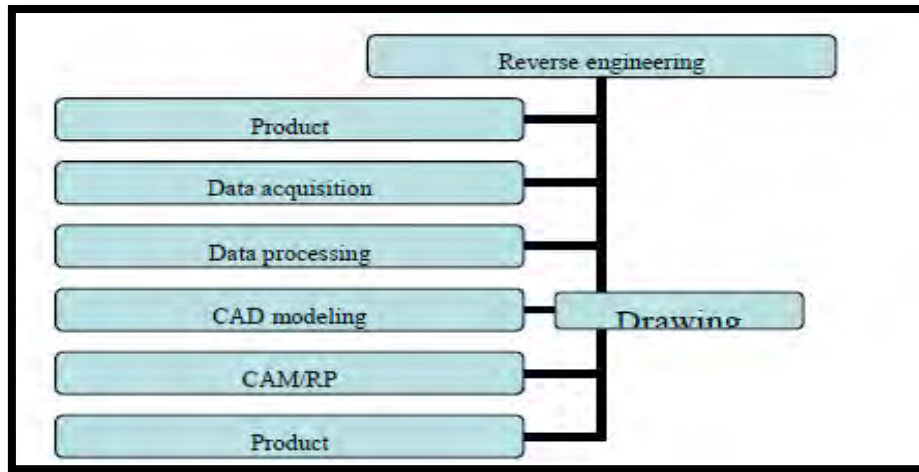


Figure 2.3: Reverse engineering process

Source: Zhiliang Xia, 2014

### 2.1.3 Application of Reverse Engineering

Reverse engineering can be used in various kinds of fields range from automotive to architecture and medical to software applications. Below are some examples of applications of reverse engineering in different kinds of fields.

#### (a) In Aerospace and Ship Hull Craft

Reverse engineering approach has been used by Boeing and other aerospace companies to create digital inventories of spare parts or to convert legacy data into today's CAD environments. Reverse engineering method is a key to the future of aerospace manufacturing as CAD tool. The modern aerospace industry uses reverse engineering for these key reasons (Kumar A., Jain, P.K. & Pathak, P.M., 2013) :

- To create legacy parts that does not have CAD models.
- To overcome obstacles in data exchange.
- To short out problems arising from discrepancies between the CAD master model and the actual tooling or as-built part.
- To confirm the quality and performance by computer-aided inspection and engineering analysis.

**(b) In Mechanical Industry**

The term engineering is generally used to describe the act of creating something beneficial. Reverse engineering has been associated with the copying an original design for competitive purposes. In the manufacturing world today, however, the concept of reverse engineering is being legally applied for producing new products or variations of old products. The term reverse comes from the concept of bi-directional data exchange between the digital and physical worlds. The primary thrust in the early development of computer-aided design (CAD), engineering (CAE) and manufacturing (CAM) was to create a product in a computer and bring the results out to the real world. CAD was supposed to be able to define a simple part or a complex assembly entirely from its dimensional characteristics. CAE components, such as structural or thermal analysis software, would take this digital representation and analyze it. The CAM software would take this same electronic definition and create the paths to cut the tools for part manufacture. Today, the reverse engineering is applying in surface creation of complex geometry mechanical parts such as turbine blade, gear, car engine, casing, gas kit etc (Kumar A., Jain, P.K. & Pathak, P.M., 2013).

**(c) In medical field**

Reverse engineering has been employed in generating data to create dental or surgical prosthetics (artificial body parts which replace missing part), tissue engineered body parts, or for surgical planning. A virtually perfectly custom-fit prosthetic can be duplicated to replace the missing part such as knee joint, femur bones and teeth lost by injury (traumatic) or missing from birth (congenital) or to supplement defective body parts. Figure 2.4 shows how reverse engineering is applied in medical field to produce a prosthetic finger (Toh Ban Sheng, 2009).



Figure 2.4: Prosthetic finger duplicated by reverse engineering

Source: Toh Ban Sheng, 2009

#### **2.1.4 Need for Reverse Engineering**

Reverse Engineering is needed when the original manufacturer of a product no longer produces a product and there is inadequate documentation of the original design. Reverse engineering also applied in product design and development when the original manufacturer no longer exists but the product needs by customer. When the original design documentation has been lost or never existed, RE can be used to redesign the product as well.