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Date : 6 April 2007

**APPLICATION OF MODERN PRODUCT DEVELOPMENT TOOLS IN
PRODUCT DESIGN DEVELOPMENT**

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**This Thesis Is Submitted to Faculty of Mechanical Engineering
As Partial Fulfillment of the Requirements for the Award of the Degree of
Bachelor of Mechanical Engineering (Design & Innovation)**

**Faculty of Mechanical Engineering
Kolej Universiti Teknikal Kebangsaan Malaysia**

2007

DECLARATION

“I hereby declare that this thesis entitled “Application of Modern Product Development Tools in Product Design Development” is my own work and results except for the work that had clearly stated the sources.”

Signature : 

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Date : 6 April 2007

To my dearest parents, sister and brother

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ABSTRACT

Since the past ten years, advance Reverse Engineering and Rapid Prototyping technologies have become important and significant to artist and engineer especially in engineering design development. Normally both of the technologies used in product development and re-design of the existing products. The main advantages in this fields is enhancing the existing product and to reduce the manufacturing cost and time. This project focuses on applying modern product development tools in developing an air freshener front cover and toy car. Modern product development tools such as Computer Aided Design (CAD) software, 3D-scanner and Rapid Prototyping machine are used in this project. There are two product development approaches in this project which are bottom-up approach for air freshener front cover and top-down approach for toy car. The air freshener front cover begins with Reverse Engineering to obtain the scanned data. This scanned data of air freshener is then transferred to CAD and CAD repairing software to develop the CAD data. Eventually, the CAD data of air freshener is transferred into RP machine for mock-up fabrication. On the contrary, the toy car started with the CAD to develop the computational 3D model. The toy car 3D model is then transferred to the RP machine to mock-up. A study was carried out to investigate the deviation between RP model with the CAD data with RE for the toy car and compare the existing air freshener front cover with the mock up. Consequently, the applications of modern development tools have improved the product development.

ABSTRAK

Semenjak sepuluh tahun yang lalu, Reverse Engineering dan Rapid Prototyping yang canggih telah menjadi elemen yang penting untuk artis and jurutera dalam pembangunan rekabentuk kejuruteraan. Lazimnya, kedua-dua teknologi ini digunakan untuk pembangunan produk baru dan rekaan semula bagi produk asal. Kebaikan teknologi ini adalah dapat membaiki mutu produk asal. Di samping itu, juga dapat mengurangkan masa dan kos perbelanjaan pengeluaran produk. Projek ini memberi focus dalam aspek penggunaan perkakas pembangunan produk moden dalam pembangunan penutup depan penyaman udara dan kereta mainan. Perkakas pembangunan produk moden yang dimaksudkan dan digunakan dalam projek ini ialah Computer Aided Design (CAD), 3D-scanner dan Rapid Prototyping. Dua pendekatan digunakan dalam projek ini, iaitu pendekatan “bottom-up” untuk penyaman udara dan pendekatan “top-down” untuk kereta mainan. Pembangunan produk untuk penutup depan penyaman udara dimulakan dengan Reverse Engineering untuk memperolehi data yang diperlukan. Data-data ini dipindahkan kepada CAD dan software pembaikan CAD untuk membina data CAD. Akhirnya, data CAD dipindahkan kepada mesin RP untuk membina mock up. Berlainan daripada pembangunan penutup depan penyaman udara, rekabentuk kereta mainan bermula dengan CAD untuk membina model 3D dengan computer. Model 3D kereta mainan ini dipindahkan ke mesin RP untuk mock up. Satu kajian akan dilaksanakan untuk memerhatikan perbezaan antara model RP, CAD data dengan RE untuk rekabentuk kereta mainan dan membandingkan penutup depan penyaman udara dengan mock up yang dibuat dengan menggunakan RP machine. Kesimpulannya, aplikasi perkakas pembangunan moden telah membaiki mutu pembangunan produk.

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CHAPTER 1

INTRODUCTION

1.1 Introduction of Project

The competition in the world market for manufacturing products has intensified tremendously in recent year. The enormous competition force is that the manufacturing company to produce product in good quality, more quickly and lower cost. In order to increase the competency of a product, time to market is a key factor and play a main role to win in the product competition. Reverse Engineering (RE), Computer Aided Design (CAD) and Rapid Prototyping (RP) process can reduce the time to market of the products. These theses describe the approaches in developing a new product by applying modern product development tools.

1.2 Aim

The aim of the thesis is to use modern product development tools such as RE, RP and CAD to design and develop products. The products that described in this thesis are toy car and air freshener. There are two different design and development of product mentioned in this thesis. The first product development involves the application of RE method to get the physical data of existing air freshener front cover. Then manipulate the scanned data for air freshener front cover to obtain 3D CAD data. The 3D CAD data is then used in prototyping process by using RP machine. On

the other product development, a design of a toy car is design by using CAD software. Then prototype of toy car mock up is build by using RP machine. RE technology is then used to identify the deviation between scanned data and CAD data. Both product developments apply the modern product development tools which could reduce the time to market and quality of the product.

1.3 Objective

The objectives of the thesis are to apply modern product development tools such as Reverse Engineering (RE), Computer Aided Design (CAD) and Rapid Prototyping (RP) to develop the air freshener front cover and toy car. This thesis also develop the product design by apply two product development approaches, which are bottom-up approach for air freshener front cover and top-down approach for toy car.

1.4 Scope

The scope of this thesis is to:

- i. Study on the Reverse Engineering method.
- ii. Manipulate the scanned data to obtain the CAD data for air freshener front cover and toy car.
- iii. Compare scanned data with the CAD data for toy car.
- iv. Study the deviation between the scanned data with CAD data for toy car.
- v. Create a mock up of the products by using the RP machine.

1.5 Thesis Outline

This thesis consists of five chapters. Chapter one (1) is the introduction of the project which contains the objective, aim and scope of the thesis and the thesis outline. Chapter two (2) with the title Literature Review consist of three sub-titles which are RE, CAD and RP. Chapter three (3) is about the methodology for developing the products of this project. Product development flow chart is discussed in this chapter. Chapter four (4) is the result of the comparison CAD data and the scanned data. Chapter five (5) is the discussion of the thesis and Chapter six (6) is the conclusion of the thesis which including the future recommendation.

CHAPTER 2

LITERATURE REVIEW

2.1 REVERSE ENGINEERING

Reverse Engineering (RE) is one of the methods to develop or re-design an existing product. RE is also used in the step of getting the complete dimension of a physical model into a 3D computational model. The RE process is the opposite or inverse of the normal design and manufacturing sequence, which involves object surface scanning process and then transferred into CAD data. However, new scanning technologies combine with advance RE software tools have offered new opportunities for both artists and engineers to convert the real part model into a computational model directly and easily. RE even allows the most complex of sculpted original shape to be prepared for tooling and ultimately mass product [1].

RE helps in prototypes manufacture by Rapid Prototyping (RP). RE also is a process of discovering the technologies principles of a mechanical application through analysis of its structure, function and operation. RE enables CAD to be Master by automatically updating the computer model to reflect changes in physical tool or prototype [2].

2.1.1 Conventional Design and Development Process

The conventional design and development process is started after market research is conducted and then the development process proceeds to product specification and proposals. In this process, as much as possible of the part or product designs are considered and the sketching of the designs are generated. From the product specification process, normally the model or prototype will sculpt manually (such as sculpt tile in clay) from sketches based on the certain materials. This process is very labour intensive and time consuming.

2.1.2 Reverse Engineering in Product Design and Development Process

The new design and development process using RE starts with the market research leading to specification and proposals. The physical part is then scanned using RE applications such as 3D scanner, CMM machine and etc. The scanned image of the part surface design is exported to a package that allows the two-dimensional (2D) data to be modified and editing into 3D surface data.

The 3D scanning system could be contact or non-contact method. Normally for hard surfaces both of the contact and non-contact method are suitable while for the soft surfaces non-contact method is more suitable. This is because the non-contact method captures the data without touching the surface. A 3D scanning system eliminates the manual editing of pixels from 2D scanned image to create 3D data sets. Then a polygonized model is created from 3D data sets. Finally, the 3D sets data are converted to STL file for prototyping by using RP system. The prototype could be produced from resin or other materials, depending on whether the part design is at prototype stage or production stage.

2.1.3 Application in RE

RE is increasingly popular as manufacturers rush to meet the demands of reducing the product development time [3]. By scanning the model and exporting the scanned data into RP machine can reduce time needed to manufacture a tool. While the traditional method using the Coordinate Measuring Machine (CMM) may not too accurate and waste time.

Typical RE Application		
Creating data to refurbish or manufacture a part for which there is no CAD data, or for which the data has become obsolete or lost.	Creating 3D data from an individual, model or sculpture for creating, scaling or reproducing artwork.	Generating data to create dental or surgical prosthetics, tissue-engineered body parts, or for surgical planning.
Inspection and/or Quality Control - Comparing a fabricated part to its CAD description or to a standard item.	Documentation and/or measurement of cultural objects or artifacts in archaeology, paleontology and other scientific fields.	Documentation and reproduction of crime scenes.
Creating 3D data from a model or sculpture for animation in games and movies.	Fitting clothing or footwear to individuals and determining the anthropometry of a population	Architectural and construction documentation and measurement.

Table 2.1: Typical RE Application

1.2.4 Phases of RE

There are two main phases in Reverse Engineering; there are scan phase and application phase. The Scan phase is data capture while the application phase is data manipulation. Two phases to any reverse engineering application:

- **Scanning/ digitizing:** Is the process to collect the requisite data from an object by using different technologies to collect three dimensional data.
- **Data manipulation:** This process is begun after scanning or collecting data. The situation is analogous or scanning two-dimensional printed or photographic material or getting that picture into a presentable form. This process is labour-intensive and quite take time to complete it.

1.2.5 3D Data Acquisition System

Acquisition system can be divided into several hierarchical groups as shown in Figure 2.2. The RE approach can be classified into two main categories which are contact and non-contact method in 3D data acquisition system. The contact method is where the equipment needs to connect or touch to the object when is taking the data. While by using the non-contact method, this method takes data without touching connection between scan object and the equipment. The processes which use the contact method are quite slow and time-consuming compare to the non-contact method.

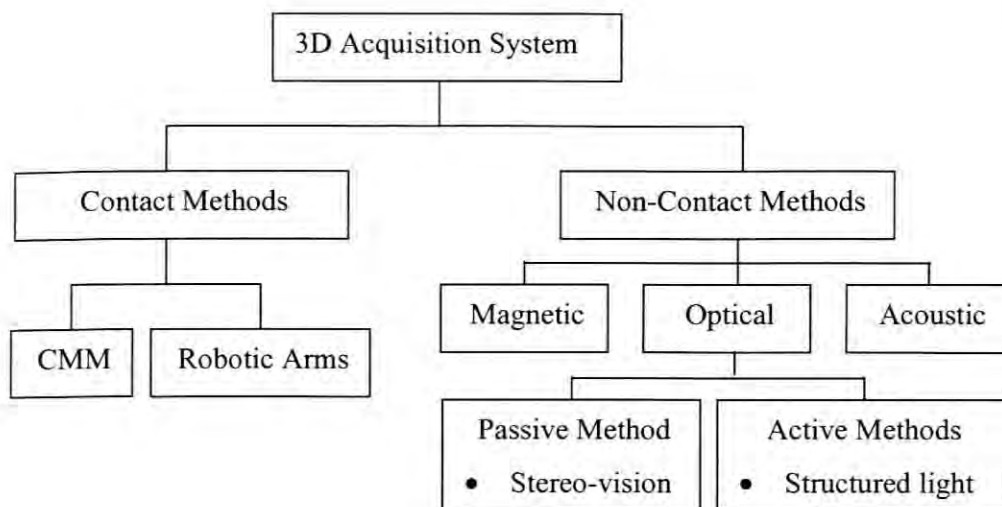


Figure 2. 1: 3D data acquisition Diagram

2.1.6 3D Scanning

A 3D scanning system can scan and digitize the object from the physical model into computer. The scanned data can be used to construct 3D computational model, this three dimension objects are used in many applications such as industrial design and prototyping process.

2.1.7 Contact 3D Method

In general there are two types of the contact 3D scanner, touch triggered probe and analogue probe. The example for the touch triggered probe is Coordinating Measuring Machine (CMM), it is used mostly in industrial measuring and the machine can be very costly. On the other hand, the analogue probe is the stylus continuous touching with the object when scanning probe.

The disadvantages of Contact 3D Scanner method:

- The CMM machine or the articulated arm requires touching the object when scanning and data acquisition. Thus, this might modify and harm the original object.
- Contact scanning method is relatively slow in speed on scanning performance compared to other scanning methods.
- The process to get the data is quite time consuming.
- The machines just can operate on a few hundred hertz compare to the laser scanner.



Figure 2. 2: Coordinate Measuring Machine [4]



Figure 2. 3: Contact RE Using CMM Machine [5]