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AN APPLICATION OF 3D MODELING AND SIMULATION ANALYSIS IN THE DEVELOPMENT OF CONSUMER PRODUCT DESIGN

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This report is presented in
Partial fulfillment of the requirements for the
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Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

APRIL 2010

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"I declare this report is on my own work except for summary and quotes that I have mentioned its sources"

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Date :

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To my beloved mother, Jamilah binti Budin
and my late father, Ibrahim bin Hashim

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Next, I would like to thank my mother, Mrs. Jamilah binti Budin who never stops to support me morally and always give her advice prolonged. I also would like to thank to all my housemates for their help and kindness; Muhyiddin, Febrian, Saifuddin, Faruqy, Shukri and Dzulhisham. Not to forget to my coursemates, BMCD final year students for their opinions and critics.

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ABSTRACT

In recent times, CAD is very important in engineering in order to design and create a sketch drawing mainly technical and engineering drawings for a part or product items. In addition, the use of computers is important in increasing production rate, quality and performance. Meanwhile, CAE (Computer-Aided Engineering) also play the important role in engineering as CAD. CAE is the utilization of information technology to support engineers in tasks such as an analysis, simulation, design, manufacture, planning, diagnosis, and repair. Regarding this study, the area that CAE covers for analysis is Finite Element Analysis. These two elements are the major scope to complete this study which is applied to consumer product. The consumer product that is selected for subject matter in this study is Biceps Curl Machine which is widely used by consumer for fitness purposes to increase biceps development. This project is run by implementing the appropriate design process. During design process, there was an iteration process which made the design have a continuous improvement and some modifications also were been applied to the design. Finite Element Analysis is a method used in this project to determine the failure of the product. The results obtained shows that the product is safe enough to use. This project indicates the steps to produce a consumer product design. The analysis and methods used are well defined in order to achieve the specified objectives.

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ABSTRAK

Pada masa kini, Lukisan Berbantu Komputer sangat penting bagi membantu merekabentuk dan terutamanya membuat lakaran lukisan teknikal dan lukisan kejuruteaan bagi sesebuah komponen atau produk pengguna. Di samping itu, penggunaan komputer memainkan peranan dalam meningkatkan kadar pengeluaran, mutu dan prestasi kerja. Sementara itu, CAE (Kejuruteraan Berbantu Komputer) juga memainkan peranan penting dalam kejuruteraan sama seperti CAD. CAE adalah pemanfaatan teknologi maklumat untuk menyokong tugas-tugas jurutera seperti analisis, simulasi, rekabentuk, pembuatan, perancangan, diagnosis, dan pembaikan. Sesuai dengan kajian ini, bahagian yang meliputi analisis CAE adalah FEA (Analisis Unsur Terhingga). Kedua-dua elemen ini adalah lingkup utama untuk menyelesaikan kajian ini yang diaplikasikan pada produk pengguna. Produk pengguna yang dipilih untuk perkara subjek dalam kajian ini adalah mesin angkat berat yang secara luas digunakan oleh pengguna untuk tujuan kecergasan. Projek ini dijalankan dengan melaksanakan proses rekabentuk yang tepat. Semasa proses rekabentuk, terdapat proses iterasi yang membuat rekabentuk menjalani pembaikan yang berterusan. dan beberapa pengubahsuaian juga telah dilaksanakan untuk rekabentuk semasa proses tersebut. Analisis Unsur Terhingga adalah kaedah yang digunakan dalam projek ini untuk menentukan kegagalan produk. Keputusan yang diperolehi menunjukkan bahawa produk ini cukup selamat untuk digunakan. Projek ini menunjukkan langkah-langkah untuk menghasilkan rekabentuk produk pengguna secara keseluruhannya. Analisis dan kaedah yang digunakan telah ditakrifkan dengan baik untuk mencapai objektif yang telah ditetapkan.

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CHAPTER 1

INTRODUCTION

Fitness Equipment is one of the most utilized consumer products which are often found in the gymnasium, fitness center and even in house. In the present, fitness equipment offered in the market come in different range of design, function, sizes and prices. Broad studies have been performed regarding this subject matter and it had involved people from various fields such as doctors, human anatomy experts, biomechanics experts and engineers, in order to develop and produce this particular machine. Actually, the development of the product takes plenty of years to achieve a good and satisfying result so that they meet consumers' needs and are following accordingly to the human factor design. Among the many types of exercise machines, weight machine is one of them, and it is widely used by individuals and consumers that lead a healthy and fit lifestyle. Biceps Curl Machine which is one type of weight machine is chosen as consumer product to specify the scope of fitness equipment for this project as there are too many types and design of fitness equipment available.

The main purpose of this project is to demonstrate the product itself whether it is a new invention product or existing product. The phases that are involved in the project are including concept designing, followed by the generation of the actual/final design using 3D modelling software and analysis of the product using Finite Element Analysis (FEA). As there are already fine designs of Biceps Curl Machine in the market from established manufacturers, therefore this project is carried out to research on Biceps Curl Machine and study it's usage within local region or specifically within Malacca. In this research, ideas of concept designs are

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identified and gathered to generate new and personal concept designs. Minor improvements can be made to the product whenever possible. This project will implement according to engineering design process as defined by Tufts School of Engineering which can be used to devise a system, component or process to meet desired needs .This process is generalized for large projects done by large organizations or companies. For small organizations or student projects, some of the steps can be simplified or ignored. Figure 1 (Ertas and Jones, 1996) shows a schematic block diagram of this process and will be made as reference for this project.

Figure 1-1: Engineering Design Processes Flow Chart

(Source: engineering.tufts.edu, 2009)

The definition of design process is "The process of applying the various techniques and scientific principles for the purpose of defining a devise, a process or a system in sufficient detail to permit its realization. Design may be simple or enormous complex, easy or difficult, mathematical or non-mathematical; it may

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involve a trivial problem or one of great importance."(Norton, 1992). Engineering design process has many methods and some common elements such as brainstorming and some type of analysis. All design process must include iterative decision making. Designs are never perfect for the first time and will always improve with iteration.

1.1 Objectives

1. To conduct and demonstrate 3D modelling and simulation analysis in advance design software.
2. To produce innovative and creative design works in developing consumer product design.

1.2 Scope

1. To conduct a literature study on advance design software in local industries.
2. Design and develop conceptual modelling of consumer product according to engineering design specifications.
3. To conduct simulation on FEA (Finite Element Analysis).

1.3 Problems Statement

The most recent recommendations indicate that people of all ages should include a minimum of half an hour of physical activity of moderate intensity on most, if not all, days of the week. It is also acknowledged that for the majority of people, health improvement can be obtained by engaging in physical activity of more vigorous intensity. Physical activity has numerous beneficial physiologic effects, for example on the cardiovascular and musculoskeletal systems, but benefits on the metabolic, endocrine, and immune systems performance are also considerable.

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To maximize the benefits and results arising from workout it is necessary to perform a moderate amount of exercise on a regular basis. Exercising at home provides a convenient form of physical activity with the major advantage of maximizing time and effort. Nonetheless, conventional home gym fitness equipments such as weight machine or biceps curl machine in particular, have several disadvantages such as the space required, their cost and the effective time spent when using them. On the other hand, they are rarely used by most persons, mainly due to the lack of motivation and the need to quit home routine.

1.3.1 Relevance of the Study

As mentioned earlier, to design fitness equipment or universal weight machine for this project, it does take a long time. Hence, this project tends to design a particular weight machine which functions to develop a particular part of the human body. The project will apply a user-centred design (UCD) philosophy which the scope of consumer or user of the machine is focusing on home-based application. The alternative weight machine is use to assist an amateur user or beginner. The application of the Biceps Curl Machine as subject matter in this project is to study and understand the design process in order to get the best design. Design process will be gone through in details by student to develop the product design. Furthermore, student will analyze the design by considering the engineering points.

1.4 Overview of Methodology

To complete this project, several methods are applied to ensure the project run smoothly. These methods are referred from the flow of Engineering Design process and represent in the flow chart below to implement methods. The details about methodology will be explained later in this report. Below is the flow chart for this project to run until final stage.

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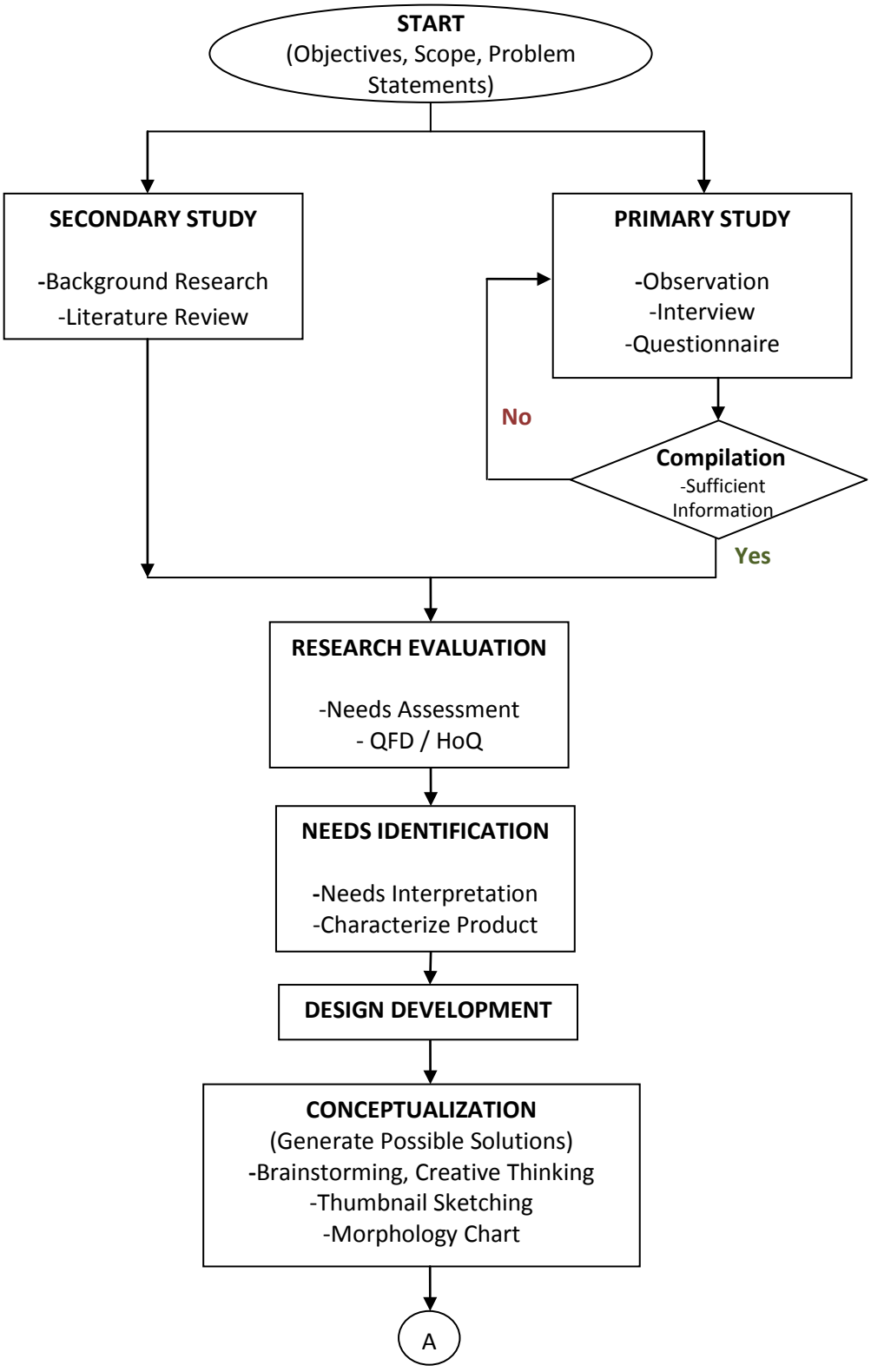
1.4.1 Flow Chart of Final Year Project



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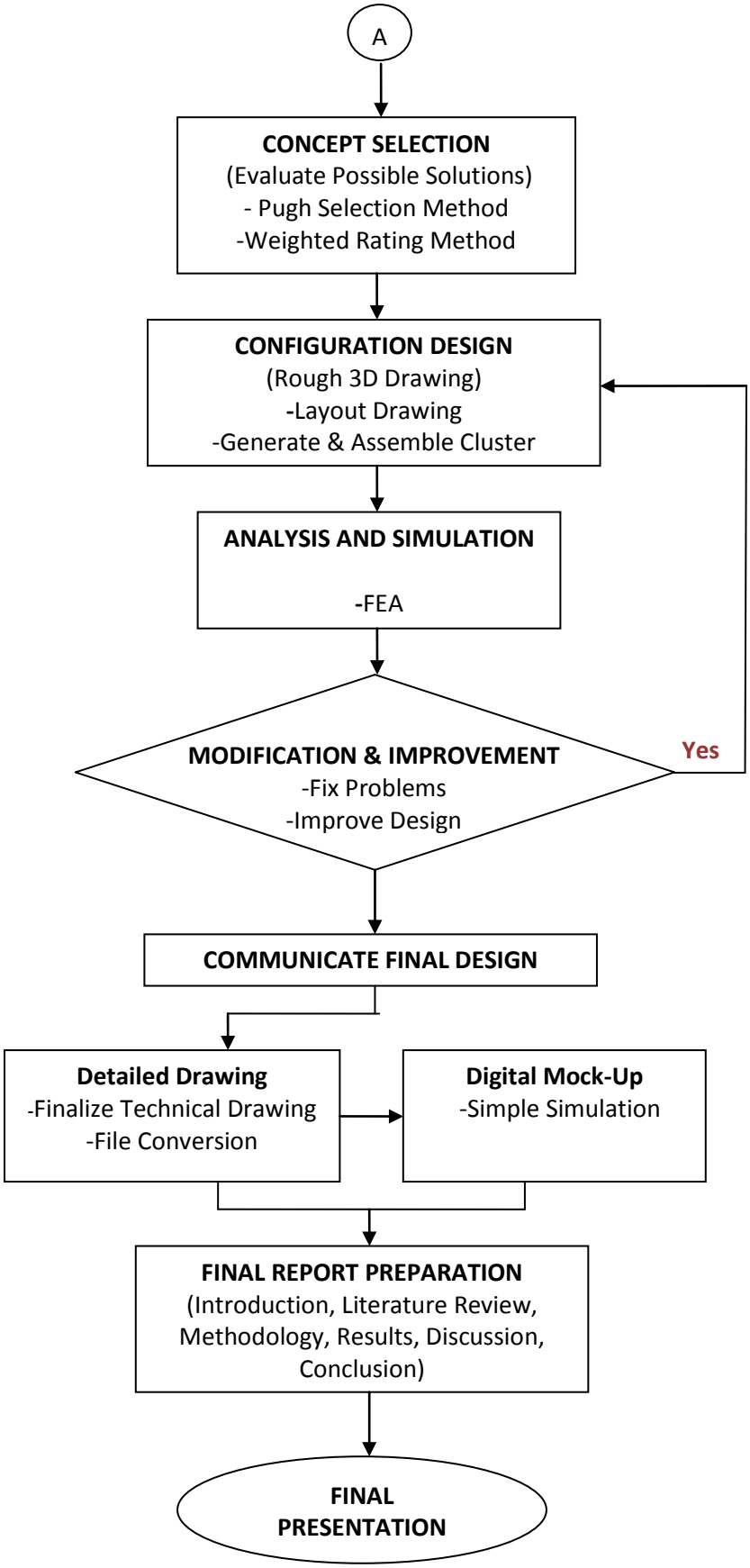

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CHAPTER 2

SECONDARY LITERATURE STUDY

This section will explain about the understanding on the study. The explanations are given in sequential flow based on the scope of the study. Secondary literature study is referred from previous study and basic information regarding the subject matters.

2.1 3D Modelling

2.1.1 Introduction of 3D Modelling

3D modelling is the process of developing a mathematical representation of any three-dimensional object either inanimate or living via specialized software. It can be displayed as a two-dimensional image through a process called 3D rendering or used in a computer simulation of physical phenomena. Models may be created automatically or manually. The manual modelling process of preparing geometric data for 3D computer graphics is similar to plastic arts such as sculpting. 3D models represent a 3D object using a collection of points in 3D space, connected by various geometric entities such as triangles, lines, curved surfaces, etc. Being a collection of data (points and other information), 3D models can be created by hand, algorithmically (procedural modelling), or scanned.

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In present time, 3D models are used in a wide variety of fields. The fields that are mostly use 3D models are video movie, game, architecture, medical and engineering. For example, the movie industry uses them to create characters and objects for animated and real-life motion pictures. The video game industry uses them as assets for computer and video games. The science sector uses them as highly detailed models of chemical compounds. The architecture industry uses them to demonstrate proposed buildings and landscapes through Software Architectural Models. The medical industry uses detailed models of organs. The engineering community uses them as designs of new devices, vehicles and structures as well as a host of other uses. In recent decades the earth science community has started to construct 3D geological models as a standard practice (Wikipedia, 2009).

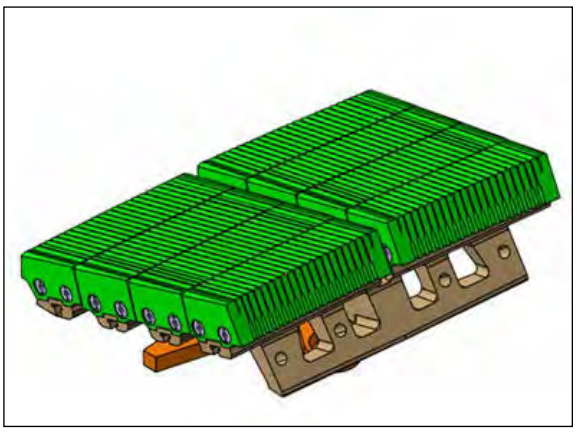

Figure 2-1: 3D model of W-LBSPR block of the JET tokomak diverter using CATIA V5 (Source: www.eng.fea.ru, 2009)

2.1.2 3D Models Representation

There are two categories of 3D model representations which are:

1. Solid: These models describe the volume of the object they represent (like a rock). These are more realistic, but more difficult to build. Solid models are mostly used for non-visual simulations such as medical and engineering simulations, for CAD and dedicated visual applications such as ray tracing and constructive solid geometry.

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