



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**DESIGN OPTIMIZATION USING FINITE ELEMENT
ANALYSIS**

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

By

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FACULTY OF MANUFACTURING ENGINEERING

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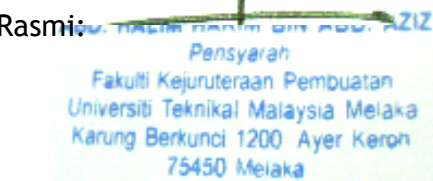

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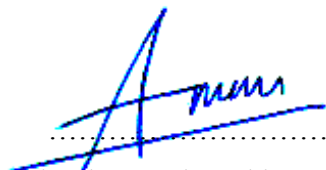
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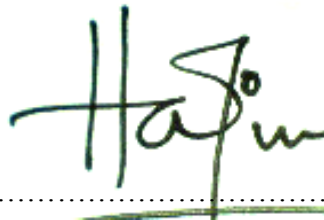
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ABSTRACT

Design is important stage in manufacturing. It is because any product produced must be through design stage where in design stage consist conceptual design, concept selection, identify customer need, concept selection, analysis and others. In design, it should be consider many factors such as product design must be satisfied by customer, material used the ability product to work and others. All part in design is to fulfill customer need. Beside that design will gave an effect to company such as profit, loss and reputation of the company. This projects study deep on design optimization using finite element analysis. Where the product to be study is bicycle frame design. In this project consist the survey the existing bicycle frame, redesign and improve the existing bicycle frame until the bicycle frame get the better design and best of result analysis. Beside that this project also provides optimization process. This optimization process done in redesign process, where the current design will change the shape, size or others until the bicycle frame have best result of analysis. In this project material to be used is steel because the bicycle frames to be design just for normal used or standard. Finally this project are guide by three main objective, firstly to redesign and improve existing bicycle frame, to analyze bicycle frame using Finite Element Analysis and lastly to optimize bicycle frame design.

DEDICATION

Dedicated to my father, Rahim Bin Yaakob and my mother, Haidah bte Baba.

To my supervisor, lecturers and friends for all of their help and friendship.

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I would like to convey my appreciation and indebtedness to those who has been great surprised and helpful for the completion at the project to bring it to success in respect with favorable advice and feasible solution

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Today computer is one of the most important equipment in design and manufacturing industry. It is also gave an impact more in the industrial sector. Computer is used for various activities in the industries. However in manufacturing industries it made a very substantial change in their working. The computer does not only used to simplify many of the traditional manufacturing tasks but also made it almost impossible for manufacturing industries to survive in the modern ere without it. Thus it is important for everyone concerned with the manufacturing industries to learn the use of computer

Among the usages of computer in manufacturing, Computer aided design and Computer aided manufacturing (CAD/CAM) are by far the best known as well as the best application. In order to remain competitive in the global economy, it is imperative that all manufacturing industries adopt CAD/CAM.

In the earlier days of CAD/CAM development the cost used to be prohibitive and did not allow the small and medium scale industries to adopt it. However, this has changed since the invention of the microprocessor and the rapid developments taking place in the very large scale integration (VLSI) of the electronic circuit. The cost of computing equipment in the present stage is relatively low, and this allowed the devolvement of large for these

powerful computers. The mass manufacture techniques employed for the manufacture of computer have further reduced the cost. This has allowed the small and medium scale companies to use the powerful computers in their day to day operations.

Along with the developments in the hardware, the software, too, continued to develop at a similar pace. The present day software is easier to use and very powerful, thereby guaranteeing the result in a much shorter time than was possible earlier. This has prompted the small and medium scale to enterprises to embrace CAD/CAM in a big way in the development world. It is, therefore, not uncommon to see even small companies using CAD or CAM in to improve their productivity.

CAD/CAM is related to the design where design is an activity which needs to be well-organized and takes into account all influence that are likely to be responsible for the success of the product under development. A product here means single components, which is functional in itself like a wrench or an assembly of large number of part or component all of which will contribute to he functioning of the part such as an automobile engine. In design, it has stages of the design process. The flow of design process such at the below:

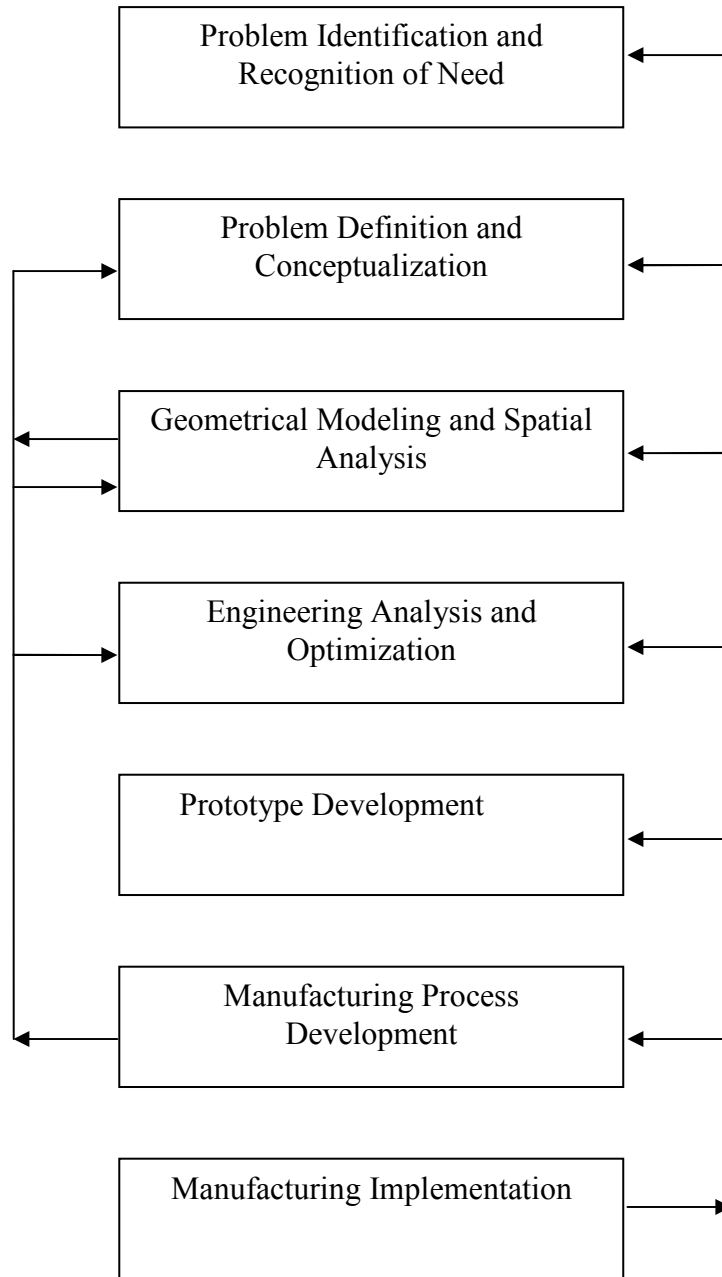


Figure 1.0: Stages in the design process

To design, CAD technology is used. CAD or computer aided design is the use of computer method to develop the geometric model of the product in the three dimensional form, such that the geometric and manufacturing requirements can be examined. Many type of cad software can be use such as SOLIDWORK, CATIA, INVENTER and other. CATIA software is CAD/CAM family software but it one of the best CAD software and that suitable for this project. CAD technology is used because CAD technology can provide the necessary help in the following below:

1. Computer Aided Design (CAD) is faster and more accurate than the conventional method.
2. The various construction facilities available in CAD would make the job of developing the model and associated drafting a very easy task.
3. In contrast with the traditional drawing method, under CAD it is possible to manipulate various dimensions, attributes and distances of the drawing element. This quality makes CAD useful for design work.
4. Under CAD work will never have to repeat the design or drawing of any component. Once a component has been made, It can be copied in all further works within seconds including any geometric transformation need.
5. Modification of a model is very easy and would make the designers task of improving a given product simple to take care of any future requirement.
6. Use of standard component makes for very fast model development work.

Then for the next process after product design is do an analysis of the product. Where it is used finite element analysis as a tools. The finite element analysis (FEA) is a very powerful analysis tool, which can be applied to a range of engineering problem. The finite element modeling process allowed for discrediting the intricate geometries into small fundamental volumes called finite element. It is then possible to write the governing equations and material properties for these elements. These equations are then assembled by taking proper care of results that describe the behavior of the original complex body being analyzed. Application of FEA is no limited to mechanical system

alone but to range of engineering problem such as stress analysis, dynamic analysis, and deformation studies fluid flow analysis, heat flow analysis and other.

With the FEA software it is possible to try a number of alternative designs before actually going for a prototype manufacture. The use of FEA tools can converting the geometry into discretised element and calculating various properties for each element such as geometry, material properties, constraint and loading. This forms the input for the analysis. It also can generating the finite element mesh by making a suitable approximation to the geometry. Then it can calculate the nodes and element properties and allowed the material properties to be specified. Under FEA it has steps involved in the use of finite element method for solving a physical problem. The software used for run this Finite Element Analysis such PATRAN and CATIA.

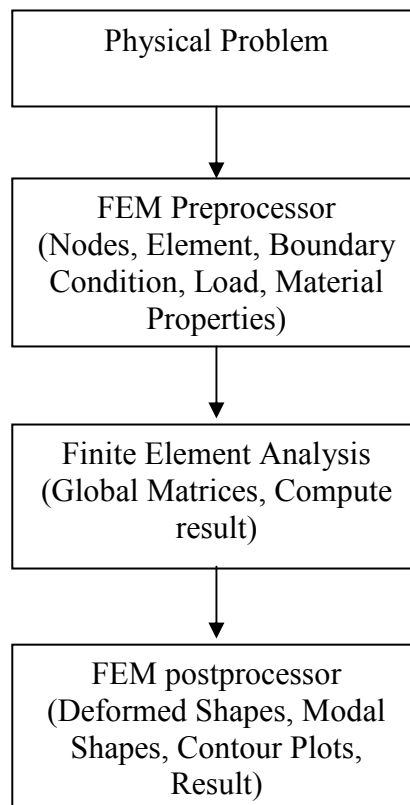


Figure 1.1: Step Involved in the use of Finite Element Method for solving a physical problem.

Finally, for this PSM project mainly focused on design optimization of bicycle frame and to proposed the best design and analysis. Bicycle frame is important part in a bicycle. It is because bicycle frame become a main body or main frame at bicycle. As a important part at bicycle, bicycle frame must be high strength, tough and durability. It is because, the body frames usually applied with large force where the force comes from weight of rider. The bicycle frame usually applied with load around 40kg to 90kg of people. So for this PSM project focus on design and improve the current bicycle frame design and do the analysis to the bicycle frame design by using Finite Element Analysis. Then optimize the design of bicycle frame design by redesign bicycle frame until the get the best result of analysis. This project tries to propose the best design and analysis of bicycle frame. The optimization to increase quality, reduce product cost and full fill the customer satisfaction. For this project CAD tools as tools to design deep fry basket and FEA tools for the analysis. For this project software to be used are SOLIDWORKS as CAD software and NASTRAN PATRAN software as analysis software.

1.2 Problem Statement

Bicycle is one of transport used in the world. Most of people in the world known what are bicycles. It is because most of people in the world used bicycle at least one time in their life. In a bicycle the important part is bicycle frame. It is because the large amount of load is always applied directly the bicycle frame. The load directly applied come from weight of rider or people. So the bicycle frame must be strongly enough, less displacement, high strength and cheaper. The current products are strongly enough but to produce the product take to long time, much prototype, more cost and more testing. So by the entire causes make the bicycle produced expansive and wasted time.

1.3 Objectives

- To redesign existing bicycle frame
- To optimize bicycle frame design using finite element analysis
- To propose best design and analysis of bicycle frame

1.4 Scope of project

This project describes the design and analysis of the bicycle frame. The purpose of this project is to improve and optimize the current design of bicycle frame. That means the current bicycle frame will redesign. Before the redesign process the current product will be drawn by CAD software (SOLIDWORKS) and analyze the current design by using CAE software (NASTRAN PATRAN). In the design process, it consist conceptual design where more then three current design will generate. After that all design will analyze by using CAE software. And then the result will differentiate between each other. And one of the design results will taken as a guideline. After that from previous conceptual design, the new design will be generate and analyze. The redesign process will conducted until the best result and design created. The best result here means are the bicycle design must be has smallest maximum displacement then the current design result. Beside that this project need some survey the mean of weight human in the world. The other process is to identify the material used for bicycle frame and the properties of bicycle frame.

CHAPTER 2

LITERATURE RIVIEW

2.1 Introduction

Literature review includes study and research of published material like journals, thesis, case studies, technical document, book and online library. Generally, the purpose of the review is to analyze critically a segment of a published body of knowledge through summary, classification, approach used in their project, and any technique that used in their study, review of literature and theoretical articles. This chapter will describe topics that related of Computer Aided Design (CAD), design, conceptual design, Optimization, Finite Element Analysis (FEA), Design Process and other relevant topic for this project. These chapters to carry out any approach that can use in bicycle frame design and analysis using Finite Element Analysis method and carry out current product design.

2.2 History of bicycle

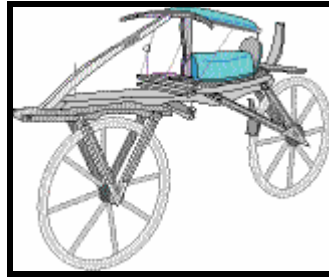


Figure 2.1: The steerable Draisienne was invented (Suman Bandrapalli, 2001)

The figure 2.1 shown that bicycle was invented at 1817's in German by Germany's Baron von Drais. This bicycle almost completely made from wood, and having no pedals, riders pushing their feet against the ground. The speed record of the bicycle is 15km/h. This bicycle was used until 1830's. In 1842, this bicycle equipped with solid rubber tire (Suman Bandrapalli, 2001)

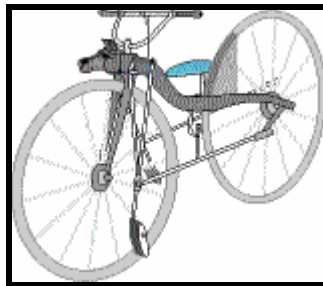


Figure 2.2: The MacMillan velocipede was the first of its kind to be ridden with the legs off the ground. (Suman Bandrapalli, 2001)

The figure 2.2 shown that the MacMillan velocipede was the first of its kind to be ridden with the legs off the ground. This bicycle was invented by MacMillan velocipede in year 1839's. This two-wheeled vehicle was designed by Kirkpatrick MacMillan, a Scottish blacksmith. It was the first of its kind that allowed people to ride without touching their feet to the ground. In MacMillan's hometown of Coathill, Scotland, the one hundredth anniversary since the creation of the MacMillan velocipede was celebrated in September 1946 after an eight-year delay caused by WWII, but recently the actual existence of this vehicle has come under suspicion. (Suman Bandrapalli, 2001)



Figure 2.3: The world's first mass-produced riding machine (Bicycling Popularization Association of Japan, 1999)

The figure 2.3 had shown the world's first mass- produced riding machine. This type of bicycle was invented by France's Pierre Michaux in year 1860's. The inventers was involved in the repair of horse carriages and the manufacture of baby carriages and tricycles. He came up with his design when a customer brought a Draisienne in for repairs. After his son tried riding it and had difficulties with his feet on downhill roads, Michaux came up with the idea of connecting crank arms and pedals directly to the front wheel as a means of propulsion. (Bicycling Popularization Association of Japan, 1999)



Figure 2.4: The Phantom, with its ordinary drive, is released (Bicycling Popularization Association of Japan, 1999)

The figure 2.4 shown the Phantom, with its ordinary drive, is released. The type of bicycle was invented by Reynolds' of Great Britain in year 1869's. It was an epoch-making development with its light-weight metal frame, first wheels to ever use a double-spoke construction, solid rubber tires nailed to wooden wheels, and other innovations. (Bicycling Popularization Association of Japan, 1999)