
**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

# Finite Element Analysis of a Motorcycle Alloy Wheel

Thesis submitted in accordance with the partial requirements of the
Universiti Teknikal Malaysia Melaka for the
Bachelor of Manufacturing Engineering (Manufacturing Design)

By

**Ruzanna Nadia Binti Nisah**

Faculty of Manufacturing Engineering
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# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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JUDUL: FINITE ELEMENT ANALYSIS OF A MOTORCYCLE ALLOY WHEEL

SESI PENGAJIAN : 2007/2008

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Alamat Tetap:
NO. 3 PRSN. JENTAYU TMN.
ANGGERIK, 31000 BATU GAJAH,
PERAK

Cop Rasmi:
WAHYONO SAPTO WIDODO
*Pensyarah*
Fakulti Kejuruteraan Pembuatan
Universiti Teknikal Malaysia Melaka
Karung Berkunci 1200, Ayer Keroh
75450 Melaka

Tarikh: 4 APRIL 2008

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| Author's Name | : | RUZANNA NADIA BINTI NISAH |
| Date | : | 4 APRIL 2008 |

# APPROVAL

This PSM submitted to the senate of UTeM and has been as partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Design). The members of the supervisory committee are as follow:

WAHYONO SAPTO WIDODO
*Pensyarah*
Fakulti Kejuruteraan Pembuatan
Universiti Teknikal Malaysia Melaka
Karung Berkunci 1200, Ayer Keroh
75450 Melaka

(Mr. Wahyono Sapto Widodo)
(Official Stamp & Date)

# ABSTRACT

The project is to design the motorcycle alloy wheel using the CATIA and analyzed with the Finite Element Analysis. Finite element analysis is a tool used for the evaluation of systems and structures. It is needed to analyze complex structures, whereas very simple ones. There are three processes involved which are pre-processing, analysis and visualization. The CATIA is used because specialized modules, sophisticated shape modeling, can be designed for large teams and easy to use. There was two way analyzed which were analysis the rim statically in a straight road and cornering. The chosen material was an Aluminum alloy. The aluminum alloy is better to the conventional steel wheels in strength and durability. It has excellent wear resistance, anticorrosion properties and longer service life as estimated by the stress frequency distribution. The analysis is done with the maximum load can be applied on rim. The rear wheel and front wheel have their own maximum load that can be supported. It is because the rear wheel is carrying a person. While the front wheel only the weight of the front motorcycle like mark guard and motorcycle handle that assembles to it.It was found that the stress of the analysis is still in the range of the yield strength of Aluminum alloy. The displacement is at the low value. This design is still in the safe condition. The project is to sharpen skill using CAD (CATIA) and CAE (FEA), practice to be creative in design the motorcycle alloy wheel and analyze the result of FEA. It is recommended if analyze with different material and can be manufactured for further study.

# DEDICATION

*For My Lovely Mom, Dad & Sisters.*

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# TABLE OF CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

# LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

| | | |
|---|---|---|
| Al/Cr | - | Aluminum/Chromium |
| BC | - | Boundary Condition |
| CAD | - | Computer Aided Design |
| CAE | - | Computer Aided Engineering |
| CAM | - | Computer Aided Manufacturing |
| CNC | - | Computer Numerically Controlled |
| e | - | Exponent |
| FEA | - | Finite Element Analysis |
| FEM | - | Finite Element Method |
| GSD | - | Generative Surface Design |
| lb | - | Pound |
| max | - | Maximum |
| min | - | Minimum |
| mm | - | Milimeter |
| N | - | Newton |
| OEM | - | Original Equipment Manufacturing |
| psi | - | Pound Square Inch |
| PSM | - | Projek Sarjana Muda |
| SF | - | Safety Factor |
| SSF | - | Semi-Solid Forging |
| UV | - | Ultraviolet |
| 3D | - | 3 Dimension |

# CHAPTER 1
# INTRODUCTION

## 1.1 Background of the Finite Element Analysis of a Motorcycle Alloy Wheel

### 1.1.1 Finite Element Analysis

Finite Element Analysis (FEA) is a tool used for the evaluation of systems and structures. It is needed to analyze complex structures, whereas very simple ones, for example, a beam can be analyzed using hand calculations. FEA is capable of performing parametric studies in which different geometries, materials, and loading conditions like thermal, structural and vibratory can be evaluated. A typical analysis evaluates the deflections and stresses which result, and compares these against acceptable defined limits.

Thus, the element equations cannot be solved alone to render the solution over each element. Instead, all the equations from all the elements over the entire structure need to be solved simultaneously. This task can only be performed by computers. It is noteworthy that, as the structure is broken into a larger number of elements, a greater number of simultaneous equations need to be solved. Thus, typically, results for more complex structures require more computing power. Functions of the FEA are a very accurate tool used for failure analysis purposes, used to quantify design defects, fatigue, buckling, and code compliance, can be used to distinguish between failures due to design deficiencies, materials defects, fabrication errors, and abusive use, provides quantified

results previously based on metallurgical and mechanical testing and excellent visual aids and animations easily understood by juries.

### 1.1.2 Motorcycle Alloy Wheel

The alloy used in the finest road wheels today is a blend of aluminum and other elements. The term "magnesium wheel" is sometimes incorrectly used to describe alloy wheels. Magnesium is generally considered to be an unsuitable alloy for road usage due to its brittle nature and susceptibility to corrosion. In market, mostly aluminum alloy wheel is used. Pure aluminum is soft, ductile, corrosion resistant and has a high electrical conductivity. In consequence it is widely used for foil and conductor cables, but alloying with other elements is necessary to provide the higher strengths needed for other applications.

Aluminum alloy wheels are cast into a mold in a hot liquid state and cooled, which makes them more accurate in both the heavier and lighter areas. The end result is a balance that has less weight on the wheel and less stress on the tire. Aluminum alloy wheels also provide a lighter weight for the racing enthusiast, and can be machined for a brilliant appearance.

Steel wheels are a great way to provide basic transportation for a basic car, but for those who want to extend the life of their tires and have a smoother ride, alloy wheels are the way to go.

Alloy metals provide superior strength and dramatic weight reductions over ferrous metals such as steel, and as such they represent the ideal material from which to create a high performance wheel. In fact, today it is hard to imagine a world class racing car or high performance road vehicle that doesn't utilize the benefits of alloy wheels. Aluminum alloy is widely used in transport, packaging, building and architecture and machine component.

### 1.1.3 CATIA

CATIA is an abbreviation of Computer Aided Three dimensional Interactive Application is a multi-platform CAD/CAM/CAE commercial software suite developed by Dassault Systemes. CATIA, CAD software is used in designing the motorcycle alloy wheel and test bench. CATIA is widely used throughout the engineering industry, especially in the automotive and aerospace sectors. Automotive companies that use CATIA are BMW, Porsche, Volvo, Fiat, PSA Peugeot Citroen, Toyota, Honda, Ford, Hyundai, Tata motors and Mahindra. GoodYear uses it in the manufacture of tires for automotive and aerospace and also uses a customized CATIA for its design and development.

## 1.2 Statement of the Problem

When a motorcycle becomes to crash, the tire of front wheel, as a rule, receives the reaction force at first, and, this force brings about a large influence on the following motion of the motorcycle and rider. Therefore, if the reaction force of tire cannot be determined at a satisfactory accuracy, it is not possible to predict, by simulation, the degree of injury of the rider. By using FEA, a detailed finite element model of wheel, which could describe, as accurate as possible alloy wheel and stress. There has been given many choices to design the motorcycle alloy wheel and test bench whether use SolidWorks or CATIA. The material of motorcycle wheel also has many choices. The alloy wheel steel wheel is selling in the market nowadays. But mostly the alloy wheel is selling more than steel wheel.

## 1.3 Objectives

The objectives of the project are:

a) An alloy wheel for motorcycle is designed using CATIA solid
b) Stresses and material behavior of the motorcycle alloy wheel is analyzed using FEA software.

## 1.4 Scope of the Project

The project is being given to expose with the writing the report and facing the working environment for the future when ever handling a project. The scope of the project acts as designed the motorcycle wheel and analyzed it. Apart from that, the suitable material for the wheel is identified.

## 1.5 Importance of the Project

The important points mentioned in this verse:

a) Applying and sharpen skill using the CATIA.
b) Exposing with analysis using the FEA.
c) Practicing handle the project and do the report follow the format.
d) Figure out the material behavior and stress of the motorcycle alloy wheel.

## 1.6 Definition of the Terms

a) FEA - Finite Element Analysis is a tool used for the evaluation of systems and structures. It is needed to analyze complex structures, whereas very simple ones can be analyzed using hand calculations.
b) Alloy - homogeneous mixture of two or more elements, at least one of which is a metal, and where the resulting material has metallic properties.
c) Aluminum alloy wheel - The material of wheel is a blend of aluminum and other elements.
d) CATIA - A multi-platform CAD/CAM/CAE commercial software suite developed by Dassault Systemes
e) CAD - computer aided design
f) CAM - computer aided manufacturing
g) CAE - computer aided engineering

## 1.7 Organization of the Report

The Table 1 shows the timeline of completing the Chapter 1, Chapter 2 and Chapter 3 within 14 weeks. The Chapter 1 consists of general information about the FEA which is used to identify the stress and behavior of motorcycle alloy wheel. Alloy wheel is widely used in market because of light weight and good performance on the road. It is also used in transport, packaging, building and architecture and machine component. The test bench is design to hold the motorcycle alloy wheel. The motorcycle alloy wheel and test bench is designing use a CATIA. The Chapter 2 is literature review of the project. This is where the journal or the article about the FEA of Motorcycle alloy wheel is summarized. It begins with the problem statement. Then, analysis or research of the motorcycle alloy wheel is done to solve the problem. The technique of the solution is the safety features to produce the wheel. While in Chapter 3 is the methodology where the method used or the steps how the motorcycle alloy wheel. From design, analysis is carried out whether the design is really good enough or not. The next chapter is result. The result shows the important finding about the analysis using FEA about the material behavior and stress of the motorcycle alloy wheel. The figures illustrated to identify the outcome. The findings is compared and related with the variable or parameter. The observation of the result is discussed in Chapter 5. Discussion is in Chapter 5 which is from the result using the FEA. The material behavior and the stress are discussed from aspect limitation, compare with other design and interpret them. Recommendation and conclusion are written after the discussion. The references via internet, journals and books are stated to show the source of information.

**Table 1.7: Gantt chart for PSM 1**

| Task | Week 1 | week 2 | Week 3 | week 4 | Week 5 | Week 6 | Week 7 | Week 8 | Week 9 | Week 10 | Week 11 | Week 12 | Week 13 | Week 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collect the Data | | | | | | | | | | | | | | |
| Chapter 1 | | | | | | | | | | | | | | |
| Refinement | | | | | | | | | | | | | | |
| Search the Journal | | | | | | | | | | | | | | |
| Chapter 2 | | | | | | | | | | | | | | |
| Refinement | | | | | | | | | | | | | | |
| Design | | | | | | | | | | | | | | |
| Chapter 3 | | | | | | | | | | | | | | |
| Refinement | | | | | | | | | | | | | | |
| Verification | | | | | | | | | | | | | | |
| Writing up | | | | | | | | | | | | | | |
| Submit the Report | | | | | | | | | | | | | | |

**Table 1.7.1: Gantt chart for PSM 2**

| Task | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 | Week 9 | Week 10 | Week 11 | Week 12 | Week 13 | Week 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Design | | | | | | | | | | | | | | |
| Analysis | | | | | | | | | | | | | | |
| Chapter 4 | | | | | | | | | | | | | | |
| Refinement | | | | | | | | | | | | | | |
| Discussion | | | | | | | | | | | | | | |
| Chapter 5 | | | | | | | | | | | | | | |
| Refinement | | | | | | | | | | | | | | |
| Conclusion | | | | | | | | | | | | | | |
| Chapter 6 | | | | | | | | | | | | | | |
| Refinement | | | | | | | | | | | | | | |
| Verification | | | | | | | | | | | | | | |
| Writing up | | | | | | | | | | | | | | |
| Submit the Report | | | | | | | | | | | | | | |

Table 1.7.1 shows for PSM 2 where Chapter 4, result, Chapter 5, discussion is working on and Chapter 6 is conclusion. It started with design and then analysis. It continues with discussion to talk more detail about the result of stress and material behavior motorcycle alloy wheel. Finally, conclude the project.

## 1.8 Summary

FEA has become a solution to the task of predicting failure due to unknown stresses by showing problem areas in a material and allowing designers to see all of the theoretical stresses within. This method of product design and testing is far superior to the manufacturing costs which would accrue if each sample was actually built and tested. the suitable design for the motorcycle alloy wheel whether to put 3 or 4 spokes or more for balancing while rider moving straight or cornering and slow motion or fast motion. The alloy wheel is mostly used in market because of light weight and less stress on tyre. While SolidWorks is less costly than CATIA because it is a simpler product. It contains fewer lines of code, and installation is simpler, reducing the need for on-site application engineers. Complex products that need to be optimized for weight and performance can benefit from the advanced engineering software integrated with CATIA.

# CHAPTER 2
# LITERATURE REVIEW

## 2.1 Introduction

### 2.1.1 Finite Element Analysis

Finite element analysis (FEA) has become ordinary in recent days, and is now the source of income in the industry. Numerical solutions to even very complicated stress problems can now be obtained using FEA. The method is so important that even introductory treatments of Mechanics of Materials. Finite element codes are less complicated than many of the word processing and spreadsheet packages found on modern microcomputers. Nevertheless, they are complex enough that most users do not find it effective to program their own code. A number of prewritten commercial codes are available, representing a broad price range and compatible with machines from microcomputers to supercomputers1. However, users with specialized needs should not necessarily shy away from code development, and may find the code sources available in such texts as that by Zienkiewicz[1] to be a useful starting point.

[1] O.C. Zienkiewicz and R.L. Taylor, The Finite Element Method, McGraw-Hill Co., London, 1989.

#### 2.1.1.1 Principle FEA

In practice, a finite element analysis usually consists of three principal steps:

a) Preprocessing:

The user constructs a model of the part to be analyzed in which the geometry is divided into a number of discrete subregions, or elements, connected at discrete points called nodes. Certain of these nodes will have fixed displacements, and others will have prescribed loads. These models can be extremely time consuming to prepare, and commercial codes vie with one another to have the most user-friendly graphical \preprocessor" to assist in this rather tedious chore. Some of these preprocessors can overlay a mesh on a preexisting CAD file, so that finite element analysis can be done conveniently as part of the computerized drafting-and-design process.

b) Analysis:

The dataset prepared by the preprocessor is used as input to the finite element code itself, which constructs and solves a system of linear or nonlinear algebraic equations $K_{ij}u_j = f_i$ where u and f are the displacements and externally applied forces at the nodal points. The formation of the K matrix is dependent on the type of problem being attacked, and this module will outline the approach for truss and linear elastic stress analyses. Commercial codes may have very large element libraries, with elements appropriate to a wide range of problem types. One of FEA's principal advantages is that many problem types can be addressed with the same code, merely by specifying the appropriate element types from the library.