UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND FABRICATION OF AN IN HOUSE AUTOMOTIVE WHEEL RIM TESTING EQUIPMENT

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours.

by

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I hereby declare that this project report entitled "Design and Fabrication of an in-house Automotive Wheel Rim Testing Equipment" 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 partial fulfilment of the requirement for the degree of Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours. The member of the supervisory is as follow:

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(Project Supervisor)

ABSTRAK

Prestasi hentaman rim roda adalah satu kebimbangan utama dalam reka bentuk baru. Dalam usaha untuk mencapai kualiti yang lebih baik, reka bentuk rim roda dan pembuatan menggunakan beberapa ujian rim roda untuk memastikan bahawa rim roda yang dihasilkan memenuhi keperluan keselamatan. Projek ini tertumpu kepada kajian mengenai kaedah metodologi ujian roda rim automotif mengikut piawaian dengan tujuan untuk menghasilkan rekabentuk peralatan ujian roda rim automotif menggunakan CATIA dan membuat peralatan ujian dengan ciri-ciri tertentu berdasarkan kajian yang dibuat. Peralatan ujian perlu mematuhi piawaian antarabangsa. Ujian hentaman roda bertujuan untuk menilai kebolehan rim roda menghadapi hentaman, penghentam dengan beban tertentu dijatuhkan dari ketinggian yang ditetapkan di atas pemasangan tayar rim roda. Beberapa aspek akan dipertimbangkan semasa peringkat reka bentuk seperti bahan bagi setiap bahagian, penghentam, jig, mekanisme gelongsor, dan banyak lagi. Peralatan ujian yang dihasil berbeza daripada pasaran semasa sebaliknya ia mesti memenuhi kriteria tertentu di mana ia akan digunakan di UTeM

ABSTRACT

Wheel rim is one of the vital component in vehicle system since it gives huge effect related to vehicle safety. Several tests are mandatory during development phase of a wheel rim such as the impact test. The wheel impact test is intended to evaluate the impact performance of a wheel and the testing equipment used must comply with the latest international standard. This project focused on study of the standard wheel rim testing methodology which currently used in the industry with the aim to design of an in house automotive wheel rim testing equipment that meets the international standard requirements. Based on the requirement provide by SAE, several concept design and solution are generated for each requirement and finalized using Screening and Scoring method which then the 3D design for each part are made using Catia. To analyse the strength performance of the designed parts, stress analysis then will be conduct to several designed parts which considered as critical during the real service condition. Structural analysis result shows that all critical parts able to withstand the specific amount of forces. Thus, the design then finalized and the detailed design for each part are made along with bill material and product cost estimation.

DEDICATION

To my beloved father and mother

Mr. Abdul Rahim Bin Pandak Ismail

Mrs. Saniyah Bt Hussin

And my brother and sisters

ACKNOWLEDGEMENT

Alhamdulillah,

I would like to take this opportunity to express my sincere gratitude and appreciation especially to my supervisor, Mr Saiful Naim Bin Sulaiman for his constant guidance, invaluable knowledge, and constructive idea in leading me to accomplish this project.

I also would like to express my sincere appreciation to all my friends, lecturers, faculty member and others whose comment and help most in preparing this project. Last but not least my parent for giving me full support and encouragement for me to do my best in this project. Thank you

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CHAPTER 1
INTRODUCTION

1.0 Background of the Research

Automotive wheel rim is one of the vital component since it supports vehicle loads during its operation. The development phase of a wheel rim must be properly made since it gives huge impact related to the safety of the vehicle. Several testing methods have been highlighted to ensure the development of the wheel rim meet the safety requirement. This project will study the standard method used by local manufacturer to evaluate a good car rim. Based on the study, a testing methodology will be created. This project will focus on designing and fabrication of an in-house automotive wheel rim testing equipment.

1.1 Problem Statement

The accuracy of wheel impact test result is important to ensure the wheel rim can serve its purpose. Hence, the equipment used for testing process must be good enough since its influence the result of the impact performance of a wheel rim. The common equipment used by local manufacturer is commonly large in dimension and it equipment with certain high technology features which comes with expensive price. The aim of this project is to produce an in-house automotive wheel rim testing equipment that can produce an accurate result as the product that currently in the market. Several aspects must be considered in this project such as during the design stage where this product must be designed with a non-complicated structure. Material selection for each component plays an important role where each of the parts must be

able to withstand a large sum of impact without any failure to produce an accurate result.

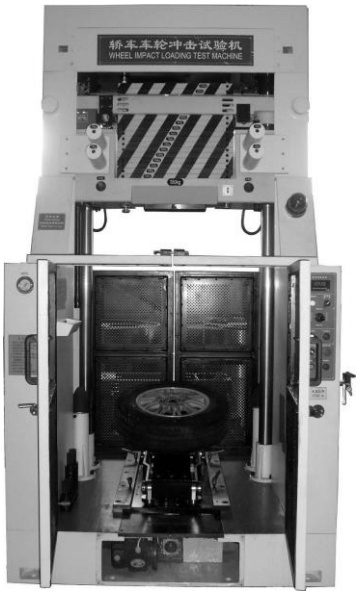

Figure 1.1: Wheel Impact Test Machine.

1.2 Objective

(a) To study the international standard testing methodology along with testing methodology used by local manufacturer.

(b) To design an in-house automotive wheel testing equipment using Catia.

(c) To analysis the strength performance of each design parts using Catia.

1.3 Scope

(a) Develop a testing methodology based on the study of current method used.

(b) Develop a suitable design of the equipment using Catia software.

(c) Analysis of strength performance of each design parts using Catia.

(d) Estimate the total cost of the equipment.

CHAPTER 2
LITERATURE REVIEW

2.0 Automotive Wheel Rim

2.0.1 Introduction to Automotive Wheel Rim

Wheel rim is one of the important component in vehicle system. When it comes to automotive part, the development process for each part must be follow the standard requirement to ensure it meets the safety requirement. The wheel rim is the device which is holding the tire of the vehicle. It is the outer edge of the wheel. It makes circular design of a vehicle. The rim holds the tire on which the inside edge. The tire mounted on the automobiles. In its basic form, a wheel rim is a transfer element between the tyre and the vehicle. The following are the main functions of a wheel rim:

- Mechanism to transfer the produce torque during acceleration and deceleration
- Hold the vehicle weight and its passengers
- Provide additional weight for driving stability
- Eliminate the heat produced from deceleration
- Absorbs the impact forces cause by improper road condition

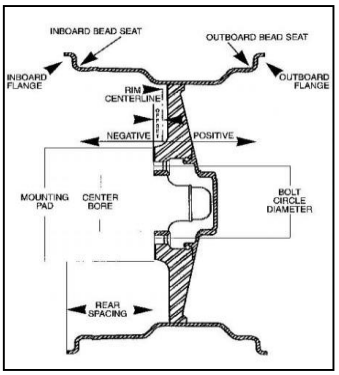

Figure 2.1: Nomenclature Diagram of a Wheel Rim

2.0.2 Material

Automotive wheel rim is produce using various type of material and sheet metal is one of the most common among them. Several factors need to be considered during material selection of a wheel rim such as yield strength of the material, ability prevent corrosion and several other factors.

2.0.2.1 Steel Wheel Rim

Steel wheel rim is a standard type of a rim. Due to its properties, steel is one of the most important engineering and construction material. Steel features great formability, permeability and durability. Its notch-toughness makes it possible to resist cracks that may lead to collapse of a product structure. Steel is a cost-effective material as it is less exotic material and its manufacturing process is not so complicated. Steel wheels are heavier than aluminium, so when a steel wheels is placed on a car that has had alloy wheels, it tends to show that the extra weight dampens acceleration and agility, lowers the car's centre of gravity and in general makes it drive more like a tank. Steel wheels are significantly stronger than alloy wheels. It takes greater force to bend steel wheels, and it is almost impossible to crack them. Given their usual utilitarian

look, purely cosmetic damage is not generally a major issue. There are wheel covers that can placed on steels to make them look like alloy wheels.

Figure 2.2: An Example of Common Steel Rim Design

2.0.2.2 Alloy wheel Rim

This automobile part is manufactured from an alloy of magnesium or aluminium. One of the main benefits is the lightweight that results in better handling and reduction of unsprung weight besides improve the fuel efficiency. Alloy rims provide better heat conduction. This improves braking performance as the heat is dissipated from the vehicle's brakes. It also reduces a possibility of overheating.

The disadvantage of the alloy rims includes inability to withstand corrosion. It is necessary to apply a paint layer or another coating to prevent rust. Higher price is another disadvantage of this material. Alloy wheels are also difficult to repair. Most alloy wheels are constructed as one-piece product.

Figure 2.3: Example of alloy wheel

2.0.2.3 Composite Wheel Rim

Composites are combinations of two Materials in which one of the material is called the matrix phase is in the form of fibres, sheets, or particles and is embedded in the other material called the reinforcing phase. Another unique characteristic of many fibre rein forced composites is their high internal damping capacity. This leads to better vibration energy absorption within the material land results in reduced transmission of noise to neighbouring structures.

Many composite materials offer a combination of strength and modulus that are either comparable to or better than any traditional metallic metals. Because of their low specific gravities, the strength to weight-ratio and modulus to weight ratios of these composite materials are markedly superior to those of metallic materials. The fatigue strength weight ratios as well as fatigue damage tolerances of many composite laminates are excellent.

For these reasons, fibre composite have emerged as a major class of structural material and are either used or being considered as substitutions for metal in many weight-critical components in aerospace, automotive and other industries (Paropate & Deshmukh 2013). They benefit in terms of attractive appearance and high-end performance.

Material / Factor Considered	Aluminium	Magnesium Alloys	Steel C1008 (Sheet metal wheel)	Carbon Fiber	Forged steel
Weight	Light	Medium	Heavier than Mg & Al	Light	Heavier than Mg & Al
Appearance	Pleasant	Pleasant	Bright	Somewhat dull	----------
Cost of Rim	Costlier	Costlier	Cheap	Costlier	Expensive
Material Cost	Costlier	Costlier	Cheap	Costlier	Cheap
Deformation under load	Too much deformation	Less as compared to Al	Less as compared to Al & Mg	----------	Less deformation than other materials.
Corrosion Resistance	Excellent	Excellent	Poor but improved by adding alloys.	Excellent	----------
Cast ability	Casted easily	Casted easily	Difficult to cast	----------	----------
Maintenance/Repair of rim	Easy to repair	Can't repaired	----------	----------	----------
Effect on Unsprung Weight	Reduce	Reduce	More than the Al & Mg	----------	More than Al, Mg & Steel C1008
Heat Dissipation	Better	Best	Good	----------	Good
Durability	As equal to forged rim	Durable	----------	----------	Durable
Mechanical properties	Poor than Steel	Poor than Steel	As good as forged steel.		Better than forged wheels
Number of Piece in a Rim	If casted single piece & Sheet metal multi piece	Generally casted hence single piece	Generally two piece.	----------	Single piece
Flammability	Not Flammable	Flammable	Not Flammable	Flammable	Not Flammable
Driving comfort	----------	----------	----------	----------	----------
Road Handling	----------	----------	----------	----------	----------
Ground contact	Regain Easily	Regain Easily	Good ground contact for light weight rims.	Better ground contact.	Poor Ground contact.

Figure 2.4: Comparison of Various Materials for different aspects (IJARIIE)

Following table depicts comparative study of various factors considered while designing wheel rim for materials such as aluminium alloys, Magnesium Alloys, Steel C1008, Carbon Fibre and Forged Steel(Kale 2015).

2.0.3 Manufacturing Process of a Wheel rim

Casting, forging, press working are the three main manufacturing processes are used to produce any type of automobile wheel rim. In any wheel rim types of defect occurred such as manufacturing defect and service defects. The defects introduced during the manufacturing process are known as manufacturing defects while defects introduced during service life of wheel rim are known as service defects. In casting several types of casting processes are

used such as low pressure and high pressure die casting, gravity die casting, squeeze and centrifugal. Generally casting introduces so many types of defects such as blow holes, subsurface defects cavities, porosity and uneven shrinkage. Forging is one of the excellent manufacturing methods for better quality rim, but this method is very costlier as compare to other methods.

2.0.4 Casting processes

Among aluminium wheels, cast ones represent more than 80% in Europe, 85% in USA for passenger cars and light trucks, and 93% in Japan. The major casting processes for wheels are:

- Low-pressure die casting (mainly used)
- Gravity permanent mould casting (less used)
- Squeeze-casting process (marginally used)

After casting process, the wheel rim is x-ray inspected and heat treatment process are made before it goes to machining process. This step is followed by a pressure tightness testing before drilling valves and bold nut holes. After a cosmetic inspection, wheels are then painted or varnished, this operation including a pre-treatment such as degreasing, phosphatizing and chromating for 3D dimensional controls, dynamic balance checking, bending and rim roll fatigue Impact tests are statistically performed.

2.0.4.1 Forging

Forged aluminium wheels are one-piece wheels formed from a single block of metal by hot forging, hot or cold spinning and machining operations. The forging process permits flexibility in design of the styled disk, like cast wheels.