UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ANALYSIS OF WHEEL RIM ON THEIR DESIGN AND STRENGTH

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

by

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This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology Bachelor Degree of Mechanical Engineering Technology (Automotive) (Hons.). The member of the supervisory is as follow:

……

(MR. MOHD SULHAN BIN MOKHTAR)

ABSTRAK

Projek ini bertujuan untuk memberi panduan yang tepat untuk memilih jenis roda kereta yang tepat untuk disesuaikan dengan tayar. Bentuk dan kekangan yang hadir mestilah dapat disesuaikan untuk menampung tayar tertentu untuk kenderaan. Rekabentuk adalah aktiviti utama yang memberi kesan kepada kualiti produk dan roda roda cakera dipertimbangkan dalam kajian ini. CATIA V5R18 digunakan untuk merekabentuk model rim roda dan semakin lama masa yang dihabiskan akan mengurangkan risiko dari segi reka bentuk dalam proses pembuatan. Di dalam projek ini, model rim roda dibuat dengan menggunakan CATIA dan analisis dijalankan ke atas model rim tersebut. Analisis 'Von Misses' digunakan sebagai simulasi daya iitatic , iaitu tekanan yang bertindak ke atas komponen dan juga untuk mengukur daya tekanan selain dapat menyerupai keadaan sebenar dari segi perubahan bentuk , keupayaan lenturan dan secara tidak langsung dapat mengurangkan masa digunakan berbanding dengan penggunaan kaedah pengiraan matematik biasa. Didalam kajian ini, analisis dijalankan terhadap dua jenis rim roda yang biasa digunakan oleh pengguna kereta iaitu rim roda aluminum dan rim roda besi. Untuk keseluruhan projek ini, rim roda aluminum dijangka menjadi roda yang lebih kuat berbanding rim roda besi.

ABSTRACT

The objective of this car wheel rim analysis guides a firm base on which to fit the tire. Its constraints and shape should be suitable to sufficiently accommodate particular tire compulsory for the vehicle. Car wheel rim belonging to the disc wheel category is considered in this study. Design is a key industrial activity which affects the quality of the invention. CATIA V5R18 is used to modeling the wheel rim. Modeling the complex 3-D models, lot of time spent and will reduce risk consists of design and manufacturing process. In this case, modeling of the wheel rim is made by using CATIA and the model is undergoes static analysis. Von Misses Stress is used to simulating the static forces, pressure acting on component and also for calculating the results. It calculates the stresses, deformations, bending ability and their related moments and will reduces the time compared with the use of method mathematical calculations by a human. In this study, static analysis work is conducted by considered two different materials that is aluminum and steel the performance has been observed. In this paper by observing the expected results of static analysis obtained steel is suggested as best material.

DEDICATION

This report is dedicate for my beloved family who never failed to give me financial and moral support, for giving all my need during the time I developed my system and for teaching me that even the largest task can be accomplished if it done one step at a time.

I also want to send this message to my soul mate who always give moral support during hard time.

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PCD	-	Pitch Circle Diameter
BCD	-	Bolt Circle Diameter
SDAS	-	Secondary Dendrite Arm Spacing
MPa	-	Mega Pascal
MIG	-	Metal Inert Gases
FEM	-	Finite Element Method
FEA	-	Finite Element Analysis
CATIA	-	Computer Aided Three- dimensional Interactive Application

CHAPTER 1
INTRODUCTION

This project introduction includes the explanation of project background, problem statement, objective, and scope of this study.

1.1 Background

Nowadays, many types of wheels are used in automotive industry which commonly divided in two main material groups, aluminum alloy and steel wheels. Aluminum alloy wheels are made from an alloy of aluminum or magnesium which usually lighter that helps to reduce fuel consumption. Other than that, aluminum alloy wheels offer better heat conduction that improves braking performance in more demanding driving conditions affect braking failure due to overheating. In addition, alloy wheel enhanced cosmetic appearance over steel wheels. Meanwhile, steel wheels are made of steel and physically heavier than aluminum, so when you put steel wheels on a car that has had aluminum alloy wheels, you tend to find that the extra weight dampens acceleration and agility. Obviously this can be unwanted for summer performance applications, but in the winter the effect can be a important physical and psychological advantage. Heavier wheels will make tires bite the snow tougher, and when driving in snow, having a car with reduced acceleration and speed can be a very good thing.

Table 1.1: Basic Comparison of aluminum alloy and steel wheel rim

Type	 Aluminum alloy wheel	 Steel wheel
Material	Alloy mixture from aluminum and silicone	Steel metal
Common usage	Suitable for summer application	Suitable for summer and snow application
Weight	Lighter	Heavier
Design	Come with variable number of spoke and piece	Only made from 2 piece steel that is disc and steel that welded together
Size	Usually available from 13 inch to 17 inch and maybe higher for car use	Available only from 13 inch to 15 inch for car use
Manufacturing	Casting and forging	Casting

Generally, wheel rim can be divided into a few basic criteria like wheel offset, size, PCD (pitch circle diameter) and number of spoke that affect the strength of the wheel rim. Wheel offset is the distance from the hub-mounting surface to the rim's true centerline that can be measured in millimeters, negative or positive. When the width of the wheel changes, the offset also changes numerically that affecting the handling of the car.

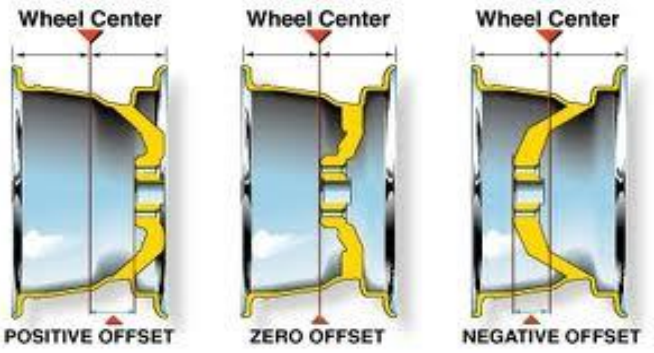

Figure 1.1: Types of wheel offset

Next criteria is the wheel size of the sport rim that shows the distance from the hub-mounting and usually wheel size is depend on the size of the car used while PCD is the diameter of a circle drawn through the center of your wheel's bolt holes and wheel spoke consisting of a radial member of a wheel joining the hub to the rim. Currently, car manufacturers use different stud or bolt hole patterns for the fitment of their wheels and these must line up exactly with a new ones enabling them to seat properly against the hub.

1.2 Problem Statement of Study

Nowadays, plenty of wheel rims in market were introduced with different material such as steel, aluminum alloy, magnesium and etc. Aluminum alloy rim are obviously more pleasing to look at than steel rim but in term of comparing the strength, we did not know which wheel rim is more durable and strong. Many customers facing the same problem which is dented wheel rim in case when collide with aperture road in daily usage. Most wheel manufacturer just priorities the looking of wheel rim rather than the durability and toughness of car wheel rim. This situation are worsen by the raising of aftermarket wheel rim with many fancy styles and design that can affect a lot of car user to fit it at their car without knowing the risk of their wheel to damage easily.

Other than that, extensive aftermarket wheel size and offset that easily fit to the cars by customers is dangerous to the stability and control of the car. Wider wheel can increase the load on the wheel shaft that affect the shaft to bend and crack easily. This situation can be worse when the driver lost control of the car and involve in car accident. This example has shown enough that there is no proper guideline for car user and extensive variety of wheels rim available on market makes it an overwhelming experience for users to choose the right ones they need for their car. For this research, we are focusing on the strength analysis of both aluminum alloy and steel rim to find which is more durable and creates a long lasting life for daily usage.

1.3 Objective

To come out with analysis data (comparative) on aluminum alloy versus steel rim and to analyze the strength of both wheel rim by using simulation in CATIA software.

1.4 Project Scope

Scope of this project encompasses of using aluminum alloy and steel rim with wheel diameter of 15 inch. Plenty of car users nowadays use compact cars with commonly use 15 inch wheel rim. Result data of this project can be used to guide majority car user to choose better wheel rim for their car. This project also undergoes computational analysis to determine the strength of both wheel rims by using simulation in CATIA software. Von Mistress static analysis is use with the model is subjected to a distributed circumferential load start with 1000N to 10000N with incremental of 1000N and is stopped immediately when the deformation of the wheel is more than 30mm. Then, the analysis is continue with the lab testing which using pressing machine with the same

range as computational analysis (1000N to 10000N with incremental of 1000N). Width wheel data is collected in every test to check the deformation and damage to the wheel.

CHAPTER 2

LITERATURE REVIEW

2.1 Types of Wheels

A wheel rim is an important part of each car .Depending on the material used in the production of wheel rims, there are some types of common wheel rims available in the automobile market that is aluminum alloy and steel rims. Wheel rim is the outer circular design of the metal on which the inside edge of the tire is mounted on vehicles such as automobiles and types of rims include wire spoke, steel disc, light alloy and aluminum alloy, magnesium alloy wheel, titanium alloy wheel, and composite material wheel. Alloy wheels are now standard on most cars because they offer both cosmetic and performance advantages. Alloys tend to bend more easily than steel under the effect of the road, and have a tendency to crack if bent too far. To the degree that the alloy wheels are soft or brittle depends on how much nickel is added to aluminum to make the alloy more brittle, less light means a softer wheel and tend to bend more easily .Construction methods such as casting or forging pressure also has an effect on the strength of this alloy. Alloy wheels can be polished, painted, machined or chrome that is different finishes should be treated in different ways. They are also exposed to a variety of cosmetic damage such as scrapes the curb, saltwater corrosion and acid cleaners.

As earlier mentioned aluminum alloy wheels are very popular and still in use today on roadsters and low-riders. They tend to be obviously low in weight, and are realistically strong. They have an “old school” look and style which is often highly pursued after. More rare wheels can be produced from several combinations of these technologies.

Large earth-moving vehicles such as the more gigantic dump trucks often have some degree of the vehicle's suspension actually built into the wheel itself, lying in the middle of the hub and rim in place of spokes. Similarly, many companies make wheels which are designed like steel wheels but are made of aluminum. The design is actually called the center line wheel and the most famous of these are made by centerline.

They used to be made of magnesium for their light weight and strength, but magnesium catches fire somewhat easily and is very difficult to put out. This is unfortunate, because it is superior to aluminum in every other way. This tendency also makes it a dangerous metal to work with, because piles of shavings tend to burst into flame and burn through concrete surfaces when they get too hot.[1]

Steel wheels are heavier than aluminum, and when you put steel wheels on the car, you tend to find that extra weight dampened acceleration and agility , decrease the center of gravity of the car and in general make it drive more like a tank. Obviously this can be unwanted for application of summer performance, but in winter the effect can be a physical and psychological advantage significantly. Heavier wheels will make snow tires bite harder, and when driving in the snow, having a car with sluggish acceleration and agility, low center of gravity and make sense of toughness and weight can be a very good thing. Steel wheels are stronger than alloy wheels and it takes more force to bend the steel wheels and it is difficult to crack them. Given their functional looks familiar, purely cosmetic damage is not usually a big issue.

There are wheel covers that you can put on steels to make them look like alloy wheels; they often come on steels sold as OEM choices, and can be found online as well. Wheel covers are fragile, look kind of cheesy, and are most often held on by a spring steel friction grip that has a distressing tendency to come off at inconvenient times and roll away. Steels are generally only made in 16" sizes or less. There are a very few 17" steels out there, but not a single 18" steel that I know of. I would imagine that 18" steel would be ridiculously heavy. Consequently, putting on steels will often involve downsizing. Some high-performance cars will not accept downsized wheels because of oversized

brake calipers or other suspension issues. Steels are also usually 75-80% less expensive than alloy wheels, making them great for a second set, and inexpensive to replace if badly damaged. Thus for many reasons alloys are the only choice when high performance and/or looks are the qualities you need. Steels are generally better for those no-nonsense daily drivers, or for any cars that don't have to look pretty or do fancy maneuvers because they work for a living. They are especially ideal, however for that extra set of winter wheels. [2]

2.2 Design of Wheel

2.2.1 Pitch Circle Diameter (PCD)

PCD stands for Pitch Circle Diameter and also known as Bolt Circle Diameter (BCD). The Bolt Circle Diameter (BCD) is the diameter of the circle that passes by the center of the bolts. This is very easily measured on wheels with even number of bolts by measuring the distance between the centers of two opposite bolts in mm. In the diagram the blue circle highlights the BCD on a 4bolt wheel. The red line represents the diameter measured from bolt hole to the opposite bolt holes (for simplicity is easier to measure from one side of one bolt to the same side of the opposite bolt.