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Design and Load Analysis Toward the Strength of Rim Modification Using SolidWorks Software on Motorcycle as a City Transportation

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***Abstract*—The purpose of this study was to design and analyze the loading of the modified rim strength (cast wheel type) on the motorcycle. The method used is to use SolidWorks software, loading simulation analysis performed with 3 variations of the rim model and three (3) variations in the number of spoke (8, 6, and 4 spoke) at a speed of 70 km/hour. Research results show almost all the modified rim models (cast wheel type) were analyzed get a safety factor score included in the category of safe to use, except the rim of model A with 4 spokes. Modified rims (cast wheel type) model A with the number of spoke 4 obtain the largest maximum stress value of 3.157 × 108 N/m^2, while the smallest maximum stress value is obtained on the rim of model C with the number of spoke 4 which is equal to 2.753 × 108 N/m^2.**

Keywords: loading, modified rim, cast wheel, SolidWorks software, city transportation

I. Introduction

The safety aspect is very important to be taken into account in the automotive world because it is closely related to the lives of passengers. So that in modifying each component must be considered carefully. In the automotive field there have been many accidents caused by plastic deformed rims. A rim is the frame of a tire that holds the force and stress due to the weight of the vehicle and the impact or blow from the road surface. Blows from the road surface can cause stress and deformation. Aluminum alloy rims have an area called a critical area, where the critical area is an area where stress concentration occurs. The critical area on the rim is located in the hub, spoke and flange areas. Damage that occurs in the aluminum alloy rim is the lip rim that undergoes plastic deformation or broken spoke on the cast wheel rim due to the force and stress that occur exceeds the maximum allowable stress.

By considering these problems, it is necessary to conduct research on “Design and Load Analysis Toward the Strength of Rim modification using SolidWorks software on Motorcycle as a city transportation”

This research is also very instrumental in realizing the vision and mission of the Department of Mechanical Engineering, Faculty of Engineering, Halu Oleo University in increasing research productivity in the field of mechanical engineering.

Various types of problems have been analyzed using MEH. The Finite Element Method application can be classified according to three categories [Huebner; 1975 \. The first is the type of problem that is known as an equillibrium problem or steady-state problem. Examples the equillibrium problem in solid matter mechanics is the peng stress (strain) and strain counts [1].

A. Force

Force is defined as the pull or push acting on an object that can cause changes in motion. Generally, the force causes two effects, namely:

1) Causes an object to move if it is stationary or changes in motion if it has moved and,

2) Deformation occurs. The first effect is also called the external effect and the second is called the internal effect [2].

B. Circular Motion

Circular motion is the motion of objects whose path is circular around a fixed point, as shown in Fig. 1 [3].

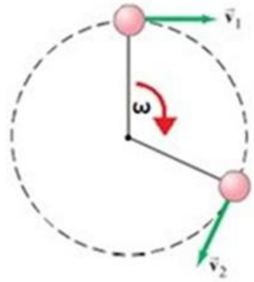

Fig. 1. Circular motion using the equation of angular velocity and angular acceleration [2].

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As indicated on Fig. 1, Velocity (v) is a linear velocity or speed that is usually found in a straight motion. Angular velocity or omega (ω) and linear velocity (v) are related to (1):

$$\omega = v / r \quad (1)$$

Where: v = linear velocity (m/s)

r = path radius (m)

In circular motion, there is an acceleration on the object that leads to the center of the track point called centripetal acceleration. The centripetal acceleration (αs) is perpendicular to the linear velocity [3].

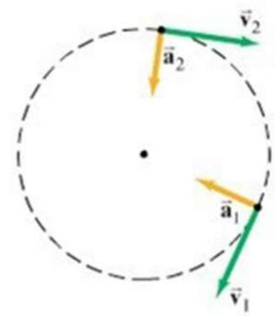


Fig. 2. Centripetal acceleration.

The centripetal acceleration equation is as shown on Fig. 2:

$$\alpha s = \omega^2 . r = v^2/r \quad (2)$$

Where: αs = angular acceleration (m/s^2)

Centripetal acceleration (αs) causes centripetal force (Fs) which also leads to the center of the trajectory. The centripetal force must exist so that the object continues to move in its path (circle) [3].

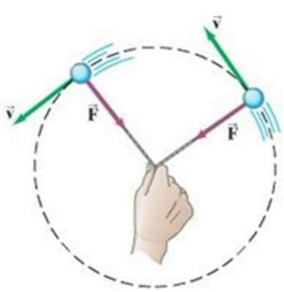


Fig. 3. Centripetal force motion [3].

The centripetal force equation as shown in Fig. 3 is:

$$\Sigma F_s = m.a_s = m.\omega^2.r = m.v^2/r \quad (3)$$

Where: Fs = centripetal force (N)

m = mass of body (m)

When a rigid body undergoes translation, all particle matter has the same acceleration [4].

C. Stress and Strain

The strength of materials can be referred to as the study of the relationship between external forces acting on elastic objects and stress-strain inside caused by the forces acting [4].

Stress is the force per unit surface area. There are two types of stress, namely shear stress and normal stress. Normal stress is represented by σ, which is the amount of force (F) acting perpendicular to the surface with A area [5].

If an object is stretched it will stretch (extension), there is a relationship between the length increase with the applied force. If the broad unity force is called stress and length accretion is called strain, then this relationship is expressed by stress-strain graph on Fig. 4 [6].

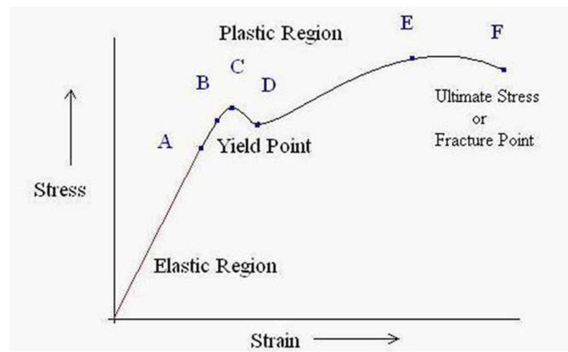


Fig. 4. Stress-strain diagram [6].

D. Allowable Stress and Safety Factor

A structure is every object that must carry or distribute the burden. If structural failures must be avoided, the burden that a structure can bear must be greater than the burden that will be experienced during its lifetime [6].

The ratio of actual strength to strength needed is called the safety factor (n) [6]:

$$n = Actual\ strength\ /\ Strength\ needed \quad (4)$$

The safety factor must be greater than 1.0 if failure is to be avoided. Depending on the situation, a safety factor is used with prices slightly above 1.0 to 10 [7].

E. Introduction to Basic SolidWorks

As can be seen on Fig. 5, SolidWorks, a CAD software, is recognized by its users as user friendly software in assisting the object design process [8].

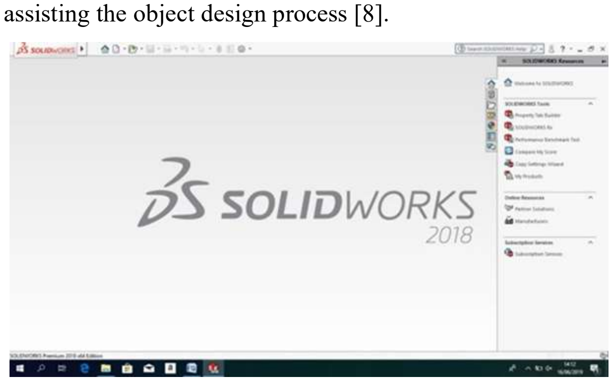


Fig. 5. Initial appearance of the SolidWorks program [8].

F. Basic Concepts of Solidworks

Solidwork is a 3D computer aided design (CAD) program that uses the Microsoft Windows operating system. This program was developed by Solidworks Corporation, which is a subsidiary of Dessault Systemes. This program is relatively easy to use compared to similar programs [9].

G. Poisson ratio

If a stem increases in length due to a loading pull it will contract in each direction that is perpendicular to direction of loading. Within the elastic limit, the ratio of the compressive strain to the the pitch of the axial tensile strain is constant, and is named Poisson ratio (v). So an axial stress o x will give rise an axial strain e x = a x / E and a lateral strain e v = - ve *, de- n y denotes the normal direction for x. A negative sign is used so that the tensile strain is positive and the compressive strain is negative [10].

II. Research Methods

This research was conducted at the Computational Laboratory of the Department of Mechanical Engineering, Faculty of Engineering, University of Halu Oleo, Kendari and other flexible workspaces.

The tools used in this study are as follows:

a. Caliper, to measure a certain diameter at the rim.

b. Ruler, to measure a certain length on the rim.

c. One laptop unit that has been equipped with SolidWorks software.

The material used in this study is the modification of the cast wheel rim on a two-wheeled vehicle.

The types of aluminum alloys from the modified rim employed in this study are Aluminum Alloy 4032-T6, with specifications is as shown on TABLE I.

TABLE I. Property of aluminum alloy 4032-T6

Property	Value
Elastic Modulus	7.9×10^{10} N/m^2
Poisson's Ratio	0.34 N/A
Shear Modulus	2.6×10^{10} N/m^2
Mass Density	2680 kg/m^3
Tensile Strength	380000000 N/m^2
Yield Strength	315000000 N/m^2
Thermal Expansion Coefficient	1.9×10^{-5} K
Thermal Conductivity	138 W/(m.k)
Specific Heat	850 J/(kg.K)

III. Results and Discussion

The analysis in this study was carried out on all parts of the rim modification (cast wheel type). In the static loading of the force exerted by the overall weight of the motor along with two passengers.

In this analysis, each modified rim model will be applied to the rim region.

The value of the load on the modified rim (cast wheel type) comes from the overall motor load which is assumed to be 150 kg plus the weight of two adult passengers which is assumed to be an average of 75 kg for one person, then the total load on a motorcycle with two adult passengers is amounting to 300 kg. Because there are two wheel rims on a motorcycle, the load is divided in half, amounting to 150 kg. So the great force applied to the rim of the type of cast wheel modification that is equal to:

$$F = m \times \alpha s = \text{mass} \times \text{centripetal acceleration}$$

$$= 150 \text{ kg} \times 1750.39 \text{ m/s}^2$$

$$= 262588.5 \text{ kg-m/s}^2$$

$$= 262588.5 \text{ N}$$

The results of the analysis in this study are the results obtained based on analysis using 2018 SolidWorks software.

A. Modified Rim Design (Cast Wheel Type) Motorcycle

1) Design the modification of the rim model A is as shown on Fig. 6, as follows :

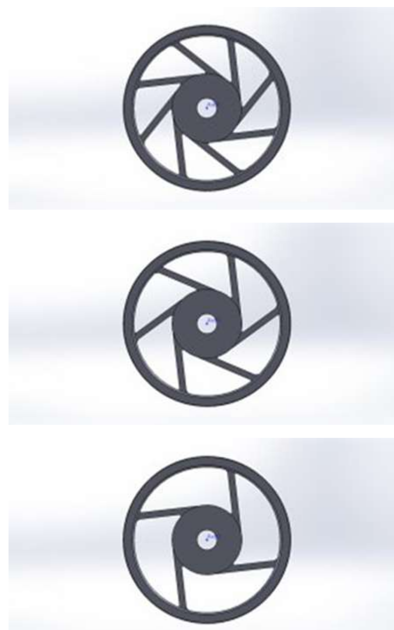


Fig. 6. Model A with 8, 6, and 4 spoke.

2) Design model rim modification B is as indicated on Fig. 7

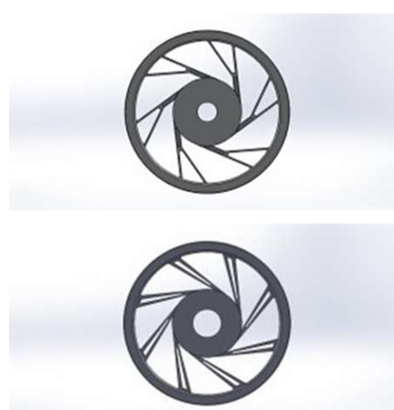


Fig. 7. Model B with 8, 6, and 4 spoke.

3) *Design rim modification of model C is as shown in Fig. 8, as follows :*

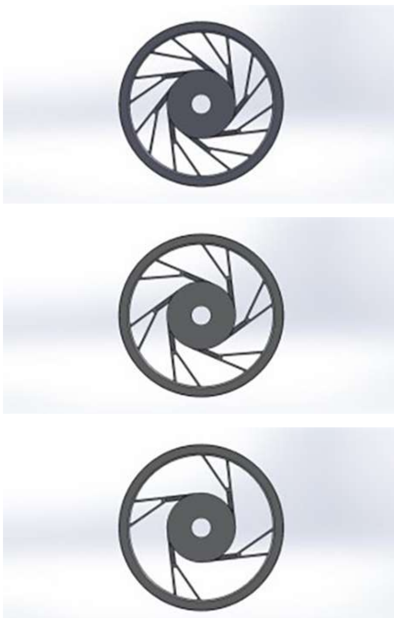
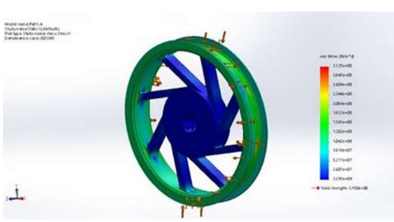


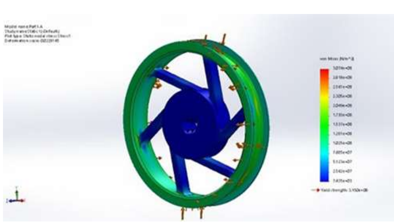
Fig. 8. Model C with 8, 6, and 4 spoke.

B. Analysis Results, Motorcycle Modificatiosn Simulation (Cast Wheel Type)

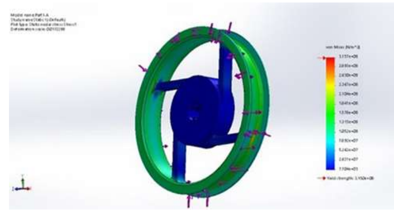
1) *Analysis of the modification of the rim A simulation model is indicated on Fig. 9.*



(I)



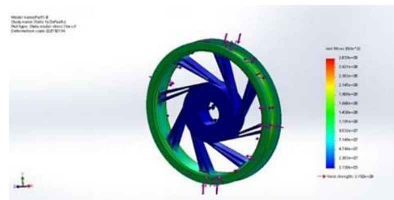
(II)



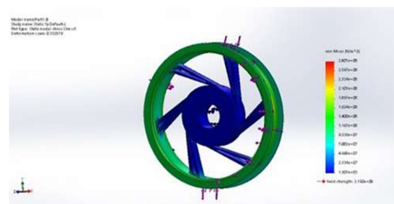
(III)

Fig. 9. Model A Stress simulation result with (i) 8 spoke (ii) 6 spoke (iii) 4 spoke.

2) *The analysis of the modified rim B simulation model is demonstrated on Fig. 10 below.*



(I)



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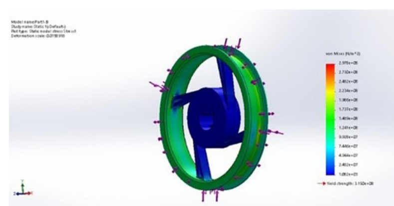
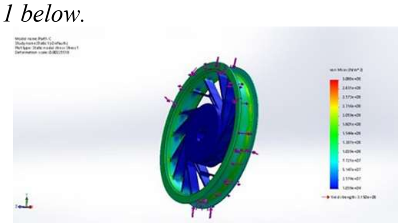


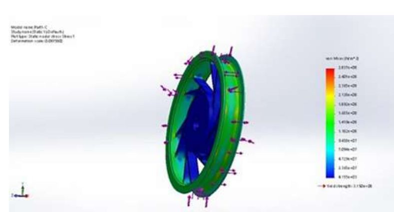
(III)

Fig. 10. Model B Stress simulation result with (i) 8 spoke (ii) 6 spoke (iii) 4 spoke.

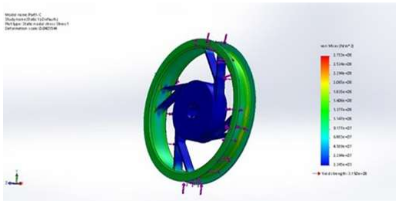
3) *Analysis of the simulation rim of model C is as shown on Fig. 11 below.*



(I)



(II)



(III)

Fig. 11. Model C Stress simulation result with (i) 8 spoke (ii) 6 spoke (iii) 4 spoke.

IV. Discussion

The results of the simulation of modified rim (cast wheel type) on a motorcycle, Maximum stress is obtained with a number of different spoke on each rim model design in TABLE II.

Based on the results of the simulation analysis, then obtained a comparison of the rim model analyzed by varying the number of different spoke using SolidWorks software.

For model A modification rim with number of spoke 8, 6, and 4, each obtained a maximum stress value in an order of 3.125×10^8 N/m^2; 3.074×10^8 N/m^2; and 3.157×10^8 N/m^2. Where, the modification rims of model A with the number of spoke 4 are not safe to use because the maximum stress value exceeds the allowable stress value on the material, while the rim modification of model A with the number of spoke 8 and 6 in safe conditions to use.

For model B modification rim with the number of spoke 8, 6, and 4, each obtained a maximum stress value of 2.859×10^8 N/m^2; 2.801×10^8 N/m^2; and 2.978×10^8 N/m^2. Where, in the B model modification rim for all spoke numbers in safe condition because the maximum stress value does not exceed the allowable stress value on the material.

For modification rims of model C with the number of spoke 8, 6, and 4, each obtained a maximum stress value of 3.088×10^8 N/m^2; 2.837×10^8 N/m^2; and 2.753×10^8 N/m^2. Where, in the C model modification rim for all number of spoke in safe condition because the maximum stress value does not exceed the allowable stress value on the material.

TABLE II. TABLE TYPE STYLES RESULTS OF MOTORCYCLE RIMODIFICATION (CAST WHEEL TYPE)

	Number of Spoke	Max Stress(N/m^2)		Allowed Stress (N/m^2)	Safety Factor	Condition
		simulation	theoretical			
Rim A model	8	$3.125 x 10^8$	$1.291 x 10^5$	$3.150 x 10^8$	1.008	Safe
	6	$3.074 x 10^8$	$1.291 x 10^5$	$3.150 x 10^8$	1.025	Safe
	4	$3.157 x 10^8$	$1.291 x 10^5$	$3.150 x 10^8$	0.998	Not Safe
Rim B model	8	$2.859 x 10^8$	$1.291 x 10^5$	$3.150 x 10^8$	1.102	Safe
	6	$2.801 x 10^8$	$1.291 x 10^5$	$3.150 x 10^8$	1.125	Safe
	4	$2.978 x 10^8$	$1.291 x 10^5$	$3.150 x 10^8$	1.058	Safe
Rim C model	8	$3.088 x 10^8$	$1.291 x 10^5$	$3.150 x 10^8$	1.020	Safe
	6	$2.837 x 10^8$	$1.291 x 10^5$	$3.150 x 10^8$	1.110	Safe
	4	$2.753 x 10^8$	$1.291 x 10^5$	$3.150 x 10^8$	1.144	Safe

V. Conclusions

- Almost all the modified rim models (cast wheel type) analyzed, obtained the value of the safety factor which is included in the safe category to be used, except for the 4 spoke rim model A.
- Modified cast wheel type A rim with the number of spoke 4 gets the largest maximum stress value of 3.157×10^8 N/m^2, while the smallest maximum stress value is obtained on the model C rim with the number of spoke 4 which is 2.753×10^8 N/m^2.

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