ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Monthly Peer Reviewed Open Access International e-Journal

Design, Evaluation and Optimization of Zinc Alloy Wheel for Four Wheeler under Different Loads Conditions

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ABSTRACT:

Alloy wheels are automobile wheels which are made from an alloy of aluminum or magnesium metals Or sometimes a mixture of both. Alloy wheels differ from normal steel wheels because of their lighter weight, which improves the steering and the speed of the car.

At present four wheeler wheels are made of Aluminum Alloys. In this thesis aluminum alloys are replaced with zinc alloy due to its less cost and its density is less compared with that of aluminum. Due to less density, the weight of the wheel reduces by using zinc alloys. Structural analysis is done on the wheel at different loads, only vehicle weight, vehicle weight + 4 persons weight and vehicle weight + 6 persons weight. Design is optimized by analyzing the model by taking the constraints as ultimate stresses and variable as thickness at different loads.

Keywords:

Optimization of zinc alloy wheel, magnesium alloy, mesh model, solid model.

TYPES OF WHEELS:

- Alloy Wheel.
- Steel wheel
- rally wheel
- mag wheels

- Spoke wheels

LOADING METHODS ON AUTOMOTIVE WHEEL:

Finally, a method proposed assumes the area in contact with the rim spans half of the tire or 900 symmteri-cal about the point of loading. The loading method is similar to a cylindrical bar in a clevis, assuming no gap exists.

According to the SAE, a wheel should maintain structural integrity without any cracks or plastic deformation for more than 4 x 109 rotations under a radial load, Q, expressed by the following equation.
Q S r *W............... =(1)
where, Sr means acceleration test factor (Sr = 2.2) and W means maximum tire load.
This may not be valid for the run flat tire due to its stiff side walls, which would reduce the contact patch area. According to the manufacturer, a run flat tire deflects about 12 mm for every 4448 Newton's of force; The P22560R16 tire under the load of 10.45 kN, the tire should deflect 29.71 mm. This is in good agreement with the experimental tests that predicted 8.9 mm at 3113 N load. For a corresponding height of 29.71 mm and based on a tire diameter of 663 mm, the angle 400, swept out is 48 degrees. The calculations were based on segments of circle geometry. This analysis however did not prove to be entirely accurate and was later found to be almost 900. This can be rationalized, because of the additional strength needed in the bead seat area of the tire.

By using the cosine function accordingly, the distributed pressure, Wr, is given by the following equation:

$$W_r = W_0 * \cos\left(\frac{\pi}{2} * \frac{\theta}{\theta_0}\right)$$

The total radial load W is calculated by using Eq. (2) as follows.

$$W = b \int_{-\theta_0}^{\theta_0} W_r * r_b d\theta$$

$$W = b \int_{-\theta 0}^{\theta 0} W_0 * r_b * \cos\left(\frac{\pi}{2\theta_0} * \theta\right) d\theta$$

$$W = b * W_0 * r_b * \frac{1}{\left[\frac{\pi}{2\theta_0}\right]} * \sin\left(\frac{\pi}{2} * \frac{\theta}{\theta_0}\right)\Bigg|_{-\theta 0}^{\theta 0}$$

$$W = 4 * b * r_b * \theta_0 * \frac{W_0}{\pi}$$

or

$$W_0 = \frac{W * \pi}{b * r_b * 4 * \theta_0}$$

b=19.8 mm, W=10.4 kN ,rb=7202 mm. Applying these yields Wo = 2045 kPa. where, rb is the radius of the bead seats and b means the total width of the bead seats.In this analysis, the total radial load W = 9496 N is applied to the model, and the magnitude of the load is the same as applied to the actual wheel in the stress measurement experiment.

In this stress measurement experiment, the wheel is assembled with a Goodyear Eagle aqua steel tire (P22560R16) which is inflated to a pressure of 241 kPa and pressed against a flat plate with a load of 3113 N. Strain gages are attached to the wheel in circumferential direction. The central angle 0o the pressure distribution is 80 degree.

LITERATURE REVIEW:

Loading Methods On Automotive Wheel:

The total weight of a car is balanced with a vertical reaction force from the road through the tire. This load constantly compresses the wheel radially. While the car is running, the radial load becomes a cyclic load with the rotation of the wheel. Hence, the evaluation of wheel fatigue strength under radial load is an important performance characteristic for structural integrity. According to the SAE, a wheel should maintain structural integrity without any cracks or plastic deformation for more than 4 x 109 rotations under a radial load, Q, expressed by the following equation.

Q S r *W............... =(1)
where, Sr means acceleration test factor (Sr = 2.2) and W means maximum tire load.

Under a radial load, the strength of the rim usually determines the fatigue life of a wheel, so the stress evaluation is mainly focused on the rim. In this analysis also, the contact condition between the discs spoke flange and the rim well is assumed to be tightly closed, and the contact area is modeled by one element with the summed thickness of the disc and the rim.

This may not be valid for the run flat tire due to its stiff side walls, which would reduce the contact patch area. According to the manufacturer, a run flat tire deflects about 12 mm for every 4448 Newton's of force; The P22560R16 tire under the load of 10.45 kN, the tire should deflect 29.71 mm. This is in good agreement with the experimental tests that predicted 8.9 mm at 3113 N load.

$$W_r = W_0 * \cos\left(\frac{\pi}{2} * \frac{\theta}{\theta_0}\right)$$

The total radial load W is calculated by using Eq

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$$W = b\int_{-\theta 0}^{\theta 0} W_0 * r_b * \cos\left(\frac{\pi}{2\theta_0} * \theta\right) d\theta$$

$$W = b * W_0 * r_b * \frac{1}{\left[\frac{\pi}{2\theta_0}\right]} * \sin\left(\frac{\pi}{2} * \frac{\theta}{\theta_0}\right)\Bigg|_{-\theta 0}^{\theta 0}$$

$$W = 4 * b * r_b * \theta_0 * \frac{W_0}{\pi} \quad \ldots\ldots\ldots(4)$$

or

$$W_0 = \frac{W * \pi}{b * r_b * 4 * \theta_0}$$

b=19.8 mm, W=10.4 kN ,rb=7202 mm. Applying these yields W0 = 2045 kPa. where, rb is the radius of the bead seats and b means the total width of thebead seats.

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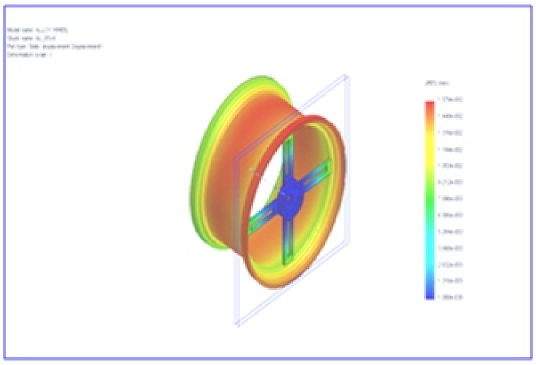
PROJECT OBJECTIVE:

Present used material for for four wheeler is Aluminum Alloy. In this the material is replaced with Zinc alloy. Analysis and Optimization is done by applying different loads,

1.only vehicle weight,

2.vehicle weight + 4 persons and



5.Vehicle weight + 6 persons.

Materials – Aluminum alloy and Zinc alloy
Loads – Vehicle weight, vehicle weight + 4 persons and Vehicle weight + 6 persons
Analysis – Original model and optimizing by varying thicknes

ALLOY WHEEL-AL_65x4-Displacement Displacement1

RESULTS TABLE

	ALUMINUM ALLOYS			ZINC ALLOYS		
WORKING CONDITIONS	STRESS (N/mm^2)	DISPLACEMENT (mm)	STRAIN	STRESS (N/mm^2)	DISPLACEMENT (mm)	STRAIN
WITHOUT LOAD	3.16511	0.0128269	$3.92534e^{-5}$	3.17938	0.0104	$3.09e^{-5}$
VEHICLE WEIGHT + 4 PERSONS	3.89372	0.0157922	$4.82976e^{-5}$	3.91231	0.0128055	$3.809\ e^{-5}$
VEHICLE WEIGHT + 6 PERSONS	4.26421	0.0174179	$5.2732e^{-5}$	4.2809	0.0140517	$4.16e^{-5}$

CONCLUSION:

In this thesis a wheel is designed used in a four wheeler. Present used material for wheel is aluminum alloys. In this thesis aluminum alloys are replaced with zinc alloy due to its less cost and its density is less compared with that of aluminum. Due to less density, the weight of the wheel reduces by using zinc alloys. And also strength of the zinc alloys is more compared with that of aluminum alloys.

When aluminum alloy is used, the wheel weight is 3.88kgs while we use zinc alloy, its weight is 2.2928kg. The weight is almost reduced by 1.5kgs which increases the efficiency of the wheel. Structural analysis is done on the wheel at different loads, only vehicle weight, vehicle weight + 4 persons weight and vehicle weight + 6 persons weight. By observing the analysis results, using zinc alloy for wheel is safe since the analyzed stress values are less than its yield stress value.

Design is optimized by analyzing the model by taking the constraints as ultimate stresses and variable as thickness at different loads. Present thickness of the wheel is 6mm. The wheel is optimized by considering the thickness from 3mm to 6mm.

By observing the optimization results, by optimal value for wheel thickness is 3mm. By reducing the thickness of the wheel, its weight is decreased.

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