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Design of wheel rim by using design of experiments

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ABSTRACT

There are many failures occurred such as Defects occurred during manufacturing, Initiation of Crack, over tightening of bolts and Corrosion. Some of the people have used FEM methods in their Research. They all have worked only on the negative offset and zero offset wheel rims. In this Paper we are focusing more on the positive offset wheel rim as they consume less material as compared to negative offset and positive offset wheel rims. In this Paperwe know the natural frequency and deformation of the original rim and we are going to design more than 2-3 designs for wheel rim. Using those designs and analysis types such as Static, Modal and mainly the Design of experiments we are going to produce the alternate design for the wheel rim which will be more sustainable and lesser in cost.

Keywords: *FEM Methods, Wheel Rim*

1. INTRODUCTION

It started several thousands of years ago; wheel is used when the human race began to travel the heavy objects from one place to another. Original wheel were sliced and used in this form for centuries on the carts and wagons. Wheel rim is an inseparable part of an automobile mounted on the axle hub of a vehicle. Its main functions are to rotate over the axle of an automobile so as to use power from engine to take automobile in motion, provide support for braking system over its body, dissipate heat generated in the body of wheel rim to surrounding environment, support whole body weight as well as withstand against impact load due to pot holes and road irregularities. There are many different types of wheel rims and they can be divided into many types depending on the manufacturing processes material used etc. This is an exciting time to be a part of the automobile industry (wheel industry) which is witnessing major structural changes. Even though the demands on the industry have never been greater. Customer expectations of wheel quality, safety, reliability and utility are at an all-time high. There is a call for sustainable designs with higher life expectancy thus the wheel manufacturers are investigating and developing more design tools to improve the quality of their products. CAE helps them to reduce the time to produce that design which improves the quality of design.

2. LITURATURE REVIEW

Mangire-Did comparison study of original rim and with the new rim which is modeled by him. Rims are crucial components of vehicle. The wheel is a component which movements the object on the surface when the force pressing the object to the surface efficiently. In the present every vehicle was designed with alloy wheels which are more efficient than spokes wheels. In this paper rim modelled from the existing dimensions by using the SOLIDWORKS. One model is used in day to day life, second one is changed which can be used in new vehicles and the last one is the modified version of new rim.

Patel-Evaluation of the fatigue life of steel rim is proposed in paper. The ANSYS software is used to obtain the static results on steel wheel. The two types of material used which are Aluminum and structural steel. The predictions for fatigue life for both the wheels are made using this. The analysis is showing that the baseline wheel failed the test and initiation of the crack was around the hub.

Dr. Torgal-The main objective in this paper is to analyze the failure causes of rim. The rim undergoes with surface cracks, bents. Damage to the rims will cause increase in vibration. Damage, such as rust, cracks, dents, etc. which could result in excessive vibration, pressure, loss and even structural failure of the rim. The paper tell us about various failures which can arise in the rim. This paper tells about the calculation of von-misses stresses and deflections with the help of analysis software.

3. METHODOLOGY

1) Types of Wheel Rim:

a. Wire Spoke- Spokes are the connecting rods between the bicycle hub and the rim. Their main purpose is to transfer the loads between the hub and the rim, which are caused by the weight of the rider and the bike.
b. Steel Disc-The steel disc performs the functions of the spokes. The wheel is fitted on the axle by bolting to flange attached to the axle. Some slots are generally provided in the wheel disc to allow the air to the inner side for better cooling of the brake drum inside.
c. Light Alloy Wheel-In the automotive industry, alloy wheels are wheels that are made from an alloy of aluminum or magnesium. Alloys of aluminum or magnesium are typically lighter for the same strength, provide better heat conduction, and often produce improved cosmetic appearance over steel wheels.

2) Material of Wheel Rim:
a. Steel Wheel-Steel wheels are made with an alloy of iron and carbon. They are heavier but they're more durable and can be easier to repair and refinish. Because of the way they're made cut out on a press and welded together they don't offer all the aesthetic spoke choices of other wheel types.
b. Aluminum Alloy Wheel-Aluminum wheels (sometimes called alloy wheels) are built with a blend of aluminum and nickel. The majority of wheels today are cast aluminum alloy, meaning they're made by pouring molten aluminum into a mold. They are lightweight but strong, withstand heat well and are generally more attractive than steel wheels.
c. Magnesium Alloy Wheel- Magnesium wheels are wheels manufactured from alloys which contain mostly magnesium. Magnesium wheels are produced either by casting, or by forging. Magnesium has several key properties that make it an attractive base metal for wheels: lightness; a high damping capacity; and a high specific strength.
d. Titanium Alloy Wheel-high mechanical strength and resistance to deformation, the offered rim can easily withstand high outer shocks and impacts. Also, it is called the main face of the wheel and it is solid, rigid and accurate in shape in order to balance heavy load of the car.

3) Wheel Nomenclature:
a. Wheel: Wheel is generally composed of rim and disc.
b. Rim: This is a part where the tire is installed.
c. Disc: It is a part of the rim where it is fixed to the axle hub.
d. Offset: This is a space between wheel mounting surface where it is rushed to center and focus line of rim.
e. Flange: The flange is a part of rim which holds the both beds of the tire.
f. Hump: It is a knock bed situate for the dot to keep the tire from sliding off the rim while the vehicle is moving.
g. Well: This is a piece of edge with width to encourage tire mounting and expulsion from the rim.

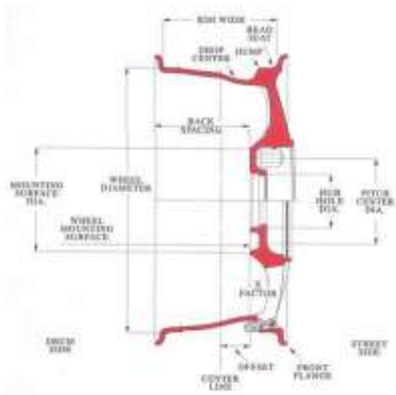

Fig.1.Wheel Rim Nomenclature

4) Wheel Rim Specification:
- Rim Diameter-381 mm
- Rim Width-177.8 mm
- Offset- 0
- Aspect Ratio-30-65.
- Maximum Power-70 KW
- Maximum Torque-155 N-m.

5) Mechanical Properties of Wheel Rim:
a. Aluminum Alloy.
- Young's Modulus=71 Gpa
- Poisson's Ratio=0.33
- Density=2.82 kg/m^3
- Yield Strength=310 Mpa
- Grade=211.

b. Magnesium Alloy.
- Young's Modulus=42 Gpa
- Poisson's Ratio=0.35

- Density=1.8 kg/m^3
- Yield Strength=130 Mpa
- Grade=AM 60.

6) CAD Modeling Using Solid Works.

Fig.2.Isometric View of wheel rim

7) Analysis.

➢ Static & Stress Analysis on the Model:

- Loading Condition

a. Radial Load=8000N.

b. Lateral Load=3000N.

We have applied the 8000 N Radial Load and 3000N. As shown in the figure below.

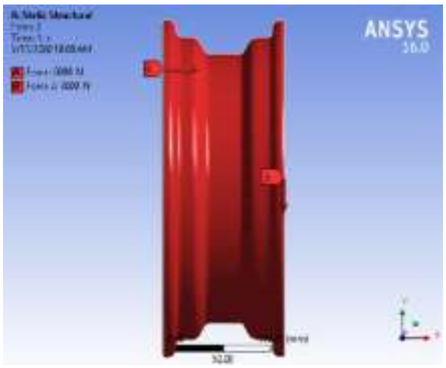

Fig.3.Loading Condition

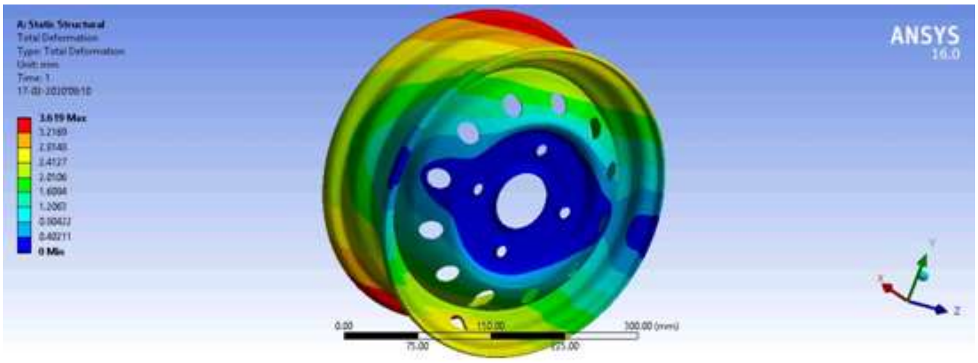

Fig.4.Static Analysis

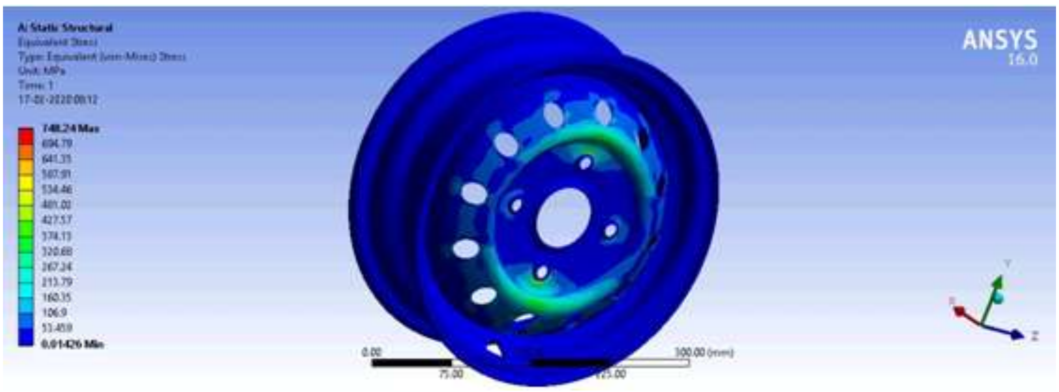

Fig.5.Stress analysis

Maximum deformation for the static analysis for the original Wheel rim is 3.619 mm with the stress value of 748.24 MPa.As of now our main aim is to reduce the deformation of the rim as well as the stress induced in the rim.

➢ Material Used.

1. Aluminum Alloy:

- Model.1. Static Analysis (Aluminum Alloy).

We have applied the 8000 NRadial Load and 3000 N. As shown in the figure below.

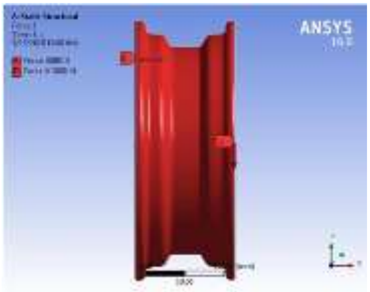

Fig.6.Loading Condition

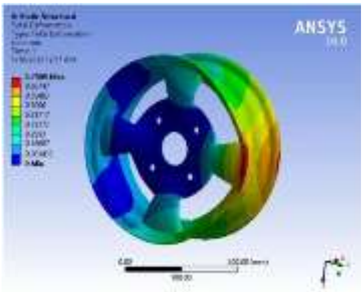

Fig.7.Total Deformation

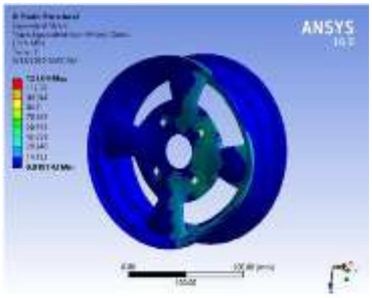

Fig.8.Equivalent Stress

- Model.2. Static Analysis (Aluminum Alloy).

We have applied the 8000 NRadial Load and 3000 N. As shown in the figure below.

Fig.9.Loading Condition

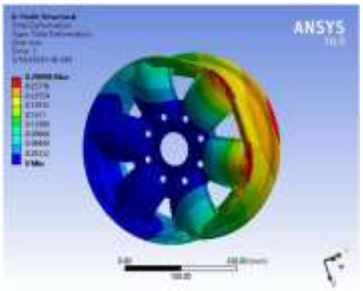

Fig.10.Total Deformation

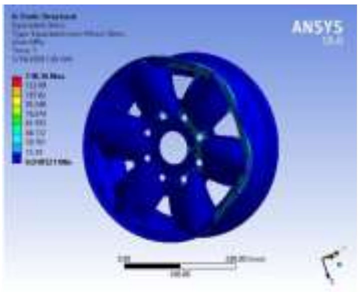

Fig.11.Equivalent Stress

- Model.3. Static Analysis (Aluminum Alloy).

We have applied the 8000 NRadial Load and 3000 N. As shown in the figure below.

Fig.12.Loading Condition

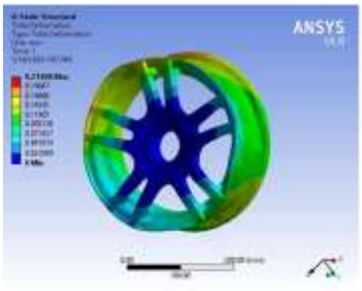

Fig.13.Total Deformation

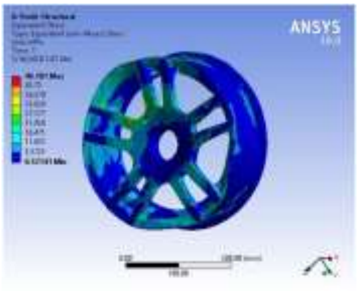

Fig.14.Equivalent Stress

- Model.4. Static Analysis (Aluminum Alloy).
-

We have applied the 8000 NRadial Load and 3000 N. As shown in the figure below.

Fig.15.Loading Condition

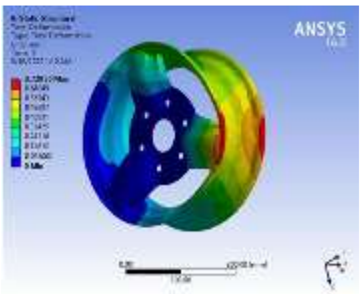

Fig.16.Total Deformation

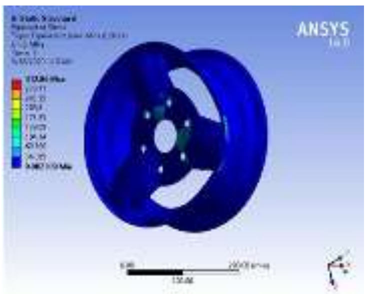

Fig.17.Equivalent Stress

- Model.5. Static Analysis (Aluminum Alloy).

We have applied the 8000 NRadial Load and 3000 N. As shown in the figure below.

Fig.18.Loading Condition

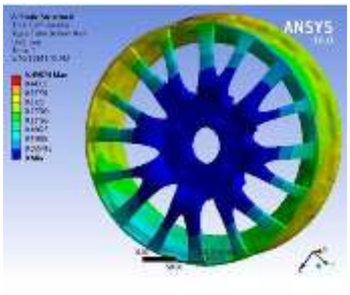

Fig.19.Total Deformation

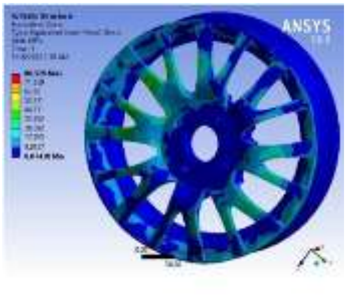

Fig.20.Equivalent Stress

2. Magnesium Alloy:

- Model.1. Static Analysis (Magnesium Alloy).

We have applied the 8000 NRadial Load and 3000 N. As shown in the figure below.

Fig.21.Loading Condition

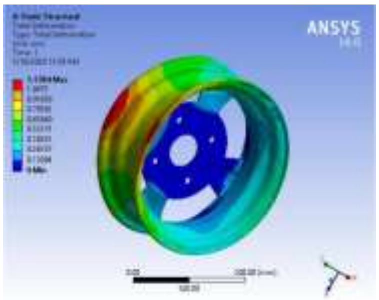

Fig.22.Total Deformation

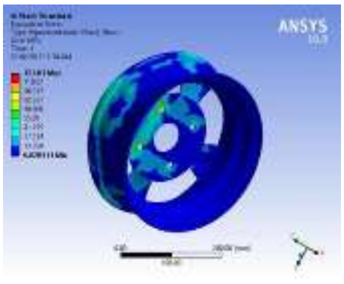

Fig.23.Equivalent Stress

- Model.2. Static Analysis (Magnesium Alloy).

We have applied the 8000 NRadial Load and 3000 N. As shown in the figure below.

Fig.24.Loading Condition

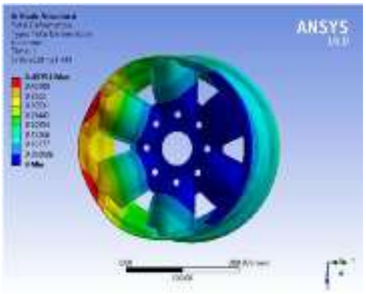

Fig.25.Total Deformation

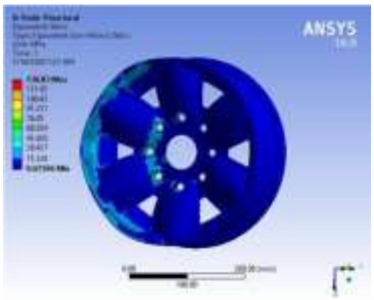

Fig.26.Equivalent Stress

- Model.3. Static Analysis (Magnesium Alloy).

We have applied the 8000 NRadial Load and 3000 N. As shown in the figure below.

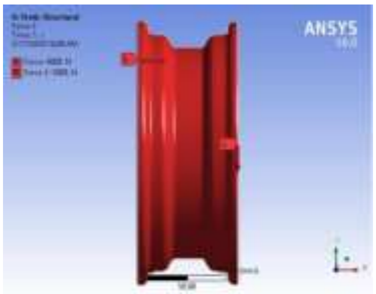

Fig.27.Loading Condition

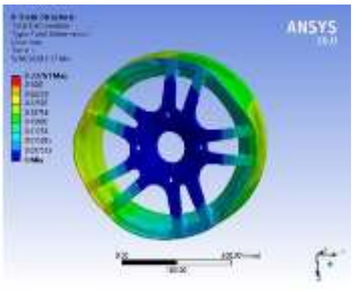

Fig.28.Total Deformation

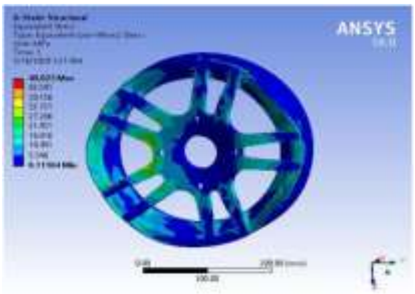

Fig.29.Equivalent Stress

- Model.4. Static Analysis (Magnesium Alloy).

We have applied the 8000 NRadial Load and 3000 N. As shown in the figure below.

Fig.30.Loading Condition

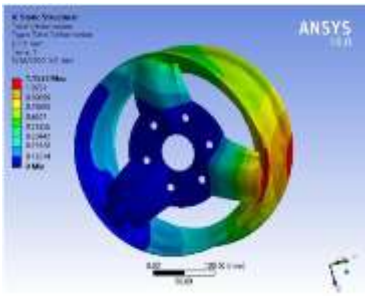

Fig.31.Total Deformation

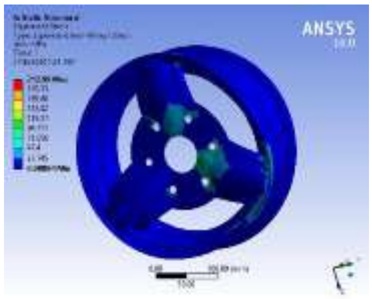

Fig.32.Equivalent Stress

.Model.5. Static Analysis (Magnesium Alloy).

We have applied the 8000 NRadial Load and 3000 N. As shown in the figure below.

Fig.33.Loading Condition

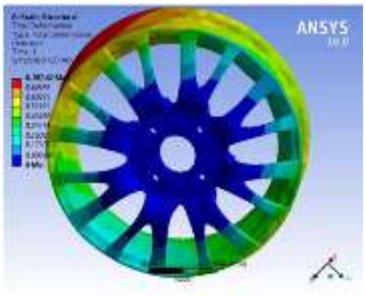

Fig.34.Total Deformation

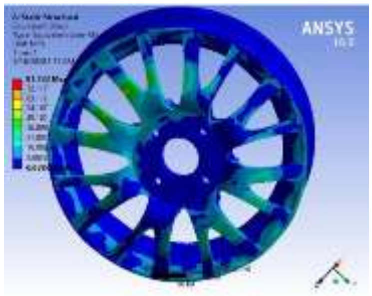

Fig.35.Equivalent Stress

4. COMPARISION OF RESULTS:

- Material Used: AluminumAlloy

	Original	Model 1	Model 2	Model 3	Model 4	Model 5
Total Deformation (mm)	3.6	0.75	0.28	0.21	0.73	0.40
Equivalent Von-misses Stress (MPa)	168.2	127.22	138.36	49.8	312.86	80.52
requency(Hz)	165.41	304.91	436	760	324.8	456
Total Deformation (mm)	40.14	40.51	36.51	45.92	42.9	33.3
Weight (Kg)	3.77	2.5	2.48	3.35	3.13	2.61

Material Used: Magnesium Alloy

	Model 1	Model 2	Model 3	Model 4	Model 5
Total Deformation (mm)	1.17	0.45	0.33	1.15	0.78
Equivalent Von- misses Stress (MPa)	123	136.83	49.02	200.9	81.12
'requency (Hz)	302.14	432.9	751.68	324.83	451.9
Total Deformation (mm)	50.3	45.3	57.6	42.9	41.33
Weight (Kg)	2.3	2.03	2.19	1.93	2.5

5. CONCLUSION

i. Design 5 and Design 3 has the least deformation value respected the minimum stress on the wheel rim.
ii. Design 5 has least deformation value as compared to its naturalfrequency.
iii. Maximum stress is 80.52 MPa which less as compared to yield strength of the respected material i.e. Aluminium Alloy280MPa.
iv. Design 5 and Design 3 has the least deformation value respected the minimum stress on the wheel rim.
v. Design 5 has least deformation value as compared to its naturalfrequency
vi. Maximum stress is 81.12 MPa which less as compared to yield strength of the respected material i.e. Magnesium Alloy 193MPa.
vii. From This we have concluded that Design 5 is the better among allmodels.

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