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# MODELING-AND-FATIGUE-ANALYSIS-OF- AUTOMOTIVE-WHEEL-RIM

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## ABSTRACT

The purpose of the car wheel rim provides a firm base on which to fit the tire. Its dimensions, shape should be suitable to adequately accommodate the particular tire required for the vehicle. In this study a tire of car wheel rim belonging to the disc wheel category is considered. The wheel rim is designed by using modeling software catiav5r18. In modeling the time spent in producing the complex 3-D models and the risk involved in design and manufacturing process can be easily minimized. So the modeling of the wheel rim is made by using CATIA. Later this CATIA model is imported to ANSYS for analysis work. ANSYS software is the latest used for simulating the different forces, pressure acting on the component and also for calculating and viewing the results. A solver mode in ANSYS software calculates the stresses and their relations without manual interventions, reduces the time compared with the method of mathematical calculations by a human. ANSYS static analysis work is carried out by considered two different materials namely aluminum and Magnesium alloy and their relative performances have been observed respectively. In addition to this rim is subjected to vibration analysis (modal analysis), a part of dynamic analysis is carried out its performance is observed.

**KEYWORDS**: Wheel Rim, CATIA, ANSYS, Von-Misses Stress.

## INTRODUCTION

Sport utility vehicle or suburban utility vehicle (SUV) is similar to a station wagon or estate car, and are usually equipped with four-wheeled drive for on- and-off road ability. Automobile Wheels are classified into many types based on their complexity / simplicity and their material strength to withstand worst loading conditions. In the case of heavy loading condition steel wheels (density: 7.8 g/cc) are preferred and for medium and low load condition Al (density: 2.7 g/cc) and Mg (Density: 1.54 g/cc) alloy wheels are suggested essential for aesthetic look. However, in any type of wheel, the basic construction is consisted of a rim, a hub, spokes/arms/wires and tires.

Various wheel specifications used for design are PCD, height, offset distance, bead width, humps, drop centre etc. Casting process such as low and high pressure die casting is used widely to make the wheels. Forming processes such as forging, extrusion etc are also being used for making the wheels. A new extrusion process has been developed recently for making automobile wheel out of AZ80 Mg alloy . Conducting various tests such as radial fatigue, impact and bending fatigue confirm that AZ80 Mg alloy can meet application requirement of wheel in automobile .

Additionally, casting and forging processes have been used for the manufacture of Mg alloy automobile wheel . It has been mentioned that the most accepted procedure for car wheel is to pass through the tests such as radial and cornering fatigue test . The recent introduction of alloy wheel for car, which has more complicated design and shape than a regular shape, needs prediction of fatigue life by analytical methods rather than a regular test. Limited research has been carried out on the analysis of wheel disc using finite element analysis .Ramamurty have studied the fatigue life of aluminium alloy wheels Under radial loads and reported that the predicted fatigue life of wheel is found to be in close agreement with the experimental observations. Gope has reported that minimum of three specimens are needed to predict the fatigue life using log normal distribution.

Wang have analysed the fatigue life by finite element simulation. ABACUS Software was used for building the static load finite element model. The results of Al alloy wheel rotary fatigue bench test showed that the wheel failed and the crack initiated around the bolt hole area which is closely agreed with the prediction by simulation. It was also reported that during the assembly of wheel disc, considerable amount of stress is developed in the component and alters the mean stress value. Guo have reported that inclusion of clamp load improves the prediction of the critical stress area and fatigue life.

In the previous study, it is observed that in most of the cases fatigue life estimation and prediction of suitability of alloy for wheel disc is carried out; however no attempt has been made for mass optimization and design of alloy wheel. Hence, in the present investigation an attempt has been made to analyse the alloy wheel from a solid disc shape to an improved design which resulted into use of less requirement of mass of material with improved design.

The objective of this paper is to design an aluminium alloy wheel by meeting all the design standards. In this paper, the area between the rim and the hub is considered for optimization. Topology Optimization has been carried in 5 cyclic cases where the loading conditions are similar for every 72°. This new optimized design is analyzed under radial, bending and lateral loads to determine the stresses induced in static condition of the wheel of automobile. The succeeded model is used to evaluate to determine its life period under radial loading condition.

| **Wheel Specifications** | |
|---|---|
| Rim diameter | 431.8mm |
| Rim width | 152.4mm |
| Offset | 45mm |
| PCD | 100mm |
| Hub diameter | 135mm |

## Part Design using CATIA:

We Created sketched features including, cuts, and slots made by either, extruding, revolving sweeping along a2-d sketched trajectory, or blending between parallel sections, create “pick and place” features, such as holes, shafts, chamfer, rounds, shell, regular drafts, flanges ribs etc. We also sketched cosmetic features, reference datum planes, axes, points, curves, coordinate systems, and shapes for creating non solid reference datum, modify, delete, suppress, redefine, and reorder features. Created geometric tolerances and surface finished on models, assign defines, and units, material properties oruser specified mass properties to a model.

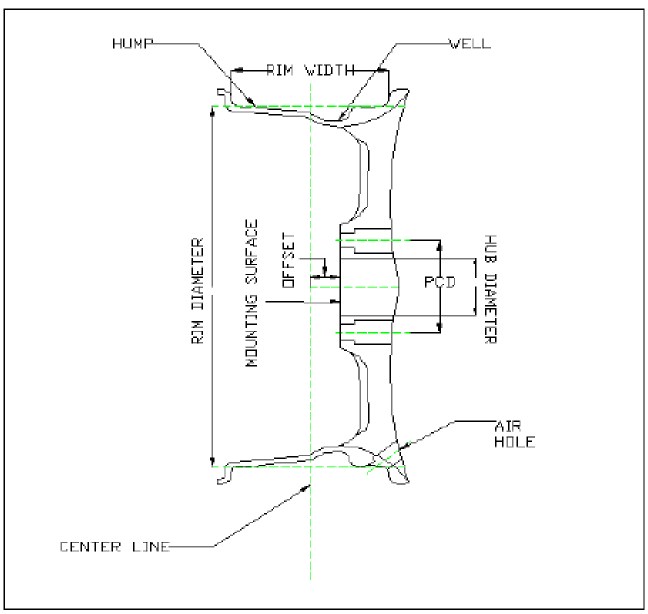



***Figure: 2D Diagram of aluminium wheel***

## DESIGN AND ANALYSIS OF WHEEL RIM IN ANSYS

### *a. LOADING UNDER STATIC CONDITION FOR Al ALLOY:*

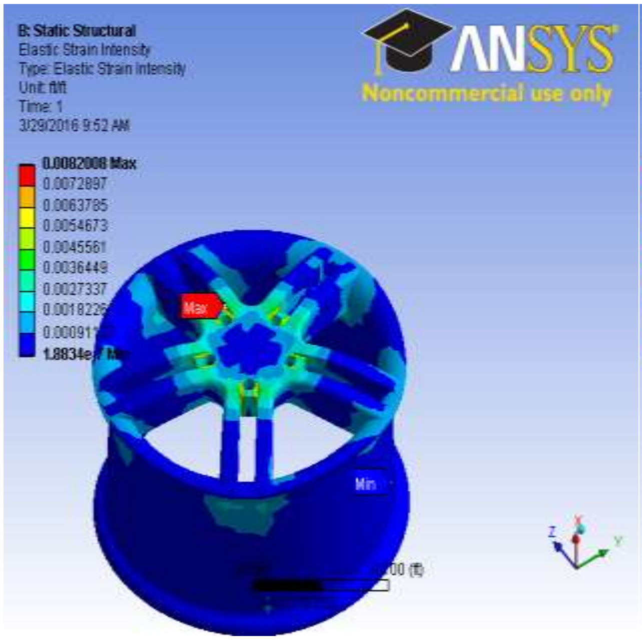



*Figure: showing elastic strain intensity of Al alloy*

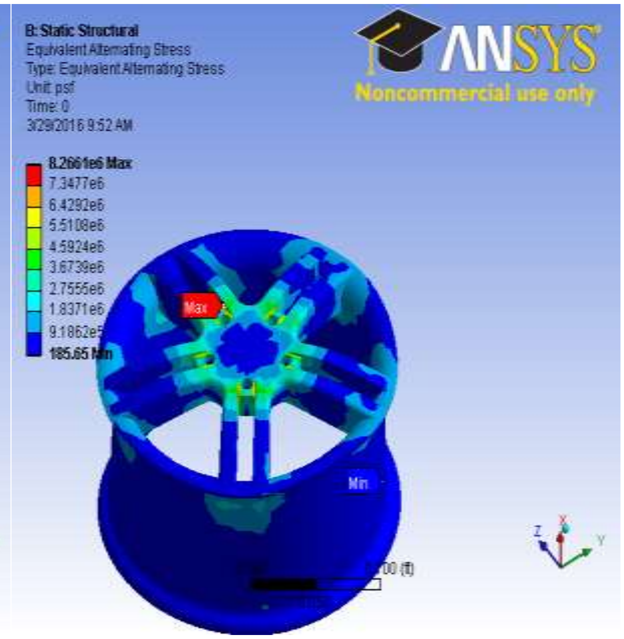



*Figure: showing equivalent alternating stress of Al alloy*

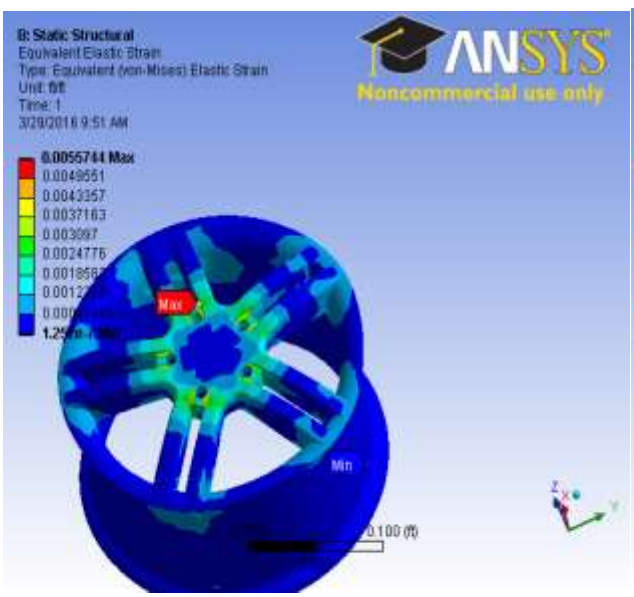



*Figure: showing elastic strain of Al alloy*

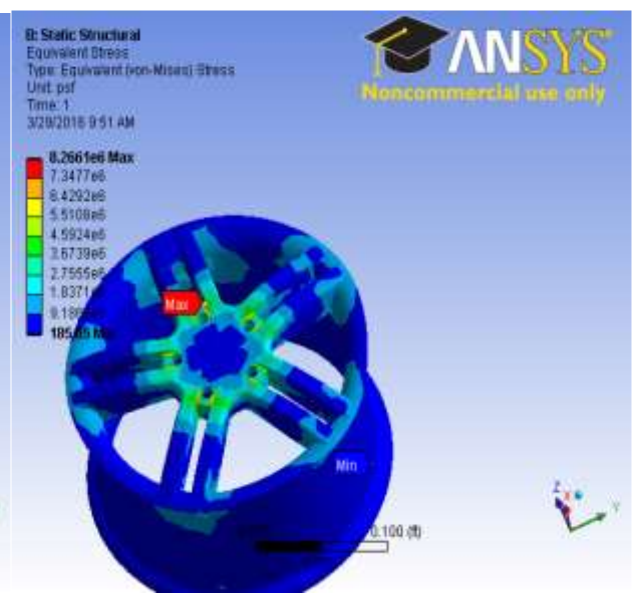
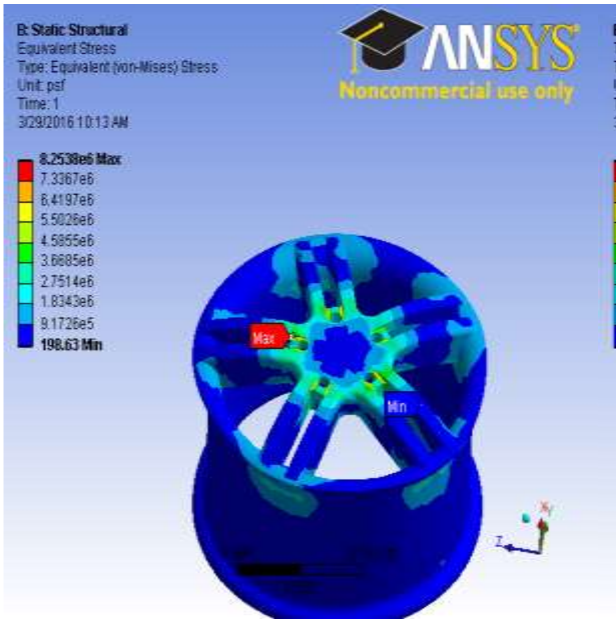



*Figure: showing equivalent stress (Von-Mises) of Al alloy*

### *b. LOADING UNDER STATIC CONDITION FOR Mg ALLOY:*



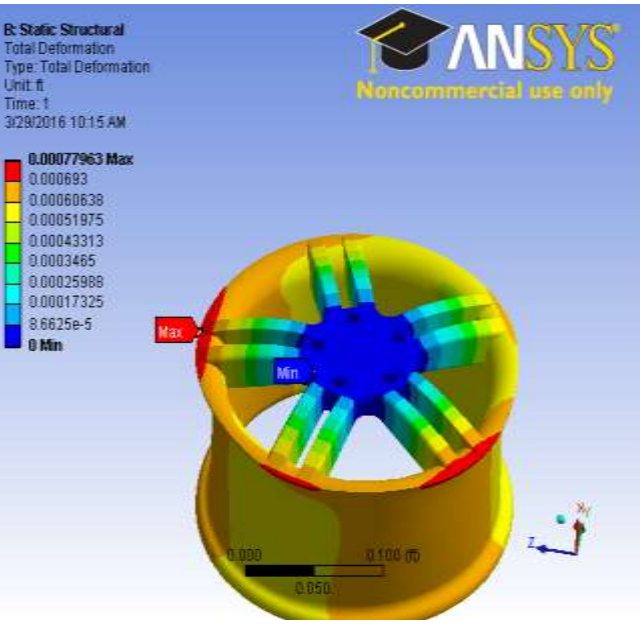
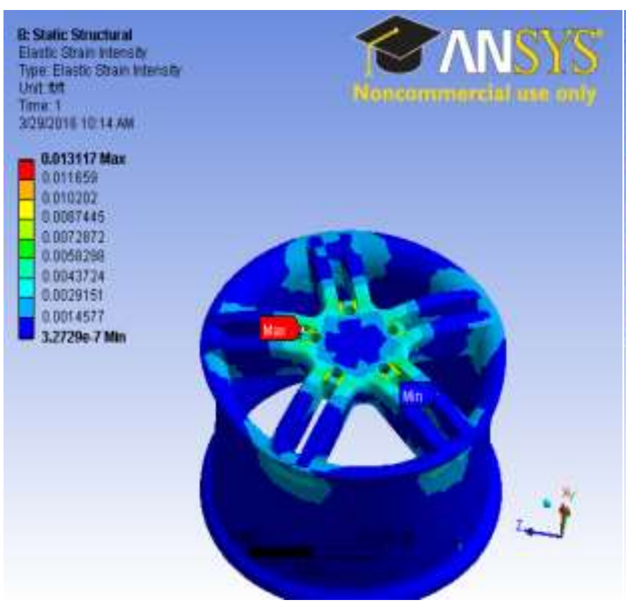




*Figure: showing equivalent stress (Von-Mises) of Mg alloy*

*Figure: showing deformation of Mg alloy*



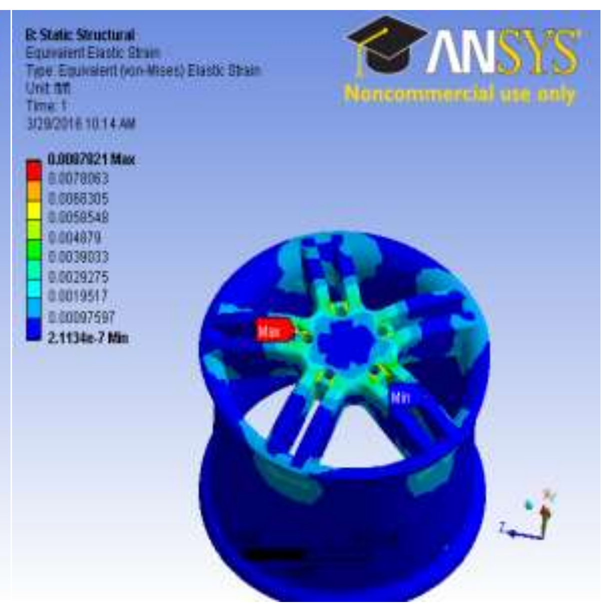




*Figure: showing elastic strain intensity of Mg alloy*

*Figure: showing elastic strain of Mg alloy*

***c. LOADING UNDER DYNAMIC / ROTARY CONDITION FOR Al ALLOY:***

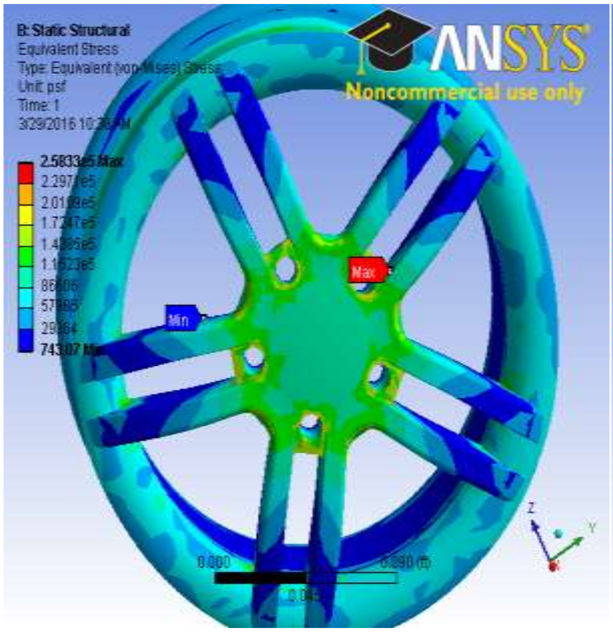



***Figure showing Equvalent (Von-mises) stress for Al alloy***

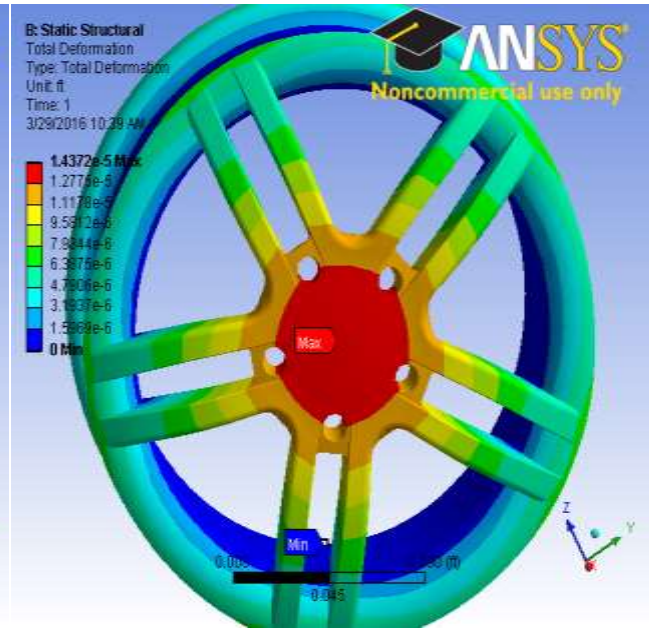



***Figure showing total deformation for Al alloy***

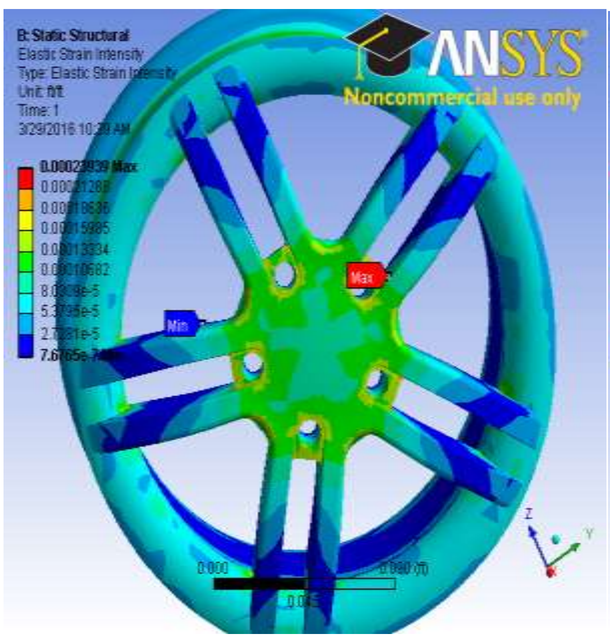



**Figure showing elastic train intensity** ***for Al alloy***

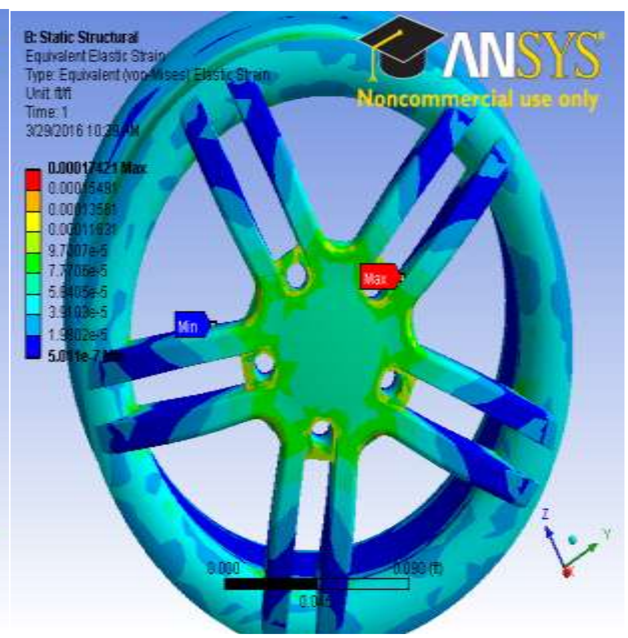



***Figure showing equivalent elastic strain (Von-*****mises)** ***for Al alloy***

### *d. LOADING UNDER DYNAMIC / ROTARY CONDITION FOR Mg ALLOY:*

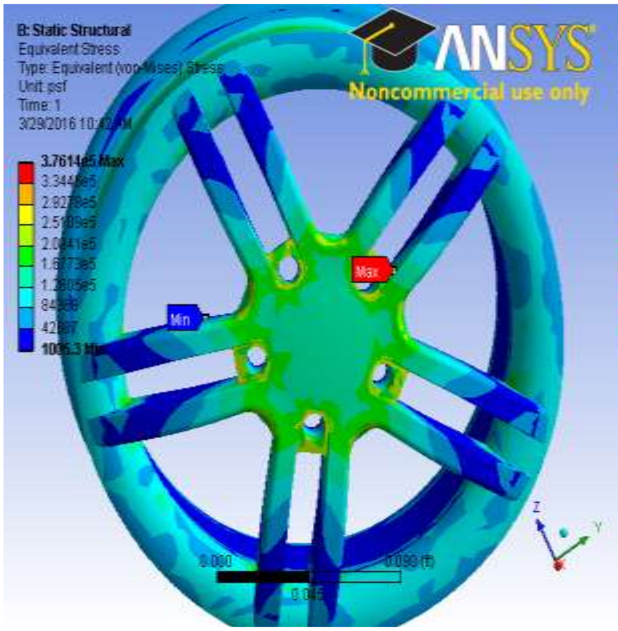



*Figure showing Equivalent (Von-mises )stress for Mg alloy*

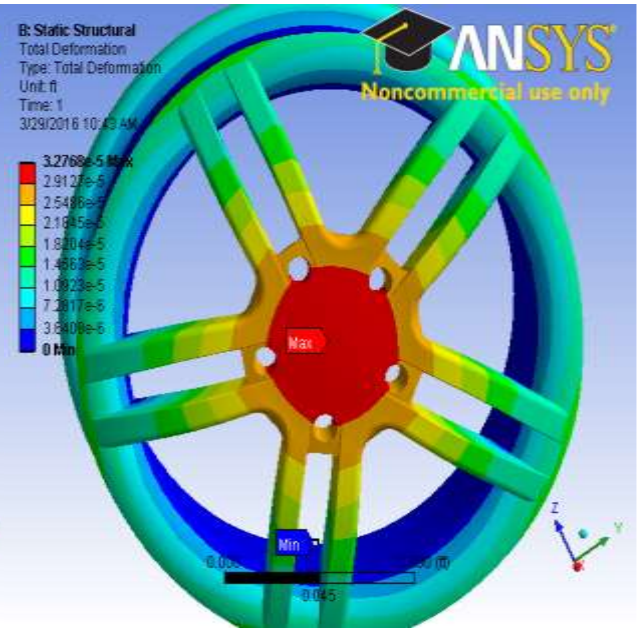



*Figure showing total deformation for Mg alloy*

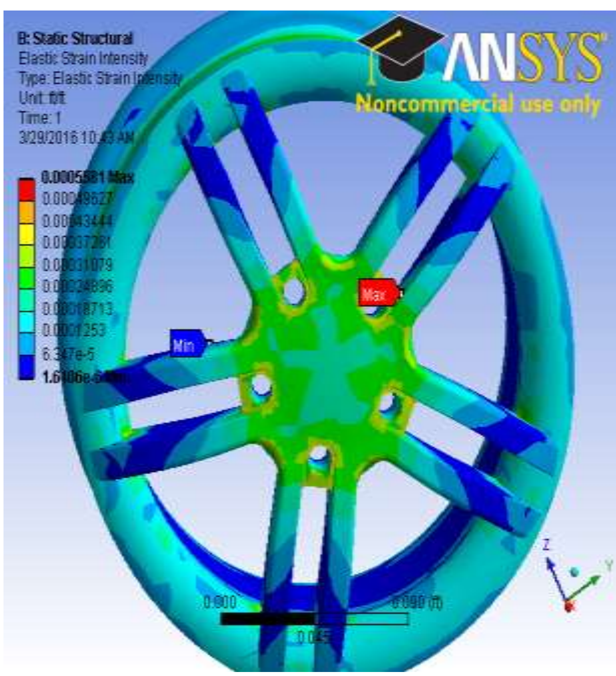



*Figure showing elastic strain intensity for mg alloy*

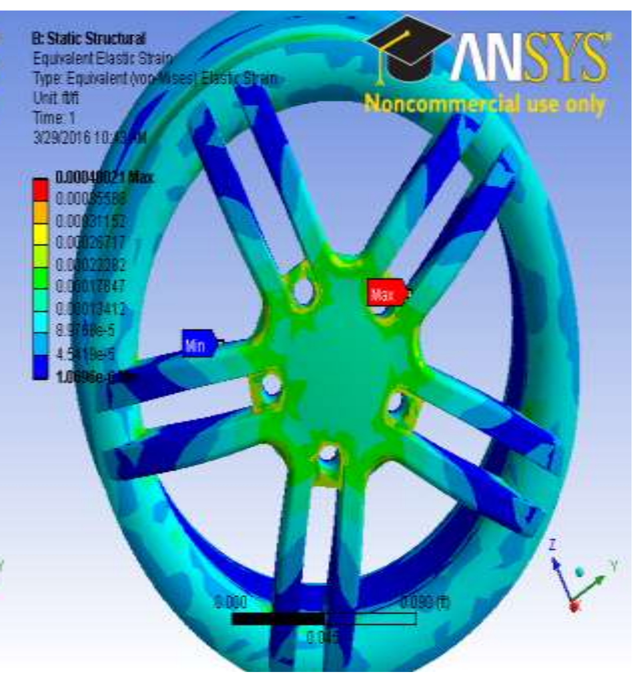



*Figure showing equivalent elastic strain (Von-mises) for Mg alloy*

## RESULTS AND DISCUSSION

***Result analysis in staticcondion:-***

| Material Type | Load Given (in lbf) | Von-mises stress | | Von-Mises strain | | Elastic Strain Intensity | |
|---|---|---|---|---|---|---|---|
| | | Maximum (psf) | Minimum(psf) | Maximum (ft/ft) | Minimum (ft/ft) | Maximum (ft/ft) | Minimum (ft/ft) |
| Aluminium alloy | 1000 | 8.2661e6 | 185.65 | 0.0055744 | 1.252e-7 | .0082008 | 1.8834e-7 |
| Magnesium alloy | 1000 | 8.2538e6 | 198.63 | .0087821 | 2.1134e-7 | .013117 | 3.2729e-7 |
| Aluminium alloy | 1500 | 1.2399e7 | 278.47 | 0.0083616 | 1.8779e-7 | 0.012301 | 2.8251e-7 |
| Magnesium alloy | 1500 | 1.2381e7 | 297.95 | 0.013173 | 3.1702e-7 | 0.019675 | 4.9096e-7 |

***Result analysis in dynamic condion:-***

| Material Type | Speed (in rps) | Von-mises stress | | Von-Mises strain | | Elastic Strain Intensity | |
|---|---|---|---|---|---|---|---|
| | | Maximum (psf) | Minimum (psf) | Maximum (ft/ft) | Minimum (ft/ft) | Maximum (ft/ft) | Minimum (ft/ft) |
| Aluminium alloy | 2000 | 2.5833e5 | 743.07 | 0.00017421 | 5.011e-7 | 0.000239 39 | 7.6765e-7 |
| Magnesium alloy | 2000 | 1.6717e5 | 446.8 | 0.00017787 | 4.754e-7 | 0.000248 05 | 7.2970e-7 |
| Aluminium alloy | 3000 | 5.8125e5 | 1671.9 | 0.00039198 | 1.1275e-6 | 0.00053863 | 1.7272e-6 |
| Magnesium alloy | 3000 | 3.7614e5 | 1005.3 | 0.00040021 | 1.0696 e-6 | 0.0005581 | 1.6406e-6 |

## CONCLUSION

The objective was to reduce the weight of the wheel rim has been achieved. We compered the stresses and strains during static and dynamic conditions in case ofAluminium and Magnesium alloy Andfound that in case of Aluminimum alloy the stresses are acting less and also having higher FOS in the model design.

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