Modeling and Cyclic Stress Analysis of Automotive Alloy Wheel Rim

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Abstract. *Aluminum Alloy wheels has superior thermal conductivity. (>150 watts per kelvin per meter) than Steel (45 watts per kelvin per meter) ,generally lighter offering more structural strength, improve handling by reducing unsprung mass, allowing suspension to follow the terrain more closely and improve grip. Alloy wheels offer better corrosion resistance, do not rust internally like steel wheels and thus last the life of a vehicle. This paper presents the modeling and simulation results of modeling and cyclic stresses analysis of wheel rim. Now a day's light alloys wheel materials are used in vehicles. To improve the quality of wheel rim evaluate in the cyclic stress life of wheel proposed in this project. In this paper we designed the rim from the Prevailing dimensions by Pro-E Solid modeling software which one is suitable for wagons wheel rim material can be analyzed by using NX NASTRAN software. Main aim is to reduce the unplanned brake failure due to overheating Lighter wheels can improve hold by reducing unsprung mass, Countenancing suspension to survey the terrain more closely and thus improve grip, conversely not all alloy wheels are lighter than their steel equivalents. Wheels are endangered to a high freight. Therefore, it is obligatory to observe a wheel for both strength and cyclic stress struggle, Further we can do optimization of material thickness to moderate the material consumption. Supplementary we can improve life of component by using Progressive cyclic stress strain life approach.*

Keywords: Thermal conductivity, UnsprungMass, Countenancing suspension, Cyclic stress life,

Introduction

Use Limit of the Wheel

Its proportions, shape should be proper to meritoriously accommodate the exact fatigue required for the automobile. In this study a two various car wheel rim belonging to the disc Wheel category is considered. Design in an imperative industrial movement which inspirations the superiority of the artefact.. This may consequence in an fortune or rapid rim miscarriage whilst loss is caused. This may upshot in an fate or rapid rim failure though the vehicle is in service. The lifecycle of a rim is diverse affording to using environments. A rim customarily lasts lengthier than a tire so at period of a tire revolution a rim should be crisscross for destruction or sign of catastrophe. If any are found the rim should be tussled. In the circumstance of steel wheel, cracks and corrosions by rust at the combined slices of rim and disc, nut seats, between ornamentation holes of the rim or the overhang is resolved, you should clash the rim.

CYCLIC STRESS ANALYSIS

Cyclic stress Mechanisms

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue-17
December 2017

The basic feature that underlies all the specific cyclic stress failure mechanisms is the existence of repeated or cyclic stresses at some point of the component. This could be considered the basic definition of cyclic stress. The cyclic stresses or strains give origin to damage accumulation until it develops into a crack that finally leads to failure of the component. Keeping in mind the basic assumption for a cyclic stress failure, different definitions will be provided for the specific cyclic stress failure mechanisms.

The diverse cyclic stress failure mechanisms are fundamentally correlated to the approach those cyclic stresses ascend in a detailed point of the factor, or to the origin of the stresses. Occasionally they are also associated to the presence of other synchronised or synergistic damaging mechanisms such as wear or corrosion.

The cyclic stress failure mechanisms are separated in to two modules: the primary mechanisms and the secondary mechanisms, conferring to the following classification:

1. Primary mechanisms: mechanisms that are intelligent by themselves to pledgee and promulgate cyclic stress crashes;
2. Secondary mechanisms: mechanisms that is not able by themselves to encourage cyclic stress fracture but might either inductee cracks or help on crack proliferation of pre-remaining cracks.

A definition for the different cyclic stress mechanisms, either primary or secondary mechanisms, will be afterward specified. Particular schemes of the mechanisms are publicized on the damaged components segment.

3D MODELLING & MESHING

Pro-E is a Para solid-based dense modeller and develops a parametric feature-based methodology to create facsimiles and assemblages. Restrictions refer to limitations whose values govern the shape or geometry of the facsimiles and assemblages. Parameters can be each numeric parameters, such as line measurements or circle spans, or geometric restrictions, such as tangent, parallel, concentric, horizontal or vertical, etc. Numeric parameters can be accompanying with each other concluded the use of relations, which consent them to apprehension design committed. Primarily the 2D drawing of wheel rim is through by using AutoCAD affording to dimensions quantified in the Table 1

Outer diameter	450 mm
Hub hole diameter	150 mm
Bolt hole diameter	20 mm
Rim width	254 mm

Table 1.1 Rim Dimensions

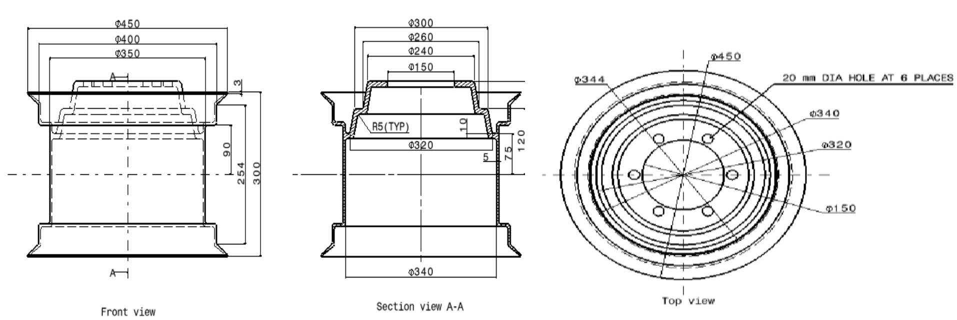


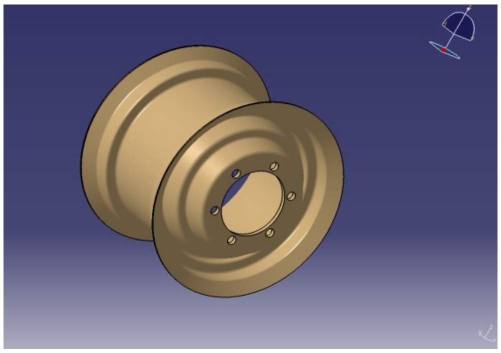
Fig 1 2D drawing of wheel rim

Mesh point:

- ✓ Mesh points stay charity to warrant the software generates nodes at definite locations
- ✓ Point established loads or boundary conditions on mesh points

Material → ISOTROPIC MATERIALS

Defined as material having the equivalent properties in all or whichever directions



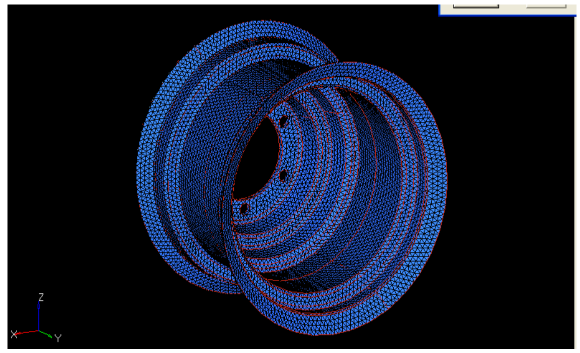


Fig 2 3D Model of wheel rimFig 3 Meshing Finished Model

THE PROCEDURE FOR A MODEL ANALYSIS

Importing the Model

The finite element meshed model (.hm file format) of wheel rim is smuggled from Hyper Mesh Software to NASTRAN Software.

1. Centrifugal force, F=mrω2 N, 2.ω =2*(22/7)*N/60 rad/s, 3.M=24 kg, 4. N=600 rpm,
5.ω =62.8 rps ,By exchanging, we acquire centrifugal force=21.3 kN,These pieces at both node of the circumference of the rim.

Boundary conditions and Loading:

To get compressive and tensile stress, a load of 21.3kN is applied on the bolt holes of the wheel rim.

Displacements→Translation in x, y, z directions is zero, Rotation in x, y, z direction is zero, Angular velocity in X direction is zero, Y direction is 62.8 rps,Z direction is zero.These conditions are realistic on the six holes provided on the rim.

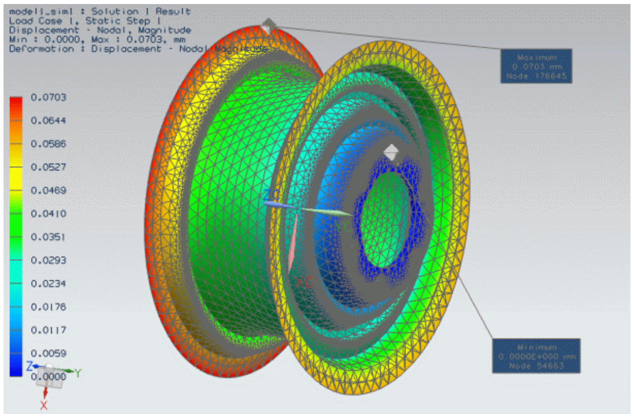
In the same way, Centrifugal force is also applied in the loading condition on the holes, NASTRAN software using analysing figures.

EXPERIMENTAL RESULTS

Static analysis is charity to define the displacements, stresses, strains and forces in erections or components due to loads that do not convince substantial inertia and restraining effects. Sturdy loading in retort conditions are presumed. The varieties of loading that can be applied in a static analysis include externally applied forces and pressures, steady state inertial marines such as gravity or revolving velocity obligatory (non zero) displacements, temperature (for thermal strain). A static analysis can be each linear or non linear and considered linear static analysis.

International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue-17
December 2017

Displacement plots



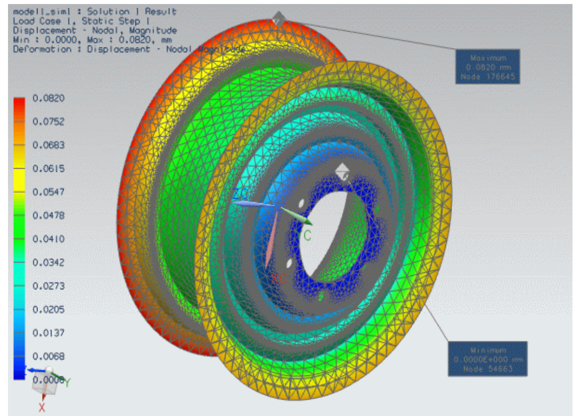
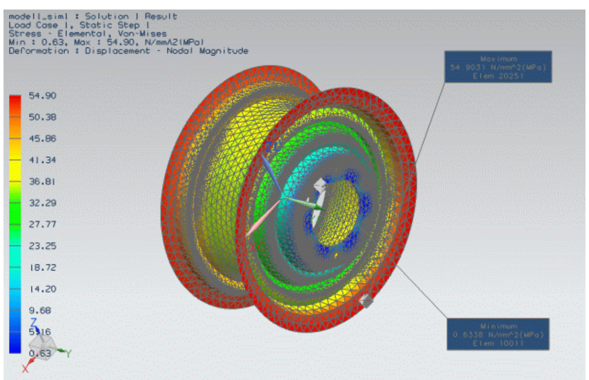


Fig 4 Displacement plots for Steel Alloy Fig 5 Displacement plots for Aluminium Alloy

Displacement=0.0703 mm Displacement=0.0820mm

Stress Plots



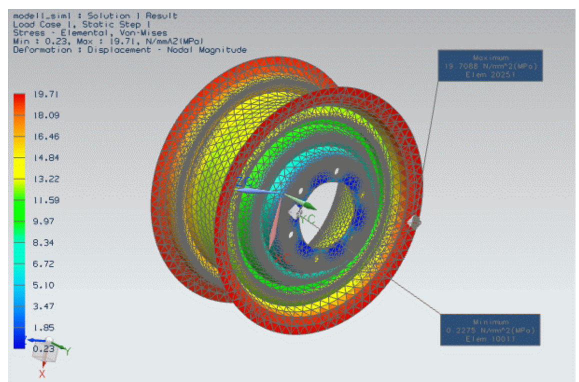


Fig 6 Stress Plots for Steel alloy Fig 7Stress Plots for Aluminium alloy

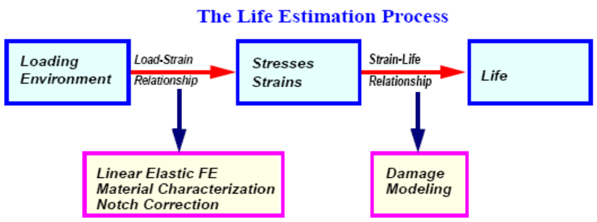
Max von mises stress = 54.90 Mpa Max von mises stress=9.71 Mpa

Min von mises stress = 0.630 Mpa Min von mises stress=0.23 Mpa

Life Estimation Process

The first relative is that of the loading situation to the stresses and strains in the constituent or model. This load-strain or load-stress relative is resolute using finite element modelling and successively linear elastic FE analysis. It is dependent on the portrayal of the material chattels and in some illustrations necessitates that a slash improvement procedure take place. For the purposes of this debate a notch rectification is simply a way to reward for flexibility from a linear FE analysis.The second relative is that of the stresses or stains to the life of the factor or model.

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue-17
December 2017



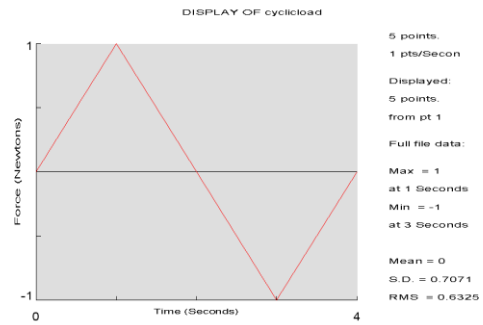
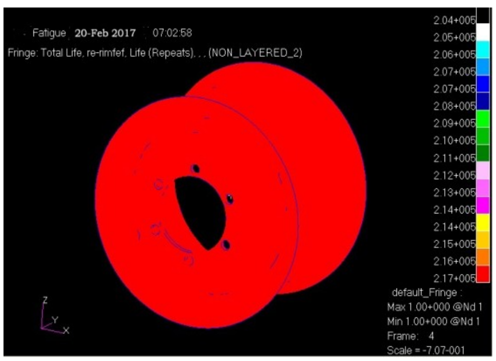


Fig 8 Life estimating process Fig 9 Display of Cycle load

Fatigue plots and S-N curves



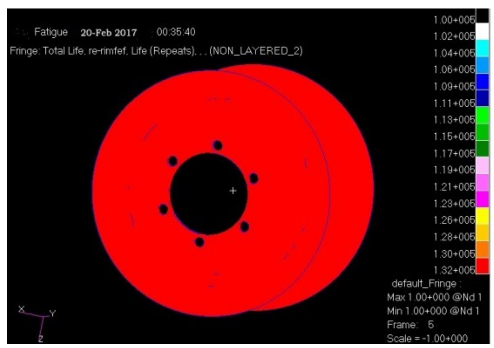
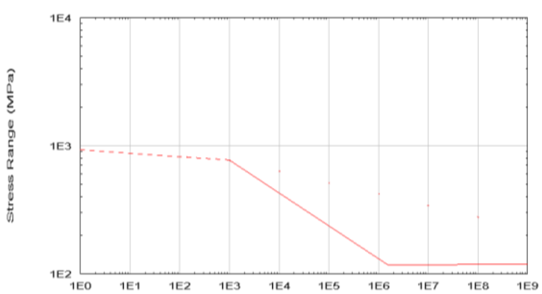


Fig 10 Fatigue Plots for Steel Alloy Fig 11 Fatigue Plots for Aluminium alloy

Fatigue strength=2.17*10^5 cycles Fatigue strength=1.32*10^5 cycles

S-N Data plot curves



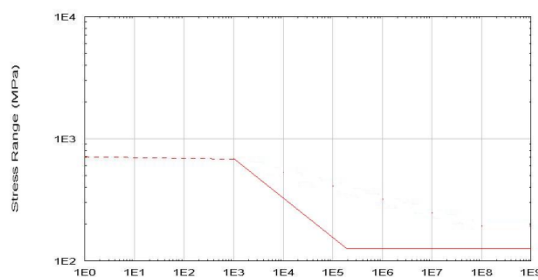


Fig 12 S-N Data plot curves for Steel AlloyFig 13 S-N Data plot curves for Aluminium alloy

RESULTS

Material properties

Steel alloy:

Young's modulus (E) =2.34*10^5 N/mm^2, Yield stress=240 N/mm^2, Density =7800kg/m^3.

Aluminium alloy:

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue-17
December 2017

Young’s modulus (E) =72000 N/mm^2, Yield stress=160 N/mm^2, Density =2800kg/m^3.

Results comparison for Steel and Aluminium

	Displacement (mm)				Stress (mN/mm^2(kPa))			
	X	Y	Z	Magnitude	Von-Mises	Min Principal	Max Principal	Max Shear
Static Step 1								
Max	6.251 e^{-002}	5.531 e^{-002}	6.229 e^{-002}	8.200e^{-002}	2.016e^{+004}	7.825e^{+003}	2.379e^{+004}	1.013e^{+004}
Min	-6.243 e^{-002}	-1.684 e^{-002}	-6.234 e^{-002}	0.000e^{+000}	0.000e^{+000}	-1.963e^{+004}	-6.165e^{+003}	0.000e^{+000}

	Displacement (mm)				Stress (mN/mm^2(kPa))			
	X	Y	Z	Magnitude	Von-Mises	Min Principal	Max Principal	Max Shear
Static Step 1								
Max	5.358 e^{-002}	4.741 e^{-002}	5.339 e^{-002}	7.029 e^{-002}	5.616e^{+004}	2.180e^{+004}	6.626e^{+004}	2.822e^{+004}
Min	-5.351 e^{-002}	-1.444 e^{-002}	-5.343 e^{-002}	0.000 e^{+000}	0.000e^{+000}	-5.467e^{+004}	-1.717e^{+004}	0.000e^{+000}

Table2 *Results for Aluminium alloy Table 3 Results for Steel*

RESULT AND DUSCUSSION

1. The von misses stresses established in steel alloy through static analysis is 54.90 N/mm^2 at load 21.3KN the stress is beneath yield stress of material for these stress assortment we have to find at what number of cycles the component is squashy or crack is going to inductees.
2. During fatigue analysis of steel alloy the fissure is originating at N_f =2.17*10^5Cycles.
3. The von misses stresses industrialized in aluminium alloy throughout static analysis is 9.71 N/mm^2 at load 21.3KN the anxiety is below yield stress of material for these stress assortment we have to find at what number of cycles the module is yielding or crack is going to pledgees.
4. During fatigue analysis of aluminium alloy the crack is initiating at N_f=1.32*10^5Cycles.
5. From consequences we can make out, in steel alloy the Number of cycles to failure (N_f)= 2.17*10^5,Cycles is greater than Aluminium. Hence Steel alloy is more practicable to use than aluminium.
6. Hence steel alloy have supplementary life and robustness compared to aluminum.

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