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International Conference and Exhibition on Automobile Engineering

September 1 – 2, 2015

Valencia, SPAIN

FINITE ELEMENT ANALYSIS OF ELECTRIC BIKE RIMS COUPLED WITH HUB MOTOR

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Şafak YILDIZHAN, Erdi TOSUN, Kadir AYDIN

Contents

Introduction

The aim of this study:

Performing static and fatigue analysis of three different electrical bikes' rim which are coupled with electrical hub motor was compared and investigated by using finite element method.

Introduction

- ✓ Nowadays, electric vehicles are becoming more and more important due to financial and energy crisis.

- ✓ Electric bike which is a bicycle with an integrated electric motor, is one of the most popular electric vehicle all over the world.

- ✓ Advantages; high efficiency, almost zero emissions, low initial, running and maintenance cost.

Introduction

- ✓ Tyres are the only part of vehicle which directly contact with the road surface. Rim, skeleton of the tyre, must be light and provide enough strength to transmit vehicle power.

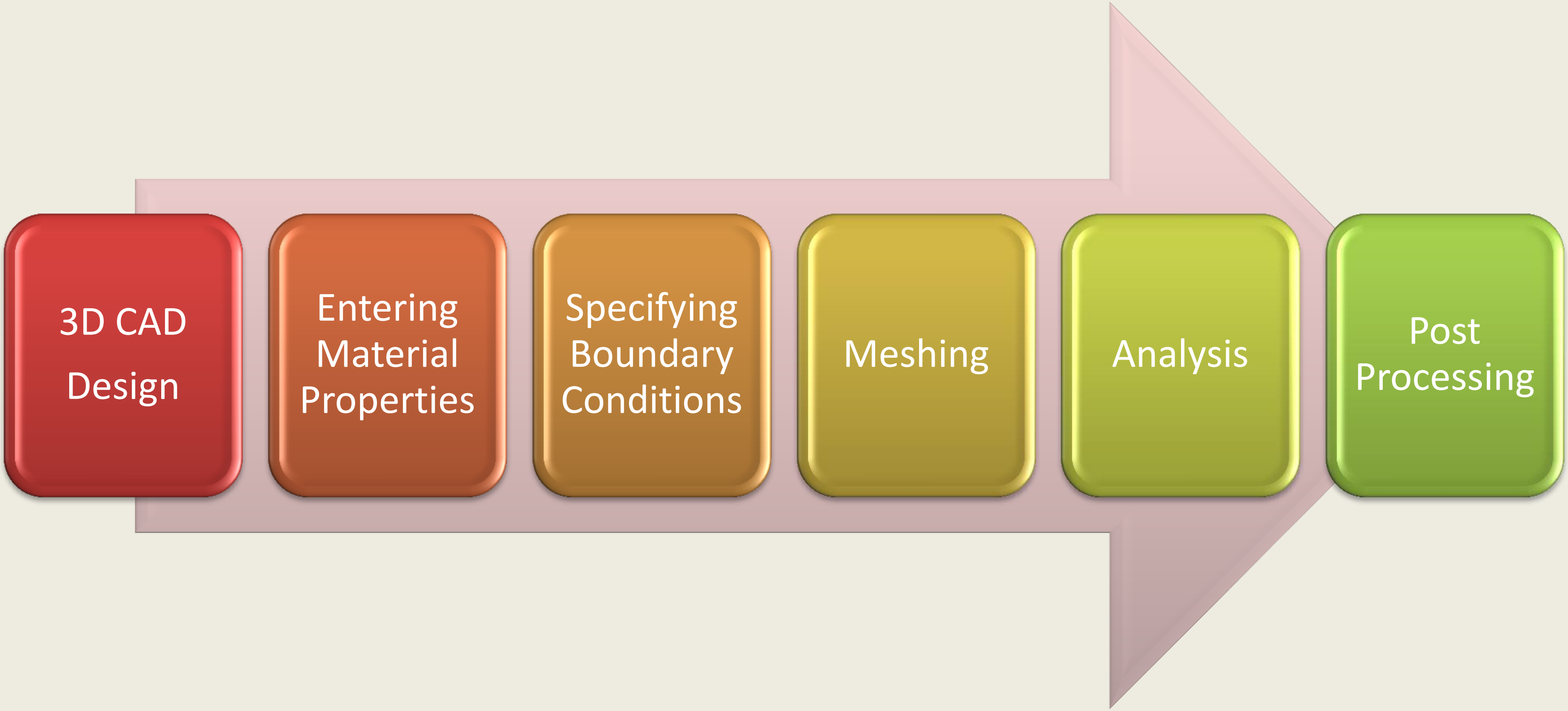
Introduction

- ✓ Over the years, scientists are researching on various rim designs. They are trying to find best material composition and best mechanical design of the rim.

Material Method

- Three different rims which has 406,4 mm (R16) outer diameter and made of aluminium alloy were compared by finite element methods in order to comprehend their behaviour on the road.
- Preparation of 3D models and analyses were carried out in Çukurova University Automotive Engineering Laboratories with the aid of workstation, which has 2 processors (24 cores) and 32 GB RAM.

Steps of Analysis



3D CAD Models

Rim A

Rim B

Rim B

3-D Model of Rim A

3-D Model of Rim B

3-D Model of Rim C

Entering Material Properties

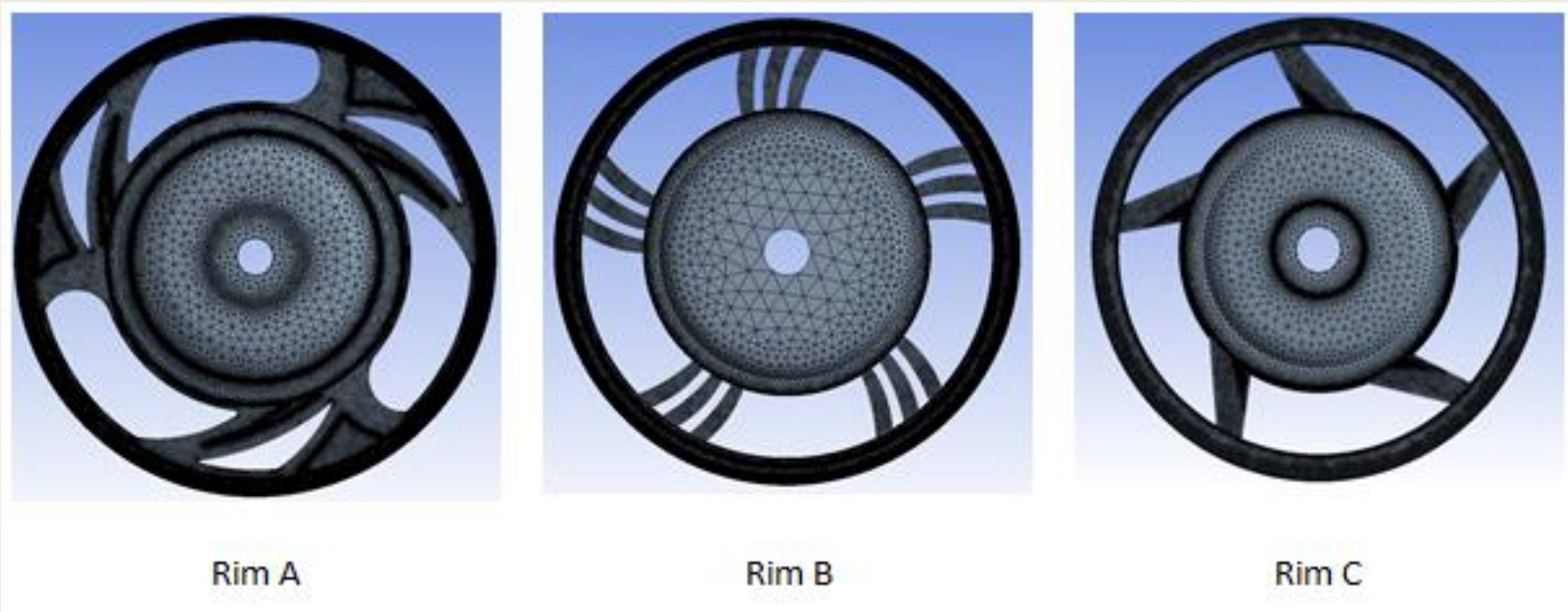
- ✓ The prepared models were exported to ANSYS Workbench software program for stress analyses.
- ✓ Default mechanical properties of aluminium alloy material according to software program was performed

Material	Young's Modulus (GPa)	Poisson's Ratio (ν)	Yield Strength (MPa)
General aluminium alloy. Fatigue properties come from MIL-HDBK-5H, page 3-277.	71	0.33	280

Specifying Boundary Conditions

- Tyre pressure was applied on the rim from outside of the circumference as 0,2344 Mpa (34 Psi)
- Radial load was considered and applied as pressure and distributed according to cosine function along to 90^0 portion of the bead seat in order to simulate the total weight of electric bike
- 43.5 rad/s rotational velocity was also added to the models
- The models were fixed from the hub where axle mounted inside it

Meshing



Nodes: 5099008
Elements: 3430607

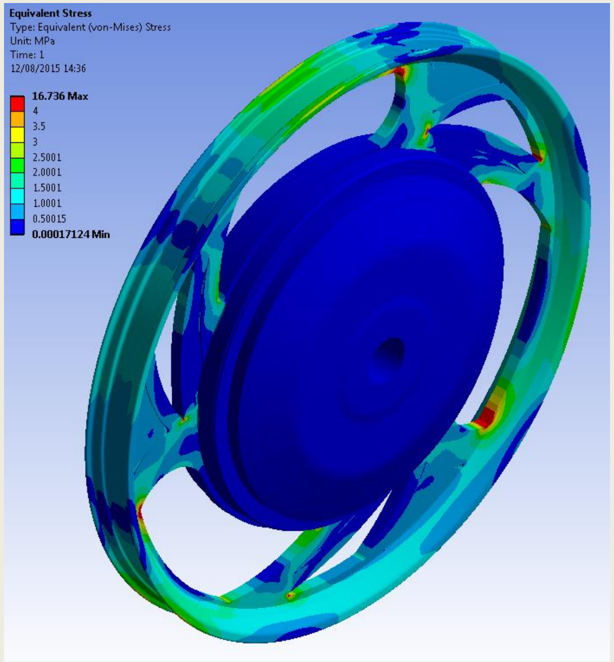
Nodes: 3843764
Elements: 2577860

Nodes: 3466721
Elements: 2336248

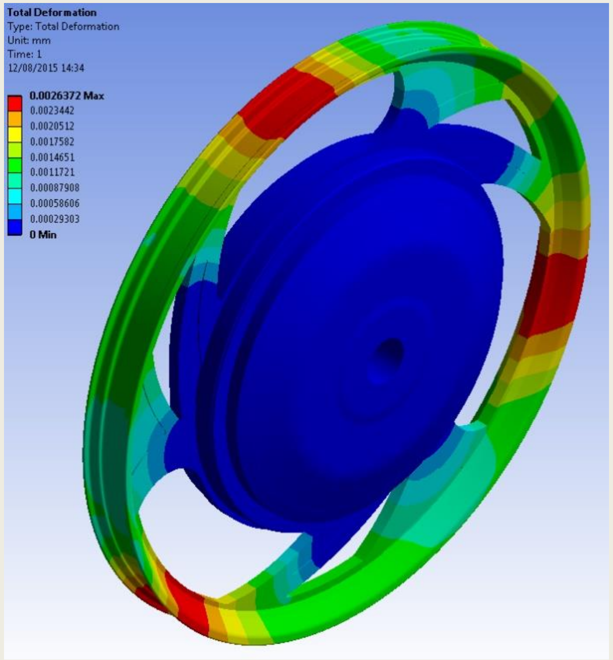
Sizing	
Use Advanc...	On: Proximity and Curvature
Relevance C...	Medium
Initial Size S...	Active Assembly
Smoothing	Medium
Transition	Fast
Span Angle ...	Coarse

Curvatur...	70.0 °
Num Cell...	Default (3)
Min Size	0.450 mm
Proximity...	0.450 mm
Max Fac...	40.0 mm
Max Size	60.0 mm
Growth ...	1.40

Results and Discussion



Rim A



von-Mises stress

Deformation distribution

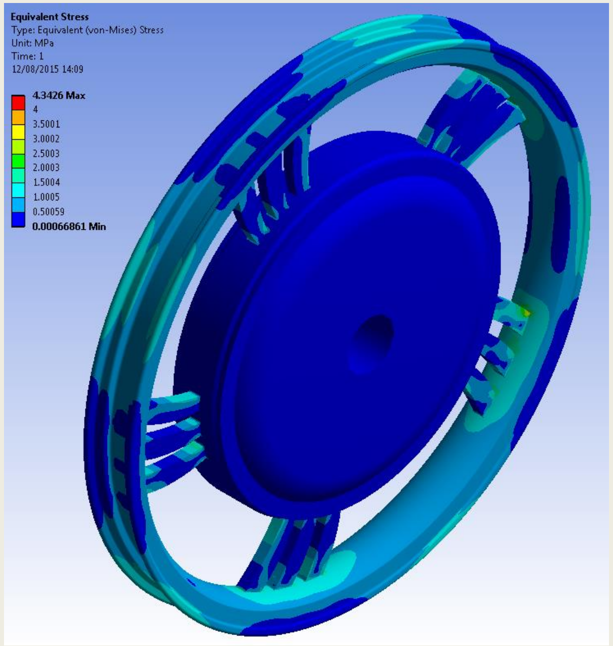
Maximum von-Mises Stress

16.7 MPa

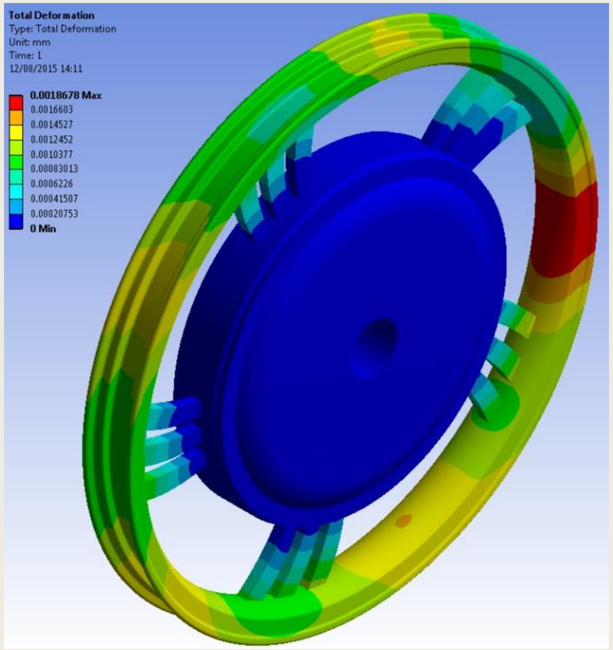
Maximum Deformation

0.0026 mm

Results and Discussion



Rim B



von-Mises stress

Deformation distribution

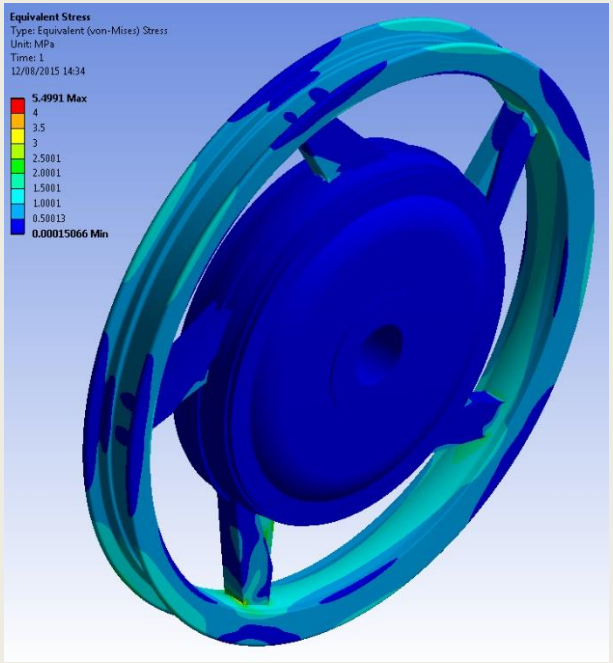
Maximum von-Mises Stress

4.3 MPa

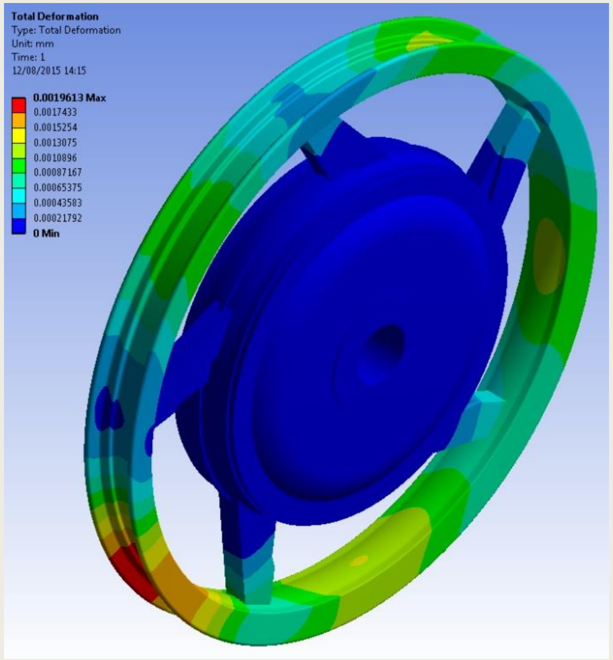
Maximum Deformation

0.0019 mm

Results and Discussion



Rim C



von-Mises stress

Deformation distribution

Maximum von-Mises Stress

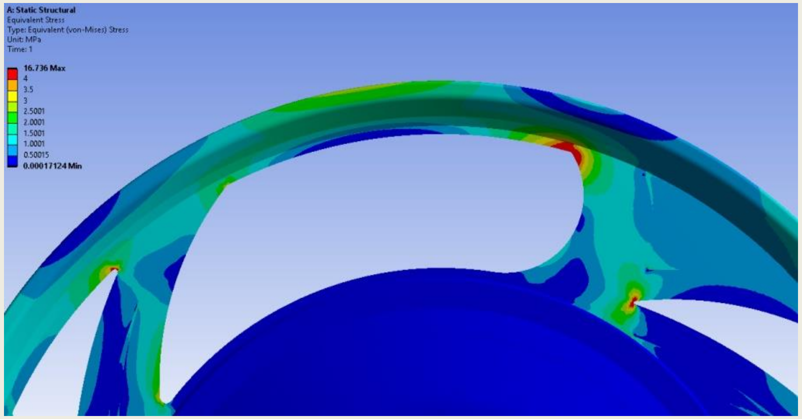
5.5 MPa

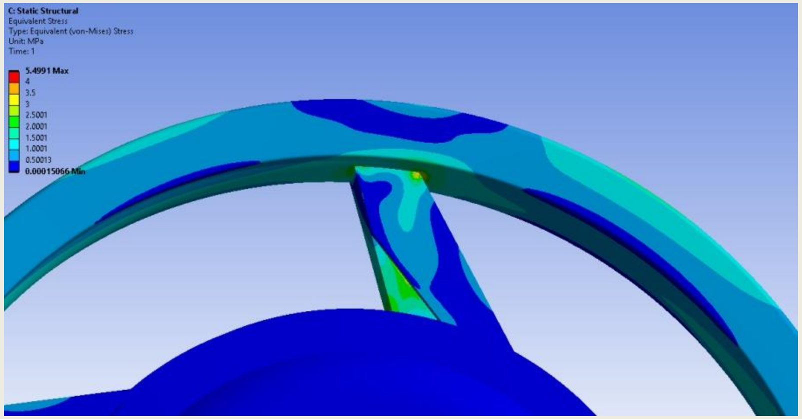
Maximum Deformation

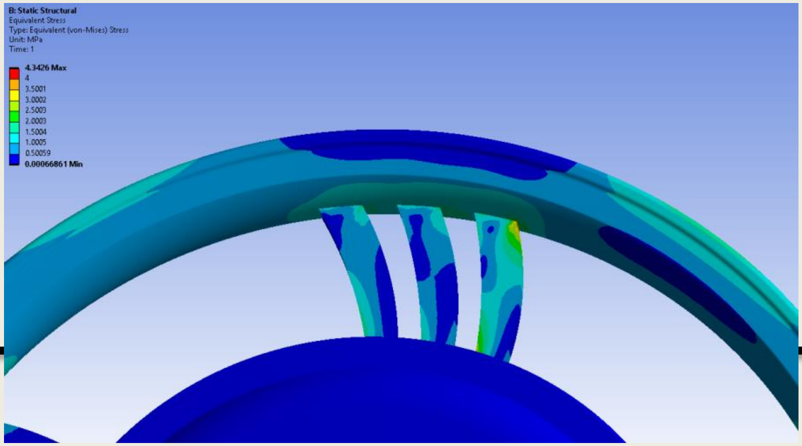
0.002 mm

Results and Discussion

- ✓ Static tests showed that the highest stresses were occurred at sharp edges and spoke to flange connections. It must be pointed out that the stress was increased when spoke-flange connection section area decreased.







- $\left(\frac{N\sigma_a}{S_e}\right) + \left(\frac{N\sigma_m}{S_u}\right)$ (1)

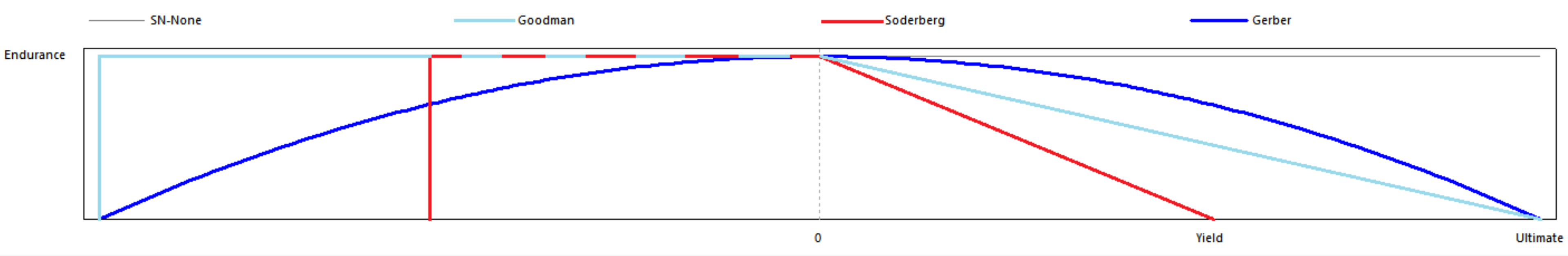
N: safety factor for fatigue life in loading cycle,

S_e: endurance limit

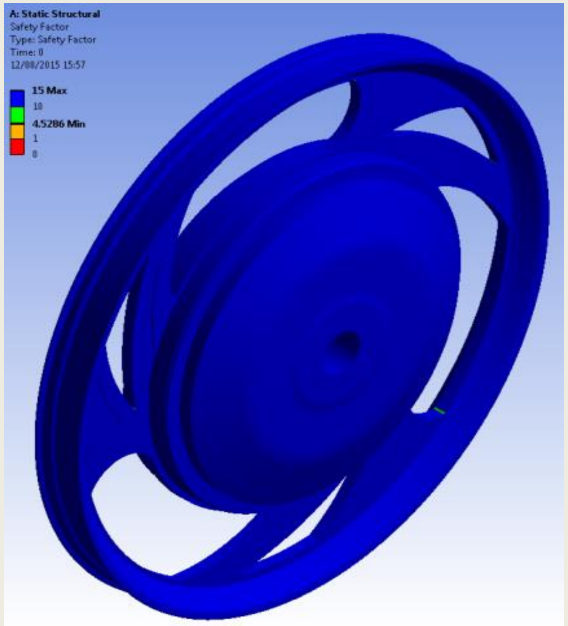
S_u: for ultimate tensile strength of the material.

Mean stress σ_m and alternating stress σ_a are defined respectively as

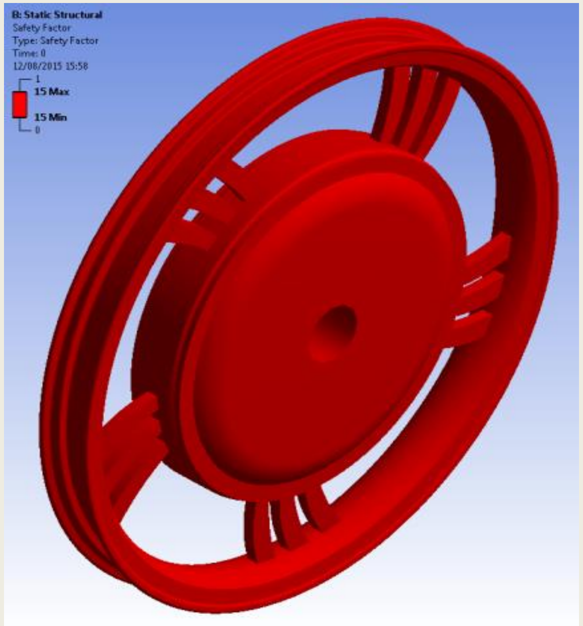
- $\sigma_m = \frac{(\sigma_{max}+\sigma_{min})}{2}$ (2)
- $\sigma_a = \frac{(\sigma_{max}-\sigma_{min})}{2}$ (3)



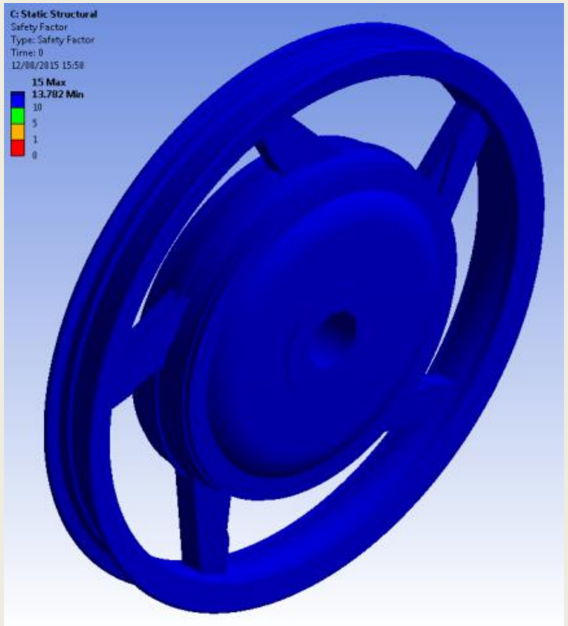
Results and Discussion



Rim A



Rim B



Rim C

Safety Factor		
4.5	>15	13.8

Conclusions

From the static and fatigue analyses tests, the following results were conducted;

- ✓ Von-Mises stresses were primarily affected by sharp corners, due to the stress concentration on edges,
- ✓ Von-Mises stress can be decreased by increasing flange to spoke cross section areas,

Conclusions

- ✓ The rims which were investigated in this study can withstand 10^6 cycles,
- ✓ All tests results revealed that test rims are extremely safe (except on sharp corners), they may be re-designed in order to cost and weight safe,

Thank you for your attention!

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