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Structural Analysis and Comparative Study of Aluminum and Magnesium Alloy Wheel

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Abstract— The main aim of this paper is to promote use of magnesium alloy for motorcycle wheels to reduce weight. Structural analysis of wheels made of A356.2, AM60B and redesigned AM60B under same service conditions were carried out, revealing that the peak stress is reduced. The peak stress in the redesigned Magnesium alloy wheel is found to be less than that in aluminum alloy wheel, revealing the fact that proper designing of Magnesium alloy wheel can meet service conditions along with improved fuel efficiency due to reduced weight.

Key words — ANSYS Workbench, wheel, finite element analysis, PRO/E.

1 INTRODUCTION

A wheel is a circular device that is capable of rotating on its axis, facilitating movement or transportation while supporting a load or performing labor in machines.

1.1. TYPES OF WHEEL

The common types of wheels used in automotive industries are wire spoke wheel, steel disc wheel and light alloy wheel

Aluminum is the material commonly used for making alloy wheels. It is the metal with features of excellent lightness, thermal conductivity, corrosion resistance, characteristics of casting, low temperature, machine processing and recycling, etc. This metals main advantage is reduced weight, high accuracy and design choice of wheel.

Magnesium wheel is about 30% lighter than aluminum and also, excellent for size stability and impact resistance. Recently the technology for casting and forging is improved and the corrosion resistance of magnesium is also improving.

Magnesium alloys are considered as the most promising material in 21st century, which possesses attractive properties compared to aluminum alloys such as low density, high specific strength and good cast ability. When used as wheel material magnesium alloy are not only able to reduce wheel mass and oil consumption, but also facilitate absorbing vibration and damping the noise emission, enhancing acceleration and braking performance thus improving riding comfort.

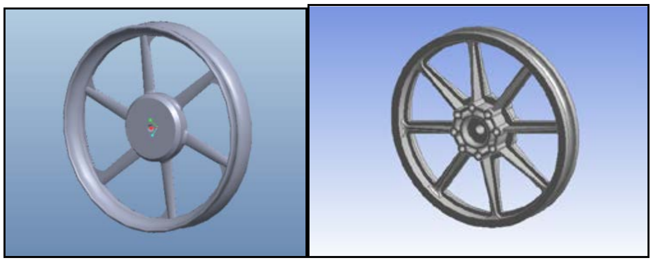
2. Material Properties of alloys

The Aluminum and Magnesium alloys used are Al356.2 and AM60B respectively. The material properties of alloys are as listed in the table.

properties	AL356.2	AM60B
Young's modulus	69000 MPa	45000 Mpa
Tensile yield strength	229 MPa	130 Mpa
Compressive yield strength	250 MPa	130 Mpa
Poisons ratio	0.33	0.35
Density	2685 kg/m3	1800 kg/m3

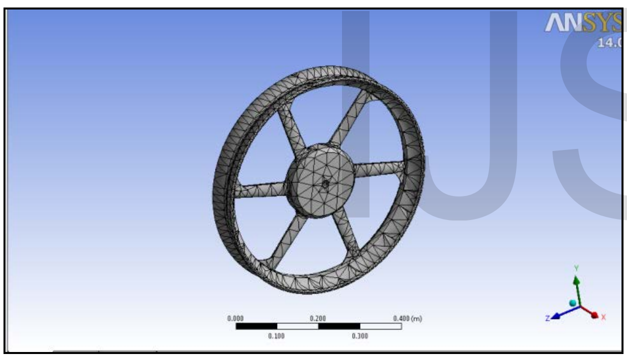
3. WHEEL 3D MODEL

The three dimensional models of wheel is created in proE and file was exported in IGES (International Graphics Exchange Specification). The three dimensional models that were developed is shown in figure below



a) 3d model b) redesigned 3d model

The mesh was meshed with 10-node tetrahedral structural solid element. The wheel was meshed with an element of minimum edge length of 0.0168 mm. total number of nodes and elements are 14756 and 7572 respectively. The finite element realization of wheel obtained is shown in figure.

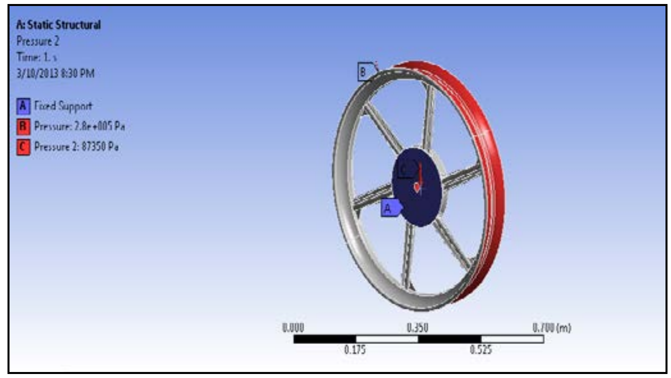


Meshing of alloy wheel

The meshing was performed by the mesh generate option in ANSYS workbench

4. LOADS AND BOUNDARY CONDITIONS

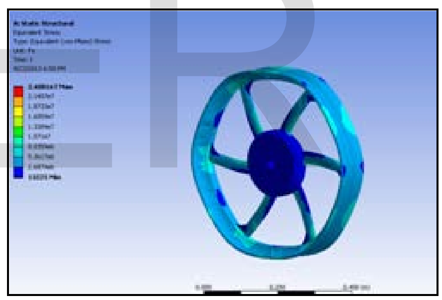
To ensure the accuracy and reliability of the analysis result, the structural and mechanical model of the rear wheel is established.Net weight of the motorcycle is 135kg and the maximum allowable load is 160kg. The tire used is a common version with inner tube filled to gas pressure 0.28mpa, uniformly distributed on the exterior ring surface of wheel. To ensure reliability of the analysis, the sum of motorcycle net weight and maximum allowable load was applied to the rear wheel alone. The sum was considered to be the maximum load, which was distributed on the inner surface of bearing supporting the axle. By calculation, the maximum load is equal to 2950N.



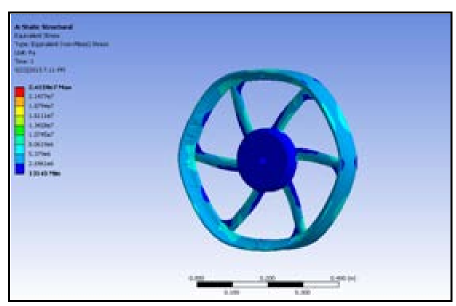
Loads and boundary conditions

5. RESULTS AND DISCUSSIONS

Following by von misses yielding principle; the results of finite elemental analysis were post-processed for visualization. Below fig shows the equivalent stress distribution of al wheel, mg wheel and the redesigned mg wheel respectively under the same working condition as illustrated in fig. the stress value is graded with colors from red to blue, reflecting the stress descending from high to low.



Stress distribution map for Al wheel



Stress distribution map for Mg wheel

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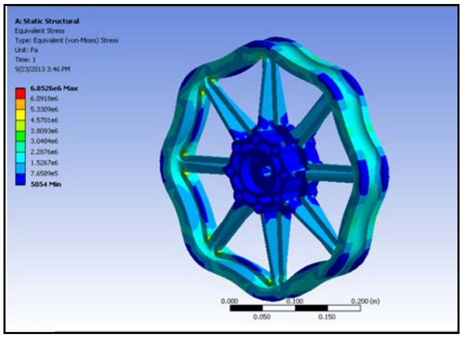

Stress distribution map for redesigned Mg wheel

As the figures indicate the maximum service stress acting on Al and Mg wheels are almost equal. Redesigned mg wheel exhibits approximately 71.46% reduction in service stress, 71.60 % reduction in strain, 87.29 % reduction in deformation and 93.12% reduction in strain energy.

6. CONCLUSIONS

1)Total deformation, equivalent stress, equivalent strain and strain energy are found to be more for old magnesium wheel, indicating low strength of Mg wheel compared to Al wheels.

2)The stress acting on redesigned magnesium wheel is found to be less than that of old Magnesium and Aluminum alloy wheel.

3)It reveals the fact that proper designing of Magnesium alloy wheels can improve the service performance and reduce the weight, thereby reducing the fuel consumption.

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