DESIGN AND FATIGUE ANALYSIS OF AN AUTOMOBILE WHEEL RIM

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ABSTRACT

In this project a parametric model will be prepared to design Alloy wheel which will be used in four wheelers by collecting data from inverse engineering process from existing model. Design has to be assessed by analyzing the model by considering the constraints as ultimate stresses and variables for different materials and different loads. The main purpose of the project is to recommend best geometric shape along with material for geometrical optimization as four different shapes of straight, inclined, Y-shape, and HONEY COMB-shape are analyzed with above defined materials by applying two loads. To determine structural characteristics, Structural analysis will be done at maximum load conditions.

Keywords: *alloy wheel, geometrical optimization, loads, structural analysis*

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1. INTRODUCTION

In the design of automobile, the industry is exploring polymeric material in order to obtain reduction of weight without significant decrease in vehicle quality and reliability. This is due to the fact that the reduction of weight of a vehicle directly impacts its fuel consumption. Particularly in city driving, the reduction of weight is almost directly proportional to fuel consumption of the vehicle. Thus in this project work the entire wheel design of two wheeler was chosen and analyzed by applying different load and redesign the wheel again to minimize the deformation and material will be changed from aluminum to PEEK (polyether ether ketone) The following materials were chosen:- Aluminum Alloy PEEK (Polyether ether ketone), PEEK with 30% Glass fiberPEEK-90, HMF 20PEEK-90 HMF 40 .The whole design is made by using NX 7.5. The whole design has been made as per original equipment manufacturer (OEM'S) requirement. Analysis has been done by Ansys 13.0 software to determine the various stress, strain and fatigue life of the wheel. The software has helped us really to achieve our goal. As the whole analysis is done by the means of software therefore result and observation are Trustworthy and meet with our expectation.

2. LITERATURE REVIEW

High cycle fatigue of a die cast AZ91ET4magnesium alloy [1]This study reveals the micro mechanisms of fatigue crack nucleation and growth in a commercial high pressure die cast automotiveAZ91E-T4Mg component. Mechanical fatigue tests were conducted under R ¼ _1conditions on specimens machined at different locations in the casting at total strain amplitudes ranging from 0.02%to 0.5%. Fracture surfaces of specimens that failed in the high cycle fatigue regime with lives spanning two orders of magnitude were examined using scanning electron microscope. The difference in lives for the Mg specimens was primarily attributed to a drastic difference in nucleation site sizes, which ranged from several hundred/s to several mm/s. A secondary effect may include the influence of average secondary dendrite arm spacing and average grain size. At low crack tip driving forces (K max< 3:5mpa) intact particles and boundaries act as barriers to fatigue crack propagation, and consequently the cracks tended to avoid the interdendritic regions and progress through the cells, leaving a fine striated pattern in this single-phase region. At high driving forces (K max> 3:5 MPa)fractured particles and boundary DE cohesion created weak paths for fatigue rack propagation, and cones quaintly he cracks followed the inter-dendriticregions, leaving serrated markings as the crack progressed through this heterogeneous region. The ramifications of the results on future modeling efforts are discussed in detail. Samples of cast Mg machined from a commercial high-pressure automotive die-casting were tested until failure under completely reversed cycling in laboratory air at room temperature at strain amplitudes ranging from 0.02%to 0.5%. Initial microstructures and fracture surfaces of the failed samples were examined with SEM, and the following observations support this primary (I) The variability in the fatigue life data in the HCF regime spans over two orders of magnitude. The question always arises when buying rims "steel or alloy wheels?" In addition to the rims look more appealing than those of alloy steel, there are technical reasons why it tends to use them: reduced weight, starting and braking, rigidity, rapid cooling. Sketch they can be controlled independently or by relationships to other parameters inside or outside of the sketch. Drawing can be finally created either from parts or assemblies and they can be generated automatically form the solid model. We can easily add notes, dimensions and tolerances to the drawing whenever required. The drawing module includes most paper sizes and standards such as, ANSI, ISO, DIN, GOST, JIS, BSI, and SAC.

3. PROBLEM EXPLANATION

Earlier steel wheels are used to manufacture wheels for the higher strength, but these alloy wheels are heavily due to its density and also giving distress to produce because of its higher melting point and tough to forge it. Weight is also playing crucial role in mileage. After that, aluminum and magnesium occupied the place for the manufacturing of alloy wheel, but these alloy wheels are not giving good existence due to its low compressive and yield strength at the larger run and also these types of materials are not allowing heavy loads.

4. INTRODUCTION TO SOLIDWORKS

Solid Work runs on Microsoft windows and is being developed by DesaltSystems solid works and it is a 3dimensional mechanical computer aided design program. By over 1.3million engineers and designers, solid works is being used and more than130, 000 companies worldwide.The 2D sketch or 3D sketch comprise of geometry such as points lines, arcs, conics and spines. To define the size and location of the geometry dimensions are added to the sketch. Drawing can be finally created either from parts or assemblies and they can be generated automatically form the solid model. The drawing module includes most paper sizes and standards such as, ANSI, ISO, DIN, GOST, JIS, BSI, and SAC.

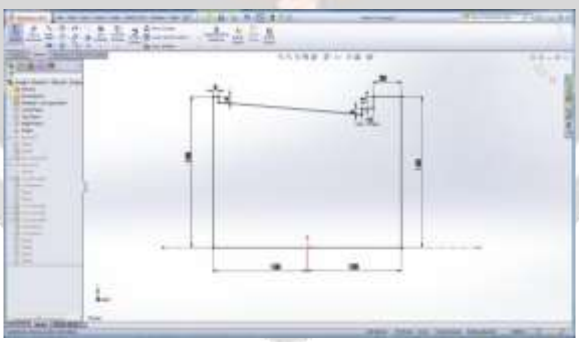

Figure 1 Dimensional drawing.

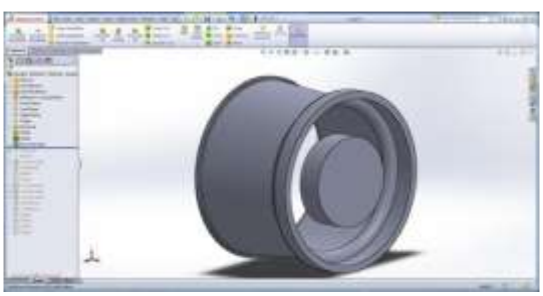

Figure 2.Dimensional Drawing

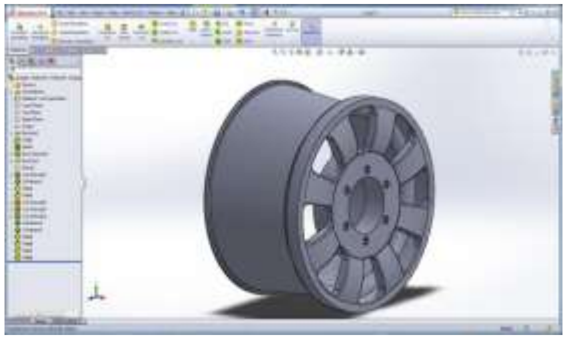

Figure 3 Straight cross member

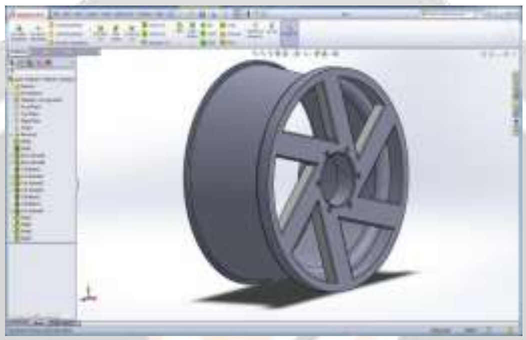

Figure 4.Inclined cross member

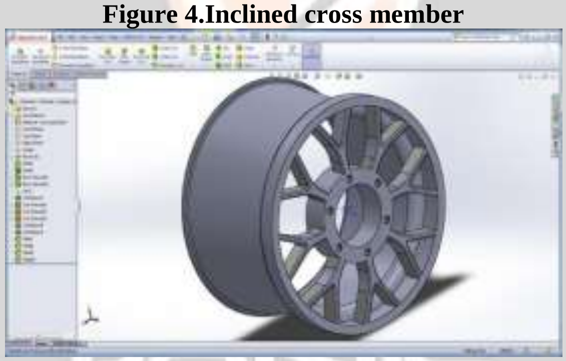

Figure 5. Y shaped cross member

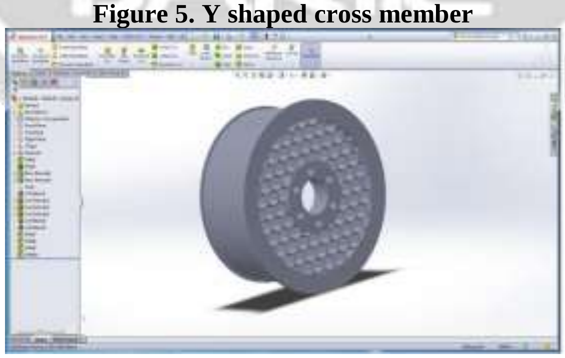

Figure 6.Honey comb cross member

5. INTRODUCTION TO COSMOS

COSMOS is an application which works on design analysis and fully incorporated with Solid Works. Finite Element Method (FEM) is used for this software to simulate the design conditions as per the requirement. COSMOS uses the

FEM and this FEM is numerical technique for designing. This is treated as a standard for analysis due its generality and suitability for computer implementation. FEM will works by splitting the model in to tiny pieces of simple shape which are called as elements. This replaces the complexity of the problem in to simple problems and solves simultaneously.

5.1. LOAD CALCULATIONS

Type of vehicle: Sedan vehicle
1.8liters, 201 Horsepower, torque1.5789mpa at 2000rotations per minute
Car weight – (wc) = 1944 kg's5 numbers of passengers + full load luggage - (wp) = 500 kg's
Area (A) = 128738.66 mm2
Case 1
Pressure: =WC/A= (1944x9.81)/128738.66= 148.13 = 0.148N/mm2
Case 2
(Wc+Wp)/A= (1944+500)x9.81/128738.66= 186 =0.186 N/mm2

5.2. MATERIAL PROPERTIES

Aluminum
Yield strength =3 .49 e+008 N/m2
Tensile strength = 3.59e+008 N/m2
Mass density = 2800 kg/m3
Elastic modulus = 7.1e+010 N/m2
Poisson's ratio = 0.33
Thermal expansion coefficient =3.5e-005 /Kelvin

Cast Alloy Steel
Yield strength = 2.41275e+008 N/m2
Tensile strength = 4.48083e+008 N/m2
Mass density = 7300 kg/m3
Elastic modulus = 1.9e+011 N/m2
Poisson's ratio = 0.26
Thermal expansion coefficient =1.5e-005 /Kelvin

Magnesium Alloy
Yield strength = 1.05e+008 N/m2
Mass density = 1700 kg/m3
Elastic modulus = 4.5e+010 N/m2
Poisson's ratio = 0.35
Thermal expansion coefficient =2.5e-005 /Kelvin

ZAMAK
Model type = Linear Elastic Isotropic
Yield strength = 2.68e+008 N/m2
Tensile strength = 3e+007 N/m2
Mass density =6040 kg/m3
Elastic modulus = 8.3e+010 N/m2
Poisson's ratio = 0.3

5.3. PROBLEM EXPLANATION

Earlier steel wheels are used to manufacture wheels for the higher strength, but these alloy wheels are heavily due to its density and also giving distress to produce because of its higher melting point and tough to forge it. After that, aluminum and magnesium occupied the place for the manufacturing of alloy wheel, but these alloy wheels are not giving good existence due to its low compressive and yield strength and these types of materials are not allowing heavy loads.

6. STRUCTURAL ANALYSIS

6.1. STRUCTURAL ANALYSIS OF STRAIGHT CROSS MEMBER TYPE WHEEL

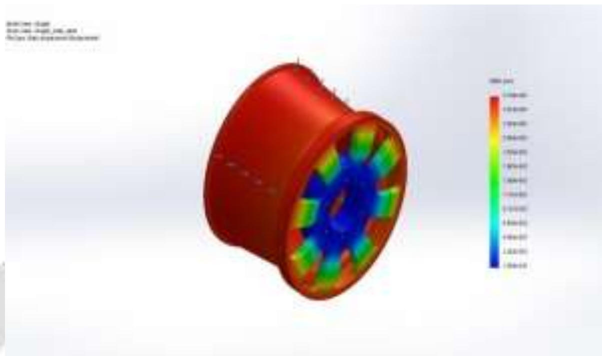

Figure 7.Von-misses stress for aluminium

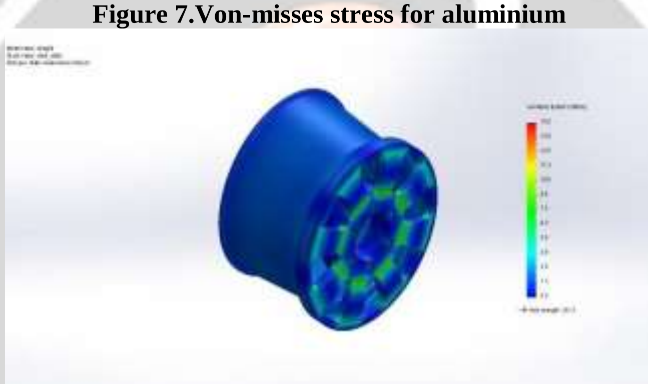

Figure 8.Von-misses stress for steel

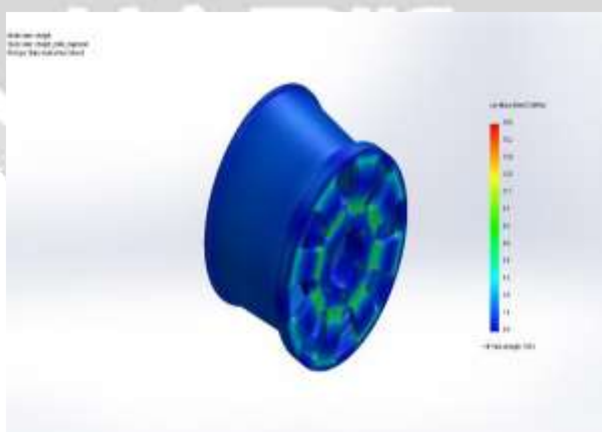

Figure 9.Von-misses for magnesium

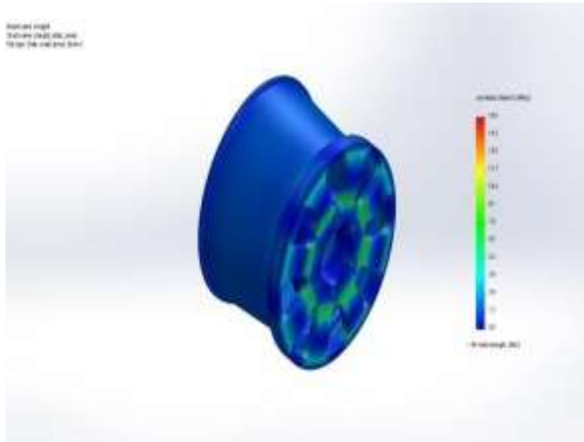

Figure 10.Von-misses stress for zamak

6.2. STRUCTURAL ANALYSIS OFINCLINED CROSS MEMBER TYPEWHEEL

Figure 11.Von-misses for aluminium

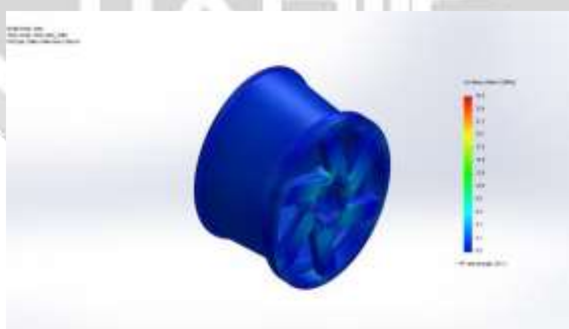

Figure 12.Von-misses stress for steel

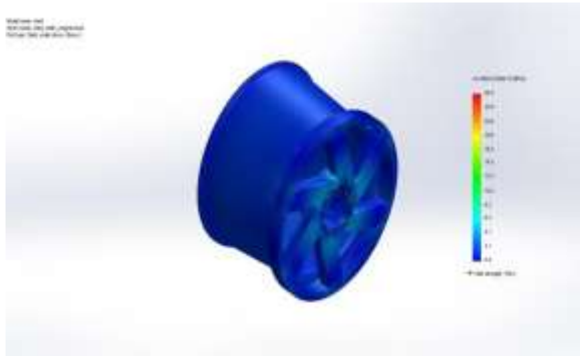

Figure 13.Von-misses stress for magnesium

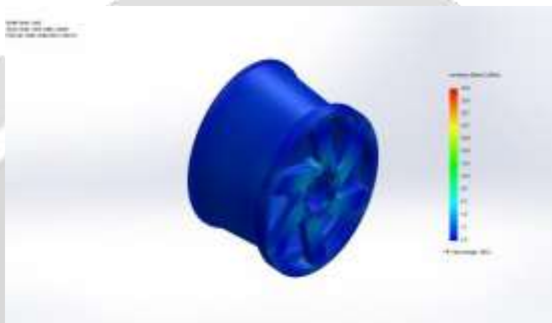

Figure 14.Von-misses stress for zamak

6.3. STRUCTURAL ANALYSIS OF YSHAPECROSS MEMBER TYPE WHEEL

Figure 15.Von-misses stress for aluminium

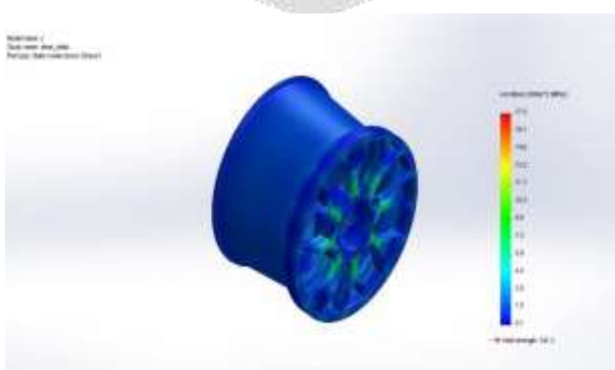

Figure 16.Von-misses stress for steel

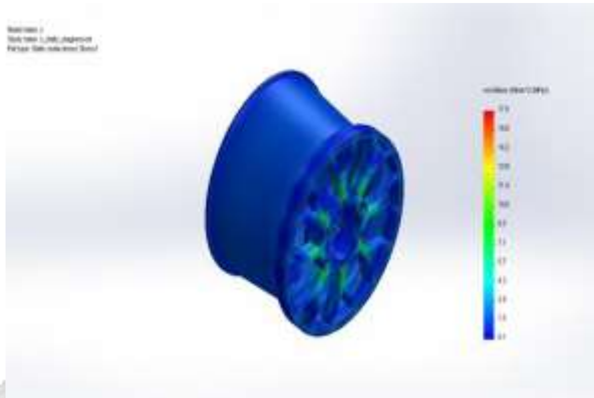

Figure 17.Von-misses stress for magnesium

Figure 18.Von-misses stress for zamak

6.4. STRUCTURAL ANALYSIS OF HONEYCOMB -SHAPE CROSS MEMBER TYPE WHEEL

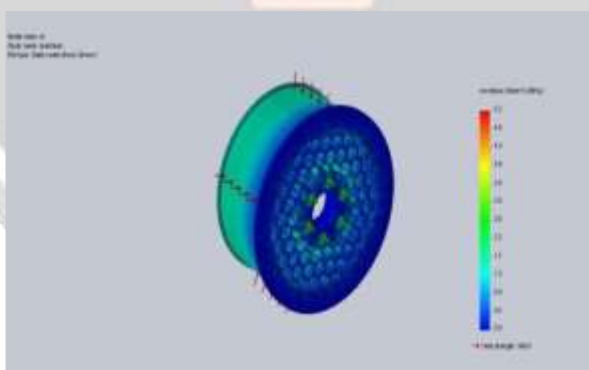

Figure 19.Von-misses stress for aluminium

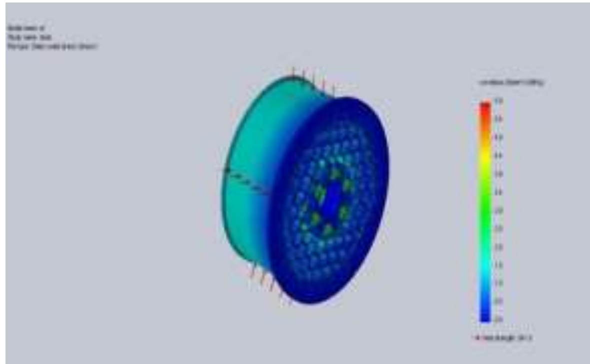

Figure 20.Von-misses stress for steel

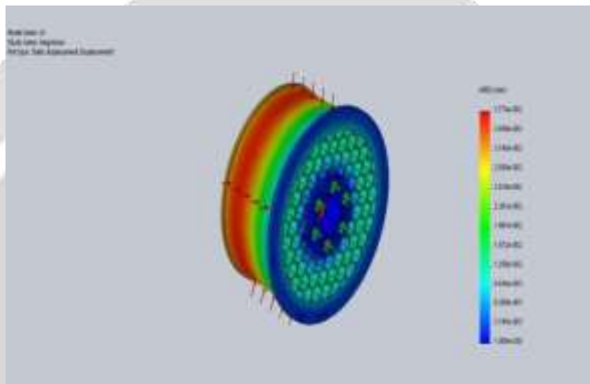

Figure 21.Von-misses stress for magnesium

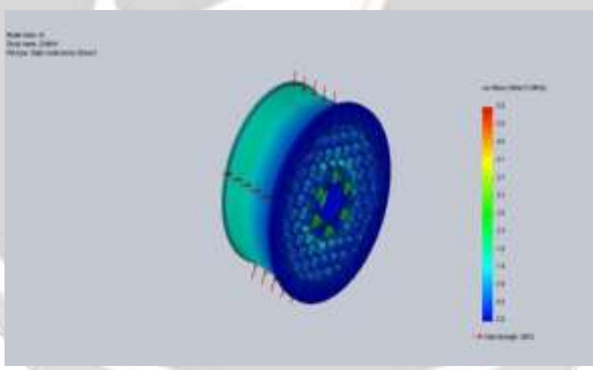

Figure 22.Von-misses stress for zamak

7. CONCLUSION

Modeling of alloy wheel was done using solid works and simulation works was done in simulation works. Simulation is done on alloy wheel with Straight, Slant and Y-shaped cross members and honey-comb structure for two load conditions to find the structural characteristics. Simulation is done using steel, aluminumA360, and Magnesium and ZAMAK materials. As per the factor of safety ZAMAK is giving maximum factor of safety with in low cost the minimum FOS value for wheel parts should be 3 or more. While comparing geometric shape honeycomb model is showing good results than other models. As per the above results ZAMAK material along with honey-comb structures better. While comparing with other materials ZAMAK is having some higher stress and displacement but the values had negligible difference. ZAMAK is the right choice due to its higher tensile and yield strength. Aluminum Yield-strength: 3.49e+007 N/m^2 ,Cast-Alloy-Steel Yield-strength: 2.41e+008 N/m^2 , Magnesium-Alloy Yield-strength: 1.05e+008 N/m^2, ZAMAK Yield-strength: 2.68e+008 N/m^2 . As per the buckle analysis also ZAMAK is the right choice due to low deflections in buckle consideration.

8. FUTURE SCOPE

We can manufacture ZAMAK alloy wheels using metal injection molding machines so that we can increase production rate and also we can reduce cost of production while comparing with steel and magnesium wheels

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