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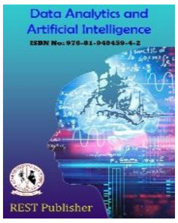

Design and Analysis of Alloy Wheel with Different Materials

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Abstract: *Alloy wheels are automobile wheels which are made from an alloy of aluminum or magnesium metals or sometimes a mixture of both. Alloy wheels will reduce the unstrung weight of a vehicle compared to one fitted with standard steel wheels. The benefit of reduced unstrung weight is more precise steering as well as a nominal reduction in fuel consumption. Alloy is an excellent conductor of heat, improving heat dissipation from the brakes, reducing the risk of brake failure under demanding driving conditions. In this project a parametric model is designed for Alloy Alloy wheel used by collecting data from reverse engineering process from existing model. Here we are using different materials for the alloy like aluminum, magnesium, carbon and silicon. Design is evaluated by analyzing the model by changing the design of rim styles to be strong and balanced. Its material should not deteriorate with weathering and corrosion.*

1. INTRODUCTION

Alloy wheel is a wheel with integral suspension, designed for better shock-absorbing performance and greater comfort. Alloy wheels give you a smoother ride. They are more comfortable than standard wheels: the carbon springs absorb tiring vibration, as well as bumps and shocks. They're extremely strong and durable. Alloy wheels are different from spoked wheels. They look, feel and perform differently. You will be used to a wheel being a rigid thing – Alloy wheels have flexibility in them in order to provide shock absorption and suspension. The hub moves within the rim; the springs flex. The whole wheel acts as a flexible moving system which constantly adjusts to the load it carries and the obstacles it encounters.

FIGURE 1. Alloy wheel

The Shock absorber which is one of the Suspension systems is designed mechanically to handle shock impulse and dissipate kinetic energy. It reduces the amplitude of disturbances leading to increase in comfort and improved ride quality. Hence, the designing of spring in a suspension system is very crucial.Designing an important industrial activity which influences the quality of the product. The Shock absorber coil spring is designed by using the modeling software Pro/ENGINEER Wildfire 4.0. In modeling the time is spent in drawing the coilspringmodelandtheriskinvolvedindesignandmanufacturingprocesscanbe easily minimized. So, the modelling of the coil spring is made by using Pro/ENGINEER. Later this Pro/ENGINEER model is imported to ANSYS for the analysis work. The ANSYS software is used for analyzing the component by varying the load applied on it and the results are observed. Also, Ver mode in ANSYS software calculates the stresses and their relation without manual interventions there by reducing the time compared with the manual theoretical work.

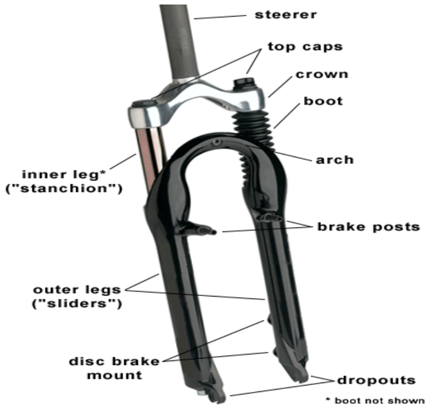

FIGURE 2. Front suspension

A wheel is a circular component that is intended to rotate on an axle bearing. The wheel is one of the main components of the wheel and axle which is one of the six simple machines. Wheels, in conjunction with axles, allow heavy objects to be moved easily facilitating movement or transportation while supporting a load, or performing labor in machines. Wheels are also used for other purposes, such as a ship's wheel, steering wheel, potter's wheel and flywheel

FIGURE 3. Vehicle suspension

Common examples are found in transport applications. A wheel greatly reduces friction by facilitating motion by rolling together with the use of axles. In order for wheels to rotate, a moment needs to be applied to the wheel about its axis, either by way of gravity or by the application of another external force or torque.
The low resistance to motion (compared to dragging) is explained as follows (refer to friction):

- The normal force at the sliding interface is the same.
- The sliding distance is reduced for a given distance of travel.
- The coefficient of friction at the interface is usually lower.

Additional energy is lost from the wheel-to-road interface. This is termed rolling resistance which is predominantly a deformation loss. This energy is also lowered by the use of a wheel (in comparison to dragging) because the net force on the contact point between the road and the wheel is almost perpendicular to the ground, and hence, generates an almost zero network. This depends on the nature of the ground, of the material of the wheel, its inflation in the case of a tire, the net torque exerted by the eventual engine, and many other factors.
A wheel can also offer advantages in traversing irregular surfaces if the wheel radius is sufficiently large compared to the irregularities. The wheel alone is not a machine, but when attached to an axle in conjunction with bearing, it forms the wheel and axle, one of the simple machines. A driven wheel is an example of a wheel

and axle. Note that wheel's pre-date driven wheels by about 6000 years, themselves an evolution of using round logs as rollers to move a heavy load—a practice going back in pre-history so far, it has not been dated.
A shock absorber is a mechanical or hydraulic device designed to absorb and damp shock impulses. It does this by converting the kinetic energy of the shock into another form of energy (typically heat) which is then dissipated. Most shock absorbers are a form of dashpot.

2. INTRODUCTION TO 3D MODELLING

Pro/Engineer, developed by PTC Corporation Ltd., is one of the world's leading CAD/CAM/CAE packages. Being a solid modeling tool, it not only 3D parametric features with 2D tools, but also addresses every design through manufacturing process. Besides providing an insight into the design content, the package promotes collaboration between companies and provides them with edge over their competitors. Pro/Engineer, developed by PTC Corporation Ltd., is one of the world's leading CAD/CAM/CAE packages. Being a solid modeling tool, it not only 3D parametric features with 2D tools, but also addresses every design through manufacturing process. Besides providing an insight into the design content, the package promotes collaboration between companies and provides them with edge over their competitors. In addition to creating solid models and assemblies, 2D drawing view can also be generated in the drawing mode of Pro/E. The drawing views that can be generated include orthographic, section, auxiliary, isometric or detail views. Pro/E uses parametric design principles for solid modeling. This modeling software provides an approach to mechanical design automation based on solid modeling technology and the following features.
3D Modeling: The essential difference between Pro/E and traditional CAD systems are the models created in Pro/E exist as 3D solids. Other 3D modelers represent only the surface boundaries of the model. Pro/E models the complete solid. This is not only facilitating the creation of realistic geometry, but also for accurate model calculations, such as those for mass properties.
Parametric Design: Dimensions such as angle, distance, and diameter control Pro/E model geometry. You can create relationships that allow parameters to be automatically calculated based on the value of other parameters. When you modify the dimensions, the entire model geometry can update according to the relations you created.
Feature – Based Modeling: We created models in Pro/E by building features. These features have intelligence, in that they contain knowledge of their environment and adapt predictably to change. Each feature asks the user for specific information based on the feature type. For example, a hole has a diameter, depth, and placement, while a round has a radius and edges to round.
Associativity: Pro/E is a fully associative system. This means that a change in the design model anytime in the development process is propagated throughout the design, automatically updating all engineering deliverables, including assemblies, drawings, and manufacturing data. Associatively makes concurrent engineering possible by encouraging change, without penalty at any point in the development cycle. This enables downstream functions to contribute their knowledge and expertise early in the development cycle.
Capturing Design Intent: The strength of parametric modeling is in its ability to satisfy critical design parameters throughout the evolution of a solid model. The concept of capturing design intent is based on incorporating engineering knowledge into a model. This intent is achieved by establishing features and part relationships and by the feature dimensioning scheme. 1894 In an overall study we get to know the fact that no way to metering was found by electronic technologies until the first an alogue and digital integrated circuits.

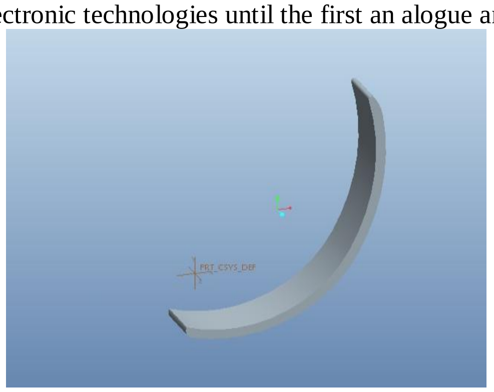

FIGURE 4. suspension

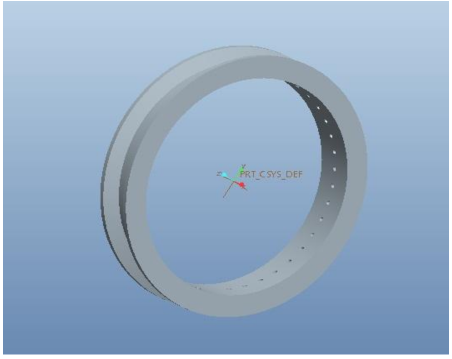

FIGURE 5. Rim

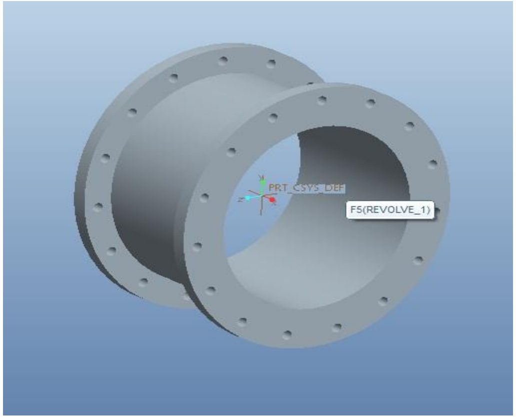

FIGURE 6. Hub

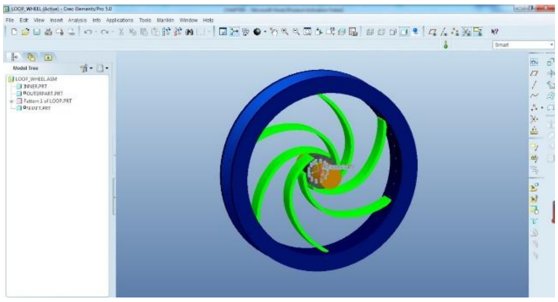

FIGURE 7. Assembled view of wheel

3. DESIGN CALCULATION OF SUSUPENSION

Dimension of cross section of the leaf is to be determined. The width of the leaf material was kept as 35mm as it cannot be more than the width of the wheel.

Considering front impact case, using impulse momentum theorem,

F*t = m*v

Time of impact, t=0.5 sec

Mass of cycle including rider,

m= 100 kg Max.

velocity, v=30kmph= 8.3 m/s

F= 1660 N

For determining the thickness of the Leaf, let us consider it as a cantilevered beam.

Bending Stress is given by,
$Sb = 1.5WL/bt^2$
Sb= 400 MPa
W= 1660 N
L= 350mm
B= 35mm
From above equation,
we get thickness of leaf, t=2.913 ~ 3mm.

4. METHODOLOGY

Objective:
1. To compare the strength between different types of wheel rims.
2. To make the test of ending endurance and radial test.
3. To determine the load case bending, pressure, centrifugal and vertical.
4. To give the consumers both safety and comfort of a car with good quality rim.
5. To increase the quality and durability rim for consumers.

Problem Identification:
- Aluminum should not balance both statically as well as dynamically
- Magnesium should not be lightest possible.
- Aluminum and Magnesium cannot possible to remove or mount the wheel easily.
- High-cost materials

Proposed Methodology Phase-I:
Here my work was done in two phases. The first phase is literature survey of fatigue analysis. Hereby I done design and structural analysis for existing material Aluminum and Magnesium. Next for phase II, the proposed material of carbon and silicon is analyzed based on stress, strain and other parameters and various wheel rim geometry and different loading conditions will impose. 3D model is created using various tools in CREO. For finding the variation the analytical calculations are done for some cases through finite element analysis. It's a powerful tool for numerical procedure to obtain solutions for engineering analysis. We can find a complex region for complex regions into simple geometric shapes. It's all done by finding loading and boundary condition

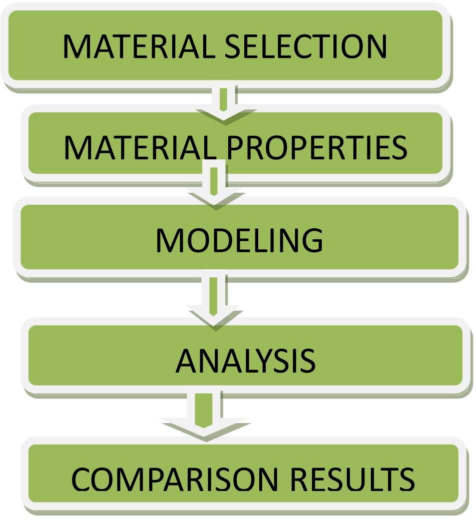

FIGURE 8 . Work Flow

Material Selection
- Aluminum
- Magnesium
- Carbon
- silicon

Workflow: This project deals with alloy wheel affects the displacement distribution, equivalent (von-mises) stress, strain and safety factor of the wheel by using Finite Element Analysis (FEA). The 3-dimensional Models of the alloy wheel was designed in modeling software CREO 2019 and further it was imported to the ANSYS 16.0 by using Parasolid format, the finite element analysis of the model was done by meshing the models using solid mesh. The 0.241317 MPa pressure was applied on the outer rim surface of the wheel. In the analysis, aluminum, Magnesium is used as an existing material and the carbine and silicon is used as a proposed material. The structural analysis is used to find life and safety factor fatigue module was used.

Advantages:

- It is to be as bright as possible so that unsprang mass is least.
- It will be robust enough to perform the directly above functions.
- It will be stable statically along with dynamically.
- It is possible to eliminate or mount the rim easily.
- Its material will not fail with weathering and period of time
-

5. RESULTS AND DISCUSSION

Aluminum material analysis result:

Table 1. Aluminum Property

Properties of Outline Row 3: Aluminum Alloy

	A	B	C
1	Property	Value	Unit
2	Density	2770	kg m^-3
3	Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
9	Alternating Stress R-Ratio	Tabular	
13	Tensile Yield Strength	2.8E+08	Pa
14	Compressive Yield Strength	2.8E+08	Pa
15	Tensile Ultimate Strength	3.1E+08	Pa
16	Compressive Ultimate Strength	0	Pa

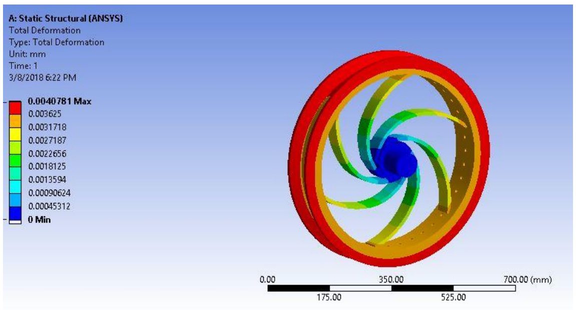

FIGURE 9. Deformation

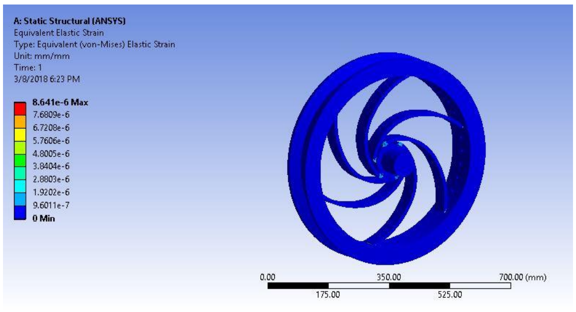

FIGURE 10. Strain

Magnesium Material Analysis Result:

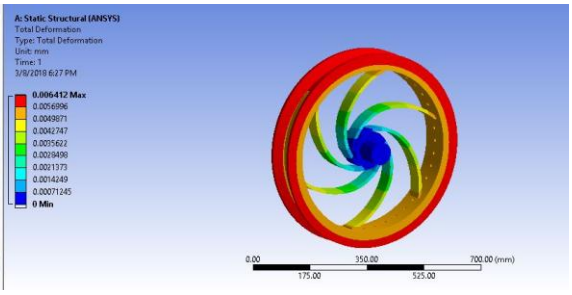

FIGURE 11. Deformation

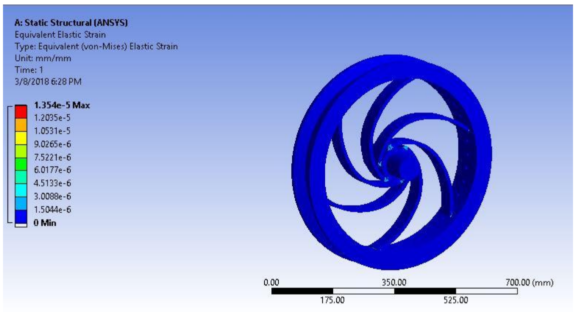

FIGURE 12. Strain

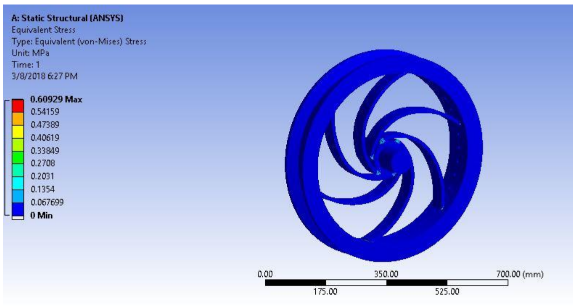

FIGURE 13. Stress

6. CONCLUSION

The wheel is constrained appropriately and the loads are calculated based on the specifications and applied to appropriate nodes. The wheel is analyzed for the calculated loading condition and the stress plot is obtained. In the case of bending test normal stress along Y-axis shows compression on the top rib and tension on the bottom rib and compression on the bottom rib. In the case of pressure loading, normal stress along X-axis shows compression on the top rim and on the inside portion of the rim there is a gradual transition from compression to tension. Normal stress along Y-axis shows bending stress coming on to ribs because when the rim is getting compressed, it forces the rib to move outwards. In the case of vertical loading normal stress along Y-axis shows tension on the outer rib and compression on the outer side of the rib. When a section plot is taken it will show a gradual transition from tension to compression. The file, which is created in ANSYS, is equivalent with the provision for flexibility by which stress can be modified to suit any possible situation that may arise in future.

REFERENCES

[1]. C.L. Chang, S.H. Yang (2008)," Finite element simulation of wheel impact test", Journal of Achievements in Materials and Manufacturing Engineering vol.28, pp 167 -170.
[2]. J Stearns, T S Srivatsan (2005)," Analysis of stress and strain distribution in a vehicle wheel: finite element analysis Versus the experimental method", J. Strain Analysis Vol. 40 No. 6
[3]. Reddy .,J N(2002), "An introduction to the finite element method", McGraw Hill publishing company .
[4]. Cameron Lonsdale (2005), "Wheel Rim Residual Stress Measurements", PP387-393.
[5]. Mala .M, Vignesh. B, Abu. A.C(2011), Design of Wheel Rim" journal (7) P.S.G data book
[6]. SOFIA, TOTOLICI (2010), "Geometrical analysis of the worm-Alloy wheel frontal gear" NON-LINEAR SYSTEMS and WAVELET ANALYSIS
[7]. Hoemson, R., (2011), "Structural design of Agriculture Wheels", American Society of Agriculture Engineers, PP84-1158.
[8]. H N Kale, Dr.C.L. Dhamejani(2015), "Comparative study of Wheel Rim Material" ,Vol 1.
[9]. S.Ganesh, Dr.P.Periyasami(2014), "Design and Analysis of Alloy Wheel Rim for four wheeler", the International Journal of Engineering and Science(IJES),Vol 3,PP29-37.
[10]. V.Radha Krishnan, M.Magudeeswaran(2016), "Design and Analysis of Wheel Rim with Alloy flexures", South Asian Journal of Engineering and Technology,Vol 2,PP162-170.

