Modeling and Structural Analysis of Alloy Four Wheeler

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Abstract: Wheel spokes are the supports consisting of a radial member of a wheel joining the hub to the rim with Carbon Fiber, Magnesium Alloy, Titanium Alloy and Aluminum Alloy. The two main types of motorcycle rims are solid wheels, in which case the rim and spokes are all cast as one unit, usually in Aluminum or magnesium alloys and the other spoke wheels, where the motorcycle rims are laced with spokes which require high spoke tension, since the load is carried by fewer spokes. If a spoke does break, the wheel generally becomes instantly un-ridable also the hub may break. Presently, for high cc bikes Magnesium wheels are used, due to its low heat resistance and micronisation of crystal grains, replacing it with Aluminum alloy. This Simulation work attempts to model the wheel of a two wheeler racing by using the Pro/Engineer Software, and conducting the tests: Static and Fatigue analysis using the Cosmos (Solid Simulation Work) software by reducing the number of spokes from 5 to 4 for the existing model. Based on simulation work, a better material for alloy wheels may be analyzed from the results obtained and validated.

KEYWORDS: Alloy Wheel, COSMOS, Static and Fatigue analysis

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INTRODUCTION

A wheel is a circular device that is capable of rotating on its axis, facilitating movement or transportation while supporting a load (mass), or performing labour in machines. Safety and economy are particularly of major concerns when designing a mechanical structure so that the people could use them safely and economically. Style, weight, manufacturability and performance are the four major technical issues related to the design of a new wheel and/or its optimization mainly for Aluminum wheels according to governmental regulations and industry standards [1-3]. In the real service conditions, the determination of mechanical behaviour of the wheel is important, but the testing and inspection of the wheels during their development process is time consuming and costly. For economic reasons, it is important to reduce the time spent during the development and testing phase of a new wheel. Finite element analysis (FEA) was carried out by simulating the test conditions to analyze the stress distribution and fatigue life of alloy wheels. The analytical results using FEA to predict the wheel fatigue life agreed well with the experimental results [4]. A mathematical model was developed to predict the residual stress distribution of an A356 alloy wheel, taking into account the residual stress evolution during the T6 quench process and redistribution of residual stress due to the material removal at the machining stage. The fatigue life of an A356 wheel was predicted by integrating the residual stress into the in-service loading and wheel casting defects (pores). The residual stress showed a moderate influence on the fatigue life of the wheel, which was more sensitive to casting pore size and service stress due to applied loads [6]. By improved Smith formula, finite element analysis of stress values as the basic parameters for wheel fatigue life prediction [5]. ABAQUS software to build the static load finite element model of Aluminum wheels for simulating the rotary fatigue test [7]. The equivalent stress amplitude was calculated based on the nominal stress method by considering the effects of mean load, size, fatigue notch, surface finish and scatter factors. The fatigue life of Aluminum wheels was predicted by using the equivalent stress amplitude and Aluminum alloy wheel S-N curve. The results from the Aluminum wheel rotary fatigue bench test showed that the baseline wheel failed the test and its crack initiation was around the hub bolt hole area that agreed with the simulation. Using the method proposed in this paper, the wheel life cycle was improved to over 1.0×105 and satisfied the design requirement. A mathematical model was developed to predict the residual stress distribution of an A356 alloy rim, taking into account the residual stress evolution during the T6 quench process [9]. Static and fatigue analysis of Aluminum alloy wheel A356 by finite element idealization modal using the 10 node tetrahedron solid element in static condition and the wheel was designed using CATIA [8], total deformation, alternative stress and shear stress is simulated by using FEA software. This paper starts by modelling of the alloy wheel in a two-wheeler racing bike using the Pro/Engineer Software for five different materials viz. LM 25, LM25TB7, LM 25TE, LM25TF and AM60A and conducting the tests: Static and Fatigue analysis using the Cosmos software by reducing the number of spokes from 5 to 4 for the existing model. Based on simulation work, a better material for alloy wheels may be analyzed from the results obtained and validated.

SPECIFICATION OF THE PROBLEM:

The objective of the present work is to design and analyses, of Aluminum alloy wheels made and also polymeric composite light weight vehicle wheel is made of three different composite materials viz., Carbon/Epoxy, E-glass/Epoxy and S-glass /Epoxy composites. polymeric composite light weight vehicle wheel was created in Pro-E. Model is imported in ANSYS 12.0 for analysis by applying normal load conditions. After analysis a comparison is made between exisisting conventional Aluminum alloy wheels and polymeric composite light weight vehicle wheel viz., Carbon/Epoxy, E-glass/Epoxy and S-glass /Epoxy in terms of deflections and stresses, to choose the best one.

INTRODUCTION TO MATERIALS

Alloy is a mixture of two or more elements where at least one of them is metal. The resulting alloy can be a solution or a solid. If only two components are mixed to produce an alloy, it is known as a binary alloy. If there are three components, it is known as ternary alloy. The amount of element in the alloy is normally measured and given by mass (as percentages). Alloys can be also classified as homogeneous if they have a single phase. If have several phases, those alloys are classified as heterogeneous. If there isn't a distinct phase boundary, then they are known as inter metallic. Alloys are produced from elements, to have improved qualities than the reactant elements. They have different qualities than the reactant components. Normally alloys have metallic properties, but they differ from pure metal elements. For example, alloys don't have a single melting point. Rather, they have a range of melting points. A composite material is defined as a material composed of two or more constituents combined on a macroscopic scale by mechanical and chemical bonds. Composites are combinations of two materials in which one of the material is called the "matrix phase" is in the form of fibers, sheets, or particles and is embedded in the other material called the "reinforcing phase". Another unique characteristic of many fiber reinforced composites is their high interal damping capacity. This leads to better vibration energy absorption within the material and results in reduced transmission of noise to neighboring structures. Many composite materials offer a combination of strength and modulus that are either comparable to or better than any tradional metalic metals. Because of their low specific gravities, the strength to weight-ratio and modulus to weight-ratios of these composite materials are markedly superior to those of mettalic materials. The fatigue strength weight ratios as well as fatigue damage tolerances of many composite laminates are excellent. For these reasons, fiber composite have emerged as a major class of structural material and are either used or being considered as substitutions for metal in many weight-critical components in aerospace, automotive and other industries. High damping capacity of composite materials can be beneficial in many automotive applications in which noise, vibration, and hardness is a critical issue for passenger comfort.

DESIGN PROCEDURE OF ALLOY WHEEL

S.No	Parameters	Value
1	Area	19875.05 mm2
2	DIAMETER	325MM
3	PERIMETER	1765 mm
4	WEIGHT OF THE CAR	1.5 T
5	PASSEENGER 5 PEOPLE	400 KG
6	EXTRA LOAD	500KG
7	TOTAL	23520N
8	TYRES AND SUSPENSION REDUCED BY 30 %	16464N
9	WEIGHT ON INDIVIDUAL WHEEL	4116N
10	PRESURE	0.08N/mm2

Table: 1 Specifications of Alloy wheel

2D DRAWING OF ALLOY WHEEL

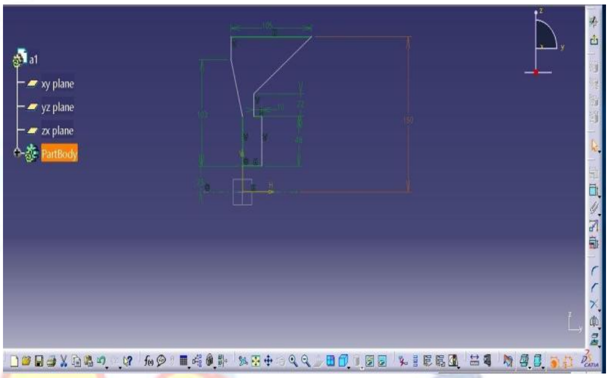


FIG NO.2 SKETCH OF ALLOY WHEEL

The design of alloy wheel can be obtained by the following steps

.First 2d sketch of alloy wheel is drawn in sketch file.

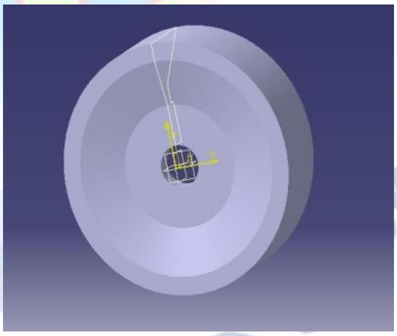


FIG NO.3 REVOLVING COMMAND USED

Then the part is revolved by using the shaft command with specifieddimensions.

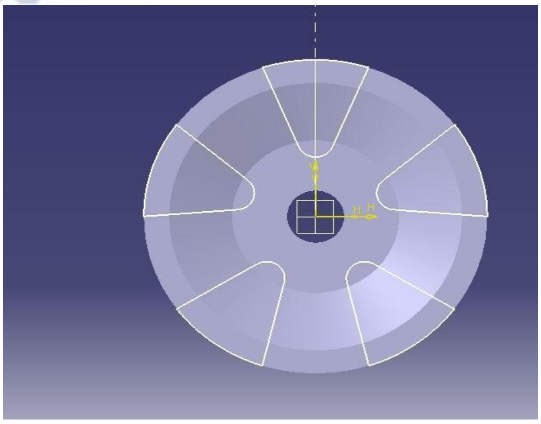


FIG NO.4 SKETCHING

Next according to our desired geometry of wheel we can do extrude or pocketing depending up on the sketch. Here we had used the pocketing command

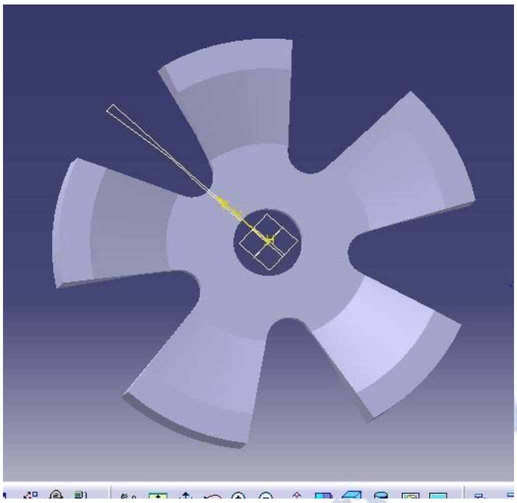
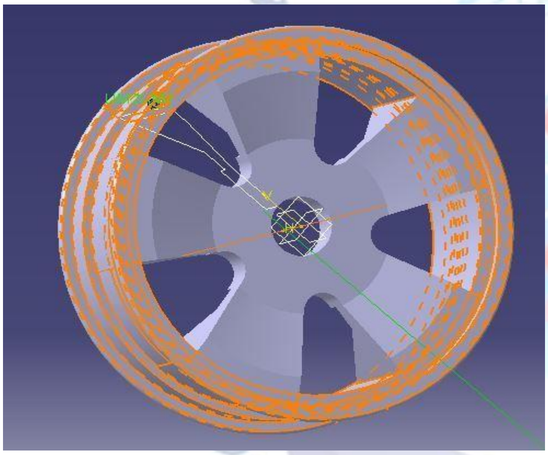


FIG NO: 5 POCKETING

Now sketch the rim part of the wheel and revolve it.



For alloy wheel five holes of counter bored shape is made by using the hole command in the part module

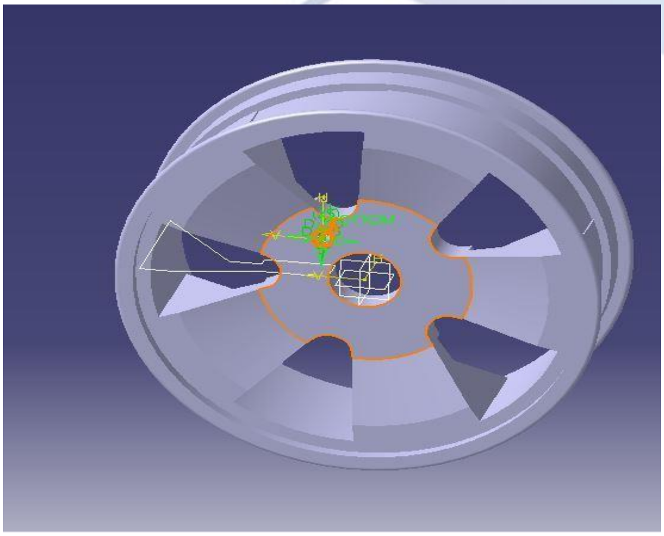


FIG NO: 6 INSERTNG HOLE COMMAND

Finally we can use edge fillet and chamfering commands for finishing purpose and the total part of alloy wheel is designed by using CATIA v5R20 software.

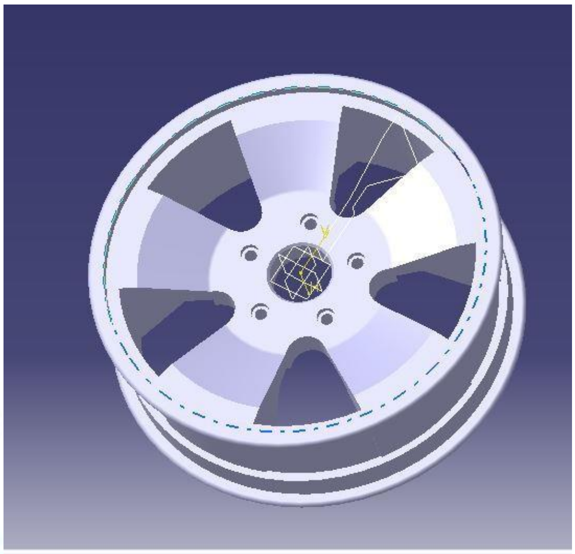


FIG NO: 7 FULL 3D MODEL

STRUCTURAL ANALYSIS OF ALLOY WHEEL

Static analysis of alloy wheel is carried out in the following steps as

1. Structural element
2. Importing the alloy wheel which should be in the form of .igs from CATIA toANSYS.
3. Generating the 3D model.
4. Meshing of model
5. Solution for different conditions and mechanical factors.

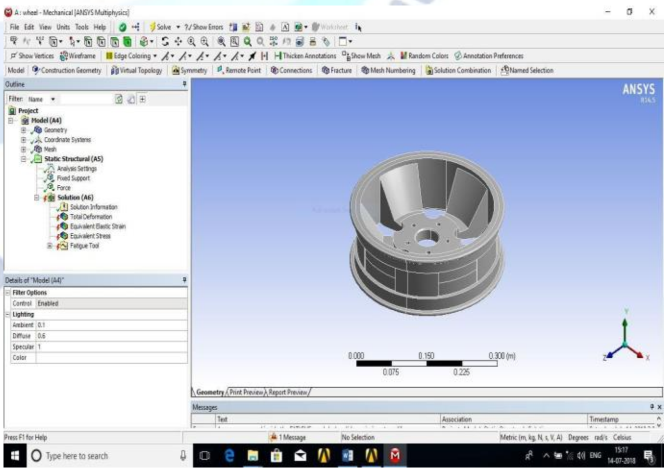


FIG NO: 8 IMPORTED MODEL OF ALLOY WHEEL

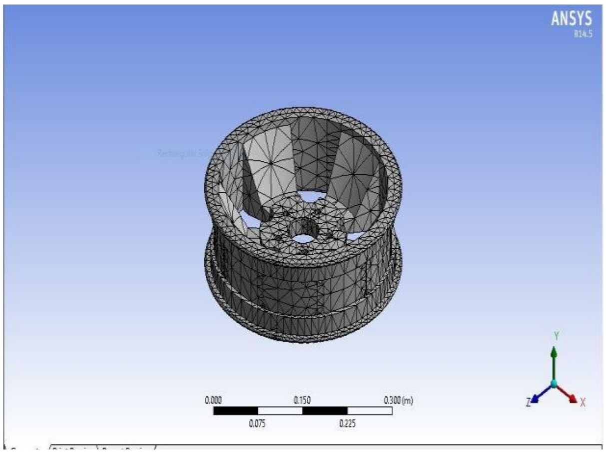


FIG NO: 9 MESHING

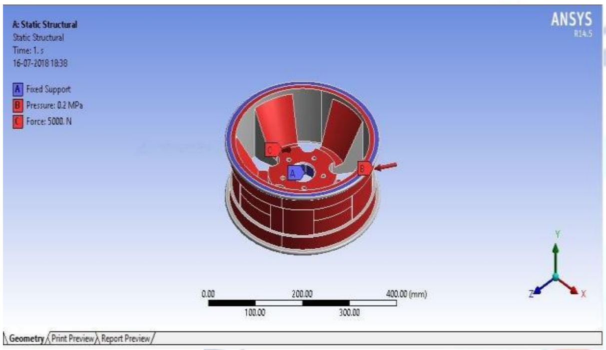


FIG NO: 10 FORCES APPLIED ON WHEEL

STAINLESSSTEEL

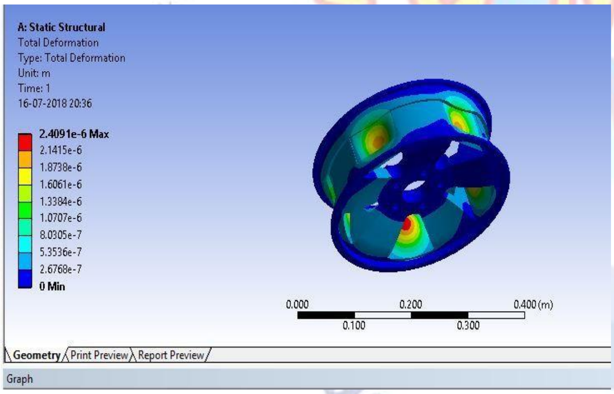


FIG NO:11 TOTAL DEFORMATION OF STAINLESS STEEL(S.S)

ALUMINIUM

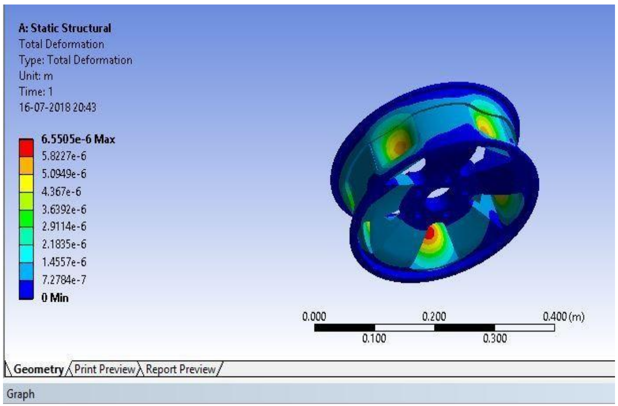


FIG NO: 14 TOTAL DEFORMATION OF ALUMINIUM (AL)

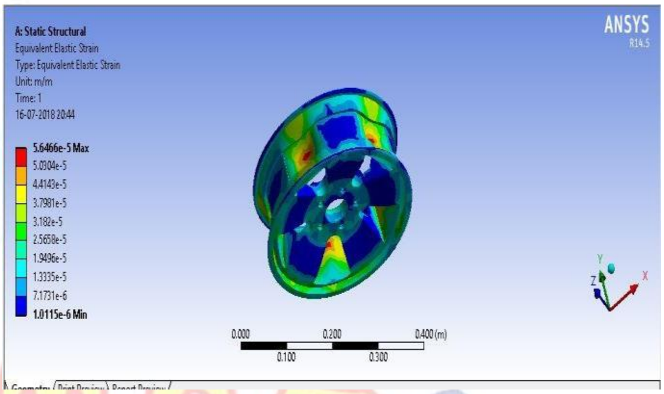


FIG NO: 15 EQUIVALENT ELASTIC STRAIN OF AL.

MAGNESIUM(Mg)

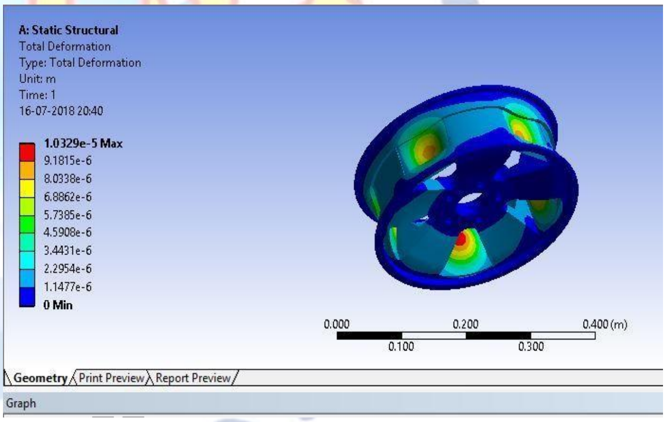


FIG NO: 17 TOTAL DEFORMATION OF Mg

Materials	Total Deformation(mm)		Equivalent Elastic Strain(mm/mm)		Eq.Stress (Von Misses Stress)(MPa)	
	Max	Min	Max	Min	Max	Min
Stainless Steel	0.0024091	0	2.075e-5	3.754e-7	3.9355	0.0298
Aluminium	0.0065505	0	5.646e-5	1.011e-6	3.9937	0.0283
Magnesium	0.010329	0	9.038e-5	1.585e-6	4.0523	0.0275
Titanium	0.0048387	0	4.267e-5	7.413e-7	4.0816	0.02749

COMPARATIVE STATIC ANALYSIS OF ALUMINIUM A 356,MAGNESIUM, TITANIUM AND STAINLESS STEEL.

CONCLUSION

This project on design and analysis of an alloy wheel for a light four wheeler vehicle had deal with the mechanical behaviour of alloy materials like aluminium, magnesium, stainless steel and titanium leads to the following conclusions:

Brief study of alloy wheel is done by using different materials and their properties.

By using CATIA modelling software alloy wheel is designed and analysis is carried out in ANSYS 14.5 workbench software. Static structural analysis is performed on different materials by applying a force of 5000N pressure of 20MPa with same conditions. Modal analysis of alloy wheel is also done with respect to total deformation, strain and stress. The results are noted and tabulated for comparison purpose.

From the analysis we can conclude that the titanium alloy has least deformation ,stress and frequency values for same loading conditions.it has excellent corrosion resistance property which makes titanium alloy best suitable than other materials. Magnesium and stainless steel have minimum vonmisses stress values.

In structural analysis and modal analysis of alloy wheel different types of mechanical factors like stress, deformation, strain, vonmises stresses, frequency of materials are evaluated .We can conclude that titanium alloy is best suited for all conditions except its high cost when compared to other materials because of its light weight and mechanical properties.

SCOPE FOR FUTURE WORK

- There is a very wide scope for future scholars to explore this area of research.
- This work can be further extended to analyse the effect of fibre orientation, loading pattern, fibre treatment on mechanical behaviour of polymer composites. The study leaves wide scope for feature investigation.
- We can go for optimization of alloy wheel by taking damage factor.

REFERENCES

1. Analysis of stress and displacement distribution in a rotating rim subjected to loads by P.C Lam and T.S Srivastam
2. Stress analysis of wheel rim international journal of mechanical engineering and research vol-1 issue-1 (page, 34-37), ISSN: 2277-8128.
3. Analysis of casting parts considering Shrinkage cavity defect By Si- YoungKwak.
4. Composition and Properties of Zinc Alloys and Comparative Data for Other Materials by Fishwercast global.
5. Simulation test of Automotive Alloy wheel using computer aided engineering Software by MOHD IZZAT FALIQFARHAN BIN BAHAROM.
6. Fatigue Life Analysis of Aluminum Wheels by Simulation of Rotary FatigueTest by Liang Mo Wang.

