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Design and Analysis of Alloy Wheel

Mr. Ajay Somvanshi[1], Mr. Jitesh Gavit[2], Mr. Saurabh Pandey[3], Mr. Veeresh Swamy[4], Prof. Yogini Somvanshi[5]
[1. 2. 3. 4]*Student, Department of Mechanical, Dr. D. Y. Patil School of Engineering and Technology, Lohegaon, Pune*
[5]*Assistant Professor, Department of Mechanical, Dr. D. Y. Patil School of Engineering and Technology, Lohegaon, Pune*

Abstract: Importance of wheel in the automobile is obvious. The vehicle (car) may be towed without the engine but at the same time even that is not possible with out the wheels, the wheels along the tyre has to carry the vehicle load provide cushioning effect and cope steering control. The main requirement of automobile wheel it must be strong and perform all operations above functions.
It should be balanced both statically as well as dynamically. It should be lightest possible so that the unsprung weight is least. The wheel has to pass three types of test before going production, they are cornering fatigue test. Radial fatigue test and Impact test. In this thesis radial fatigue analysis is done to find the number of cycles at which the wheel is going to fail. The wheel is meshed using SOLID 45 element. A load of 2500N was applied on the hub area of the wheel and a pressure of 0.207N/mm2 is applied on the surface of rim.

Keywords: wheel rim, material analysis, finite element technique, solid model

I INTRODUCTION

The wheel is perhaps the most significant discovery of old times. Wheel is an important structural member of vehicle suspension system that supports the static and dynamic load encountered during vehicle operation. A wheel is a circular device that is capable of rotating on its axis. The wheels are made up of steel, magnesium alloy and cast/forge aluminum alloys.

A. Alloy Wheels

An alloy is a material which consists of two or more metals. It is used to increase the strength of material. Alloy wheel are made up of aluminum or magnesium. Alloys are mixtures of metal and other elements. They provide strength on pure metals, which are usually much softer.
The metals of aluminum or magnesium are lighter and have same strength, it also provide better heat conduction. The material used in wheel production, is an alloy of iron and carbon. Alloy wheels are more attractive.In early the alloy wheels were made of magnesium. These wheels were having many failures to vehicles, but they were popular in 1960s. In 1960s, aluminum-casting allowed the manufacture of safer wheels. Until that, the aluminum wheels which were made with low ductility, the enlongation was 2-3%.

B. Properties Of Alloy

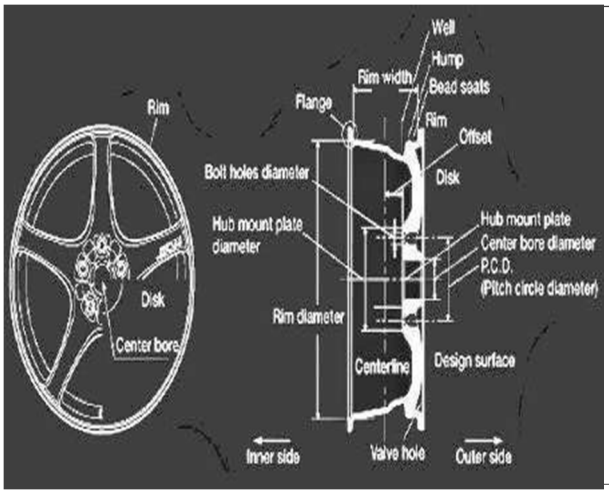
The properties of alloys are follows:
1) Alloys have strength, malleability, attractive etc.
2) The copper is a material which hardens the alloy. Whereas the bronze is made up of copper and tin.
3) Alloy is attractively due to its quality and it utilizes pure metals.

C. Characterstics Of Alloy Wheel

Alloy wheels are expensive and which produce the standard steel wheels. The alloy wheels were considered since 2000. Alloy wheels have long been included in higher-priced luxury or sports cars, with larger-sized. The cost of alloy wheel is high which makes attractive to thieves; the automakers and dealers often use locking lug nuts. Mostly alloy wheels are manufactured by casting process and other are made up of forged. Forged wheels are lighter, stronger, and more expensive than cast wheels. There are two types of forged wheels:
1) *One piece. b. Modular:* Modular forged wheels make two- or three-piece design. Typical multi-piece wheels consist of the inner rim base, outer rim lip and wheel center piece with openings for lug nuts. The parts of a modular wheel are held with bolts.

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D. Parts Of Alloy Wheel



1. Rim
2. Disk
3. Center Bore
4. Hub-Mount Plate
5. Flange
6. Well
7. Hump

Fig 1 Parts of alloy wheel

E. Materials Used In Alloy Wheel

1) Aluminum Alloy: Aluminum alloys are alloys in which aluminum is the predominant metal. The typical alloying elements are copper, magnesium, etc. The alloys are classified in to two types, namely

a) Casting alloys

b) Wrought alloys,

Whereas the casting alloy and wrought alloy are sub divided in to two types namely

- Heat-treatable
- non-heat-treatable

About 85% of aluminum is used for wrought products, for example rolled plate, foils etc. The surface of Aluminum alloy has white, which is protected by the layer of aluminum oxide. The galvanic corrosion is occurred when the aluminum alloy is placed in electrical contact with other metals. The metal corrosion, process can occur as exfoliation or intergranular corrosion.

2) Magnesium Alloy: Magnesium wheels are the first die-cast wheels which were produced, and were namely as"mag wheels. These wheels were used for racing. But they were popular during 1960s. The term "mag wheels" became synonymous with die-cast wheels made from any material, from modern aluminum alloy wheels to plastic and composite wheels used on items like bicycles, wheelchairs, and skateboards. Now a day's pure magnesium wheels are not produced, the pure magnesium wheels are being found only on classic cars. Pure magnesium has a lot of problems in it. The Vintage magnesium rims were used for pitting, cracking and corrosion. Magnesium wheels are hard to ignite, where as in pure magnesium wheels it can be ignited by a burning tire or puncture. The Alloys of magnesium were later developed to alleviate most of these problems. The Modern surface treatment technologies provide protection from corrosion and significantly extend the average lifecycle of magnesium rims.

II LITERATURE REVIEW

T.Shiva Prasad et al [1], he proposed about the stress analysis of car wheel rim. This is done by CATIA and ANSYS. The stress can be reducing by the modification and the designing of wheel rim. For the preparation of wheel the aluminum and forged steel with the relative performance. In this wheel dynamic and static analysis are obtained.

Sourav Das et al [2], he proposed the design of aluminum alloy wheel and the automobile applications which is to optimize the mass of wheel. The mass optimize from the wheel rim can be reduced from 26kg to 12.15kg.The analysis of FE shows that the stress of the alloy is actual to yield. The stress distribution and resulted displacement of the alloy wheel is under the radial fatigue load. The damage of wheel is found only 0.2%. The damage is found on the flange portion of the wheel rim.

Rajarethinam et al [3], he proposed the laterial stiffness and the radial stiffness of the vehicle that depends upon the bending inertia, torsion inertia and spoke geometry. The spoke of wheel where instrumented with the strain gauge. In order to know about the strain and fatigue resistance properties on wheel.

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Ganesh et al [4], he proposed, that the wheel is made by aluminum and magnesium alloy or sometimes it is made up of the mixture of both magnesium and aluminum alloy. Now a day's four wheels are made up of aluminum alloy. The alloy wheel is design by the parametric model for four wheeler by collecting data from the reverse engineering process. By designing and analyzing the model to change the design of rim to make it strong and balanced.

Alexandra Valentin et al [5], he proposed about the life of wheel. The car rim is analyzed by using load test of 400. The static stress is studied for finding the zone and also at which position the stress concentration is taking place. By using fatigue method and regression analysis method the result of experiment can be taken. The current design is 60% which is lighter compared to original design. The stress of 4 spoke is less where has compared to 5 spoke alloy.

Sanjay Chaudhary et al [6], he proposed the design analysis of aluminum alloy wheel by using the peek material. In the industries the design of automobiles is explored to the polymeric material in order to obtain the reduction of weight without the decrease in vehicle quality. W hen the weight of the vehicle decreases the fuel consumption increases. The designs of two wheeler were chosen by applying the different load and redesign the wheel for reduction of deformation.

III. PROBLEM STATEMENT

There are only a few types of wheels still in use in the automotive industry today. They vary significantly in size, shape, and materials used, but all follow the same basic principles. The first type of wheel worth mentioning, and by far the most-used wheel, is the steel wheel. This kind of wheel consists of several sheets of steel, stamped into shape and typically welded together. This type of wheel is strong, but heavy. They are found on every kind of vehicle from sports cars to the larger pickup trucks; the wheels look different but are essentially the same device.

IV. DESIGN AND ANALYSIS OF ALLOY WHEEL

A. Design Of Alloy Wheel

The 3D model of alloy wheel rim is created in Solidworks SP1.0 software as per company specified dimensions of Kawasaki Versys 650 Front Rim

Table 1 Specifications of Alloy wheel rim of Kawasaki Versys 650

Volumetric Properties	Model Name
Mass:6.13081 kg Volume:0.000786002 m^3 Density:7,800 kg/m^3 Weight:60.082 N	Kawasaki Versys 650 Front Rim 431.8mm R17

Table 2

Load name	Load Detail
Pressure-1	Entities:3 face(s) Value:36 Units:psi
Force-1	Entities:5 face(s) Reference:Edge< 1 > Type:Apply force Value:--, ---, 1,412.64 N

B. Mesh Information

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points for High quality mesh	16 Points
Element Size	8.11184 mm
Tolerance	0.405592 mm
Mesh Quality	High

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Mesh information - Details

Total Nodes	65155
Total Elements	32911
Maximum Aspect Ratio	42.192
% of elements with Aspect Ratio < 3	58.7
% of elements with Aspect Ratio > 10	3.62
% of distorted elements(Jacobian)	0.00304
Time to complete mesh(hh;mm;ss):	00:00:49

C. Analysis of alloy Wheel Rim

1) Aluminium Alloy 6061-T6 (SS)

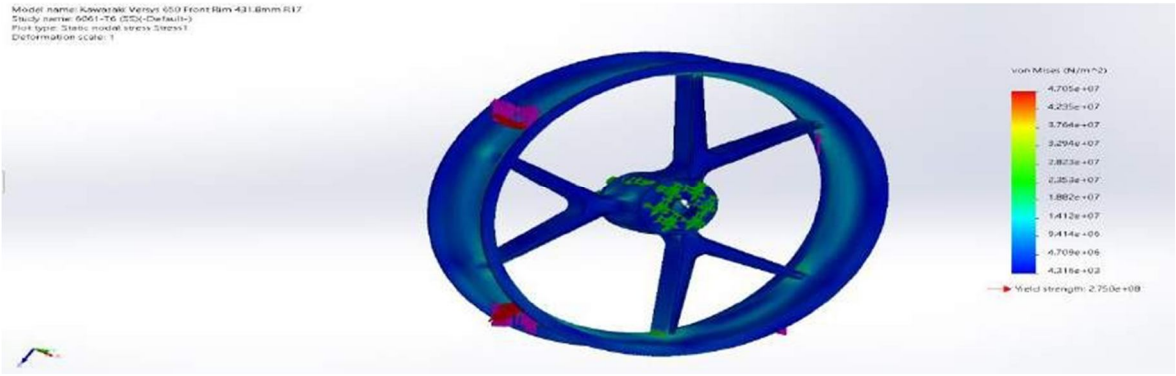


Fig a.1 static nodal stress-stress1

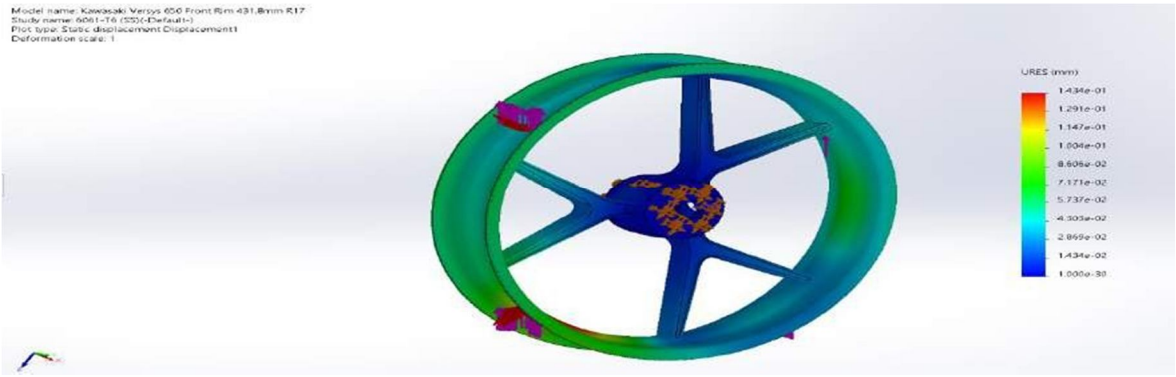


Fig a.2 static displacement-displacement1

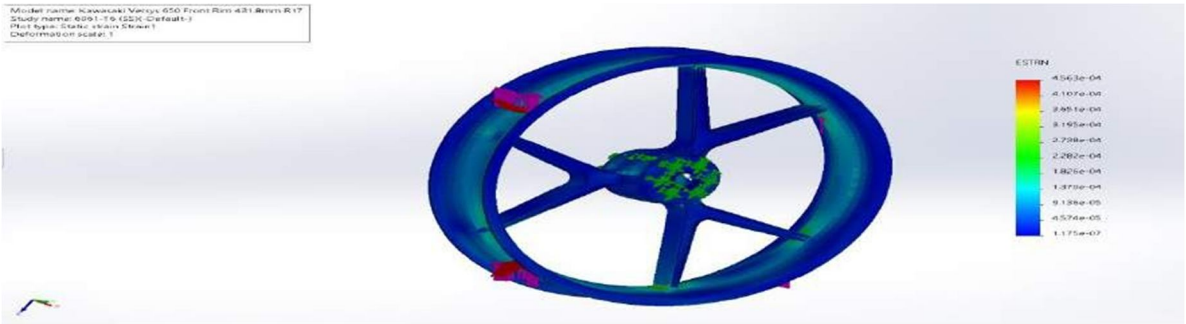


Fig a.3 static strain-strain1

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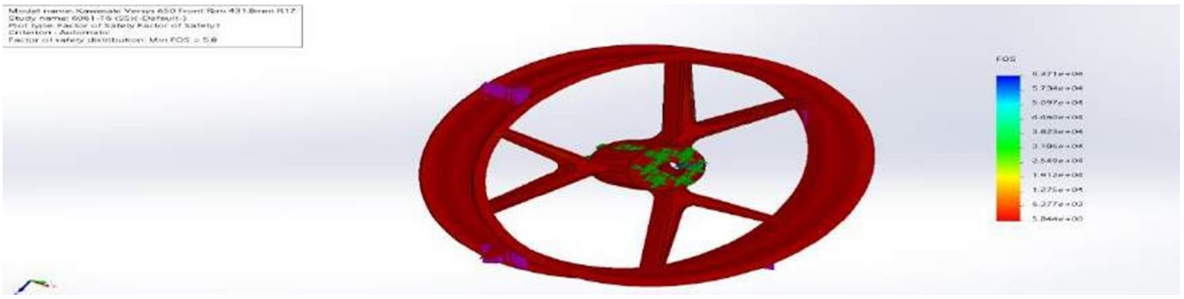


Fig a.4 Factor of safety

2) Chrome Stainless Steel

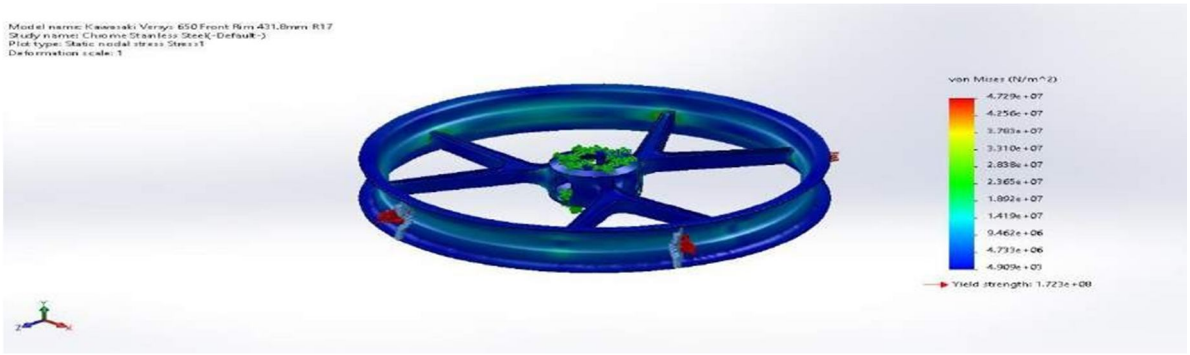


Fig b.1 Chrome Stainless Steel-Stress-Stress1

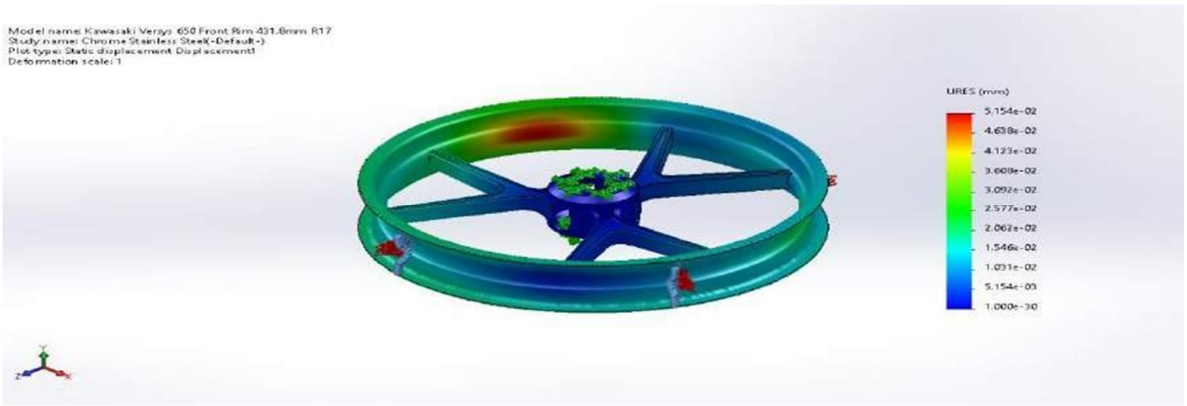


Fig b.2Chrome Stainless Steel-Displacement-Displacement1

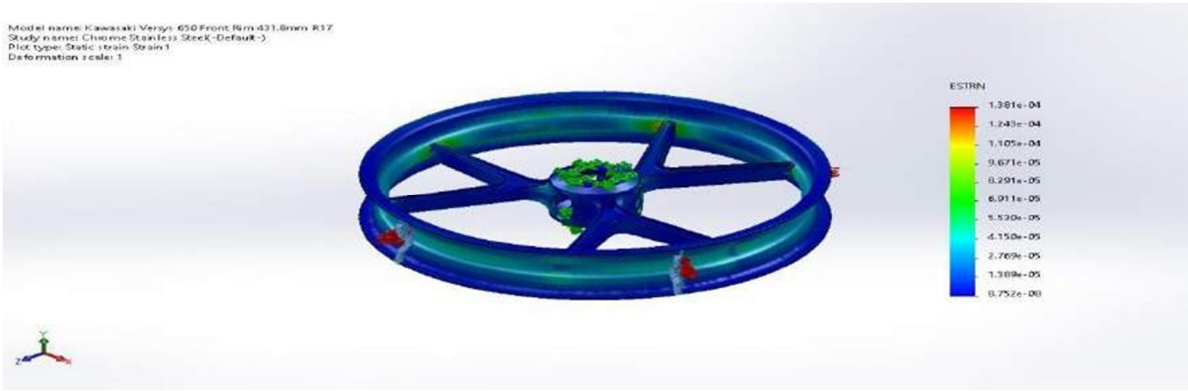


Fig b.3-Chrome Stainless Steel-Strain-Strain1

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Fig b.4 Chrome Stainless Steel-Factor of Safety-Factor of Safety1

3) Titanium alloy Ti-6Al-4VSolution treated and aged (SS)



Fig c.1 Ti-6AI-4V static nodal stress-stress1

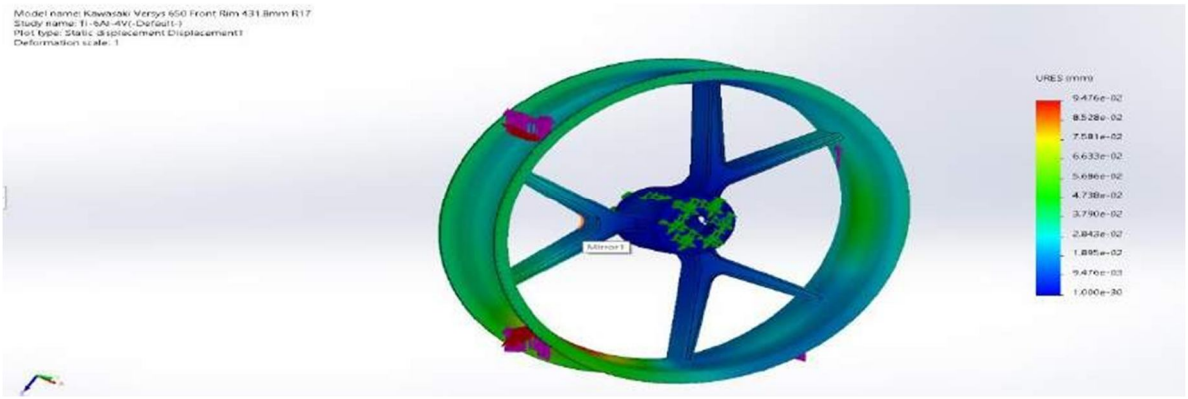


Fig c.2 Ti-6AI-4V static displacement-displacement1

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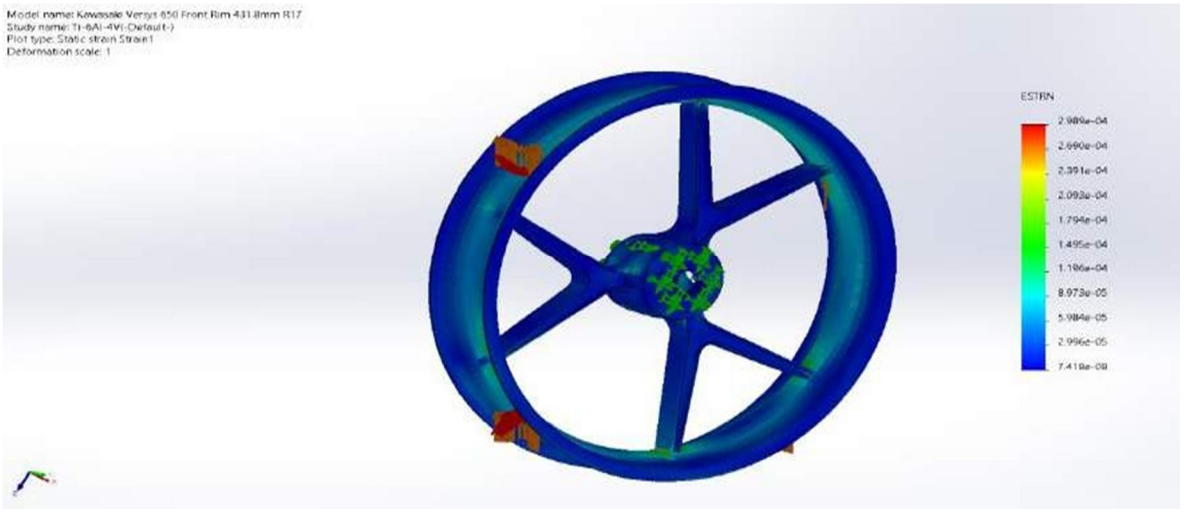


Fig c.2 Ti-6AI-4V static strain

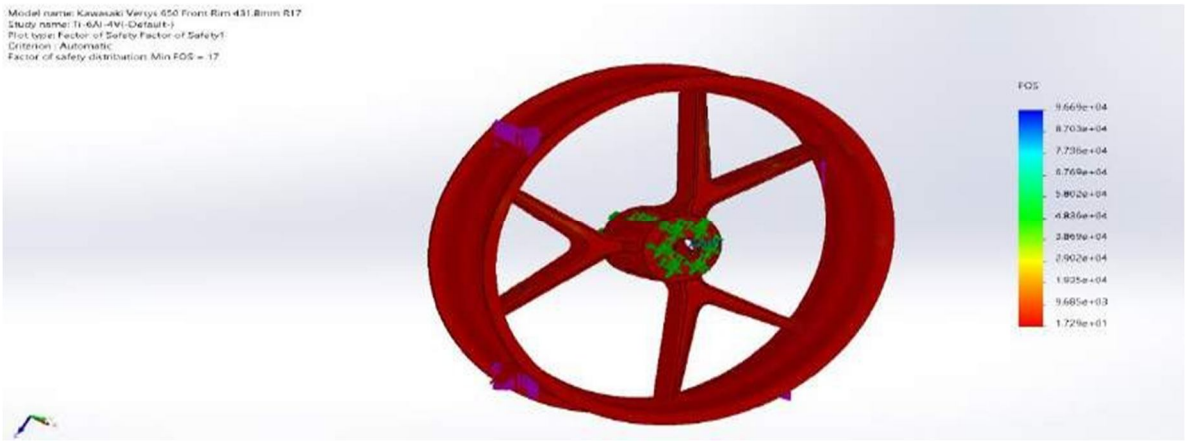


Fig c.2 Ti-6AI-4V Factor of safety

4) Magnesium Alloy

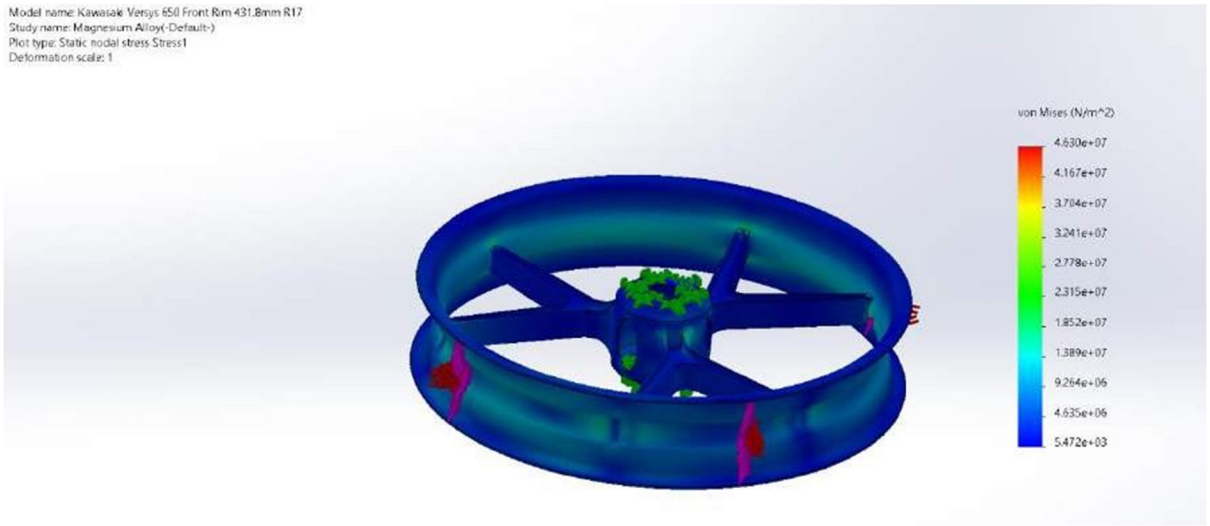


Fig d.1 Magnesium Alloy-Stress-Stress1

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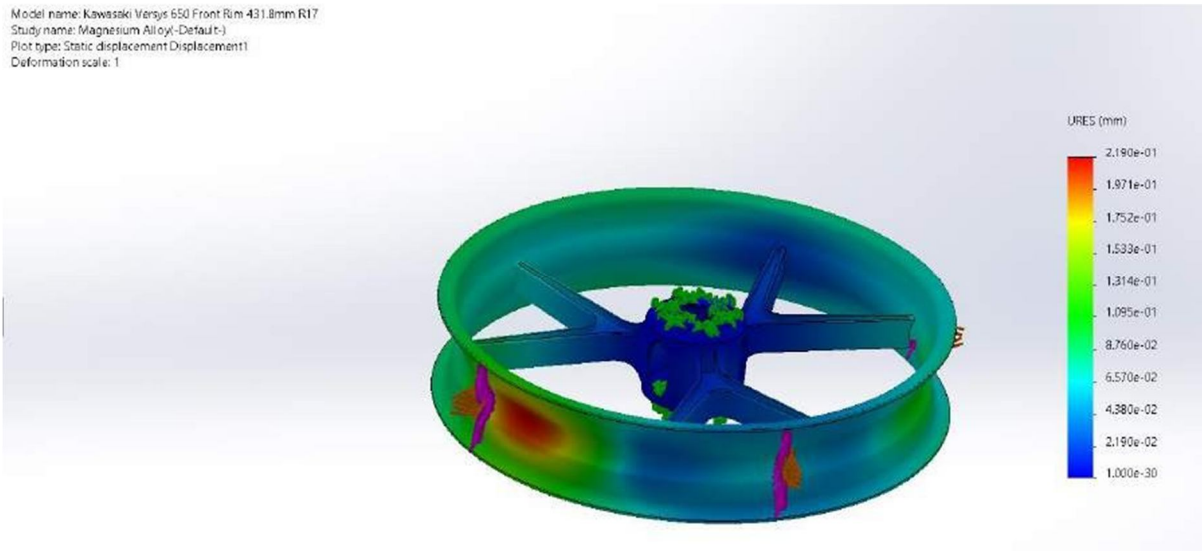


Fig d.2 Magnesium Alloy-Displacement-Displacement1

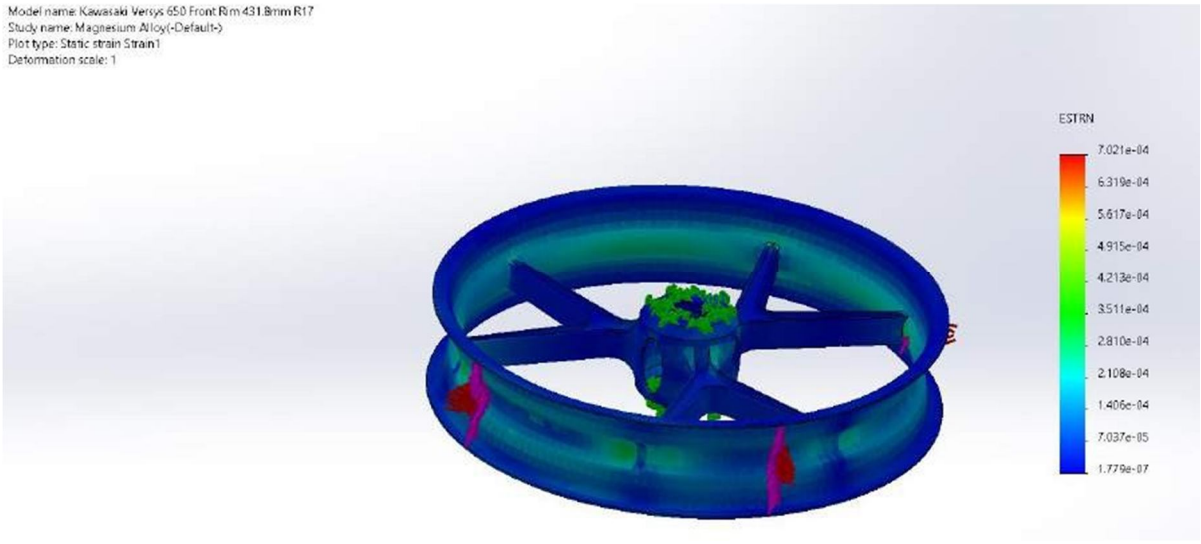


Fig d.3 Magnesium Alloy-Strain-Strain1

V. CONCLUSION

In these project the case of an automobile wheel maximum load is applied on the alloy wheel. Analysis of the wheel plays an important role for the safety of the passenger cars. This project deals with the fatigue analysis of the wheel, as explained in the previous chapters. The drafting package and the exported file ANSYS, the finite element package using IGES file to transfer where applied load of 2500N was applied on the hub area of the wheel and pressure of 0.207N/mm^2 is applied on the outer surface of the rim. The pitch circle holes are constrained in all degrees of freedom. Various numbers of cycles the analysis has been done. The minimum stress is 0.041x1e6 Pa. and the deformation is observed as the 0.515x1e-1 mm after running the fatigue cycles we found that the infinite life at 1.0x109 cycles. Same analysis can be performed with alternate materials by applying load at different areas on the wheel, to reduce the weight, which ultimately reduces the overall cost with increase in lifetime and we can find the failure by changing loads by increasing or decreasing according to our requirements of that particular wheels we also change the models or design of the wheel and to test for the fatigue and comparing with the two models which will give the more life we can identify and we can develop that model.

The applied pressure and force is wheel outer face wheel deformation and stresses Taking different three types of materials aluminum, magnesium, structural steel having different type of properties varies deformation and stress zones is different.

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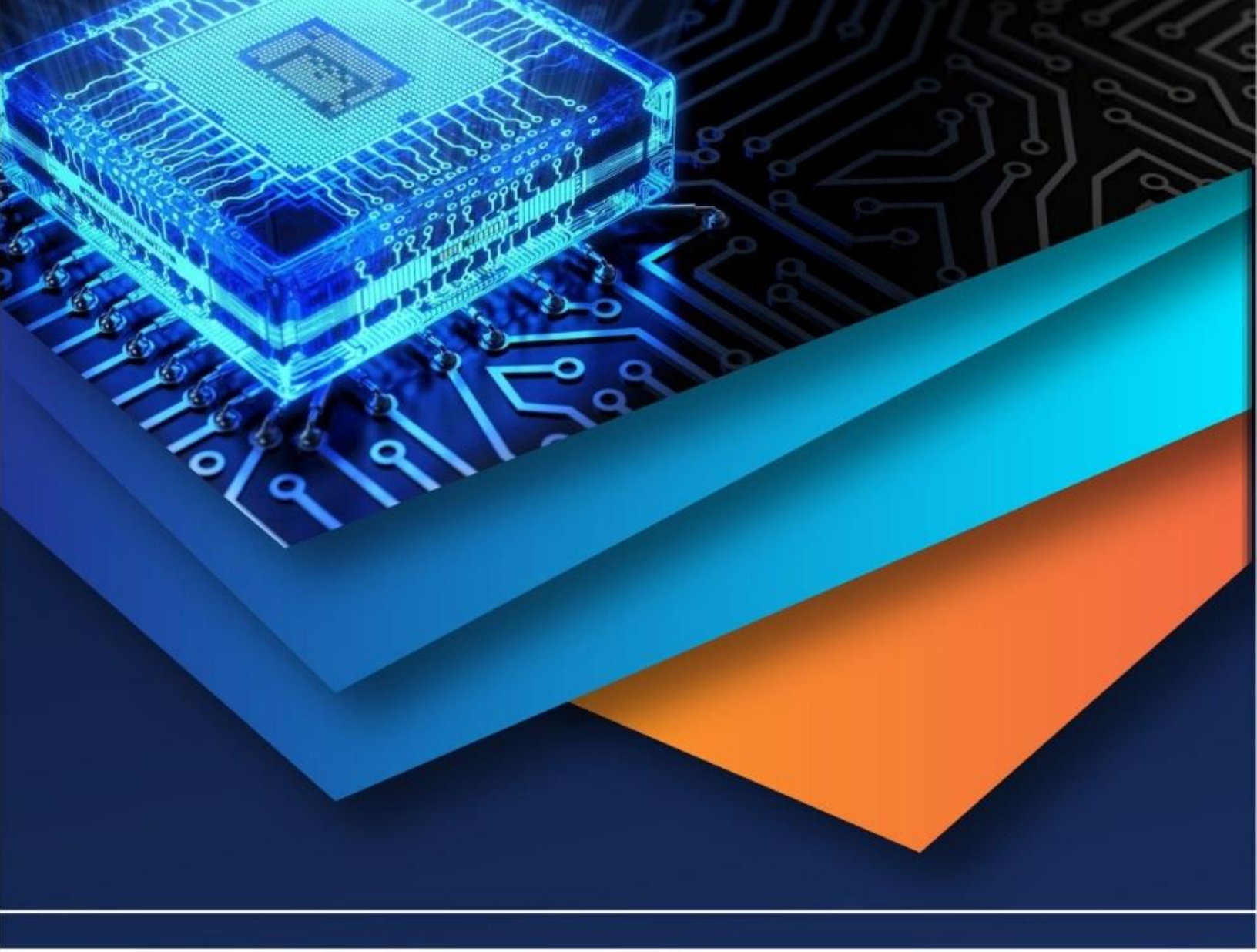
VI. ACKNOWLEDGEMENTS

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