

DESIGN AND ANALYSIS OF ALLOY WHEELS

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for the award of the degree of*

Bachelor of Technology in Mechanical Engineering

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CERTIFICATE

This is to certify that the Project Report entitled “Design and Analysis of Alloy Wheels” being submitted by **D. Jagadeesh koti (320126520L31), G. Venkata Krishna Kishore (320126520L29), K. Sai Teja (319126520144), P. Pramodh (320126520L15), K. Asween (319126520146)**, to the Department of Mechanical Engineering , ANITS is a record of the bonafide work carried out by them under the esteemed guidance of **Mrs. B. Krishna Prafulla**. The results embodied in the report have not been submitted to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

The vehicle may be towed without the engine but it is not possible without the wheels. The design and analysis of wheels have drastically improved for the last two decades. Research works have shown the possibility of using a wide range of materials that gives out maximum efficiency for the users. Alloy wheels are practically the mixtures of two or more different metals. Their unique properties over the conventional ones have made them the most favoured.

This project involves the design and analysis of an existing car model. The design and the composition of wheel is aimed towards increasing the strength and other parameters that are involved in the failure of these wheels. An alloy is selected for this purpose and its composition is to be varied for getting the best results and comparing them with the existing composition and properties. Road wheels are a crucial structural component of the vehicle suspension system that help withstand the static and dynamic loads that come with driving. The alloy wheel is subjected to the same maximum load as a car wheel. The safety of passenger cars is significantly impacted by accurate alloy wheel analysis.

Before going into production, alloy wheels that are intended for regular usage on passenger automobiles must pass the Dynamic Cornering Fatigue Test, Dynamic Radial Fatigue Test, and Impact Test. Although the majority of manufacturers of aluminium alloy wheels have tested their products extensively, information on their methodology for simulation tests is frequently withheld. Finite element analysis (FEA) is carried out by simulating the test conditions to analyze stress distribution and fatigue life of the aluminum alloy wheel rim of passenger car. Experimental analyses are carried out by radial fatigue testing machine for evaluation of fatigue life under influence of camber angle. The test indicates that integrating FEA and nominal stress method is a good and efficient method to predict alloy wheels fatigue life. In this paper by observing the results of both static and dynamic analysis the aluminum alloy is suggested as better material.

Keywords: Catia, Ansys, Static Structural analysis, Alloy wheels

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CHAPTER-1

INTRODUCTION

The Wheel is one of the most significant discovery of old times. The wheel has developed from nothing more than an oversized bearing to a fully integral part of any modern transportation vehicle. Wheel is an important structural member of the vehicular suspension system that supports the static and dynamic loads encountered during vehicle operation. A vehicle can be towed without engine or its operation but it cannot be done without a wheel. Moreover a wheel is the member or a crucial component of an automobile, which carries the whole weight of the vehicle including engine, body and all other components that it houses. The wheels thereby distribute the vehicle load to the road surface and also propel the vehicle forward by rotation of these wheels. The wheels also translate or slide through the linear axis which steers the vehicle and provides directional control. The wheels must bear the weight and retain their structural shape during sudden shocks and impact loads that act upon them. Modern day wheels are mostly alloys of aluminium, magnesium, titanium etc. Most sport cars that run on sport tracks that are well maintained also use carbon fibre wheels.

1.1 CLASSIFICATION OF ALLOY WHEELS:

In the automotive industry, alloy wheels are mostly made of aluminium and magnesium. These alloys provide greater strength over pure metals, which are usually much softer and more ductile. Alloys of aluminium and magnesium are typically lighter for the same strength, provide better heat conduction and often produce improved cosmetic appearance over steel wheels. Although steel is a most commonly used wheel in production, is an alloy of iron and carbon, the term “Alloy wheel” is usually referred or reserved for non-ferrous alloys.

The various types of alloy wheels that are used in automobiles are as follows:

1. Light Alloy Wheels
2. Aluminium Alloy Wheels
3. Magnesium Alloy Wheels
4. Composite Material Wheels

1.2 TYPE OF RIMS:

1. Steel Rims
2. Alloy Rims
3. Chrome Rims
4. Spinners



Fig 1.1 Steel Rims

This is the most common of all the rims. It is also the cheapest and it often being referred to as factory fitted rims. It is among the strongest of all the rim types. On the other hand, their weight is something else; they are heavy. They are not very pleasing to the eyes when compared to the rest of the rim types.



Fig 1.2 Alloy Wheels

Alloy rims are next in line. They are taking over from the steel rims. Alloy rims are made from aluminium or magnesium or both. They have less weight when compared to steel rims. This less weight is a good thing for the driver; you get faster acceleration and minimum stop motion.



Fig 1.3 Chrome Rims

The chrome rims are not as common as the alloy and steel rims. The chrome rims are well known for its shinny appearance. Chrome rims are mainly used for its aesthetics and not performance. Chrome rims are easily scratched and you won't love them once they start getting old.



Fig 1.4 Spinners

1.3 What is a Wheel?

A wheel is a circular object having a rim and a hub as the major parts revolve around an axle to enable it to move easily over the ground.

1.4 Types of Wheels:

- Pressed Steel Disc Wheel
- Wire Wheel
- Light Alloy Wheel
- Divided Rims Wheel
- Split Rims

1.4.1 Pressed Steel Disc Wheel:

This type of disc wheel will be used by Majority of manufacturers all over the world. This type of wheel consists of two parts. One is the steel Rim and the other is the Pressed steel disc. Only with the aid of a well is it feasible to mount or remove the tyre from the wheel; otherwise, it is not. When the tire's bead is resting in the well, it is possible to pass the tyre across the opposing sides of the rim.

The steel disc is necessary for the spokes to operate. By tightening nuts onto the mounting studs that are fixed to the flange, the wheel and tyre are attached to the axle. In order to allow air to reach the inner side of the wheel disc and properly cool the brake drum,

several holes or slots are typically installed. Particularly for larger, heavier vehicles like trucks, buses, and other vehicles.

1.4.1.1 Advantages :

- Sturdy Construction.
- Simplicity.
- Cleaning ease.
- Lower manufacturing costs.
- Less maintainance.
- High output.

1.4.1.2 Uses:

- Buses and Trucks and other large powerful vehicles use these wheels.

1.4.2 Pressed Wheel:

- It is lighter in weight and the heat dissipation will be high. It can be mounted and removed from the axle easily. The wire wheel consists of the following parts:
- Steel Rim: This type of wheel is generally used to receive the tyre.
- Hub: The wire wheel has a separate hub which is attached to the rim and a number of wire spokes are attached to it within the disc.
- Spoke: Each spoke is fitted at one end of the hub while the other end is pushed through a hole in the wheel rim.
- A tapered nut called nipple is screwed down pulling the spoke tightly.
- Make sure that spoke should not be too loose or tight, else the rim would distort.
- The spokes carry the weight of the vehicle and can transmit the driving torque and the breaking torque and also withstand the side forces while moving on corners under tension.
- The spokes are mounted in a Criss-cross section which are long and thin wires

doesn't carry any compressive or bending stress but they are always sustained under tension.

1.4.2.1 Benefits :

- Heat is dissipated to the surroundings through spokes installed in the rim and is only applicable to wheels with tubed tyres.

1.4.2.2 Drawbacks :

- The wire wheels cannot be used with tubeless tyres, and they are challenging to clean.

1.4.2.3 Applications:

Although this sort of wheel was once common, it is now only found on race vehicles and classic cars.

- The wire wheel will be employed in bikes before five years from now.
- It has a long history of use in bicycles as well.

1.4.3 Light Alloy forged or Cast Wheels:

- Using wheels made of aluminium or magnesium alloys was the most recent development in the case of automotive wheels.
- When compared to cast wheels, forged wheels have a much higher strength.
- The forged wheels and the cast wheels have to be machined to produce better appearance.

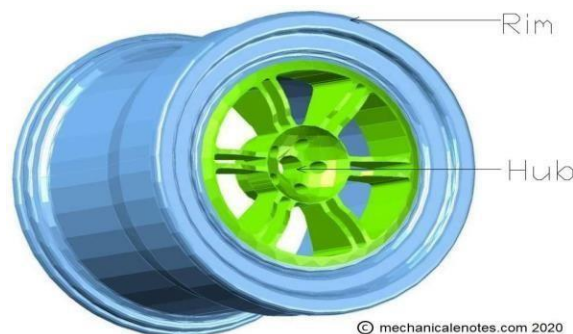


Fig: 1.5 Alloy Cast Wheels

As a result, light alloy cast wheels will be used on automobiles, while forged wheels will be utilised on large and heavy trucks.

The forged wheels and the cast wheels must be machined to produce better appearance.

Light alloy wheels are better heat conductors, which allows the wheels to dissipate the heat produced by the tyres or brakes.

1.4.3.1 Benefits:

- The main benefit of light alloy wheels is that they weigh around half as much as steel wheels and seven times as much as aluminium alloy wheels for equivalent strength.
- In this situation, light alloy wheels may be fitted with wider rims to enhance cornering stability.
- High impact and fatigue strength characteristics of magnesium alloys allow them to tolerate vibrations and shocks during loading.

1.4.3.2 Drawbacks:

- Because magnesium alloys are prone to corrosion, it is necessary to coat them with a protective material.

1.4.3.3 Applications:

- The wheels of passenger and commercial vehicles are made of aluminium alloys, whereas racing and sports cars employ magnesium alloy wheels.
- This is a thorough overview of the various types of wheels. Let's now talk in detail about the different types of tyres and their benefits.

1.4.4 Divided Rims:

- The wheels are divided into two halves, as the name suggests, and are fastened together with bolts.
- The rims must not separate while the tyre is inflated. The divided rim wheel's only benefit is how simple it is to put together and take apart.

1.4.5 Split Rims:

- Split rims are not utilized on automobiles or light vehicles, but rather on larger vehicles like trucks, buses, forklifts, etc.
- They typically consist of multiple pieces and a lacking ring is used to secure the tyre in place.

1.5 Materials:

1.5.1 Duralumin Alloy

Duralumin is known for having good mechanical properties. It is strong light-weighted and hard alloy of aluminium. It possesses maximum tensile strength up to 400Mpa. It was developed in 1909 in the US. It is known for its strength and hardness, making it suitable for various applications, especially in the aviation and aerospace industry. However, it is susceptible to corrosion, which can be mitigated by using alclad-duralumin materials.

Composition:

Duraluminum consists of 91-95% aluminium, 3.8-4.9% copper, 1.2-1.8% magnesium, 0.3-0.9% manganese, <0.5% iron, <0.5% silicon, <0.25% zinc, <0.15% titanium, <0.10% chromium and no more than 0.15% of other elements together. Although the addition of copper improves strength, it also makes these alloys susceptible to corrosion. Corrosion resistance can be greatly enhanced by the metallurgical bonding of a high-purity aluminium surface layer, referred to as alclad -duralumin.

1.5.2 Aluminium Alloy(AlSi7Mg0.3):

Here the aluminium alloy is AlSi5Mg0.3. It is a casting alloy which is mainly used in motor vehicle industry (chassis components , motor car and wheels), for components in aerospace industry , for parts in mechanical engineering etc.,

Composition:

- Silicon(Si) 4.91%
- Iron 0.09%
- Magnesium 0.28%
- Titanium 0.099%
- Manganese 0.004%
- Copper 0.001%
- Sr 0.020%
- Rest is aluminum

1.5.3 Magnesium Alloy(AM60B):

Magnesium AM60B cast alloy has excellent ductility, superior energy absorbing properties ,and good strength and castability. It is used in several components in the automobile sector. The following are the some of them:

- Brackets
- Seat Frames
- Instrument Panels
- Steering wheels etc.,

Composition:

- Aluminium 6%
- Manganese 0.42%
- Copper 0.01%
- Iron(Fe) 0.005%
- Nickel(N) 0.002%
- Rest is magnesium

1.6 Properties of materials

MATERIAL	PROPERTY	VALUE
Duralumin	DENSITY	2.7 g/cm ³
	YOUNGS MODULUS	73Gpa
	POISSONS RATIO	0.33
	YIELD STRENGTH	450Mpa
	THERMAL CONDUCTIVITY	200W/mK
	TENSILE STRENGTH	420-500Mpa
Aluminium alloy(AlSi7Mg0.3)	DENSITY	2.67 g/cm ³
	YOUNGS MODULUS	72.5Gpa
	POISSONS RATIO	0.33
	YIELD STRENGTH	195Mpa
	THERMAL CONDUCTIVITY	300W/mK
	TENSILE STRENGTH	290Mpa
Magnesium alloy (AM60B)	DENSITY	1.77 g/cm ³
	YOUNGS MODULUS	45Gpa
	POISSONS RATIO	0.33
	YIELD STRENGTH	130Mpa
	THERMAL CONDUCTIVITY	61W/mK
	TENSILE STRENGTH	225-240Mpa

Table 1.7 properties of materials

1.7 Objective of Project:

The crux of the project is to perform a static structural analysis in ANSYS, for an alloy wheel of an automobile (car wheel). The wheel design is performed in CATIA as a 3D model and then converted it to STEP/IGES file there by imported to ANSYS to perform analysis. In modern day's wheels are mostly made up of aluminum and magnesium alloys.

In this project we are taking three materials namely Duralumin, Al alloy (AlSi7Mg0.3) and Mg alloy (AM60B).

The main objective of this project is to find out better or best material by conducting static structural analysis individually to each material and compare the results

CHAPTER-2

LITERATURE SURVEY

2.1 Literature Survey:

Dr. S. Nallusamy , et.al. [1] most of aluminium alloy wheels manufacturing companies have done several testing of their product however information of their method on simulation test is often kept limited. During a part of research a static and fatigue analysis of aluminum alloy wheel A356.0 was carried out using FEA package. The 3-D model was imported from CATIA into ANSYS using the appropriate format. The distribution of displacements and stresses for the specified pressure, static load, and angular velocities have been determined using static analysis. For an aluminum alloy wheel, the Von-Misses stress for the hole side and spoke side with pressure load were examined for the various speeds between 40 and 160 kmph. It was discovered that the highest difference of Von-Misses stress in the spoke side is 0.614 Mpa and in the hole side is only 0.87 Mpa. The angular velocity of alloy wheel has been calculated in different speeds for the air pressure of 35psi. The displacement for spoke side in different speeds and the values are lies between 40 and 160 kmph is 0.433948 to 0.

Sumit Agarwal , et.al. [2] they compare equivalent stress, Total deformation and equivalent elastic strain in 19-inch wheel rim of MG Gloster by Finite element method. SOLIDWORKS 2019, a 3-D modelling programme, was used to model the rim, while ANSYS R2 2020 was used to analyse its static structure. The programme used for routine testing and simulation of the materials used for the wheel rim in order to obtain the necessary calculations and results is called ANSYS WORKBENCH R2 2020. Through the use of structural steel, carbon fibre (Low Grade), Kevlar 29, E-glass, S-glass, basalt, Al 6061 T6, and high strength low alloy steel, ANSYS WORKBENCH R2 2020 performed the structural analysis. Their respective performances have been noted. Analysis is done for moment condition, rotational velocity, and tyre inflation pressure. This investigation was done to determine which material, out of those listed, is ideal for the wheel rim and

produces the best outcomes .

k. Srinivasa Rao , et.al. [3] they analysed the existing car model wheel rim is drawn in the design software Creo 2.0 and various loads and forces are theoretically calculated and applied on the model and analysed through Ansys (17.0) software. The complex loading includes applying the pressures ie, 90° angle pressure (inflation pressure) on the bead areas, side thrust on rim flange and the tyre pressure on the well area. And the fatigue analysis which includes the product life, the damage factor and safety factors are determined and all this analysis is done by taking three different designs of the same model of car (Volkswagen polo 1.0 TSI) and rim materials (aluminium A356-T6, magnesium, MgAm60, titanium, 6Al4V) are changed in each case to know the best design and best material for a particular type of loading.

G. Ashok kumar , et.al. [4] they studied a tyre of car wheel rim belonging to the disc wheel category is considered. Design in an important industrial activity which influences the quality of the product. The wheel rim is designed by using modeling software CATIAv5R18. Later this CATIA model is imported to ANSYS for analysis work. ANSYS software is the latest software used for simulating the different forces, pressure acting on the component and also for calculating and viewing the results. A solver mode in ANSYS software calculates the stresses, deflections, bending moments and their relations without manual interventions, reduces the time compared with the method of mathematical calculations by a human. ANSYS static analysis work is carried out by considering two different materials namely aluminum and forged steel and their relative performances have been observed respectively.

Dr. M. S. Hebbal , et.al, [5] they analysed the given car rim is made up of Al- 6061 which is having precipitation aluminum alloy containing magnesium and silicon as its major alloying elements and this is subjected to different boundary conditions. In this project our aim is to carry out the different analysis such as static structural analysis. In static structural

analysis we found out equivalent von- mises stresses, deformation and maximum principal stresses. Later they compared the induced stresses are less than the allowable stresses of the material.

Jaspreet Singh and Siddhartha Saha[6] in this project, the analysis took into account a wheel. Aluminium alloy was used during the FEA analysis portion of the thesis project. Design is a crucial component of production that contributes to the product's quality. Reverse engineering technique was used to create the alloy wheel's 3-dimensional model. The three-dimensional model was created using CATIA v5 modelling software, and it was then imported into ANSYS 15.0 using the IGES format. Tetrahedron solid elements with 10 nodes were used to mesh the model's finite element analysis. For the analysis, the static condition was chosen. At the bolt, this was restricted in every degree of freedom. The alloy wheel's outside rim surface was subjected to pressure.

Gamachisa Mitiku Tadesse [7] they studied that there are different types of wheels bodies available such as Steel, Aluminum, Magnesium, Titanium, etc. In Regular commercial vehicles steel wheels are generally used. For steel corrosive resistance, thermal conductivity, weight, casting and machining properties are low compared to aluminum alloy. In the design of automobile, the industries are using aluminum alloy material in order to obtain reduction of weight without significant decrease in vehicle quality and reliability. . In this project, Aluminum alloy is compared with steel. In this project a parametric model is designed for steel wheel from existing model. The wheel model is modeled in CAD package CATIA and Static structural, Modal and Fatigue analysis are done in FEA package ANSYS WORKBENCH for Steel and Aluminum Alloy A356.2 materials. By conducting the Finite Element Analysis on the wheel Model the results of Steel and Aluminum Alloy wheel were presented.

Rajesh Dhakar and Ruchika Saini [8] in the current work, steel wheel is analysed using 3D basic finite elements. A finite element simulation programme called ANSYS Workbench was used to simulate and test the volume of wheel spokes under pressure and force. Models of alloy wheels with 6, 8, and 10 spokes, among other spoke counts, are available. Four different wheel rim configurations were modelled using solid work software, and testing was done using ANSYS15.0 using a standard number of spokes and a striker. The results of the study are displayed as a function of time, and each form is contrasted with the total cumulative impact of Von Mises' relative stress on the wheel rim.

Vaddi Naveen [9] they studied that the wheel is a main mechanical term of the vehicular suspension system that supports the static and dynamic loads encountered during vehicle action. Major five technical considerations while modeling any new alloy wheel rim are styling, aesthetic, mass, manufacturability and capability. While analyzing stress and displacement distribution in vehicle wheels subjected to increase pressure and radial load .essential efforts have been taken to discover the Finite Element Techniques. Alloy wheel rim has been designed using Catia software, after that static structural analysis is done with different materials (ZA21, AL6061, and CARBON FIBRE), load and boundary conditions using ANSYS Software. At last the results of total deformation, strain and equivalent stresses are obtained for different wheel rim materials and compared with each other. Thus, the best material can be selected for manufacturing of the wheel rim; carbon fiber material is suggested as better material for designing of wheel.

Mr. CHINTAPALLI SHEKHAR , et.al. [10] they examined the displacement and shear stress distribution in vehicle wheels that had been subjected to radial load and increased pressure. Finite Element Techniques have been discovered after much effort. utilising Catia software, an alloy wheel rim was created. ANSYS14.5 software was then used to do a static analysis utilising a variety of materials (AL6061, Mg alloy, and Carbon Epoxy Composite). Observed stress, total deformation, and shear results finally Stress on various wheel rim materials (spoke shape and elliptical spoke shape) is compared to one another. As a result, the alloy Hexagon wheel can be manufactured using

the optimum design and material.

N. Murugu Nachippan , et.al. [11] they studied that the usage of the natural fiber reinforced composite wheel rim provides more reduced weight and biodegradability. The static evaluation of the wheel rim using finite element technique was examined in this work. Geometric parameters of the wheel rim shall be used for consideration .It takes intoaccount the dimensions of the current two-wheeler wheel rim. The static investigation, for example, by using finite element techniques, deformation ,deflection, stress - strain, is performed for three variants of composites S-Glass Fiber reinforced Epoxy Composite, S-Glass Fiber + Untreated Hemp Fiber + Epoxy Composite and S-Glass Fiber + Treated Hemp Fiber + Epoxy Composite . S-glass fiber untreated hemp fiber reinforced epoxy composites are shown to show less deformation and are better suited for wheel rims.

Shanling Han ,et.al. [12] they discovered that using magnesium alloy wheels helps keep cars lightweight. Utilising the TRIZ theory, a particular type of magnesium alloy wheel was built, after which a UG NX 7.0 three-dimensional CAD model was produced. According to them, the finite-element approach had been used to model the static structural analysis of the magnesium alloy wheel. It can be seen that the high stress is primarily distributed in the area around bolt holes and in the transitional area between the wheel's rim and spokes. The yield stress of a magnesium alloy is lower than the maximum stress. For the creation of the magnesium alloy wheel, a few helpful references are offered.

Vijay Sekha, A. Chandra Mouli [13] They summarizes the application of Finite Element Techniques for analyzing stress and displacement distribution in vehicle wheels subjected to the conjoint influence of inflation pressure and radial load. The most commonly used considerations in wheel are elucidated. The 18 model is done by using “CATIA” and the analysis is carried out by using “Ansys workbench” finite element package. Wheel strength with regard to the fractures on edges and other critical points when the wheel strikes an obstacle shall be checked. Static analysis for the given radial load and the angular velocities of 40, 60, 80, and 120, with the appropriate constraint set of conditions in order to check

the wheel strength. Yield strength of the alloy wheel material is checked with the Von-Mises stress obtained, (as per the ISO 7141 - Road Vehicles - Wheels - Impact Test Procedure, and SAE J175 - Impact Test Procedures standards). Their study states that the innovative design of the wheel is safe for its operating conditions for the given loads specified.

R. Vijaya kumar, et.al. [14] they analysed car wheel rim belonging to the disc wheel category is considered. The wheel rim is model by using SOLIDWORKS 2016. By using this software, the risk involved in the design and manufacturing process can be easily minimized. So the modeling of the wheel rim is made by using SOLIDWORKS. Later this wheel rim modal is imported to ANSYS WORKBENCH 16 for analysis work. ANSYS WORKBENCH 16 static structural analysis work is carried out by considering four different aluminium alloys namely 6061 and 6066, their relative performances have been observed respectively In this analysis by observing the results of both static and dynamic analysis obtained best material is suggested for making an effective rim structure.

P. Meghashyam , et.al. [15] in this article, it was examined how the wheel rim was created using the modelling programme CATIAV5R18. Modelling makes it simple to reduce the risk associated with the design and production processes as well as the time required to produce complicated 3-D models. Therefore, CATIA is used to model the wheel rim. Later, for analysis purposes, this CATIA model is loaded into ANSYS. The most recent method for simulating the various forces and pressures acting on a component, as well as for computing and displaying the results, is to use ANSYS software. Two different materials, forged steel and aluminium, are taken into account for the static analysis work done by ANSYS, and their relative performances have been noted accordingly. Additionally, vibration is applied to the rim.

2.2 Work scope following the literature review:

We learned from the previous review that aluminium alloy is the most often used material, and the above reviews also support this claim. To complete the analysis and obtain the results, we will use Duraluminum and Magnesium Alloy materials on the wheel, with the alloy serving as the basis material.

CHAPTER-3

CALCULATIONS

3.1 Calculations:

- The total load acting on the wheels and the load acting on each wheels is calculated, we will apply this load as downward force on seathbed after design is completed.
- Tire pressure is taken as radial and pressure loads.
- Also we have taken three different speed (i.e.) velocities to observe any variation of deformation and stresses at different speeds.

- Load to be applied: Gross weight of the vehicle on wheels: 2095 kg.

$$1665 + (5 \times 70) + 80 = 2095 \text{ Kg.}$$

Where,

weight of the car: 1665 Kg

No. Of person inside the car: 5

Weight of each person: 70 Kg

Therefore, Total Load on the wheels: 2095 Kg.

- Load acting on each wheel: $2095/4 = 523.75 \text{ Kg}$ or 5137.98 N
- Pressure load acting on the wheel: Consider 35 psi of air pressure acting on the outer surface of the wheel.

$$35 \text{ psi} = 35 \times 0.4535 \times 9.81 / (25.4)^2 = 0.241 \text{ N/mm}^2.$$

- Stages of Speeds that are considered:- The wheel taken at various speeds for analysis are as follows:

A) 80 Kmph. B) 120 Kmph. C) 160 Kmph.

➤ The linear velocity of wheel is to be converted into angular velocity (rad / s)

So, $v = r * w$,

$w = v / r$,

And here,

$r = \text{Radius of wheel} = 246.518 \text{ mm}$,

$w = \text{Angular velocity}$,

$v = \text{Linear velocity}$.

A) $v = 80 \text{ Kmph} = 22.22 \text{ m/s}$.

$r = 246.518 \text{ mm} = 0.2465 \text{ m}$.

$w = v / r = 22.22 / 0.2465 = 90.15 \text{ rad / s}$.

B) $v = 120 \text{ Kmph} = 33.33 \text{ m / s}$.

$r = 246.518 \text{ mm} = 0.2465 \text{ m}$.

$w = v / r = 33.33 / 0.2465 = 135.21 \text{ rad / s}$.

C) $v = 160 \text{ Kmph} = 44.44 \text{ m / s}$.

$r = 246.518 \text{ mm} = 0.2465 \text{ m}$.

$w = v / r = 44.44 / 0.2465 = 180.28 \text{ rad / s}$.

3.2 Boundary Conditions:

- 1 Five PCD holes (i.e.), 120x5, constrained for 5 (UX, UY, UZ, RX, RZ)degree of freedom, (Rotation in Y direction is set free).
- 2 Force: Downward force applied on seat bed.
- 3 Analysis type: Static Structural Analysis.
- 4 Boundary Conditions applied are Radial load and Pressure load.
- 5 Rotational Velocities at different speeds are also applied:
 - i) $V = 80 \text{ Kmph} = 90.15 \text{ rad / s.}$
 - ii) $V = 120 \text{ kmph} = 135.21 \text{ rad/s.}$
 - iii) $V = 160 \text{ kmph} = 180.28 \text{ rad/s.}$

CHAPTER-4

3D MODELLING OF WHEEL

4.1 Introduction:

CATIA is 3D CAD modelling software used to design, visualize, and test product ideas. It allows you to create product prototypes that accurately simulate the weight, stress, friction, driving loads, and much more of products and their components in a simulated 3D environment. It enables the Creation of 3D parts, 3D sketches, sheet metal, composites and moulded for or tooling Parts up to the definition of mechanical assemblies.

It provides tools to complete product definition, ink hiding functional tolerances, as well as kinematics definition CATIA provides a wide range of applications for tooling design, for both generic tooling and mold & die. In the case of Aerospace engineering an additional module named the aerospace Sheet metal design offers the user combine the capabilities of generative Sheet metal design and generative surface design.

The main features of CATIA are:

- It allows 2D and 3D data integration in a single environment, creating a virtual representation of the final product that enables users to validate the form, fit, and function of the product before it is ever built.
- It includes powerful parametric, direct edit and freeform modelling tools as well as multi translation capabilities and in their standard drawings. It uses Shape geometric modelling . Catia competes directly with Solid Works, Solid Edge, and Creo.
- The automatic updating feature allows easy changes in models.
- With Catia prototyping can be accomplished easily by integrating 2D AutoCAD drawings and 3D data into a digital model which will serve as a virtual representation of the final product.
- By doing so, engineers are able to better design and simulate products without the need to create physical prototype.

4.2 NEED OF DESIGN:

The purpose of the car wheel rim is to provide a firm base on which to fit the tyre. Its dimensions, shape should be suitable to satisfactorily accommodate the particular tyre required for the vehicle. In this study a tyre of car wheel rim belonging to the disc wheel category is considered. Design is an important industrial activity which influences the quality of the product. The wheel rim is designed by using modeling software CATIAv5 R18. In modeling the time spent in producing the complex 3-D models and the risk involved in design and manufacturing process can be easily minimized. So the modeling of the wheel rim is made by using CATIA. Later this CATIA model is imported to ANSYS for analysis work. ANSYS software is the latest software used for simulating the different forces, pressure acting on the component and also for calculating and viewing the results. A solver mode in ANSYS software calculates the stresses, deflections, bending moments and their relations without manual interventions, reduces the time compared with the method of mathematical calculations by a human. ANSYS static analysis work is carried out by considering two different materials namely aluminium and forged steel and their relative performances have been observed respectively. In addition to this rim is subjected to Vibration analysis (Modal analysis), a part of Dynamic Analysis is carried out and its performance is observed. In this project by observing the results of both static and modal analysis obtained forged steel is suggested as best material.

4.3 Modules in CATIA:

4.3.1 Sketcher :

A feature is a building block that describes the design, like a keyway on a shaft. Each feature indicates how to add material (like a rib) or remove a portion of material. Feature adjusts automatically to changes in the design thereby allowing the capture of design intent. This also saves time when design changes are made. 24 Because features have the ability to intelligently reference other features, the change made will navigate through design updating the 3D model in all affected areas. In typical solid modelling software the designer can create a feature in two basic ways. One is to sketch the shape to be added and then extrude, revolve or sweep it to create the shape. These are called sketched features. Another type of the features is the pick and place feature. In this feature engineering operation such as placing a hole, chamfering, or rounding a set of edges, or shelling out the model is done.

4.3.2 Assembly:

The different parts developed in the PART module of CATIA are assembled in the ASSEMBLY module of CATIA. The components developed are assembled using the placement constraints available from the list in the component placement dialogue box.

4.3.3 Geometric Modelling:

Computer representation of the geometry of component using software is called a geometrical model. There are three types of geometric modelling. Those are:

- Wire-Framing Modelling .
- Surface Modelling .
- Solid Modelling .

2D a representation of a flat object in two dimensions. This goes a little beyond the two 2D capabilities by allowing the representation of a 3D object as long as it lacks side wall features. A more sophisticated geometry can be fully three-dimensionally modelled in 3D. For intricate shapes, even a three-dimensional wireframe depiction of an item is occasionally insufficient. There are numerous ways to improve wireframe models. The object is depicted in the figure with two potential upgrades. In the first, the rare edges of the object—those that would be unseen from the front—are depicted using dashed lines. The second improvement totally eliminates the hidden lines, giving the observer a less cluttered view of the object.

4.3.4 Surface Model:

This is another enhancement of wire-frame model involves providing a surface representation which makes the object appear solid to the viewer. However the object is still stored in the computer as a wire frame model Solid modelling. This is most advanced geometric modelling in three dimensions. This typically uses solid geometry shapes called picture to construct the object. Another feature of the CATIA system is colour graphics

capability. By means of colour, it is possible to display more information on the graphics screen coloured images help to clarify components in an assembly or highlight dimensions or host of other purposes.

4.4 Procedure:

Step 1: Sketcher Module:

You can construct and limit the 2D Geometries with the help of sketcher workbench's toolset. Afterward, features (pads, pockets, shafts, etc.)

These 2D profiles can be used to generate new solids or modify existing solids. There are numerous ways to get to the Sketcher workstation. You can open Sketcher in two straightforward ways: by choosing the Sketcher icon, or by utilising the top pull-down menu (Start - Mechanical Design - Sketcher). You must select a plane to sketch on while using CATIA's sketcher. Before or after selecting the Sketcher icon, you can select this plane. Select the Exit Workbench icon to leave the sketcher.

The Sketcher workbench contains the following standard workbench specific toolbars:

- **Profile toolbar** : The command located in this toolbar allow you to create simple geometries (rectangle, circle, line, etc...) and more complex geometries (profile, spline...).
- **Operation Toolbar** : Once a profile has been created , it can be modified using commands such as trim, mirror, chamfer, and other commands located in operation tool bar .
- **Constraint Toolbar** : Profiles may be constrained with dimensional (distance, angles, etc...) or geometrical (tangents, parallel, etc..) constraints using the commands located in the constraint toolbar.
- **Sketch tools toolbar** : The command in the toolbar allow you to work in different modes which make sketching easier.

Step 2 : Part Design Module :

Part design environment is used to create 3D models from the basic 2D sketches created in sketcher environment.

- Creating the base part 2D sketch.
- Converting 2D Sketch to required 3D model by using features like extrude, extrude cut, revolve, sweep, chamfers, fillets, holes, spiral etc . Saving the file with desired part name.

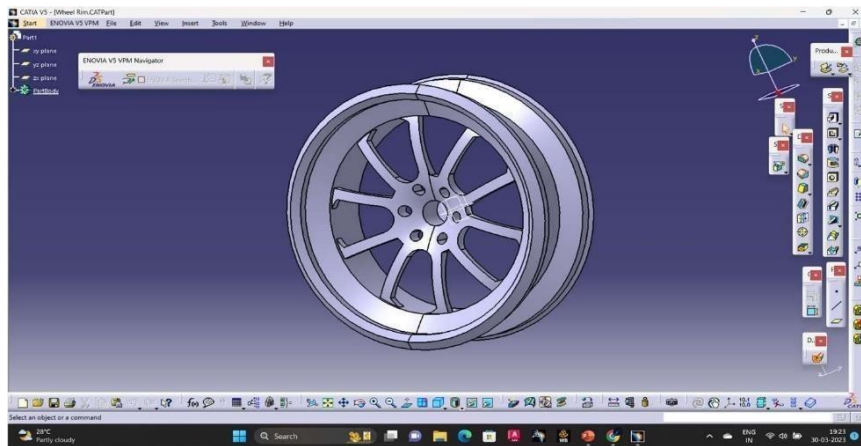


Fig 4.1 Alloy Wheel in CATIA

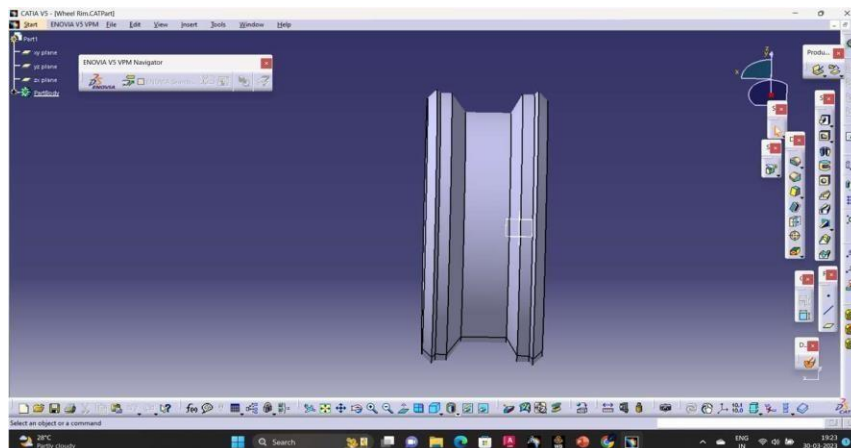


Fig 4.2 Side view of Alloy Wheel in CATIA

4.5 Drafting of Wheel :

Drafting is a process of making dimensions to a model in various views.

Some of the drafted views of the wheel rim are as follows:

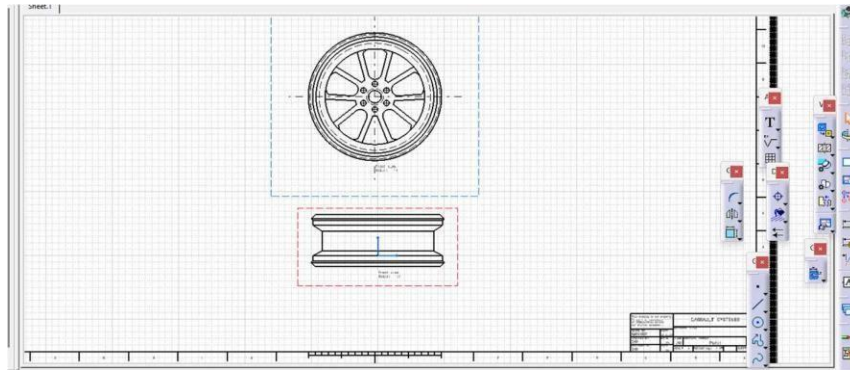


Fig 4.3 Drafting of Alloy Wheel in CATIA

CHAPTER 5

FINITE ELEMENT ANALYSIS BY USING ANSYS

5.1 INTRODUCTION:

Ansys provides a common platform for product development, from design concept to final-stage testing and validation. The company's product portfolio consists of simulation platform offerings that are used in diverse multi-physics fields like heat transfer, fluid mechanics, statics, solid mechanics, etc. However, Ansys is best known for finite element analysis (FEA), which has gained popularity as a modelling and simulation tool over the years (and especially since the introduction of powerful computers) in solving a gamut of complex engineering problems.

5.2 ANSYS SOFTWARE :

- The three primary steps in the treatment of engineering problems are to build a model, find a solution, and analyse the outcomes. The three primary components of Ansys, like many other FEA Programmes, are the processors, also known as pre – processor, solution process, and post – processor.
- Users can create geometry, specify materials, and generate element mesh using the Ansys pre – processor. Users of the Ansys processor can apply loads on problems to find solutions. The Ansys post-processor enables tabular results listing and visualization, as well as printouts of the results.
- Ansys provides a comprehensive software results suite that covers the whole physics spectrum, giving users access to practically every area of business worldwide to provide the best value for their engineering simulation mode.

5.3 FINITE ELEMENT ANALYSIS:

Finite-element method (FEM) is a good choice for the analysis of sheet metal processes since it helps in eliminating the need for time-consuming experiments to optimize the process parameters such as sheet metal thickness, the material of the sheet,

punch fillet and percentage clearance. The FEM simulations are increasingly used for investigating and optimizing the punching process.

Computer simulations reduce the number of experiments and can obtain accurate results. The results depend on the element type and type of mesh considered for analysis.

5.4 PROCEDURE IN ANSYS:

- Step 1: Start on ANSYS Workbench Project.
- Step 2: Create a Static - Structural Analysis System.
- Step 3: Add a new material.
- Step 4: Insert Geometry.
- Step 5: Create a Profile Sketch to Customize units.
- Step 6: Create an Extruded Body.
- Step 7: Launch the Static - Structural Analysis System.
- Step 8: Generate Mesh.
- Step 9: Apply Boundary Conditions.
- Step 10: Solve and Retrieve the Results.

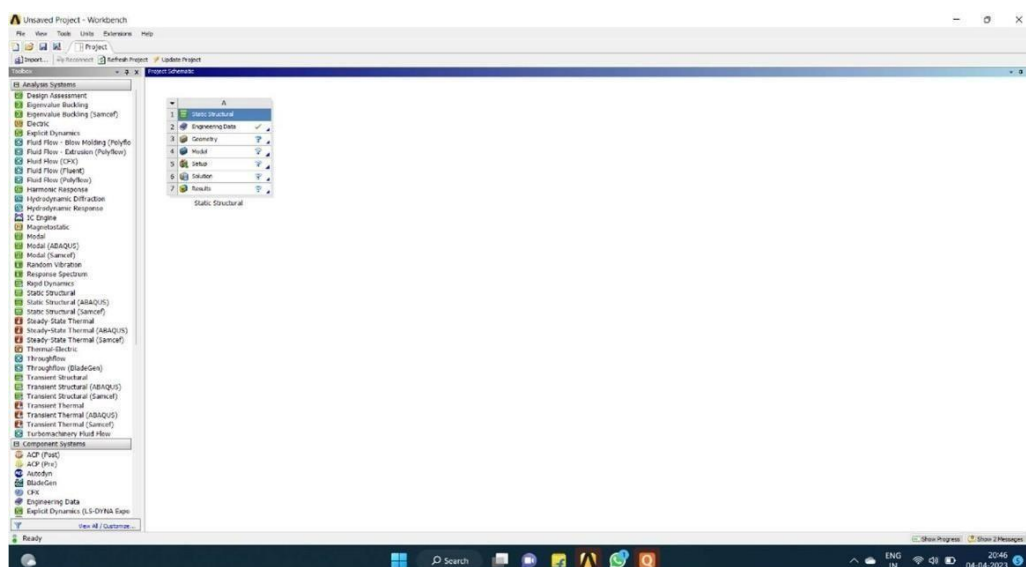


Fig 5.1 Project Setup ANSYS WORK BENCH

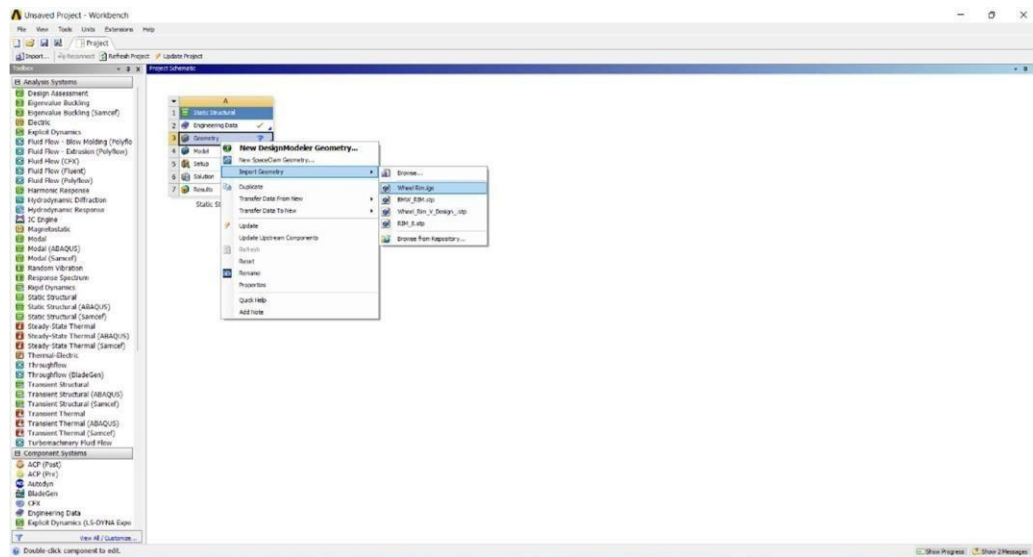


Fig 5.2 Geometry Selection

5.5 MESH GENERATION:

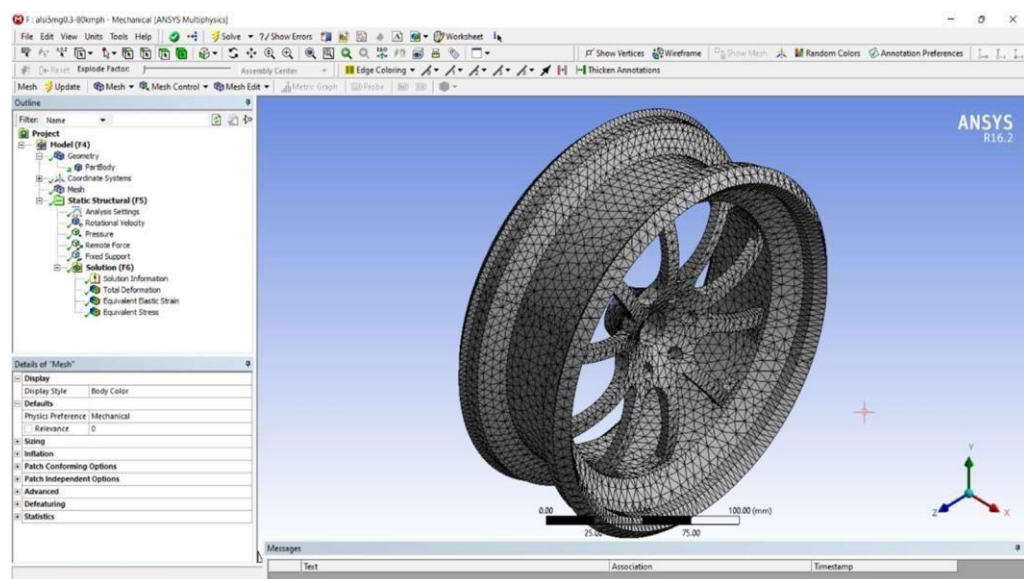


Fig 5.5 Mesh Generation

5.6 Applying Boundary Conditions:

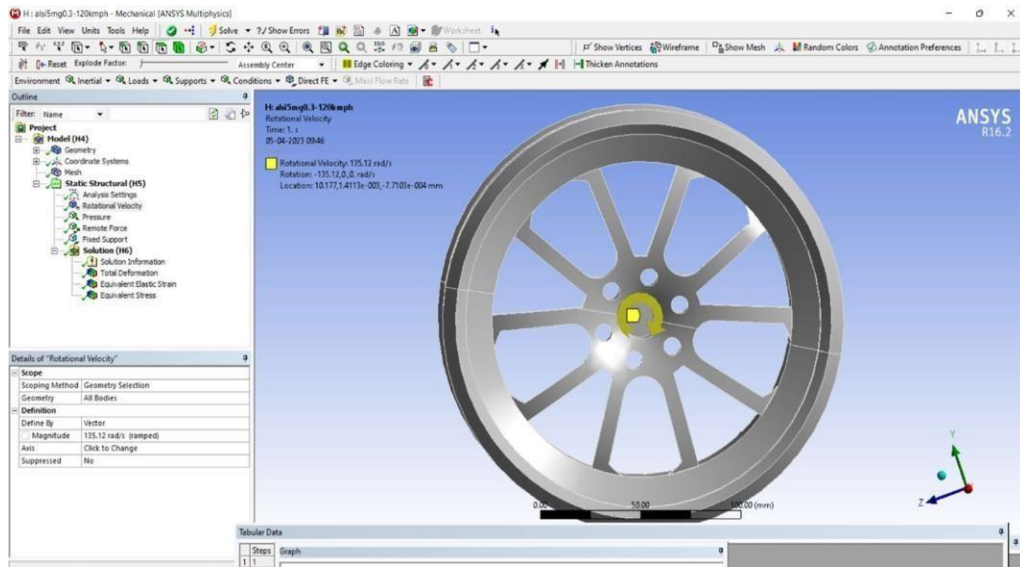


Fig 5.6.1 Rotational velocity about y-axis

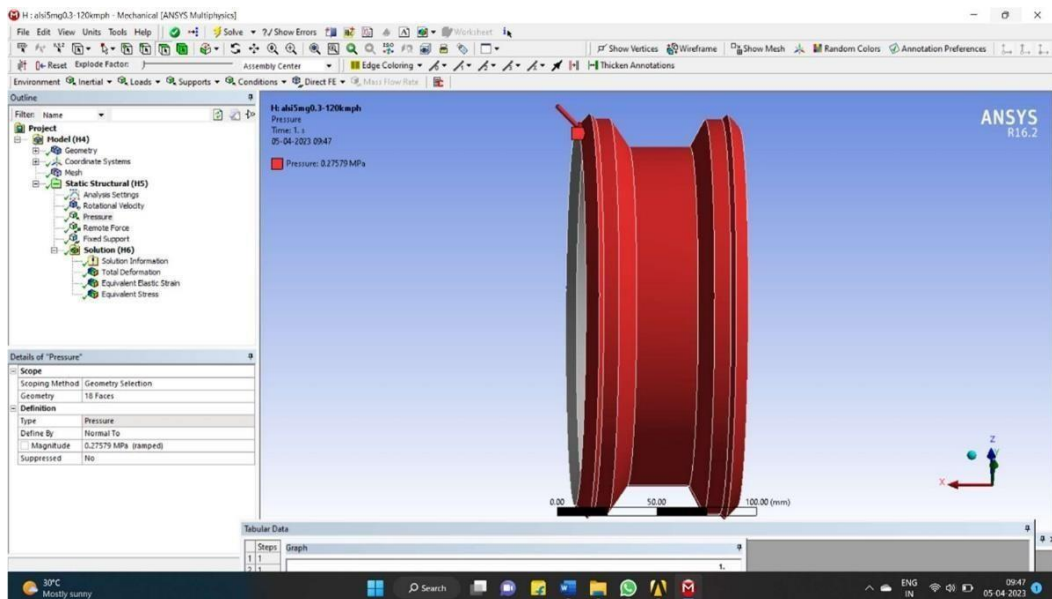


Fig 5.6.2 Radial pressure at 40Psi(0.27579Mpa)

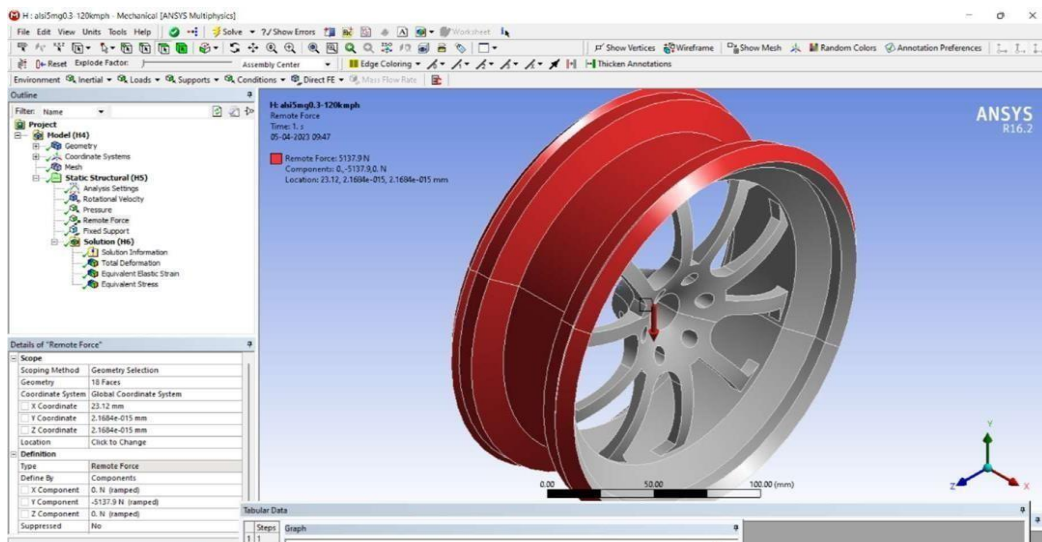
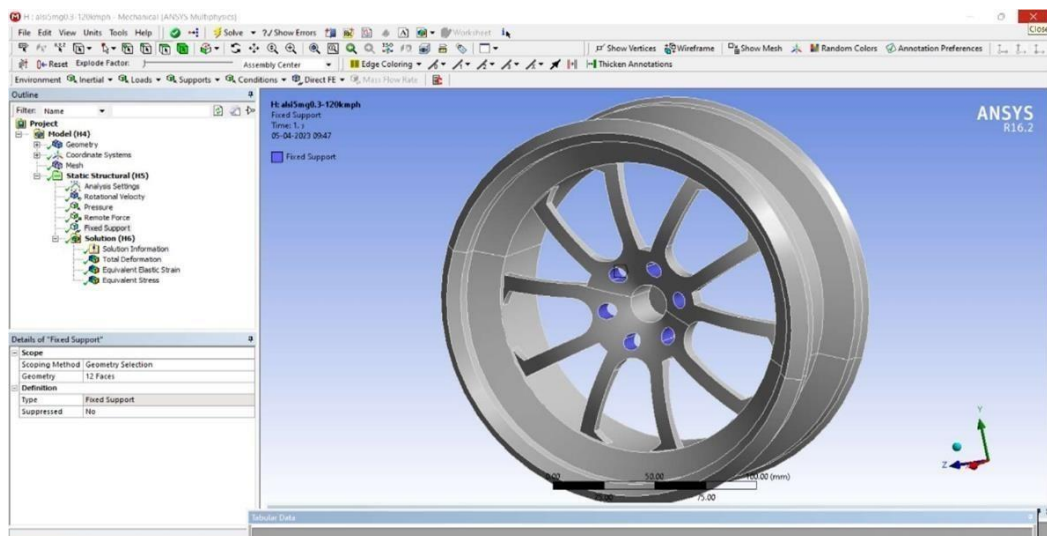


Fig 5.6.3 Remote force of 5138N



5.6.4 fixed support

5.7 Deformations of aluminium alloy (AlSi7Mg0.3):

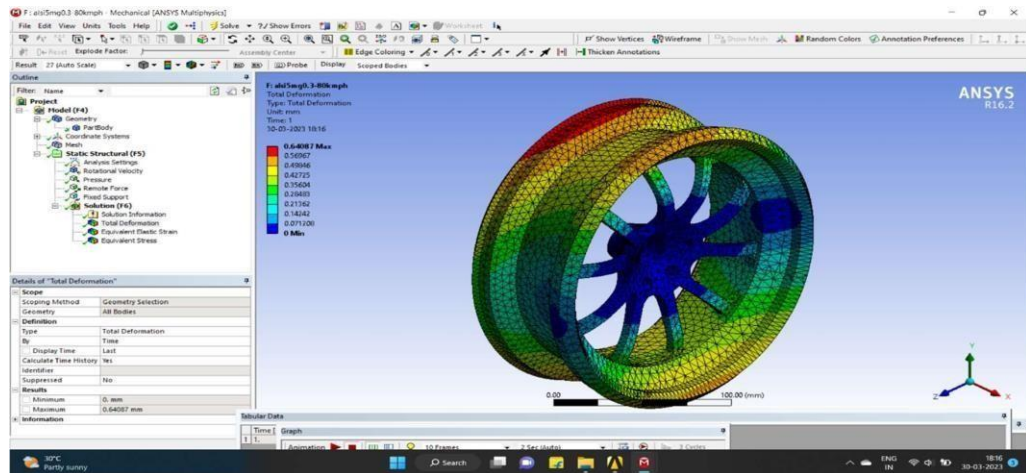


Fig 5.7.1 Total Deformation at 80kmph

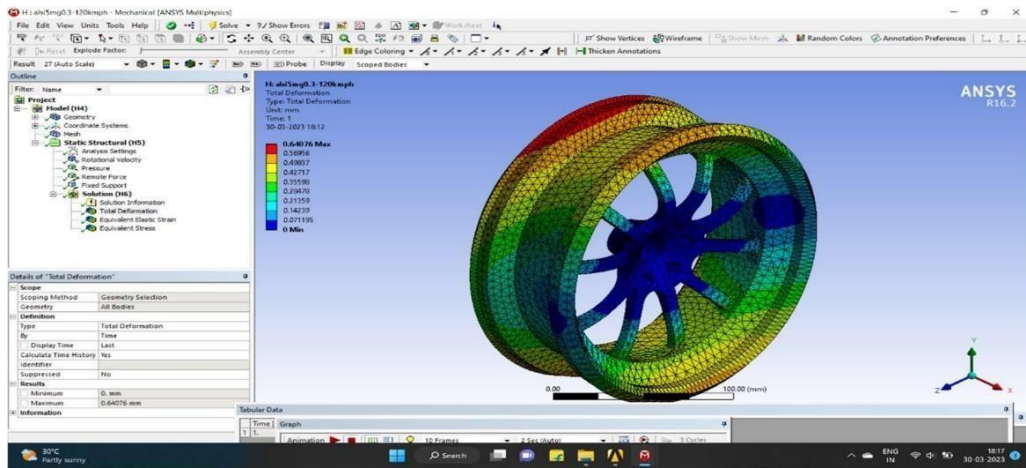


Fig 5.7.2 Total Deformation at 120kmph

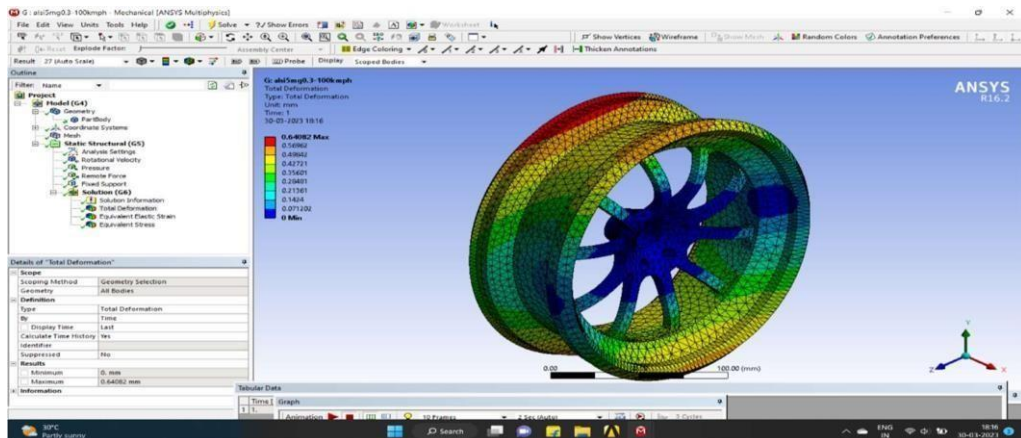


Fig 5.7.3 Total Deformation at 160kmph

5.1 Equivalent(von-misses) stresses of aluminium alloy (AlSi7Mg0.3):

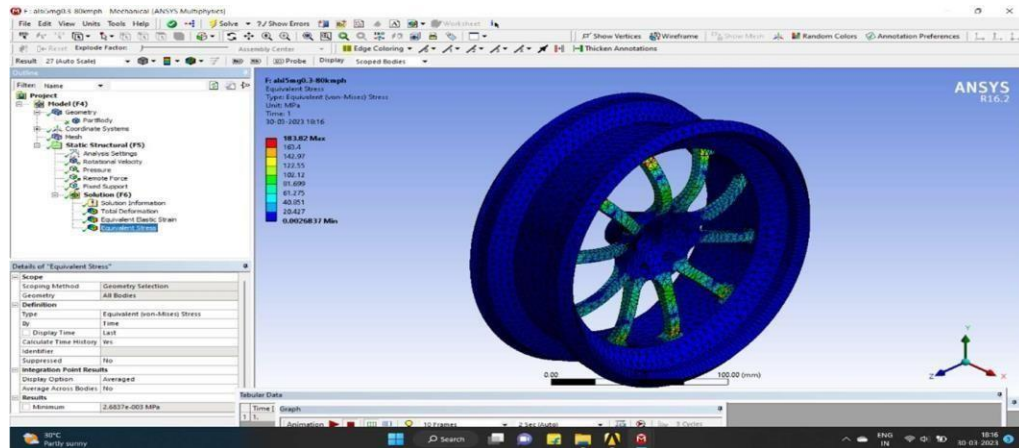


Fig 5.8.1 Equivalent (Von-Mises) stress at 80kmph

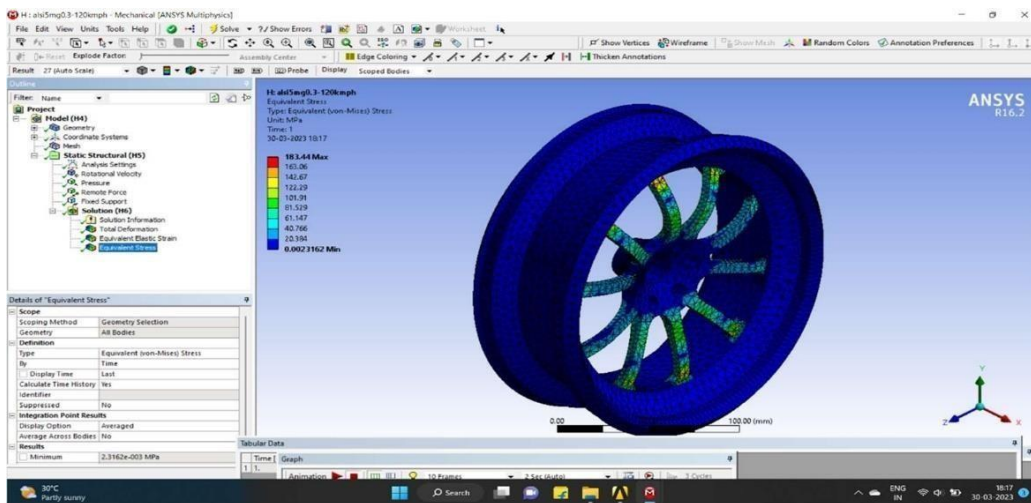


Fig 5.8.2 Equivalent (Von-Mises) stress at 120kmph

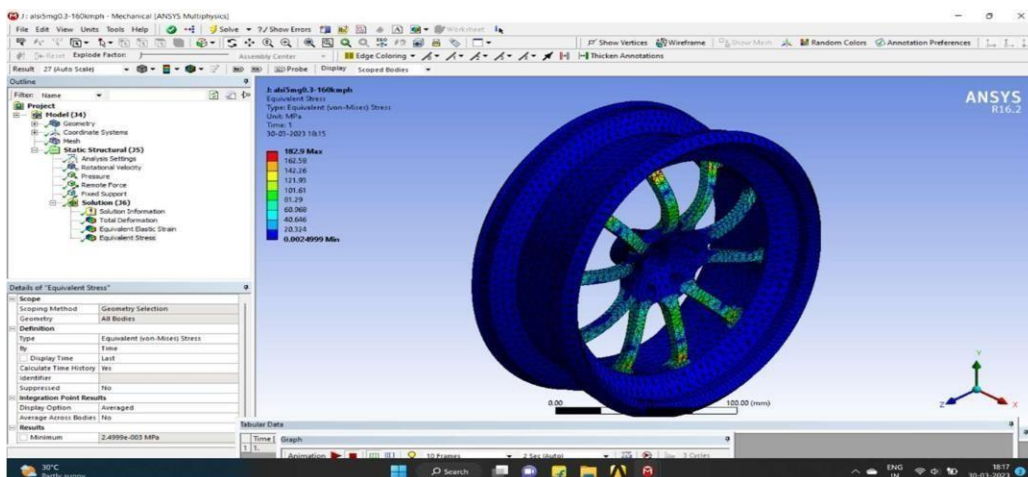


Fig 5.8.3 Equivalent (Von-Mises) stress at 160kmph

5.2 Equivalent elastic strains of aluminium alloy (AlSi7Mg0.3):

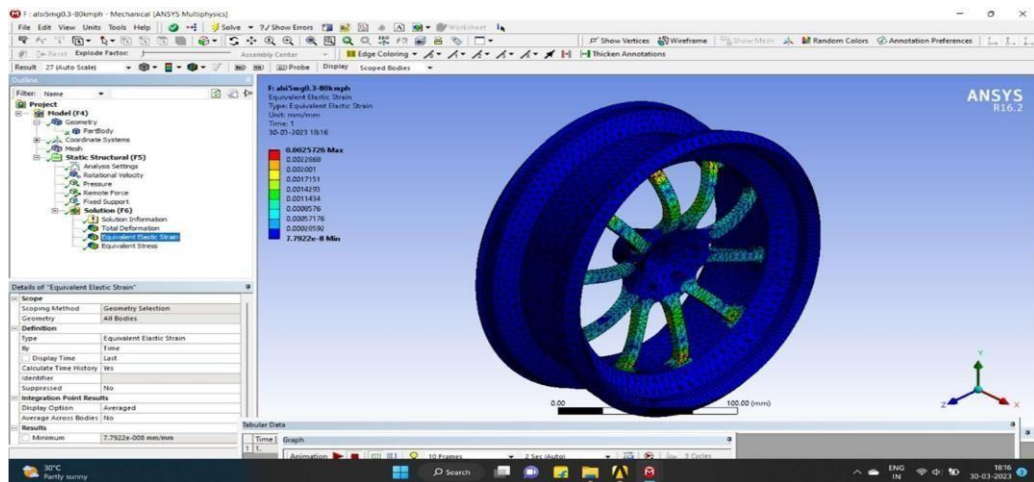


Fig 5.9.1 Equivalent Elastic Strain at 80kmph

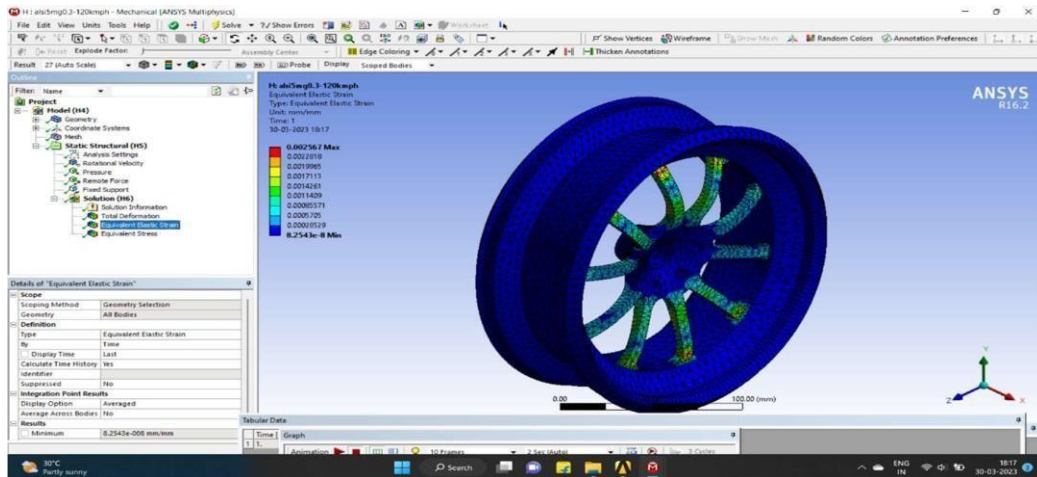


Fig5.9.2 Equivalent Elastic Strain at 120kmph

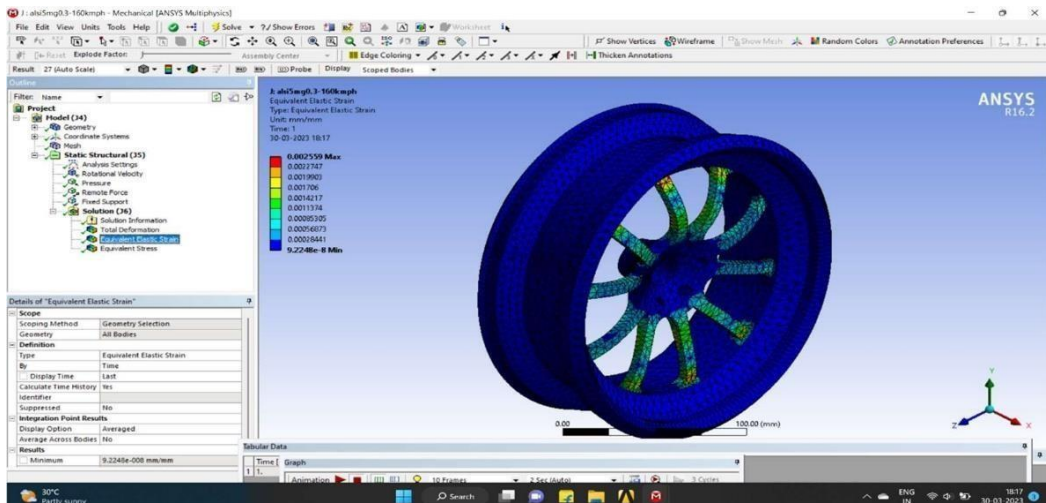


Fig5.9.3 Equivalent Elastic Strain at 160kmph

5.3 Total Deformations of Magnesium alloy(AM60B):

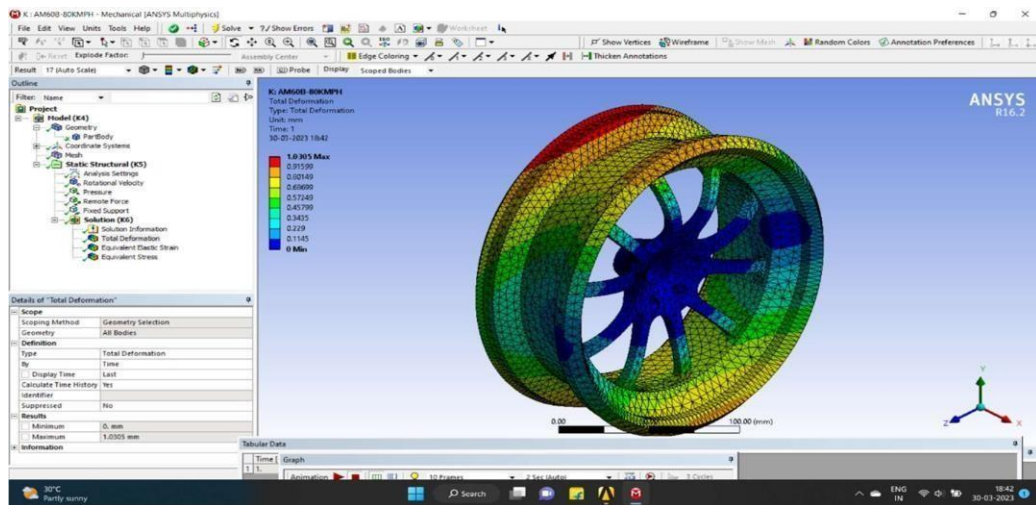


Fig5.10.1 Total Deformation at 80kmph

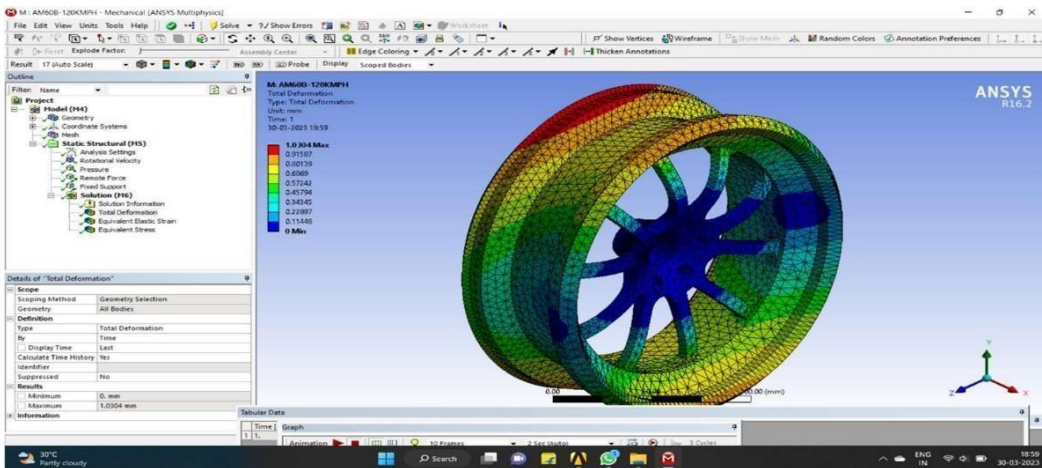


Fig5.10.2 Total Deformation at 120kmph

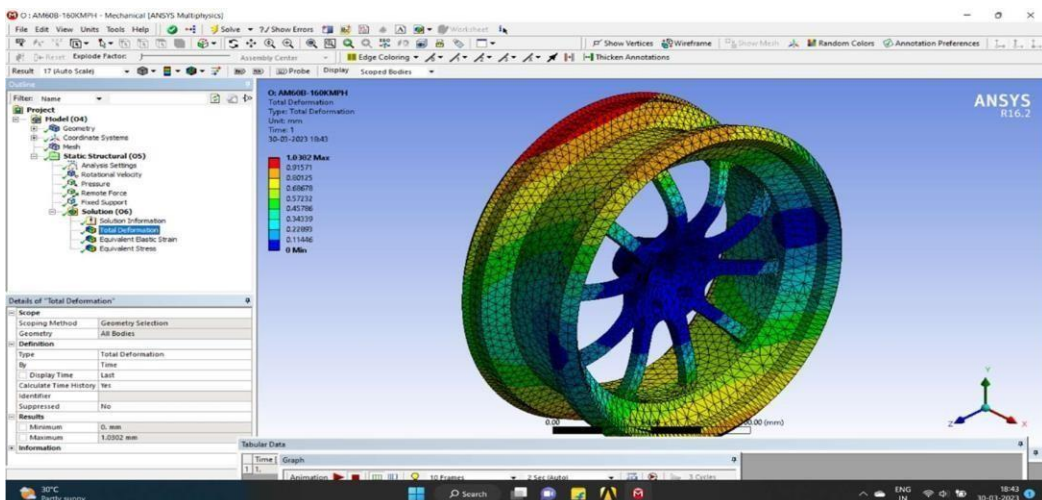


Fig5.10.3 Total Deformation at 160kmph

5.4 Equivalent (von-mises) stresses of a magnesium alloy(AM60B):

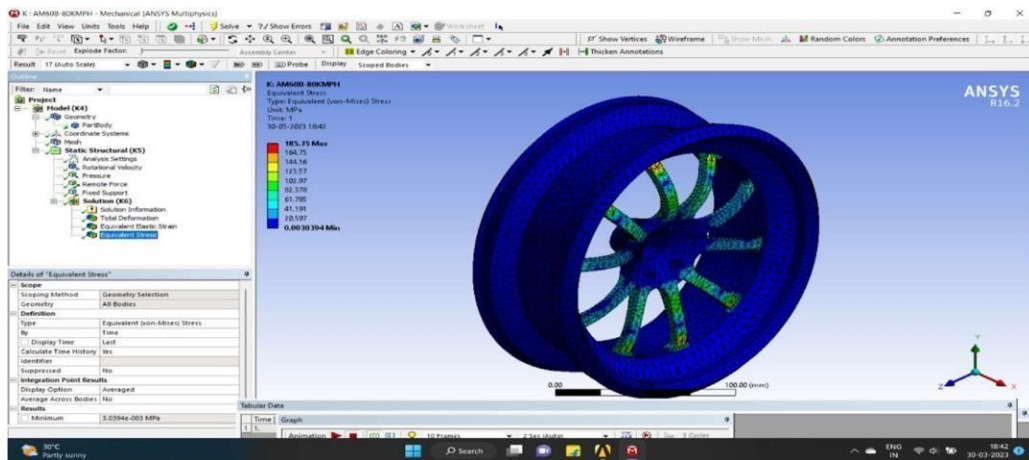


Fig5.11.1 Equivalent (Von-Mises) Stress at 80kmph

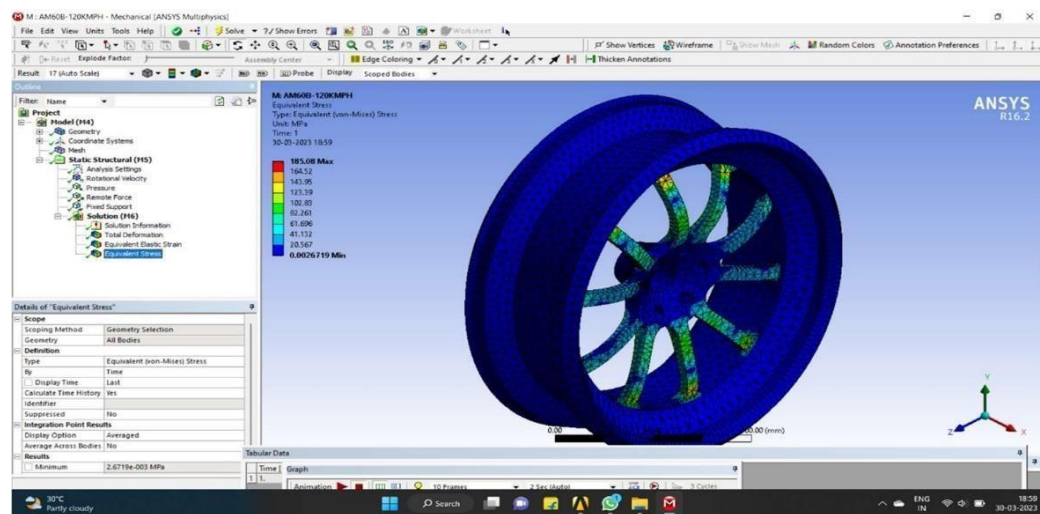


Fig5.11.2 Equivalent (Von-Mises) Stress at 120kmph

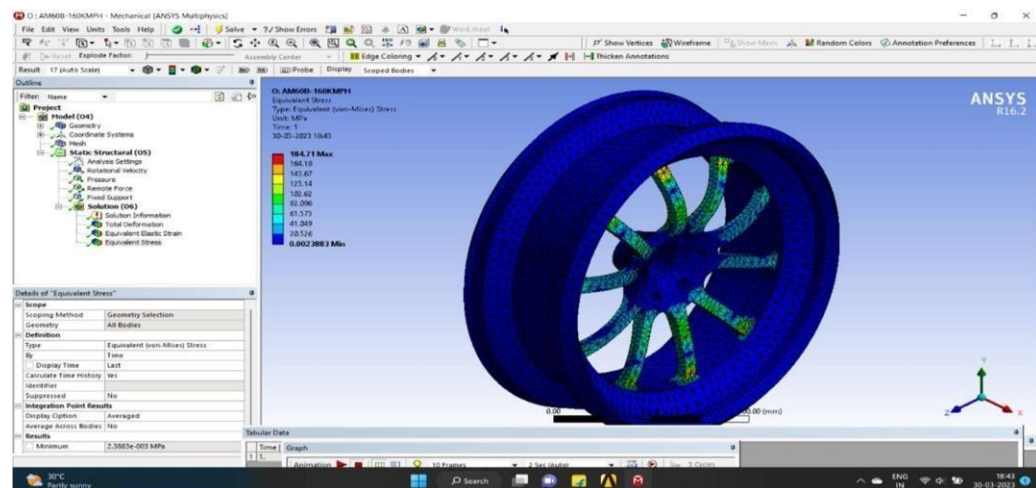


Fig5.11.3 Equivalent (Von-Mises) Stress at 160kmph

5.5 Equivalent elastic strains of a magnesium alloy(AM60B):

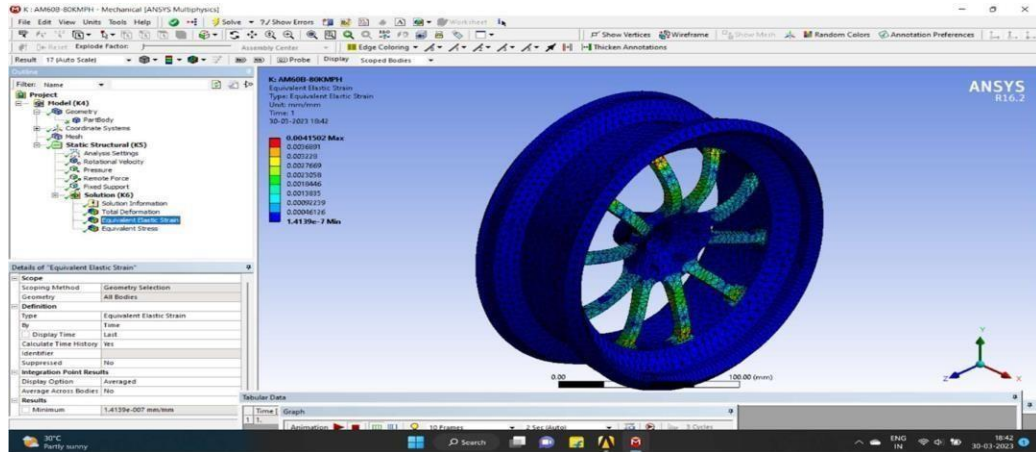


Fig5.12.1 Equivalent Strain at 80kmph

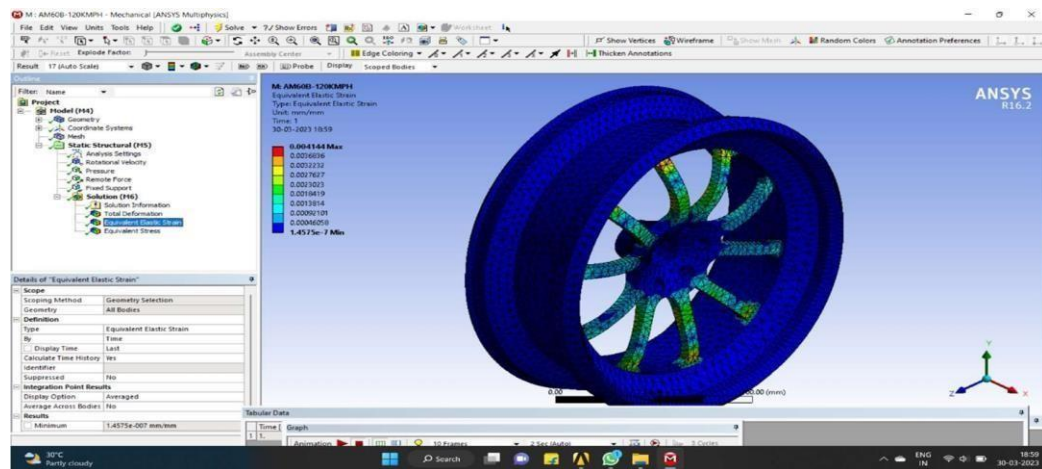


Fig5.12.2 Equivalent Strain at 120kmph

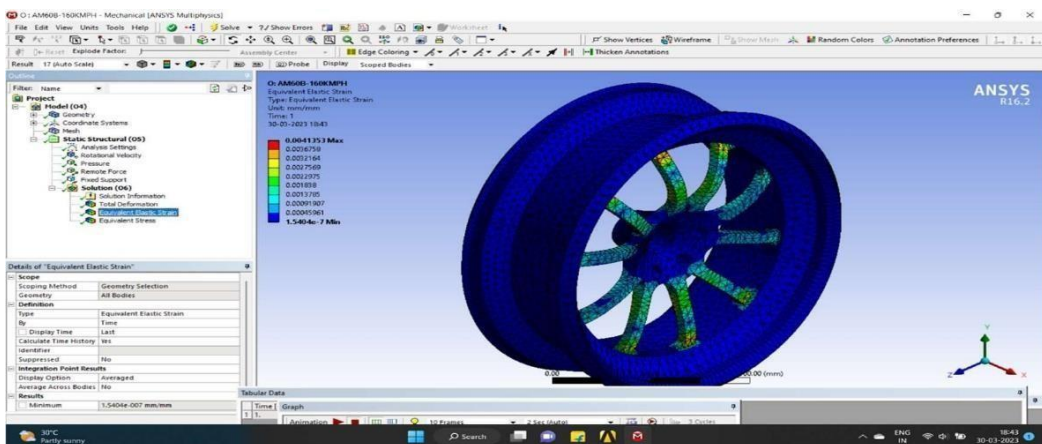


Fig5.12.3 Equivalent Strain at 160kmph

5.6 Total deformations of Duralumin:

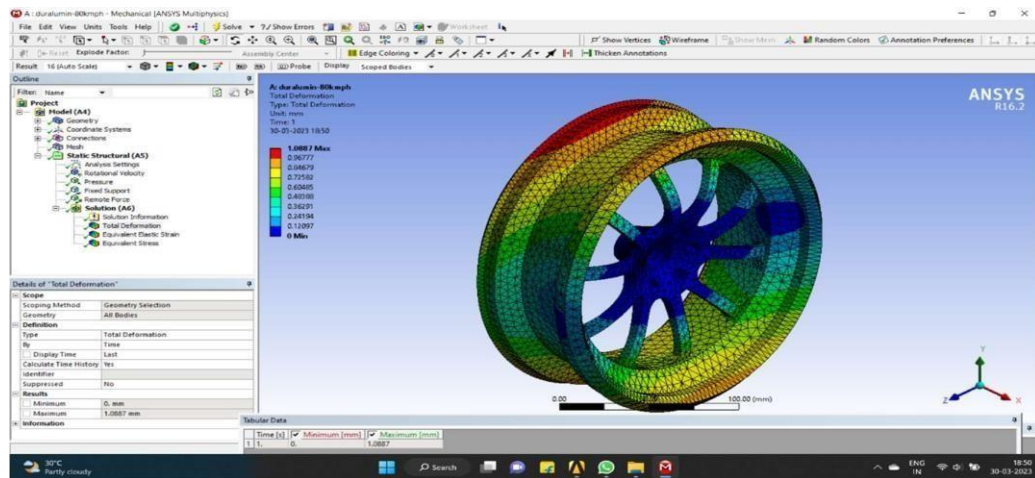


Fig5.13.1 Total Deformation at 80kmph

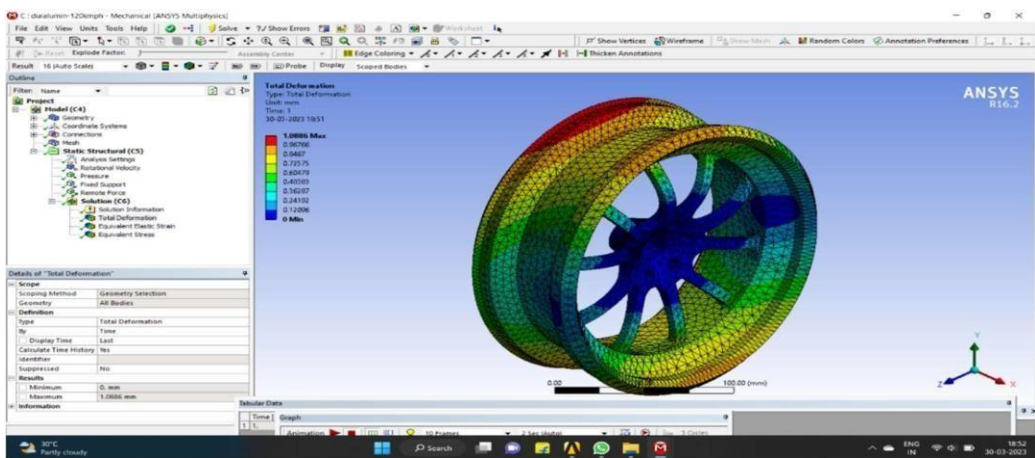


Fig5.13.2 Total Deformation at 120kmph

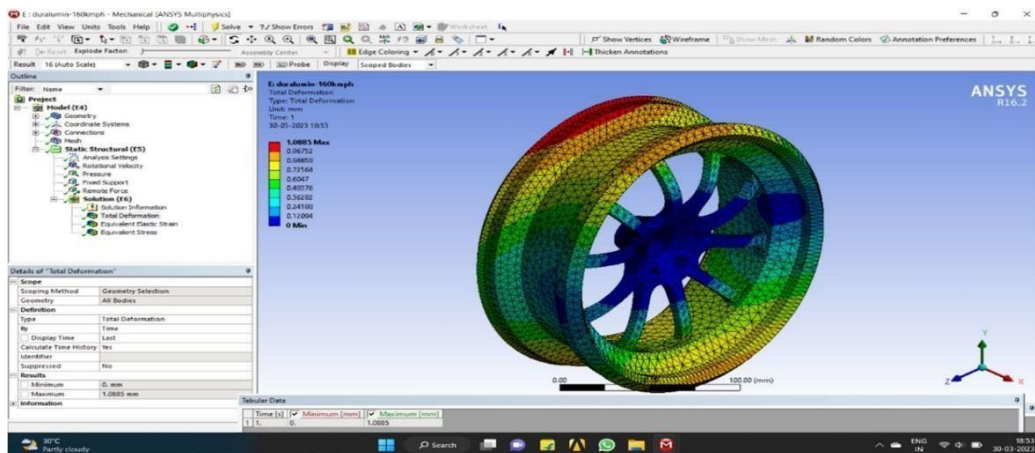


Fig5.13.3 Total Deformation at 160kmph

5.7 Equivalent(von-mises) stresses of Duralumin:

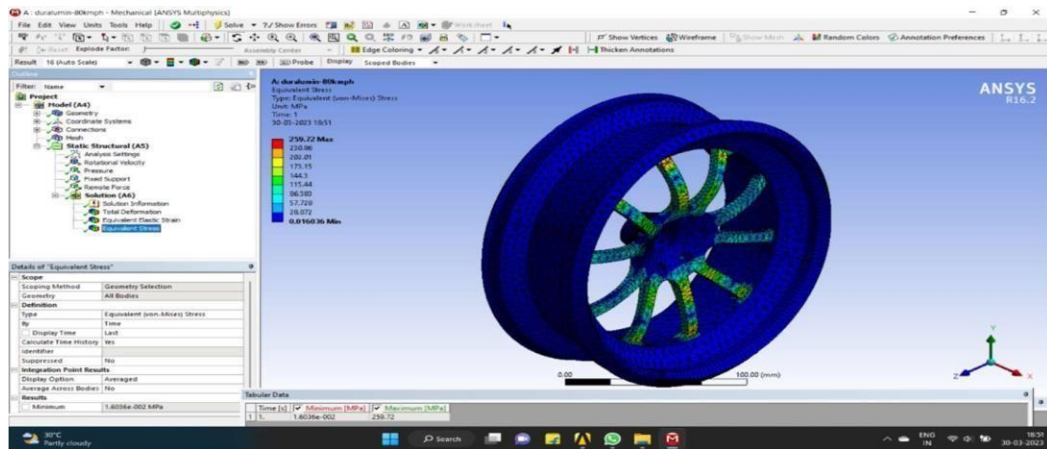


Fig5.14.3 Equivalent(Von-Mises) Stress at 80kmph

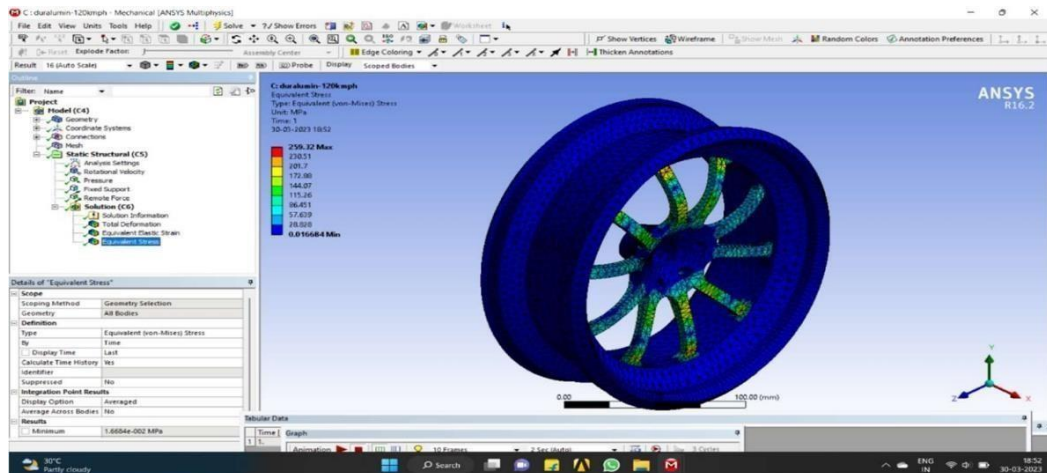


Fig5.14.2 Equivalent(Von-Mises) Stress at 120kmph

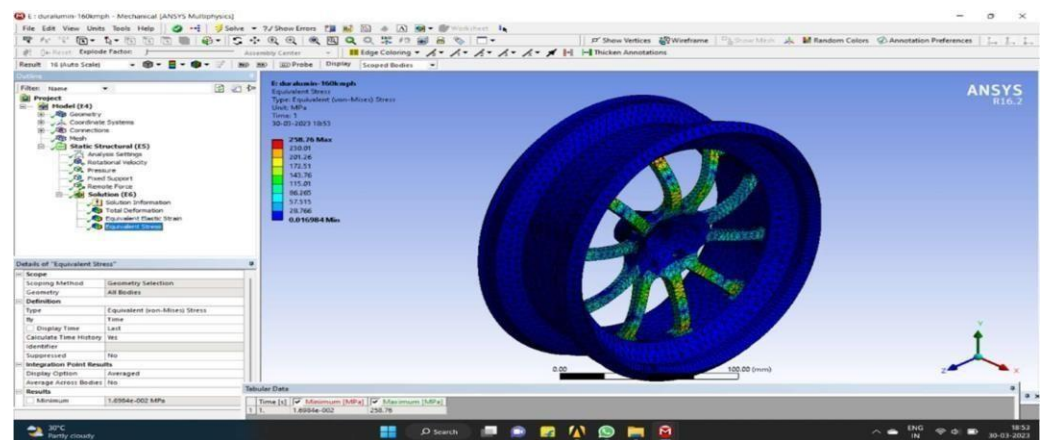


Fig5.14.3 Equivalent(Von-Mises) Stress at 160kmph

5.8 Equivalent elastic strains of duralumin:

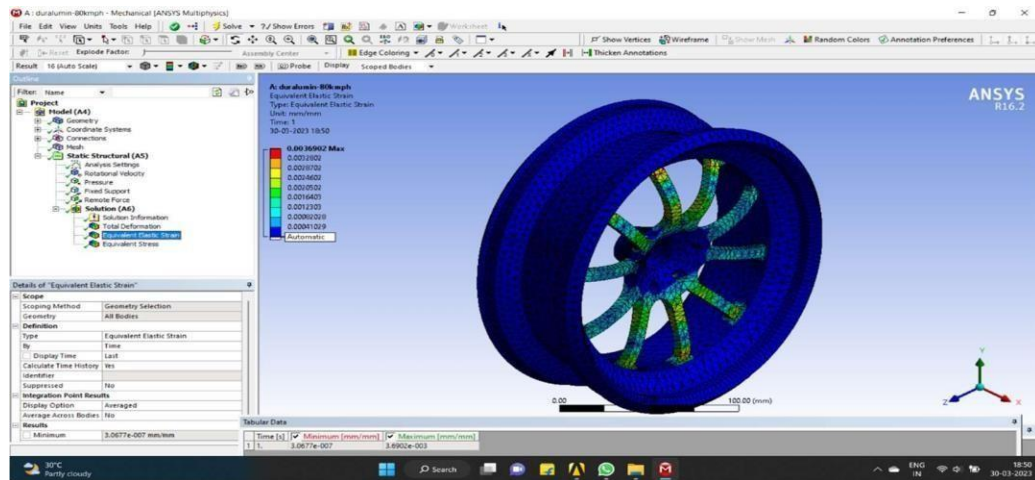


Fig5.15.1 Equivalent Elastic Strain at 80kmph

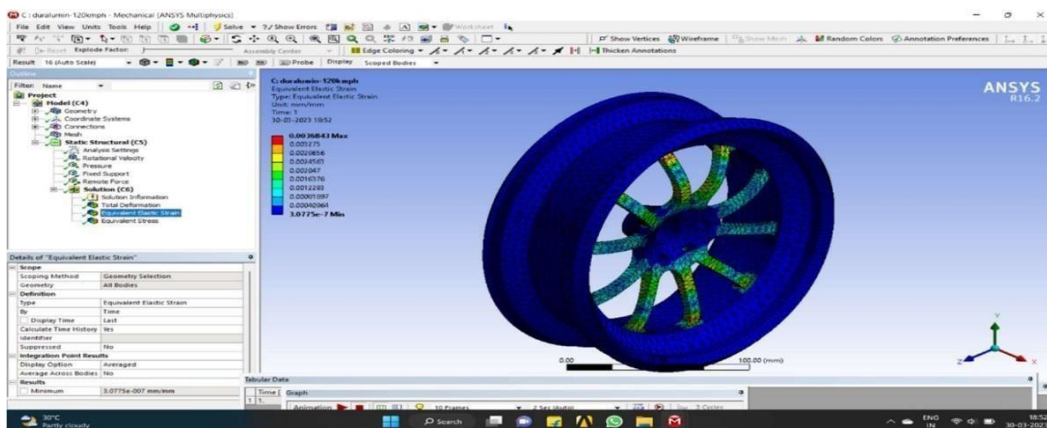


Fig5.15.2 Equivalent Elastic Strain at 120kmph

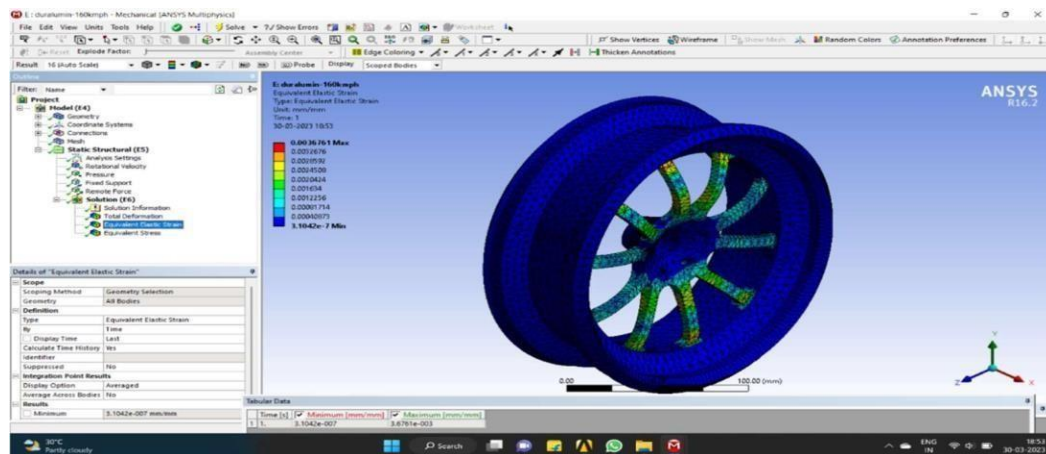


Fig5.15.3 Equivalent Elastic Strain at 160kmph

TOTAL DEFORMATION:

Material	Total deformation in mm at 80kmph	Total deformation in mm at 120kmph	Total deformation in mm at 160kmph
Aluminium alloy	0.64087	0.64076	0.64082
Magnesium alloy	1.0305	1.0304	1.0302
Duralumin	1.0887	1.0886	1.0885

Table 5.1**EQUIVALENT (von-mises) STRESSES :**

Material	Equivalent (von-mises) stress in Mpa at 80kmph	Equivalent (von-mises) stress in Mpa at 120kmph	Equivalent (von-mises) stress in Mpa at 160kmph
Aluminium alloy	183.82	183.44	182.9
Magnesium alloy	185.35	185.08	184.71
Duralumin	259.72	259.32	258.76

Table 5.2**EQUIVALENT ELASTIC STRAINS:**

Material	Equivalent elastic strain at 80kmph	Equivalent elastic strain at 120kmph	Equivalent elastic strain at 160kmph
Aluminium alloy	0.0025726	0.002567	0.002559
Magnesium alloy	0.0041502	0.004144	0.0041353
Duralumin	0.0036902	0.0036843	0.0036761

Table 5.3

CHAPTER-6

RESULTS AND DISCUSSIONS

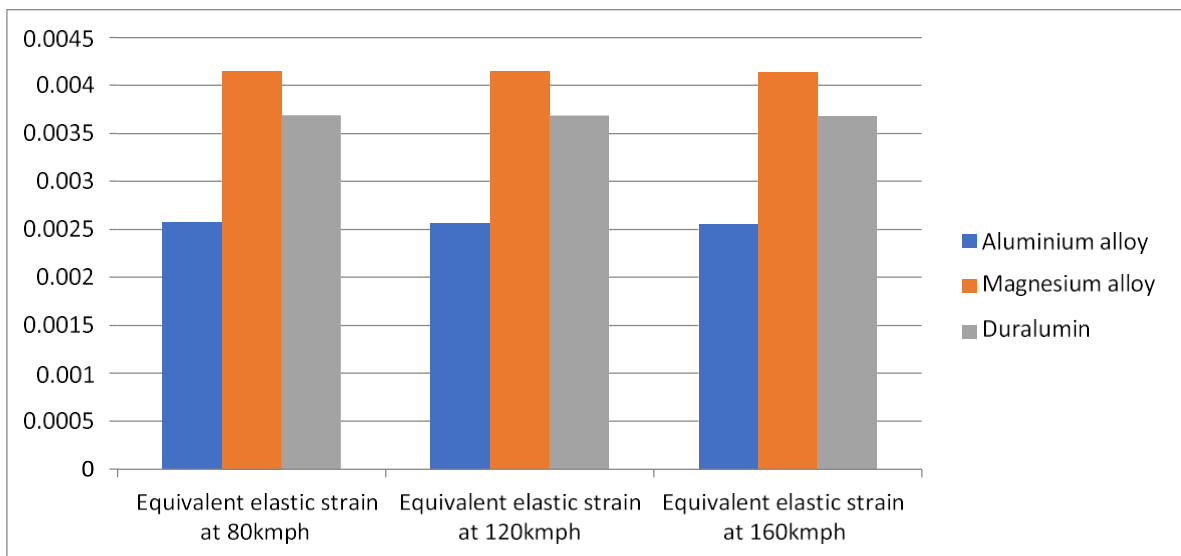
6.1 Results and Discussions:

The present work has dealt with the study of alloy wheels using different materials at different speeds analytically using software. In comparison between different materials are accomplished to obtain an idea on the which material is best among them.

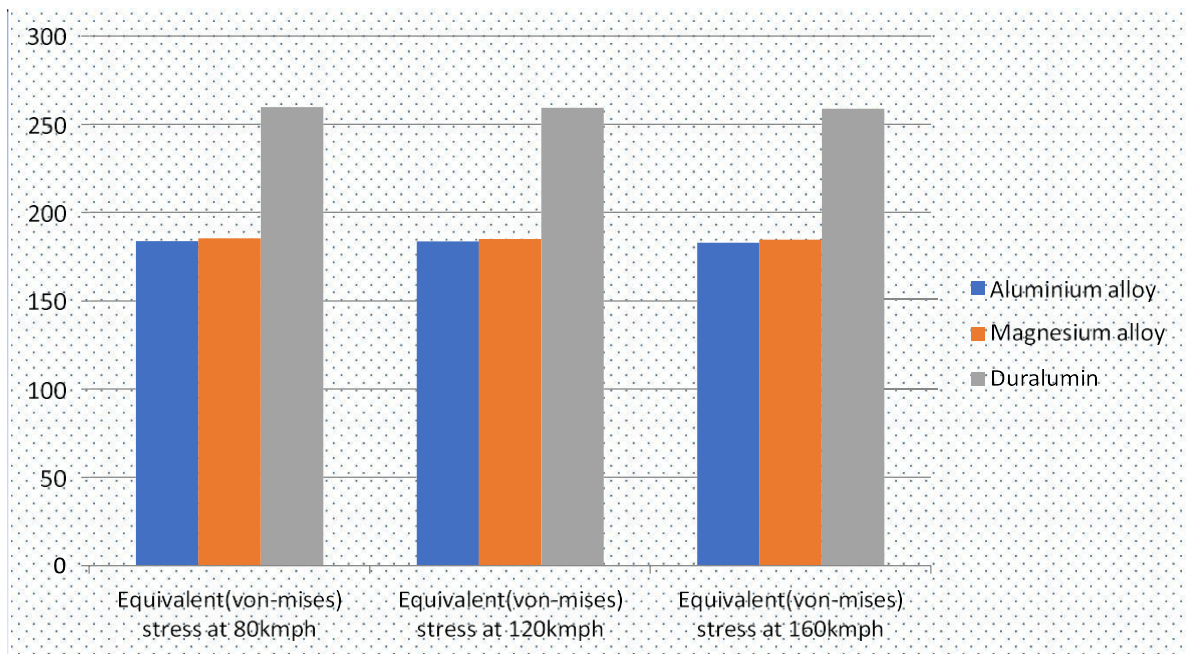
This study was carried out assuming similar boundary conditions to overall analysis. The design is assumed to be same for the entire analysis.

The study was done for three different type of materials i.e. Aluminium alloy(AlSi5Mg0.3),magnesium alloy(AM60B), duralumin. This material was choosen as wheels are generally fabricated of high strength materials. Further the analysis was carried out to get results i.e. total deformation, equivalent elastic strain and equivalent (von-mises) stress.

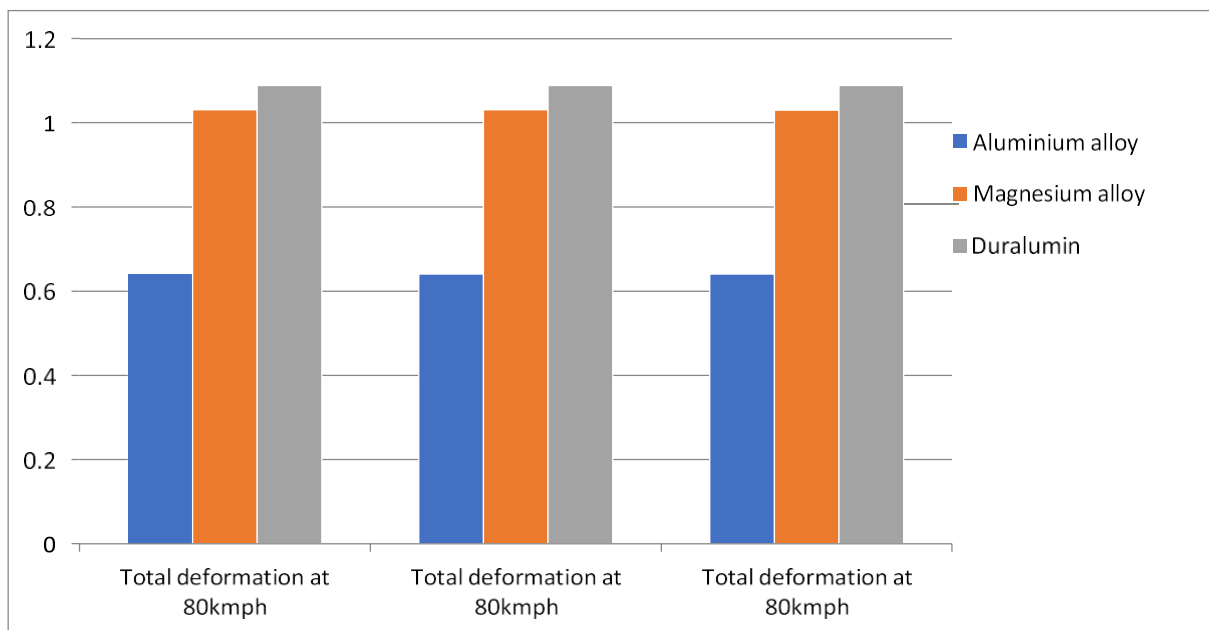
The detailed study of total deformation, equivalent elastic strain and equivalent(von-mises)stress was achieved for the design for three different:



6.1 Equivalent elastic strain at different speeds for different materials



6.2 Equivalent(von-mises) stress at different speeds for different materials



6.1 Total deformation at different speeds for different materials

- As the analysis is performed, and the result graphs are drawn, By looking at the graph 6.1 we can see that Aluminium Alloy has less Strain developed than other two materials. Also the duralumin and magnesium alloy are almost similar.
- From the 6.2 of equivalent (von-mises) Stress we can see that Duralumin has developed higher stress where Aluminium alloy and magnesium lesser and similar to each other.

- From the graph 6.3 of Total Deformation , it is clearly shows that Aluminium Alloy has less deformation far from Duralumin and Magnesium Alloy.
- By Comparing the three Graphs it also tells us that three values. Total Deformation, Equivalent (von-mises) Stress, Equivalent Elastic Strain values are almost uniform at different speeds, for each material.

CHAPTER-7

CONCLUSIONS AND FUTURE SCOPE

7.1 Conclusion:

- Alloy wheels are made of mixtures of metals and other elements. They generally provide greater strength over pure metals, which are usually much softer and more ductile.
- Modern day's alloy wheels are made of Aluminum or Magnesium as they are lighter for same strength, provide better heat conduction.
- The current work that is done in this project is the consideration of these Aluminum alloys and Magnesium alloys as they are greatly used, and also an alloy called Duralumin, that has the similar properties like strong, hard, light weight.
- The work continues to perform analysis tests using ANSYS software by applying these three materials to wheel design. (AlSi7Mg0.3, AM60B, Duralumin)
- The modelling and analysis was carried out using CATIA and ANSYS software respectively. The following conclusions were drawn from the static structural analysis test at various speeds.
- Aluminum alloy (i.e) AlSi7Mg0.3 exhibited better result with a maximum deformation of 0.64087 mm and max. von – mises stress with 183.82 MPa and with maximum value of equivalent elastic strain of 0.0025726 for same loading conditions.
- Where as, Magnesium alloy AM60B becomes the second better material and Duralumin deviates slightly from the above both alloys.
- Hence from the analysis of the project we, can conclude that rather than Duralumin, Aluminium and Magnesium alloys can be used in case of durability as Duralumin can fail before Aluminum and Magnesium alloys.

7.2 FUTURE SOPE:

From the present study it can be inferred that Aluminum alloy which is cheaper and has higher strength, it can be the best material out of the three alloys. And there is a scope for Duralumin that by altering it's chemical composition such that the durability increases and strain, stress is reduced. Then it can be tested for analysis.

CHAPTER-8

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