

Design Analysis and Optimization of a Wheel Rim

B. Venkat Vinay Kumar¹, Dr. K. Devaki Devi²

¹Student ME (CAD/CAM), Department of Mechanical Engineering, G. Pulla Reddy Engineering College, Kurnool-Andhra Pradesh, India.

² Associate professor, Ph.D., Department of Mechanical Engineering, G. Pulla Reddy Engineering College, Kurnool-Andhra Pradesh, India.

Abstract— *The motivation behind the vehicle wheel rim is to give a firm base to fit the tire. Its dimensions and shape should be suitable to adequately accommodate the particular tire required for the vehicle. Design is an important industrial activity which influences the quality of the product. The present work focuses on the design of wheel rim and to analyze for optimum shape and dimensions. The design of the rim will carried out using CREO (modelling software) and ANSYS solver mode is used to analyze the design and calculate the stresses, deflections, bending moments and their relations. Also static structural analysis has been carried out and the performance of the rim has been checked in dynamic analysis. At present literature is being reviewed to identify the existing gaps in order to carry forward to the proposed work by filling those gaps. Change of material (as well as compositions) and topology is under study.*

Keywords— *Wheel Rim, Static Structural Analysis, Modal Analysis, Materials, CREO, and Ansys.*

I. INTRODUCTION

In an Automobile industry, the fundamental goal of the Wheel rim is to be solid enough to help the vehicle and to stand up the powers brought about by customary activity. But at a same time, they must be as light-weight as achievable and to help it must downplay un-sprung weight. Wheel rims might be made of cast aluminium composite or steel Compound wheel rims are across the board to their feel and lighter weight contrasted with steel wheel edges. Most recent Innovations have shown that up to half weight can be accomplished by the substitution of steel by aluminum. This can bring about a 20–30% all out vehicle weight decrease when added to other decrease openings. The expense of Aluminium combination and worth strength remains its greatest block for its utilization in enormous scale applications. Aluminium alloy has focused on the car exchange for future development and has given fundamental assets to help this exertion. Aluminium is a higher conductor of warmth; in this way aluminium compound wheel rims will scatter heat from brakes and tires than steel ones. Most wheel edges have ventilation openings inside the edge, in this way air will stream into to the brakes. Compound wheels will be wheels that are produced using a composite of aluminium. Alloys of aluminium or steel are typically lighter for the same strength, provide better heat conduction and often produce improved cosmetic appearance over steel wheels. In spite of the fact that steel is likewise a compound, comprising of iron and carbon, it is the most widely recognized material utilized in wheel generation.

II. REVIEW OF LITERATURE

P. Meghashyam, S. Girivardhan Naidu and N. Syed Baba designed and performed static & modal analysis on forged steel wheel rim and aluminium wheel rim. In both analysis of forged steel wheel rim & aluminium wheel rim, von-mises stresses are less compared to ultimate strength. Deflections got more in aluminium rim than forged steel rim. They concluded & preferred that forged steel rim gave better results when compared to aluminium wheel rim.

Kalpesh R. Salunkhe, Prof. Shailesh S. Pimpale designed a alloy wheel in CATIA and performed analysis by using ANSYS software on wheel rim of TATA Indica. The static structural analysis was carried on alloy wheel by applying the three different materials namely aluminium (AL 6061), zinc (ZA 21) and Magnesium (Mg). They observed the equivalent stresses and total deformation of alloy wheels, and concluded that maximum total deformation and equivalent stresses are obtained lowest for ZA 21 compared to aluminium and magnesium.

Samuel Onoriode Igbudu, David Abimbola Fadare performed investigation on aluminum alloy wheel at various loads by keeping up various weights 0.3, 0.15, and 0 Mpa with a specified load of 4750N. Von mises stresses are investigated at different loads and experimental data is provided.

G. Ashok Kumar, M. Uma Mahesh, S. Madhu Sudhan T. Cholai Raj designed alloy wheel rim and performed analysis by using CATIA & ANSYS. The analysis on aluminium wheel and forged steel wheel rim was carried at different loads, and different pressures by using CATIA. Static analysis and vibration analysis is carried out by using ANSYS and the performance is observed. They gave a conclusion that the deflections is less in forged steel wheel rim and suggested forged steel wheel rim as best material.

III. METHODOLOGY

A. Types of wheel and material:

1) Wire Spoke Wheel:

Wire spoke wheel is a fundamental where the outside edge some portion of the wheel (edge) and the pivot mounting part are connected by various wires called spokes. The present autos with their high pull have made this kind of wheel make old. This kind of wheel is as yet utilized on great vehicles. Light compound wheels have creating as of late, a plan to offer accentuation to this spoke impact to satisfy client's style requirements.

2) Steel Disc Wheel:

This is a rim which practices the steel-made rim and the wheel into one by joining (welding), and it is used mainly for passenger vehicles especially original equipment tires.

3) Light Alloy Wheel:

These wheels depend on the utilization of light metals, for example, aluminium, titanium and magnesium has come to be famous in the market. This wheel quickly become standard for the first geared vehicle in Europe in 1960's and for the substitution tire in United States in 1970's.

B. Materials:

1) Steel Wheels:

Steels are commonly just made in 16" sizes or less. There are a not many 17" steels out there, yet not a solitary 18" steel that I am aware of. I would envision that a 18" steel would be ludicrously overwhelming. Thus, putting on steels will regularly include cutting back. Steels are additionally generally 75-80% more affordable than composite wheels, making them extraordinary for a subsequent set, and cheap to supplant if severely harmed.

2) Aluminium Alloy Wheels:

Aluminum is a metal with features of excellent lightness, thermal conductivity, rust confrontation, physical characteristics of casting, low heat, machine processing and reutilizing, etc. This metals main advantage is decreased weight, high precision and design choices of the wheel. This metal is helpful for vitality protection since it is conceivable to re-cycle aluminium effectively.

C. Wheel Specifications:

Model: Volkswagen polo 1.0 TSI

Rim Diameter: in 432mm

Rim Width: 152.40mm

Tire Pressure: 35psi (0.241N/mm²)

Aspect Ratio: 35-70

Maximum Power: 81KW

Centre Bore: 57.1mm

Maximum Torque: 160 N-m

D. Rim Nomenclature:

- Wheel: Wheel is generally composed of rim and disc.
- Rim: This is a part where the tire is installed.
- Disc: It is a part of the rim where it is fixed to the axle hub.
- Offset: This is a space between wheel mounting surface where it is rushed to center and focus line of rim.
- Flange: The flange is a part of rim which holds the both beds of the tire.
- Bead Seat: Bead seat approaches in contact with the dot face and it is a piece of edge which holds the tire in a spiral bearing.
- Hump: It is a knock bed situate for the dot to keep the tire from sliding off the rim while the vehicle is moving.
- Well: This is a piece of edge with width to encourage tire mounting and expulsion from the rim.

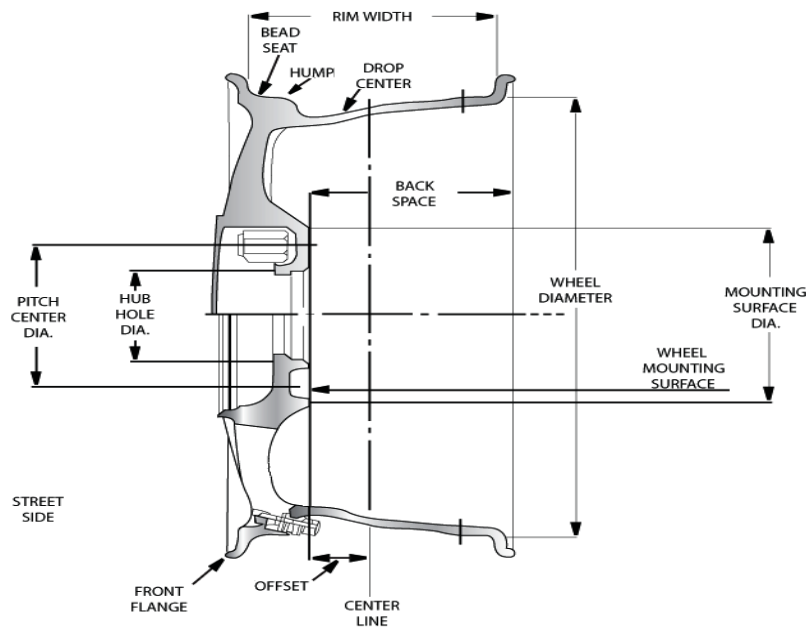


Figure 1: Rim Nomenclature

E. Mechanical Properties:

1. Aluminium 2014

- Young's modulus = 72.4 Gpa
- Poisson ratio = 0.33
- Ultimate tensile strength (UTS) = 483 Mpa
- Yield tensile strength (proof) = 414 Mpa
- Density = 2.8 g/cm³
- Shear modulus = 28 Gpa
- Thermal conductivity = 154 W/m-k
- Thermal expansion = 23 μm/m-k
- Specific heat capacity = 0.88 J/g-°c

2. Structural Steel:

- Young's modulus = 73.1 Gpa
- Poisson ratio = 0.3
- Ultimate tensile strength (UTS) = 247 Mpa
- Yield tensile strength (proof) = 400 Mpa
- Density = 7.8 g/cm³
- Shear modulus = 79.3 Gpa

a) Design And Modelling:

At first segment sketch the outline of existing vehicle model Volkswagen polo 1.0 TSI wheel rim, the sketcher according to organization determined measurements in the CREO 3.0. Later this is revolved using horizontal axis, here the design model and meshed model.

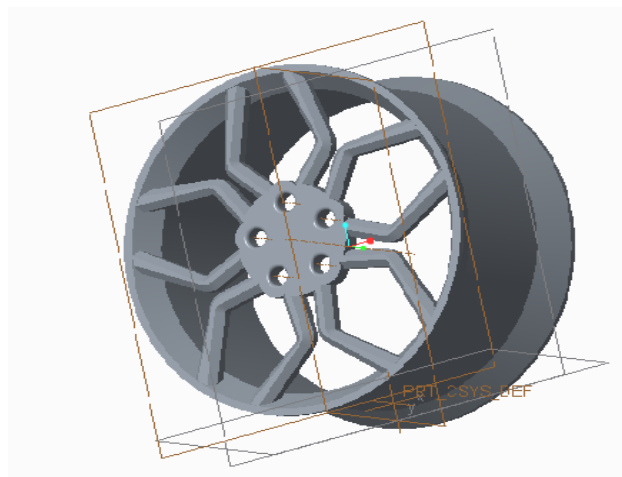


Figure 2: 3D Model of a Wheel rim

Meshing:

Very fine mesh is used in the analysis and element size of 30mm is used for meshing whole the model No of nodes: 1479796, No of elements: 877612.

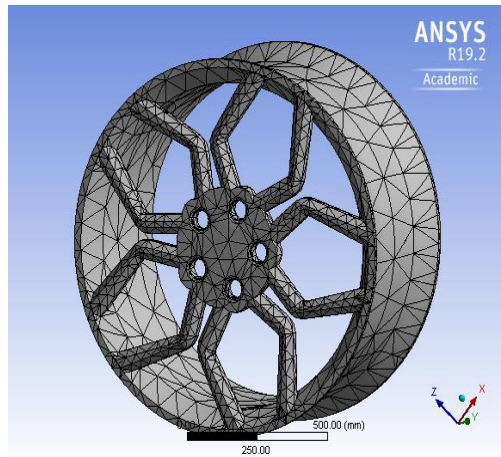


Figure 3: Meshed Wheel rim

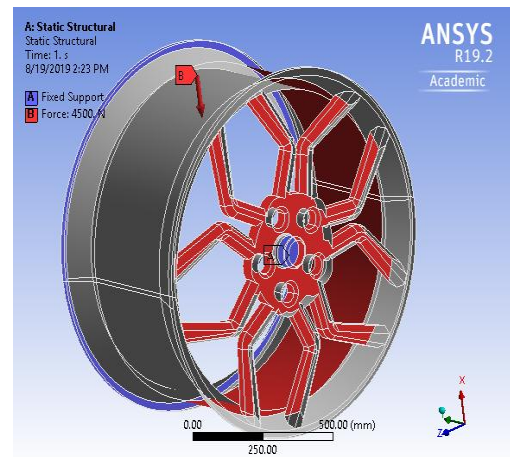


Figure 4: Determining Fixed support and Force 4500N

b) Analysis:

Static Structural:

A static analysis computes the impacts of study loading conditions on a structure, which ignoring inertia and damping impacts, for example, those brought about by time varying loads. Static analysis is utilized to decide the displacements, stresses, strain, and forces in structures or components brought about by loads that don't include significant inertia and damping impacts. Study loading and resonance conditions are accepted; that is, the loads and the structures reaction are expected to change gradually regarding time.

i. Structural Steel:

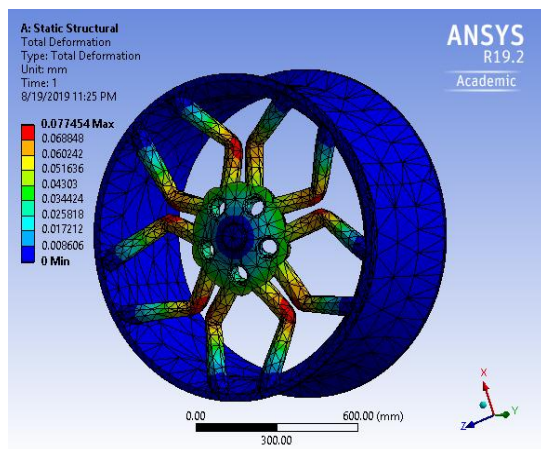


Figure 5: Total Deformation

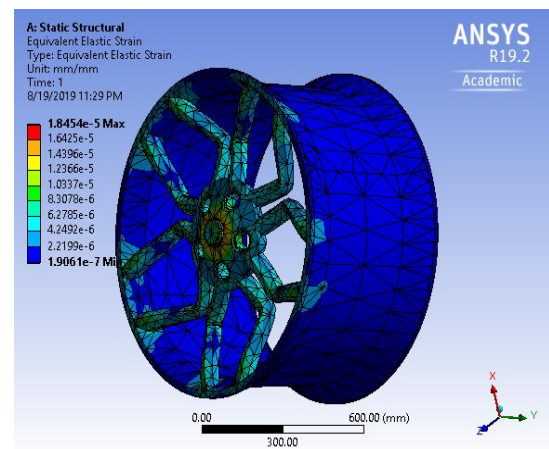


Figure 6: Equivalent Elastic Strain

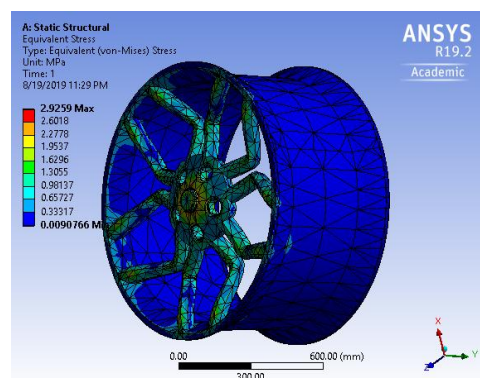


Figure 7: Equivalent Stress

ii. Aluminium 2014 Alloy:

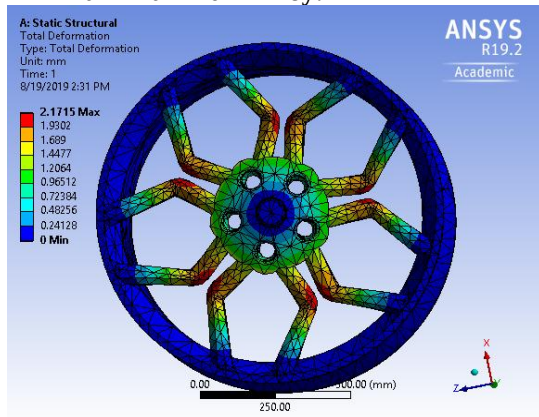


Figure 8: Total Deformation

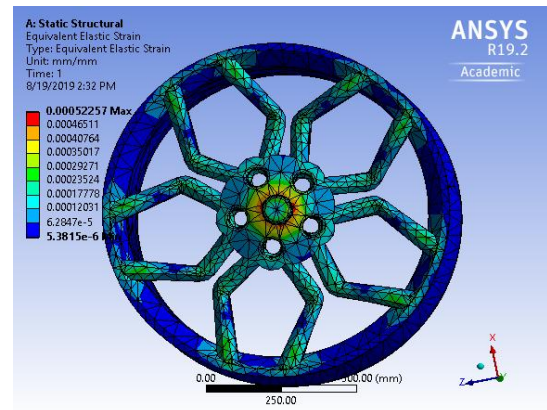


Figure 9: Equivalent Elastic Strain

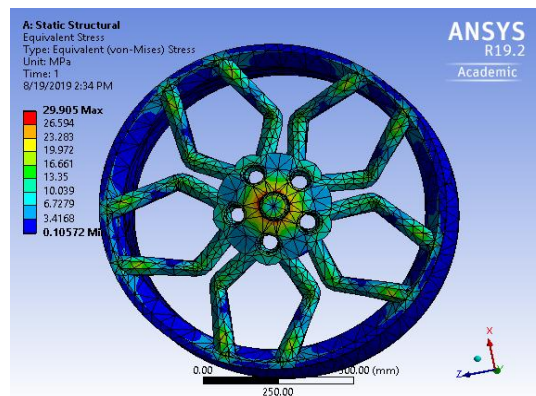


Figure 10: Equivalent Stress

Modal Analysis:

i. Structural Steel

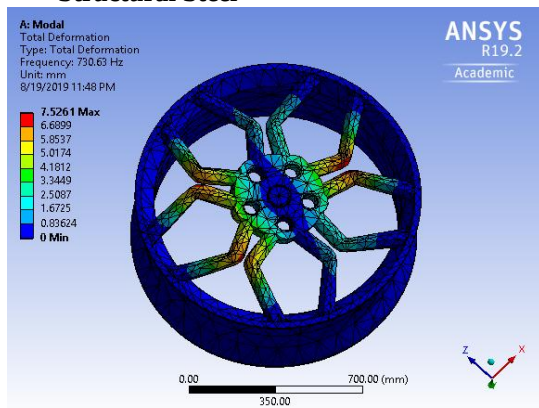


Figure 11: Total Deformation 1

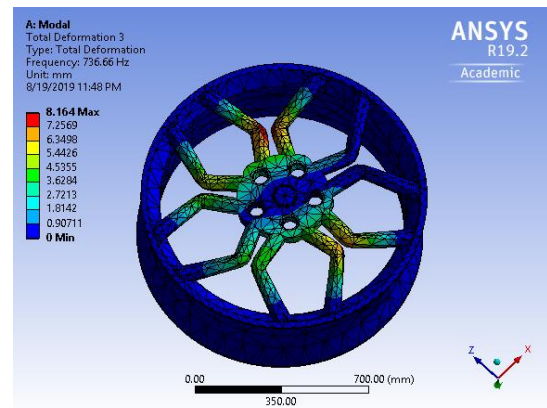


Figure 12: Total Deformation 2

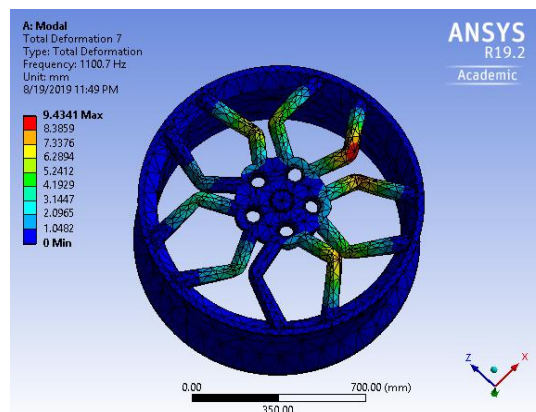


Figure 13: Total Deformation 3

ii. Aluminium 2014 Alloy:

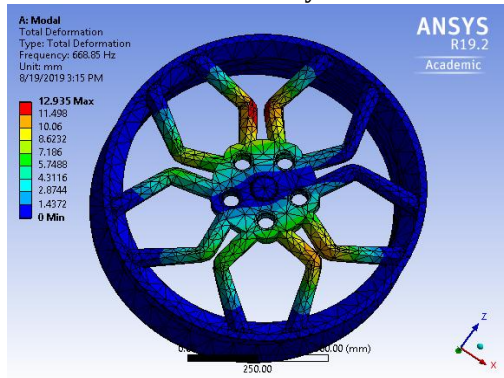


Figure 14: Total Deformation 1

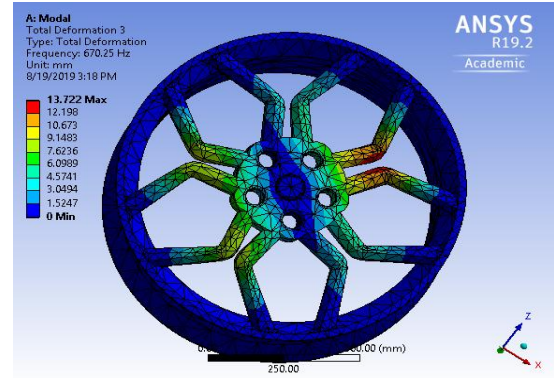


Figure 15: Total Deformation 2

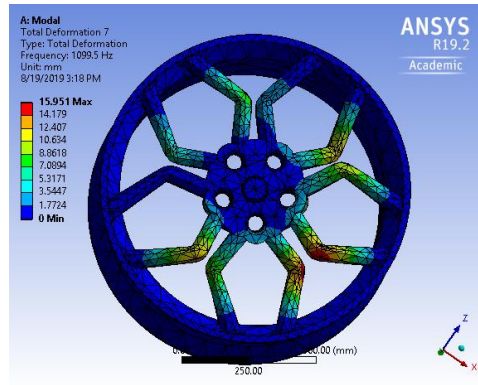


Figure 16: Total Deformation 3

IV. RESULTS

Material	Total Deformation (mm)	Equivalent Elastic Strain (mm/mm)	Equivalent Stress (Mpa)
Structural Steel	0.0774	$1.8454e^{-5}$	2.9254
Al 2014 Alloy	2.1715	0.00054	29.905

Table 1: Results for Static Structural at load 4500N

Material	Structural Steel	
	Frequency (hz)	Total deformation(mm)
Mode1	730.63	7.5261
Mode2	736.66	8.164
Mode3	769.36	6.668
Mode4	819.15	9.566
Mode5	820.17	9.076
Mode6	1100.7	9.434

Table 2: Modal results for Structural Steel

Material	Al 2014	
	Frequency (hz)	Total deformation(mm)
Mode1	668.85	12.935
Mode2	670.25	13.722
Mode3	755.94	10.598
Mode4	807.89	14.983
Mode5	808.57	14.765
Mode6	1099.5	15.951

Table 3: Modal results for Al 2014

V. CONCLUSIONS

In this wheel rim, one model designed with desired specifications and two different materials Structural Steel, Aluminium 2014 alloy were used with 4500N load condition. The above model and two different materials Aluminium 2014 alloy performed better with better deformation and stress values at each preferred load conditions comparing to other materials. Aluminium 2014 alloy is to be preferred for wheel rim due to its material stability and ductility by observing the results of static structural and modal analysis. Therefore, from the above practical results Al 2014 alloy gives good efficiency compared to others.

VI. REFERENCES

1. Kisshan, JL Miren, et al. "DESIGN AND ANALYSIS OF WHEEL RIM." International Journal of Pure and Applied Mathematics 120.6 (2018): 3933-3943.
2. Ashok Kumar, G., et al. "DESIGN AND ANALYSIS OF WHEEL RIM BY USING CATIA & ANSYS." (2016).
3. DAYAKARARAO, NANDIGAM. "DESIGN AND ANALYSIS OF ALLOY WHEEL NANDIGAM DAYAKARARAO, 2 B. KISHORE KUMAR."
4. Meghashyam, P., S. Girivardhan Naidu, and N. Sayed Baba. "Design and Analysis of Wheel Rim using CATIA & ANSYS." International Journal of Application or Innovation in Engineering & Management (IJAIEEM) 2.8 (2013): 2319.
5. Ganesh, S., and Dr.P. Periyasamy. "Design and analysis of spiral wheel rim for four wheeler." The International Journal of Engineering and Science (IJES) 3.4 (2014): 29-37.
6. Deepak, S. Vikranth, C. Naresh, and Syed Altaf Hussain. "Modelling and analysis of alloy wheel for four wheeler vehicle." International journal of mechanical engineering and robotics research 1.3 (2012): 72-80.
7. Ganesh, S., and Dr P. Periyasamy. "Design and analysis of spiral wheel rim for four wheeler." The International Journal of Engineering and Science (IJES) 3.4 (2014): 29-37. Rohan, Chaudhary Dipesh. "Design and analysis of composite wheel rim." J. Mat. Sci. Mechanical Eng. 2.6 (2015): 50-56.