

# Fatigue Analysis of Wheel Rim Using Different Alloy to Eliminate the Manufacturing Difficulties with Reduced Weight

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**Abstract:** This review paper gives the detailed information of various analysis done on disc of four-wheeler passenger car. Disc performance can be optimized by considering both static and dynamic load by doing proper manufacturing and design. Failure of wheel rim may cause extra cost or may lead to serious injury. The objective of this paper is to study various wheel rim disc failure analysis and select the appropriate material for disc and suggest proper method for manufacturing of wheel disc.

**Keywords:** Wheel rim design, dynamics of wheel rim, spoke design, rim material optimization

## 1. Introduction:

Nowadays, alloy of aluminum is used a best suitable material for car wheel. Magnesium is brittle in nature & have corrosion problem so nowadays it is generally not used for road wheels. Due to this reason, Aluminum alloy wheel is preferred material for wheel rim. Pure aluminum has various properties such as soft, ductile, high electrical conductivity and corrosion resistant. It has wide application area such as foil and conductor cables. To have application in other area, it must be alloyed with some other elements. Aluminum alloy is heated above its melting point, poured into mould and cooled upto room temperature. After this casting process, it becomes more accurate and usable for heavier as wheel as lighter application area. The result has less weight on the wheel and less stress on the tire. Aluminum is light in weight and can be machined to a good accuracy and appearance, it is also used for racing car wheel rim. Normally, Steels wheels are used for transportation in the passenger car. Those who wants to save the money by increasing the life of tyres and want shock resistant ride, alloy wheel is another best option which can be adopted.

Alloy metals have high load carrying capacity & weight to power ratio is less compared to ferrous metals which makes alloy metals as an ideal material for wheel rim. Nowadays, most of the automobile industry are using alloy wheel as the material for wheel rim to improve the customer relationship by improving the performance the vehicles

## 2. LITERATURE REVIEW

### 2.1 Kuznetsov (2010)

In this research paper, vibration analysis of automobile is done in which analysis is done on vibration profile when it is transmitted from road to passenger. In this, A mathematical model is constructed, optimized as per the standard ISO 2631, Various system parameter is calculated for suspension system. Analytical skill and experience are required to identify and treat such situations.

### 2.2 Nallusamy and Majumdar (2015)

In this Research paper, A new technique has adopted to analyze the stress and displacement distribution for the given specifications on the aluminum alloy wheel. Comparing the result they suggested that aluminum alloy is the best compatible material by the standards of ISO 7141- Road vehicle wheels impact test procedure for the aluminum alloy wheels of passenger car of HYUNDAI and FORD motor.

### 2.3 Plunt (1996)

This Research paper discusses the use of experimental transfer path analysis (TPA) to find optimized solutions to Noise, Vibration and Harshness (NVH) problems remaining late in vehicle development stages.

TPA can be considerably simplified especially for the analysis of TPA for higher frequency noise components.

### 2.4 Jadhav (2016)

This research paper for optimization of the wheel rim mass, aluminum alloy is selected as the material for the design purpose. In this analysis total 3% (200 gm) of mass reduction takes place in one of the model. Thus, longer life of component with reduced cost can be achieved by using advanced fatigue strain life approach.

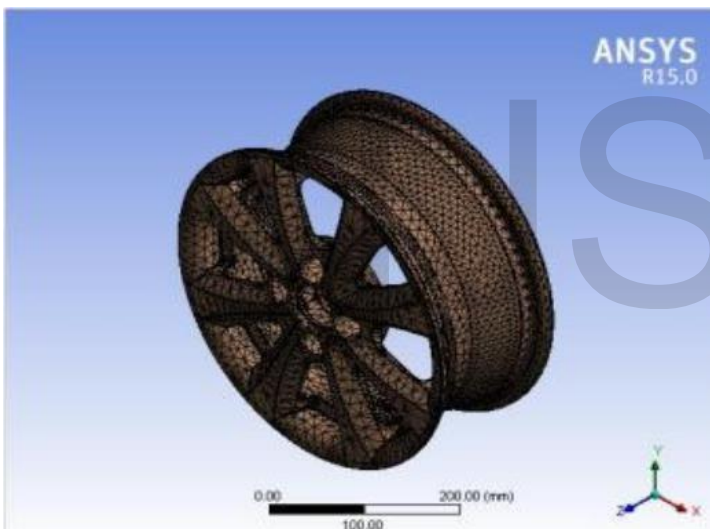


Fig1: Mesh Model

Above figure was generated in CATIA into Ansys software. Aluminum properties was chosen & meshed properly.

### 2.5 Sharma (2013)

In this paper Corner fatigue test and Radial fatigue test has carried out for optimized design of rim at different load and no. of cycles for detection of cracks and bolt looseness.

In future elimination of failure of wheel can be possible through processes like disc thickness reduction, rim thickness reduction, usage of high tensile material, disc, and rim profile change.



Fig2: Failed Wheel

Figure indicate failures of wheel rim when tested under corner fatigue test.

### 2.6 Prem, Raghupathi and Kalaiyarasan (2016)

In this paper Aluminum, steel, and magnesium wheel rim generated in Unigraphics and analyzed in ANSYS. We can interpret from results that the steel is more feasible to be used in wheel than other materials and maximum stress area had located in the bolts and surface of the wheels.

There is scope conducting the mechanical testing of wheel rim or collecting the experimental data for validation of analysis results.



Fig 3: Complete Model of Alloy Wheel

Figure shows model of magnesium alloy wheel

### 2.7 Dylan Stimson, Jason Mehta, Kenneth (2015)

The design of wheel rim done according to mechatronics analysis of suspension for very high-speed racing car. After the design model simulated in ANSYS for feasible shape.

Various types of alloy materials should have to use and simulate for better performance.

### 2.8 Radhakrishnan, Palaniappana (2016)

This article involves the analysis of wheel rim for Bending endurance and Radial endurance test. The optimized spiral flexure design of rim analyzed in ANSYS for pressure, centrifugal and vertical loading during radial endurance test.

An attempt would also made to suggest a best combination of material and rim width used for wheel, which yields high strength and durability.

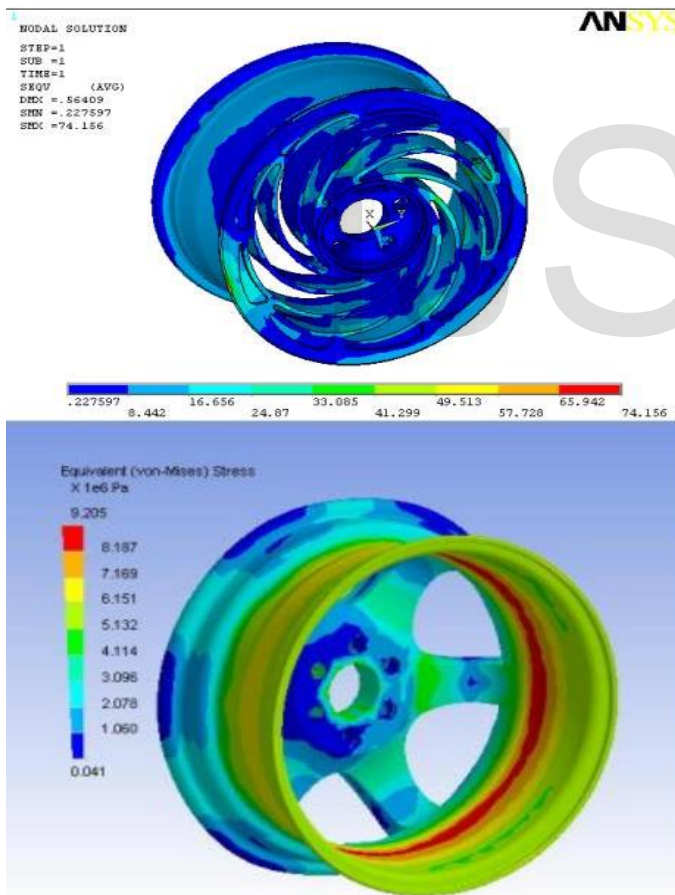


Fig No.4 Von Mises Stress Distribution  
Figure shown bending failure analysis of wheel rim under vertical load applied at a certain distance.

### 2.9 Shantaram Jadhav (2015)

This paper includes the strength analysis results using RADIOSS as a solver, for pre-processing HYPERMESH and for post-processing HYPERVIEW. The strength analysis results analyzed thoroughly with AIS 073 standard testing, pave testing and different highway profiles testing. After complete analysis it has been observed that there is significant deformation on the surface and there are no surface defects such as crack, bends etc.

The spoke wheel change pattern has a tremendous effect when whole rim pastern is considered. Hence RADIOSS software can be effectively used for this complex study.

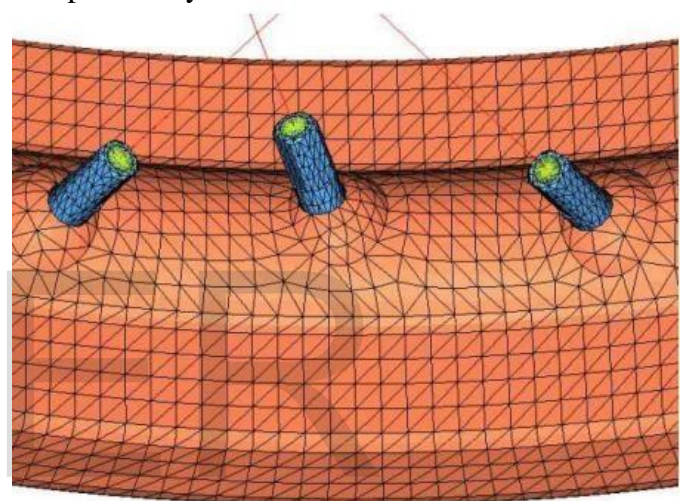


Fig No5: Wheel rim and spoke nipple  
Figure indicates meshed model of spoke, surface to surface comfort are assigned.

### 2.10 Mark Bailey (2015)

The article mainly focused on wheel separation mechanisms and various forces responsible for wheel separation.

For more development in this area new mechanisms and alloy materials can also have developed and analyzed simultaneously for more safety.





Fig No6: Fatigue fracture on Stud  
Figure indicates fracture on studs from a motor home. Right side wheel after 2900 miles.

### 2.11 Liangmo Wang (2011)

Simulation for fatigue test of wheel rim has done using ABAQUS which showed that maximum stress area is located in the hub bolt hole. In this article rotary fatigue bench test was used to validate the optimized aluminum alloy wheel.

The nominal stress method can also be used to predict the fatigue life of aluminum alloy wheels

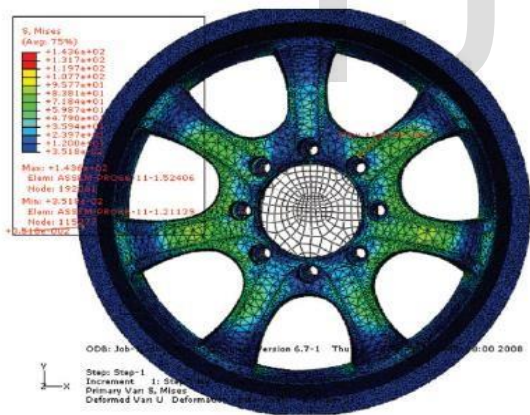


Fig No7: Node Analysis

Figure indicates fatigue analysis of wheel rim along with stress strain field intensity.

### 2.12 Turaka, venkateswara Rao (2014)

In this article normal, 5 spokes and 4 spokes wheel rim of 4 different materials are analyzed in ANSYS for stress and displacement values.

Further, to have less material consumption, there is a huge scope for optimization of material thickness.

### 2.13 J. Janardhan (2014)

This article deals by using Cornering fatigue test, Radial fatigue test and Impact test, fatigue analysis of wheel rim is done.. This experimental result compares with analytical software results for optimized design

and life cycles of the rim.

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.

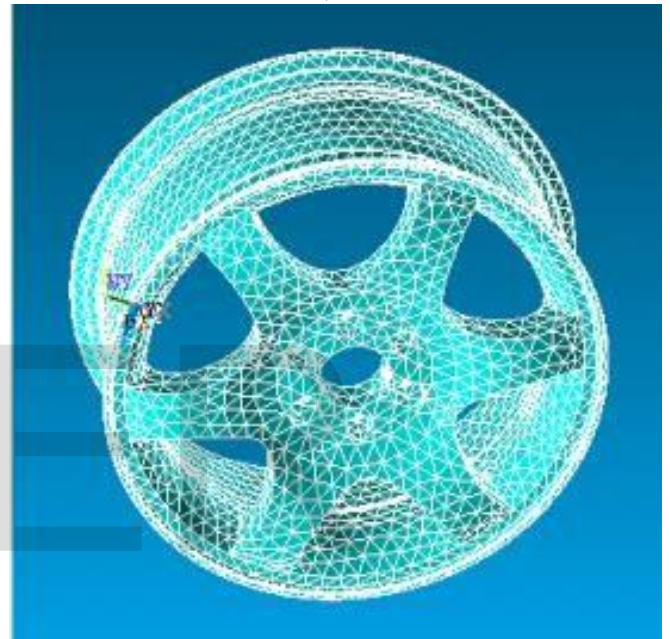


Fig No.8: Plot for meshed Model of wheel

Above figure indicates meshed model of wheel rim using Ansys under static condition.

### 2.14 Pratiksha Shrivastava (2016)

This research paper deals with the prediction of the fatigue life of aluminum wheels by using aluminum alloy wheel S-N curve and equivalent stress amplitude. These results indicate that the Fatigue life simulation can predict weakness area and is useful for improving aluminum alloy wheel. There is scope for finding the failure by changing loads by increasing or decreasing according to our requirements of those wheels.

Sr. No	Author	Paper	year
1	Alexey Kuznetsov, Veh. Syst. Dyn. 45(1), 77-92, Springer-Verlag	Optimization of Improved Suspension System With Inverter Device of The Quarter-Car Model In Vibration Analysis	2010
02	Nallusamy, K & Majumdar, Elsevier, Vol.-16, pp 17-25	Analysis of Static Stress In an Alloy Wheel of The Passenger-car	2015
03	Juha Plunt, Materials & Mech. Testing, Noordwijk, The Netherlands,	Finding and Fixing Vehicle NVH Problems with Transfer Path Analysis	1996
04	S.G. Jadhav, VJTI, Elsevier-2321-3361, Vol.-6, Issue No.-6,	CAD Modelling and FEA Analysis of Wheel Rim for Weight Reduction.	2016
05	T. Sharma, ISSN 2277-4785, Vol. 3, Issue 1,97-106	Failure Analysis Of Wheel Rim.	2013
06	Prem J., Raghupathi P and Kalaiyaran ISSN 13126-12120	Analysis Of Magnesium Alloy Wheel For Four-Wheeler.	2016
07	Dylan Stimson, Jason Mehta, Kenneth McPherso, Vol.5, Elsevier: 2250-0804	SAE Baja Major Qualifying	2015

08	G.Radhakrishna, V.R.Palaniappana, Vol.2, No.23	Design and Analysis of	2016
09	Shantaram Jadhav, India, Altair Technology Conference,	Structural Analysis of Spoke Wheel Rim	2015
10	Mark Bailey MASc, 2015 MEA Forensic Engineers & Scientists, Ltd.	Wheel Separations Failure Analysis Series.	2015
11	Liangmo Wang, Journal of Mechanical Engineering 57(2011)1, 31-39.	Fatigue Life Analysis of Aluminum Wheels by Simulation of Rotary	2011
12	Turaka.venkateswara Rao, ISSN (e): 2250 – 3005, Vol, 04 Issue, 10	Design & Optimization of a Rim Using	2014
13	J. Janardhan, ISSN: 2248-9622, Vol. 4, Issue-12(Part-6), December-2014, pp.253-258.	Radial Fatigue Analysis of An Alloy Wheel.	2014
14	Pratiksha Shrivastava, Vol.-01, Issue-03, July-2016, ISSN -2456-1037.	Implementati on And Failure Analysis Of Steel Wheel Used	2016

**SUMMARY OF LITERATURE REVIEW:**

## CONCLUSION

This paper deals with the design of aluminum alloy wheel for automobile application which is carried out paying special reference to optimization of the failures of the wheel. Scope of the further work are:

- 1) Static and dynamic analysis of wheel rim can be done together.
- 2) For static load car weight can be considered and for dynamic condition acceleration load can be considered.
- 3) For practical realistic condition harmonic excitation can be considered.
- 4) All the above factors can be considered on three different materials which after comparing in Ansys software; will suggest which the best material.

## REFERENCES

- [1] Nallusamy, K and Majumdar,K.,(2015), "Analysis of Static Stress in an Alloy Wheel of The Passenger-car", *Elsevier*, Vol.-16, pp17-2
- [2] Prem,J., Raghupathi,P. and Kalaiyarasan,A., (2016), "Analysis of Magnesium Alloy Wheel For Four Wheeler", *International Journal of Research Scientific Research* Vol.6, Issue 8,pp 13126-13130
- [3] Stimson,D., Mehta,J.and Horton,R.(2015), "SAE Baja Major Qualifying Project Final Report." Vol.5, Elsevier: 2250-0804.
- [4] Radhakrishnan.G., Palaniappan,V., and Magudeswaran,M., (2016), "Design and Analysis of Wheel Rim with Spiral Flexures", *South Asian Journal of Engineering and Technology*, Vol.2, No.23, pp. 162 – 170.
- [5] Jadhav, S.,(2015) , " Structural Analysis of Spoke Wheel Rim Assembly of Motorcycle" *Altair Technology Conference, India.*
- [6] Bailey,M., (2015), "Wheel Separations Failure Analysis Series." *MEA Forensic Engineers & Scientists, Ltd.*
- [7] Wang,L., Chen,Y.,Wang,C. and Wang,Q.(2011), "Fatigue Life Analysis of Aluminium Wheels by Simulation of Rotary Fatigue Test." , *Journal of Mechanical Engineering*, pp 31-39.
- [8] Rao,T.,Deepti,K. and Rao.K.(2014), "Design & Optimization of a Rim Using Finite Element Analysis.", *International Journal of Computational Engineering Research*, ISSN (e): 2250 – 3005, Vol, 04 Issue 10,pp 36-40.
- [9] Janardhan,J., Narayana R. and Kumar,V.(2014), " Radial Fatigue Analysis of An Alloy Wheel." , *International Journal of Engineering Research and Application*, ISSN 2248-9622, Vol.4,Issue 12,pp 253-258.
- [10] Sharma,T.,Shrivastava,M. and Jayaswal,P.(2013) "Failure Analysis of Wheel Rim", *International Journal of Automobile Engineering Research and development* ,ISSN 2277-4785, Vol. 3, Issue 1, pp 97-106.
- [11] Jadhav, S.G. and Jape. R.(2016), "CAD Modeling and FEA Analysis of Wheel Rim for Weight Reduction", *International Journal of Scientific Engineering and Research*, ISSN2321 3361, Vol.6, Issue 6, pp 7404-7411.
- [12] Shrivastava,P.,Chouksey,S. and Srivastava,S. (2016) " Implementation & Failure Analysis of Steel Wheel Used By Finite Element Method", *Accent Journal of Economics Ecology and Engineering*, ISSN -2456-1037, Vol.01,Issue03,pp 01-08.
- [13] Janardhan.J.(2014)," Radial Fatigue Analysis of An Alloy Wheel." *International Journal of Scientific Engineering and Research* ISSN: 2248-9622, Vol. 4, Issue-12(Part-6), pp.253-258.
- [14] Shrivastava,P.(2016), " Implementation and Failure Analysis Of Steel Wheel Used By Finite Element Method", *International Journal of Scientific Engineering and Research*, Vol.-01, Issue-03,pp-256-270.