Analytical and Experimental Investigation of Natural Frequency by Vibration of Optimized Alloy Wheel

S. L. Sathe[1], *R.D. Kulkarni*[2] *A.B.Ghalke*[3]

[1] *PG Student* [2] *Assi.Professor.,* [3] *Asso.Professor*

Department of Mechanical Engineering, COE, Osmanabad, Maharashtra, India

Abstract

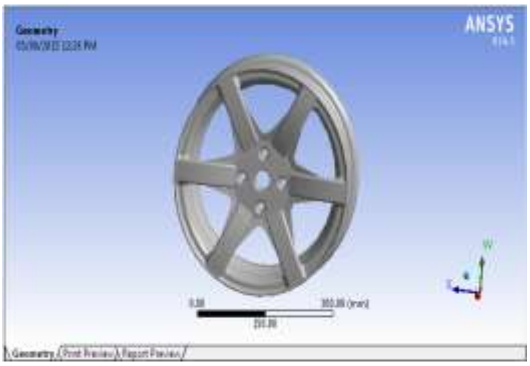
Alloy wheels differ from normal steel wheels because of their lighter weight, which improves the steering and the speed of the car. Alloy wheels will reduce the unstrung weight of a vehicle compared to one fitted with standard steel wheels. The benefit of reduced unstrung weight is more precise steering as well as a nominal reduction in fuel consumption. The weight of a vehicle is one of the most important factor that affecting the fuel economy. At present four wheeler wheels are made of Aluminum Alloys, Alloy is an excellent conductor of heat, improving heat dissipation from the brakes, reducing the risk of brake failure under demanding driving conditions. This study consists in to two major sections, Experimental and Analytical Analysis, are used to study alloy wheel. Among this experimental method be the most precise in determining resonance frequencies and vibration modes by the electrodynamics vibration shaker.

The Finite Element Method software package and experimental is used for vibration analysis of alloy wheel with the constraint condition applied on wheel by free-free analysis or wheel is clamped to machine base with help of nut and bolt arrangement doesn't make difference and assume to be same for obtained the different parameters such as natural frequency and mode shapes. The wheel design should be optimized by considering fundamental attributes of a light commercial vehicle such as NVH and Durability. The analytical and experimental results were obtained for base model and optimized model separately and finally compared. The results of FEA, experimental with the NVH Attribute for natural frequencies and vibration modes of an optimized alloy wheel are get matched and validated.

Keywords: *Alloy Wheel***,** *FEA, Electrodynamics vibration Shaker, NVH.*

1. INTRODUCTION

Alloy wheels are automobile wheels which are made from an alloy of aluminum or magnesium metals or sometimes a mixture of both. Alloy wheels differ from normal steel wheels because of their lighter weight, which improves the steering and the speed of the car. Alloy wheels will reduce the unstrung weight of a vehicle compared to one fitted with standard steel wheels. The benefit of reduced unstrung weight is more precise steering as well as nominal reduction in fuel consumption. Alloy is an excellent conductor of heat, improving heat dissipation from the brakes, reducing the risk of brake failure under demanding this collecting data from reverse engineering Process from existing model. Driving conditions. At present four wheeler wheels are made of Aluminum Alloys. In Design change proposal in order to reduce weight of wheel in this section, design change proposals will be given in order to reduce wheel weight and these proposals will be investigated for durability and NVH considerations. In order to avoid undesired interior noise the natural frequency of the wheel should be higher than 350 Hz since this value is considered as critical frequency. Moreover, durability availability will be checked on defined condition in SAE J328. 5 mm metal removing has been applied by to the areas that black colored and marked with in the oval shape. Metal removing has been applied in order to reduce weight.



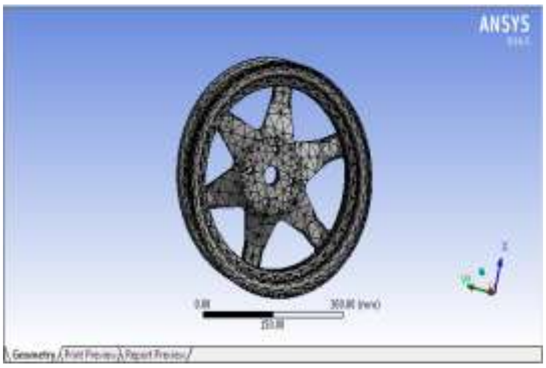


Fig.2.1 3D Model of Base Model Wheel

Fig.2.2 Fine Meshing for Base Model

2.1 MODAL RESULTS OF BASE MODEL

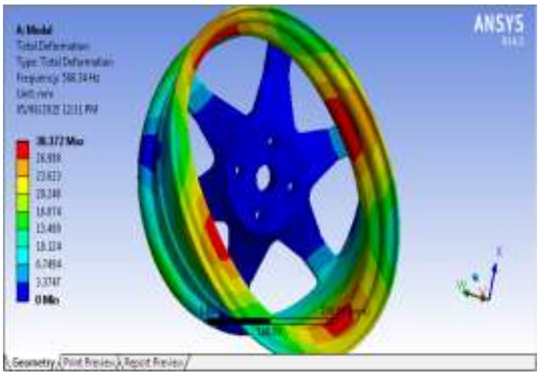


Fig.2.3 Total Deformation 1

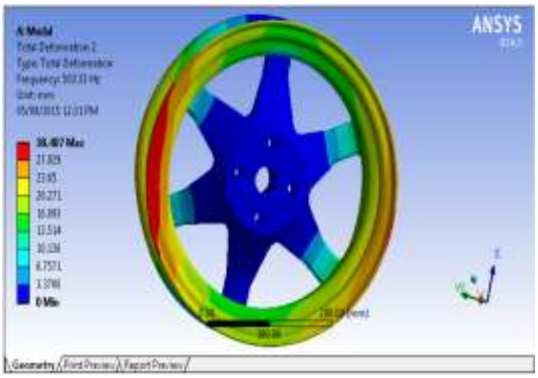


Fig.2.4 Total Deformation 2

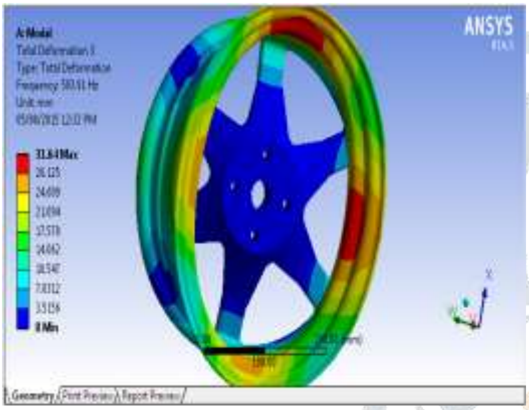


Fig.2.5 Total Deformation 3

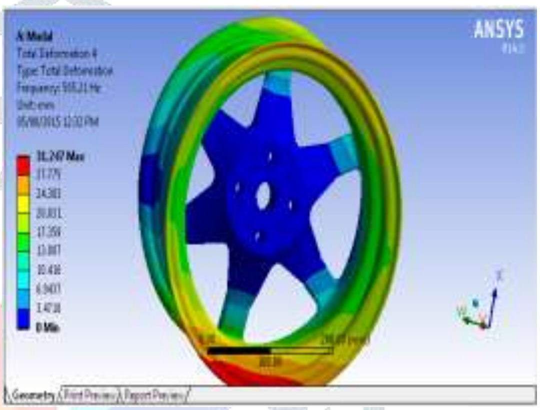


Fig.2.6 Total Deformation 4

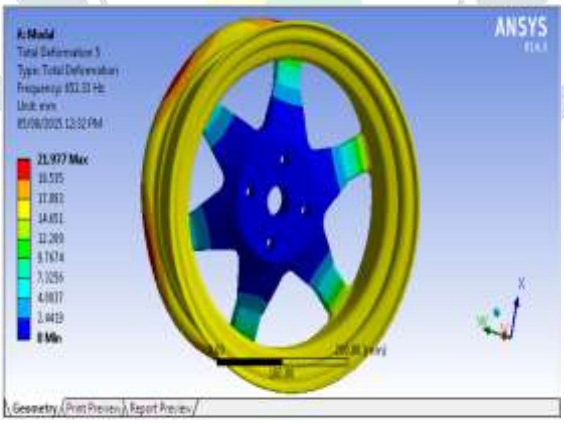


Fig.2.7 Total Deformation 5

2.2 WEIGHT REMOVAL OF WHEEL

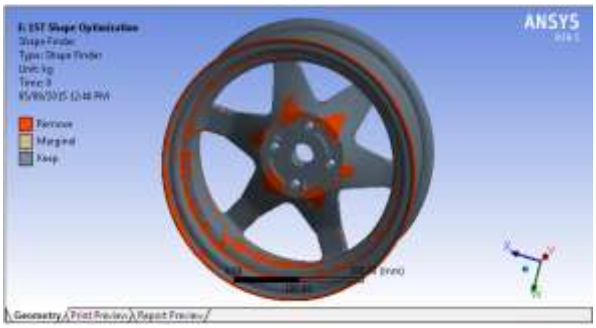


Fig.2.8 Shape Optimization of Alloy Wheel

Results	
Original Mass	7.0462 kg
Marginal Mass	1.6009 e-002 kg
Optimized Mass	6.5626 kg

Table 2.1 Results of weight optimization(12% Standard)

3. NVH EVALUATION FOR WEIGHT REDUCTION PROPOSAL

Noise, Vibration, Harshness Consideration.

[1] In order to avoid undesired interior noise the natural frequency of the wheel should be higher than 350 Hz

[2] Since this value is considered as critical frequency

Fig.3.1 3D Model of Optimized Model Wheel

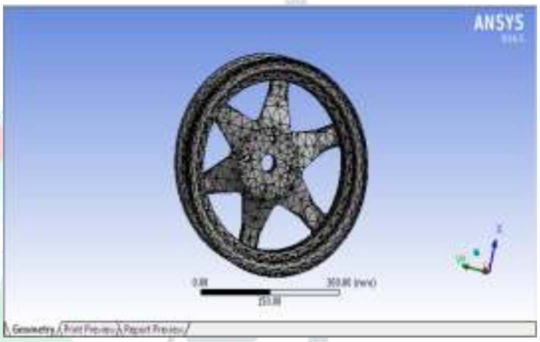


Fig.3.2 Fine meshing for optimized wheel

3.1 Modal Results of Modified Model

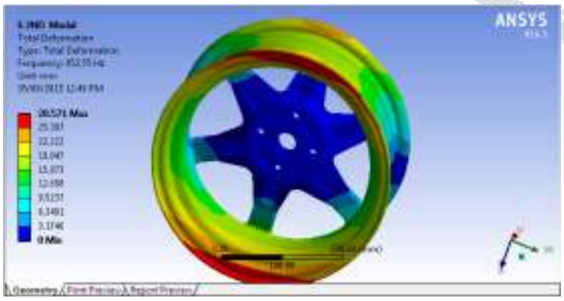


Fig.3.3 Total Deformation 1

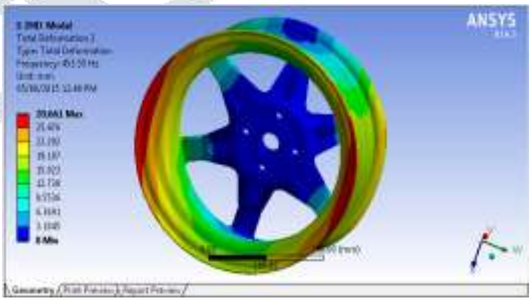


Fig.3.4 Total Deformation 2

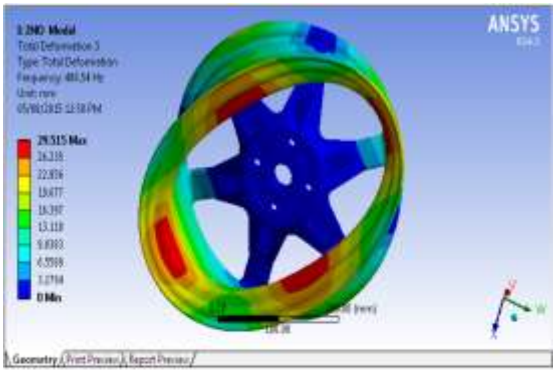


Fig.3.5 Total Deformation 3

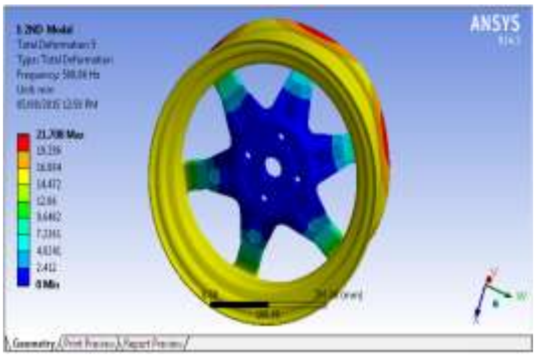


Fig.3.6 Total Deformation 4

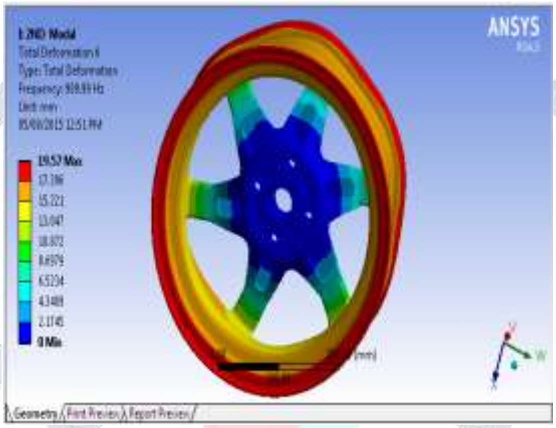


Fig.3.7 Total Deformation 5

4. EXPERIMENTAL WORK

4.1 Experimental Setup for Alloy Wheel

To know resonance natural frequency special purpose machine was used for Electrodynamics Vibration Shaker. The experimentation for alloy wheel is carried out using an Electrodynamics Vibration Shaker. The wheel is held in position with other operating conditions identical to the application.

Test Conditions are Resonance Search from 50Hz to 750Hz, Acceleration 1g.

Device under test mounted on 4 holes to the shaker table. Control accelerometer mounted with adhesive on shaker table. Monitor accelerometer mounted on device under the test with adhetive.controling and monitoring is done with vibration controller. The Experimental set up of alloy wheel is as shown in figure below

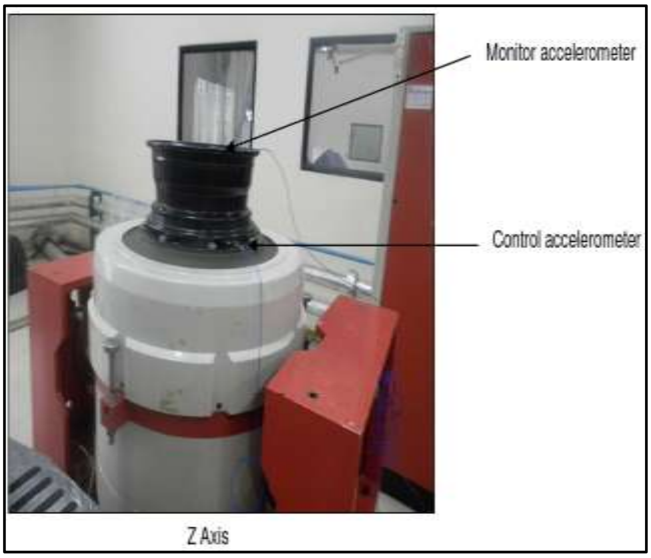
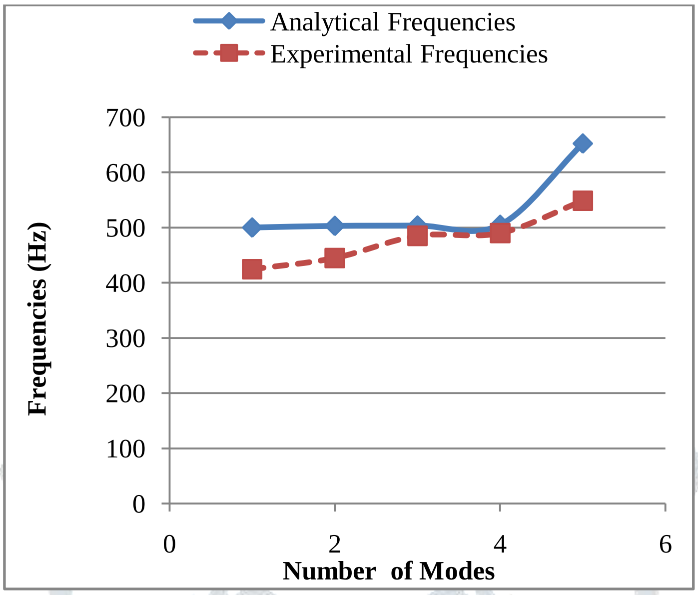


Fig 4.1 Electro dynamic vibration shaker

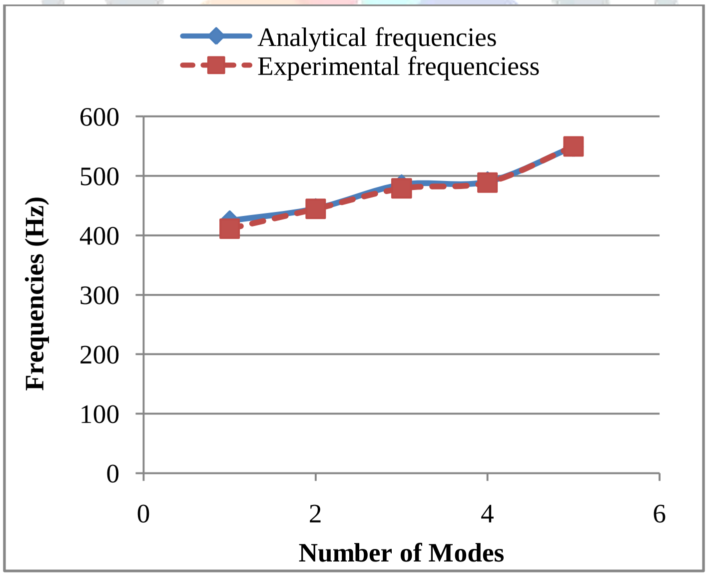
5. RESULT AND DISCUSSION

5.1 Natural Frequencies of FEA and Experimental of Case 1st for Base Model



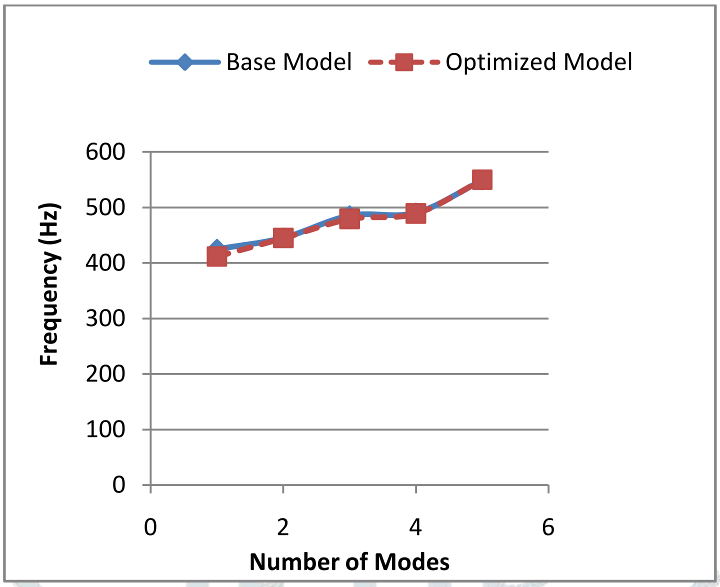
Graph 5.1 Number of Modes Vs Frequency

5.2 Natural Frequencies of FEA and Experimental of Case 2nd for Optimized Model



Graph 5.2 Number of Modes Vs Frequency

5.3 NVH Evaluation for weight Reduction Proposal Comparison between Base Model and Optimized Model



Graph 5.3 Number of Modes Vs Frequency

6. CONCLUSION

14 Hz frequency has been sacrificed from first natural frequency. Since first natural frequency decreased 411 Hz, still greater than 350 Hz which is interior noise limit, this proposal is acceptable from NVH point of view.

The fundamental natural frequency of light commercial vehicle wheel representing the dynamic behavior of real structure is 424.88 Hz.

Also, the proposal is acceptable durability point of view. By using this opportunity nearly 500gm per wheel and 2 kg and 7% per vehicle weight reduction have been gained in this study.

REFERENCES

[1] Liangmo Wang - Yufa Chen - Chenzhi Wang - Qingzheng Wang Fatigue Life Analysis of Aluminum Wheels by Simulation of Rotary Fatigue Test Journal of Mechanical Engineering 57(2011)1, 31-39

[2] R. Kh. Makaeva, A. M. Tsareva, and A. Kh. Karimov Determination of Natural Frequencies and Vibration Modes of a Constant Thickness Centrally Secured Disk ISSN 1068-7998, Russian Aeronautics (Iz.VUZ), 2008, Vol. 51, No. 1 pp. 53–59.

[3] Ichiro kido and sadgiri ueyama Coupled vibration analysis of tire wheel for road noise improvement

[4] M. Yaman, B.Yegin a Light Commercial Vehicle Wheel Design Optimization for Weight, NVH and Durability Considerations 5th ANSA & μETA International Conference

[5]Daniel M.Harris,JohnW.M.Bush Generating uniaxial vibration with an electrodynamic shaker and external air bearing http://dx.doi.org/10.1016/j.jsv.2014.09.015 0022-460X/& 2014 Elsevier Ltd. All rights

[6] M. A. Peres1, R. W. Bono1, D. L. Brown Practical Aspects of Shaker Measurements for Modal Testing Proceedings of Isma2010 Including USD2010 pp 2539-2550

[7] S.Ganesh1, Dr.P.Periyasamy2 Design and Analysis of Spiral Wheel Rim for Four Wheeler the International Journal of Engineering and Science (IJES), Volume3, Issue4, pp 29-37, 2014