Analysis and Weight Optimization of Aluminum Alloy Wheel By Consideration of Natural Frequency of NVH Limit

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Abstract: To improve the quality of aluminum wheels, a new method for evaluating the natural frequency of vibration of aluminum wheels is proposed in this paper. The ANSYS software was used to build the static load finite element model of aluminum wheels for simulating the Vibration test. For natural frequency of vibration we used to fixed the aluminum alloy wheel at bolting and take natural frequency test in ANSYS as well as in practical also.

I. INTRODUCTION

Alloy wheels were first developed in the last sixties to meet the demand of racetrack enthusiasts who were constantly looking for an edge in performance and styling. It was an unorganized industry then. Original equipment manufacturers soon realized that a significant market opportunity was being lost as car owners were leaving car show rooms with stock wheels and driving down to a dealer for fitment with high priced custom alloy wheels. Since its adoption by OEM's, the alloy wheel market has been steadily growing. Today, thanks to a more sophisticated and environmentally conscious consumer, the use of alloy wheels has become increasingly relevant. Tried and wheels on the race tracks, off-road and cross country, under some of the toughest road-conditions, alloy wheels are now considered the de-facto standard for many world cars. With this increased demand came new developments in design, technology and manufacturing processes to produce a superior with a wide variety of designs.

The key to an alloy wheel is the quality of the casting. The casting integrity depends on the process used. Wheels have been made using various casting techniques such as sand casting, gravity die casting, centrifugal, squeeze and low pressure die casting. Sand and gravity castings are less controllable operations and have problem with blow holes and shrinkages. Hence these wheels are generally not preferred by international OEMs. Centrifugal and squeeze casting yields a good quality wheel, but have the disadvantage of being unable to manufacture non-axis metric design wheels. As such this technology has not become popular. Low pressure die casting allows precise control during the casting and cooling cycle. Significantly reducing cavities, porosity and uneven shrinkage. This technology is amenable to large scale production and automation, and is today considered as the state of the art technology for manufacture of alloy wheels. Low pressure die casting is incorporated by most of the world's leading OEM suppliers.

II. METHODOLOGY

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.

1. Study of literature for alloy wheel.
2. Study of weight optimization method.
3. Study of original alloy wheel with all dimension and material property by using CMM.
4. 3D modeling of alloy wheel in CATIA
5. Finding a natural frequency of original alloy wheel by using ANSYS(NVH – 350Hz)

6. Natural frequency of alloy wheel more than 350Hz then apply weight optimization method.
7. Apply all forces and moment to wheel
8. Weight optimization by using ANSYS
9. Finding best wheel from three optimize wheel
10. Finding natural frequency of new alloy wheel in ANSYS (NVH- 350Hz)
11. If is safe then manufacture new alloy wheel
12. Finding natural frequency of vibration for alloy wheel by using magnetic vibration machine.

III. RESULT AND DISCUSSION

Fig1. 3D model of Original Alloy wheel

Finite element analysis to calculate natural frequency of vibration

Based on the wheel dynamic natural frequency of vibration, the finite element models of automotive wheels under the fixed support are constructed, and the ABSYS software is used to perform the Test. In this paper, the vibration analysis was performed by using a commercial FEA software ANSYS. ANSYS is powerful engineering finite element simulation software with a library of rich elements that can be used to simulate any geometry and typical engineering properties of materials. The software provides solutions to problems ranging from relatively simple linear analysis to many complex non-linear problems.

IV. WHEEL MESHING

When the wheel is meshed, in estimated data change gradient big spot, it needs to adopt more intensive grid to better reflect the changes of data. In the wheel hub, the danger zones are rim, junction with rim and rib, and the areas around bolt hole. Shown in the fig.2.

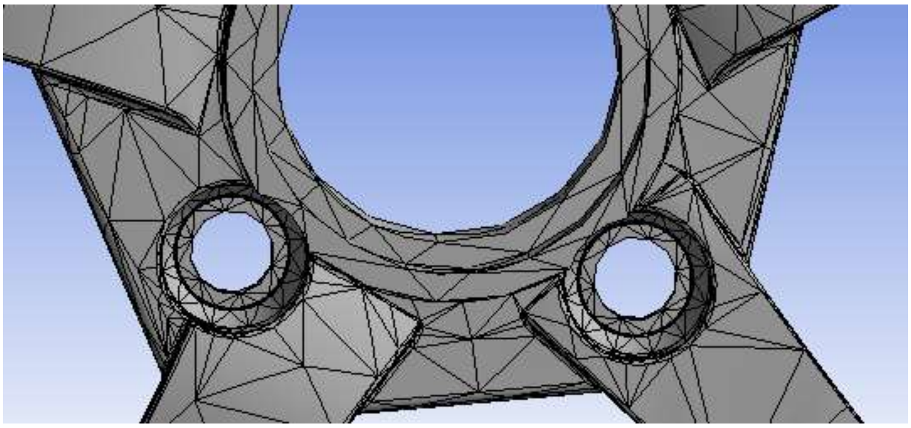


Fig.2. Meshing of Alloy wheel

V. ANSYS RESULT

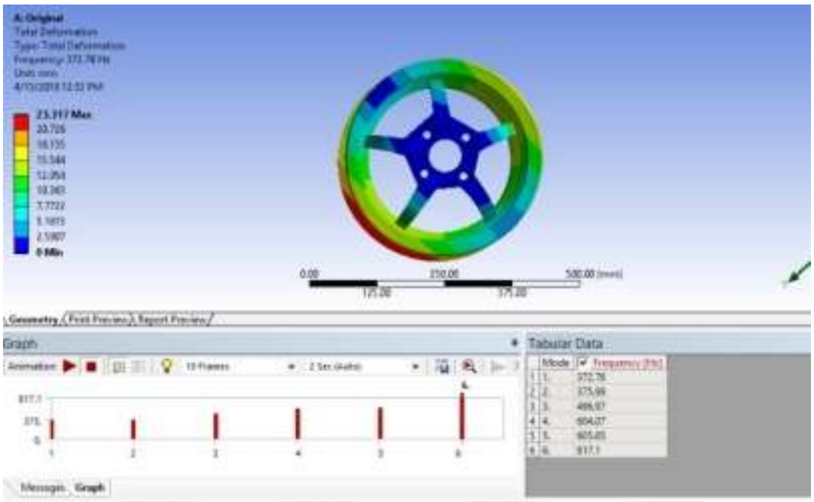


Fig.3. Original Alloy wheels Results.

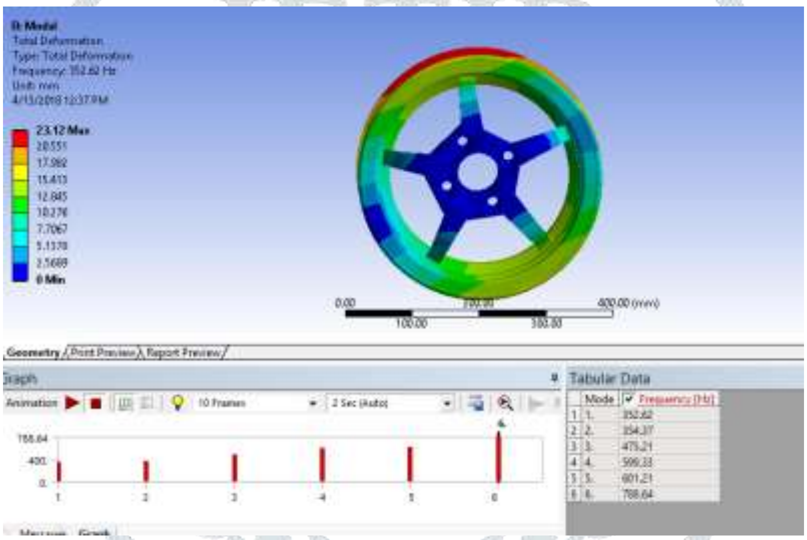
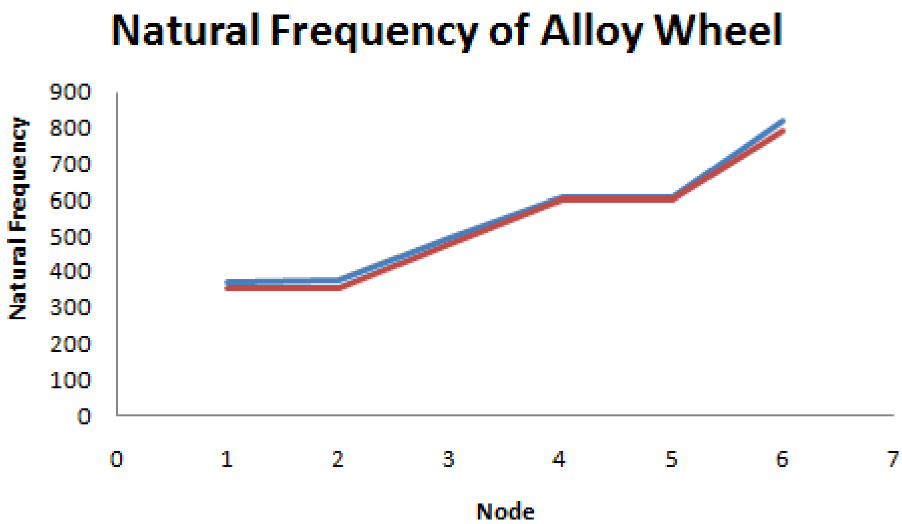


Fig.4. New Alloy wheel Result

Comparison of both alloy wheels natural frequency of vibration result show in the below graph.



VI. PRACTICAL ANALYSIS

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 adhesive. Controlling and monitoring is done with vibration controller.

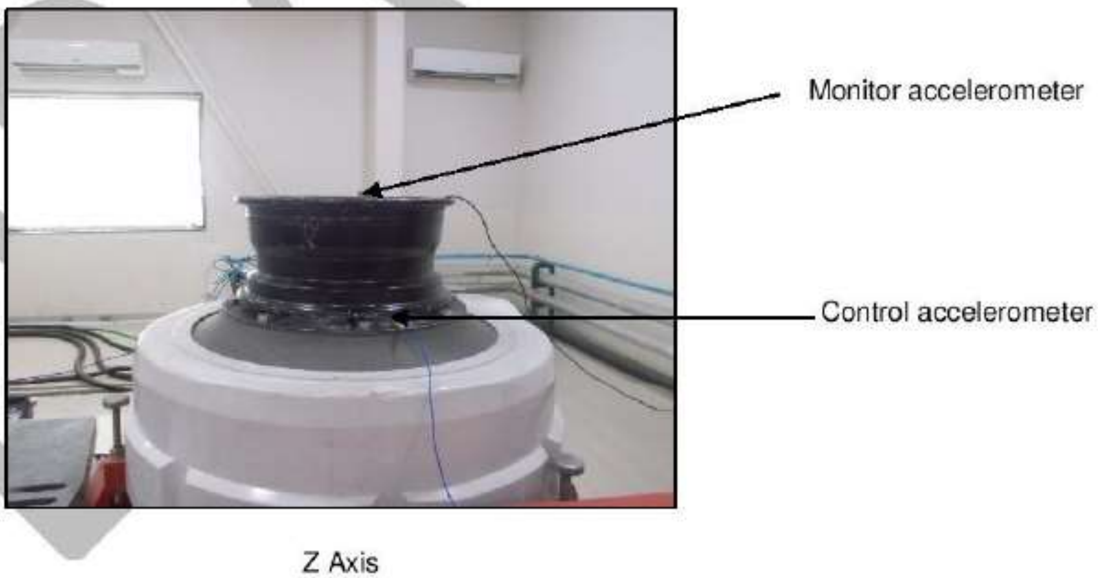


Fig.5. Practical setup of Vibration Analysis.

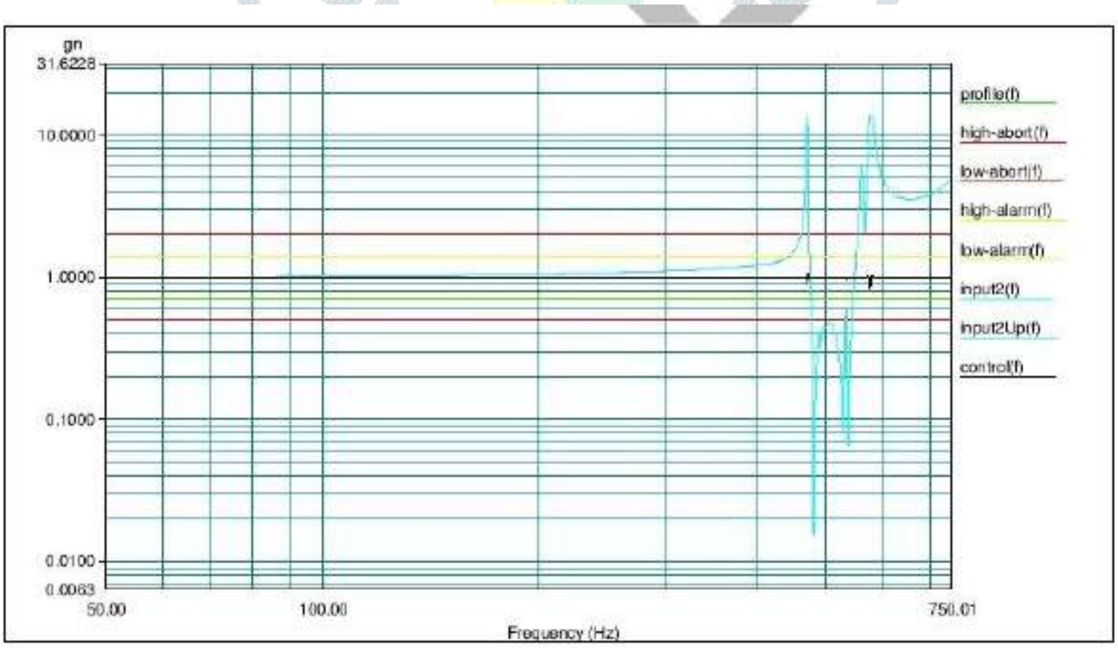


Fig.6. Practical result of vibration analysis.

VII. RESULTS

Sr. No.	Type	ANSYS	Practical
1	Original	372.76	380.66
2	New	352.62	358.63

VIII. CONCLUSION

22 Hz frequency has been sacrificed from first natural frequency. Since first natural frequency decreased 380.66 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 380.66 Hz. Also, the proposal is acceptable durability point of view. By using this opportunity nearly 500gm per wheel and 7% per vehicle weight reduction have been gained in this study.

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