# *Finite Element Analysis of an Automobile Wheel Disc*

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***Abstract:*** *Unwanted vibration associated with the wheel in passenger automobiles has become an important economic and technological problem in the industry. Improved understanding of disc vibration through research papers offers one opportunity for targeted improvements in wheel structural parameter [1]. Wheel disc vibrations are known to involve structural coupling between various components. Depending on the frequency range of interest, the hydraulic system, body panels, steering column, and other vehicle components can also become active. In an aggregate sense, the disc wheel exhibit sufficient vibration. This paper focused on investigation of effect of structural parameter like number of holes for bolting on natural frequency of wheel disc with the help of FEA (ANSYS).*

*Keyword* - ***Finite element analysis (FEA), Disc.***

## I. INTRODUCTION

The knowledge of natural frequencies of component is of great interest in the analysis of response of structures to various excitations. The study of the dynamic behaviour of annular plates with radial cracks is important, as several machine components, such as flywheels, clutch plates, circular saw plates can be considered as annular plates with radial cracks for the purpose of analysis [2].Unwanted vibration associated with the wheel in passenger automobiles has become an important economic and technological problem in the industry. Many researchers worked on analysis of disc part [3, 4] but there is no such work on modal analysis of an auto rickshaw wheel disc. Hence it is an important to know effect of structural parameter like disc hole on wheel disc natural frequency when it reduces from four to three.

Modal analysis is a technique to study the dynamic characteristics of a structure under vibrational excitation. Natural frequencies, mode shapes of a structure can be determined using modal analysis. Modal analysis allows the design to avoid resonant vibrations or to vibrate at a specified frequency and gives engineers an idea of how the design will respond to different types of dynamic loads. The wheel disc of an automobile is one such structure whose dynamic characteristics can be better studied by modal analysis. In proposed work, show modal analysis of wheel disc of auto rickshaw by using FEA method. In which find out natural frequency and mode shapes of auto rickshaw wheel disc. Figure 1 shows actual wheel disc.

**Fig -1 Actual wheel disc**

## II. MODAL ANALYSIS USING FEA

### Introduction to FEA

Finite element analysis is a numerical procedure that can be used to obtain solution of large class of engineering problem involving modal analysis, stress analysis, heat transfer etc. Clear understanding of the basic concepts will enable to use a general purpose of finite element software such as ANSYS. Modal analysis is a very important technique which helps in determining the natural frequencies as well as mode shapes of a structure. In this study modal analysis of an automobile wheel disc is carried out in ANSYS apdl and first five natural frequency and mode shapes of vibration are extracted for inner edge clamped and outer end is free boundary conditions. The mode shapes are observed which provide a comprehensive picture of deformation occurring.

Vibration analysis of an automobile wheel disc is done by FEM (ANSYS) software to get natural frequencies and mode shapes of wheel disc with same aspect ratio but variable structural parameter.

### Modal analysis of wheel disc with thickness 3.2 mm and 4 holes for bolting

Wheel disc of auto rickshaw is modelled using CATIA part design tool. Element that used in this analysis is elastic 4 node 181. This element is suitable for analyzing thin to moderately thick shell structure. It is four node element having six degrees of freedom at each node. In this case material of the disc is mild steel having Young's Modulus 210 MPa, Density 7850 kg/m$^3$ and Poisson's ratio is 0.3.The analysis being linear modal and complete subassembly is made of the same material. The technique used for meshing is free mesh with smart sizing technique and select a refinement level. Figure 2 shows meshed model of wheel disc.

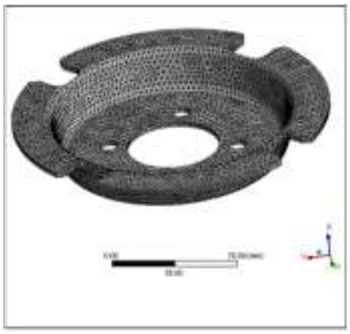


**Fig-2 Meshed model of wheel disc**

Modal analysis determines the vibration characteristics (natural frequencies and mode shapes) of a wheel disc. Boundary condition used that inner edge fixed and outer edge is free and bolt holes are constrained in all degree of freedom. Table 1 contain natural frequency of wheel disc of thickness 3.2 mm and 4 holes for bolting. Figure 3 to 7 shows respective mode shapes of wheel disc.

**Table-1 Natural frequency of wheel disc with thickness 3.2 mm and four holes for bolting**

| Sr. No. | Mode | Natural frequency (Hz) |
|---|---|---|
| 1 | 1st | 777.7 |
| 2 | 2nd | 971.39 |
| 3 | 3rd | 1106.9 |
| 4 | 4th | 1108.0 |
| 5 | 5th | 1673.6 |

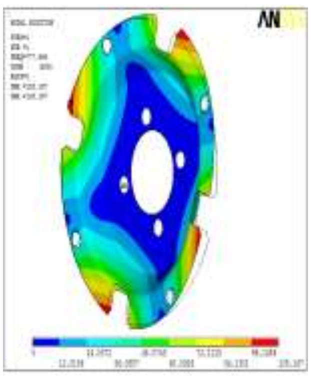


**Fig-3 First mode shape**

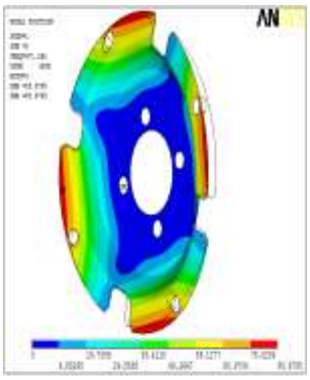


**Fig-4 Second mode shape**

Figure 3 and 4 shows first and second mode shapes of wheel disc and there natural frequency values are 777.7 Hz and 971.39 Hz respectively.

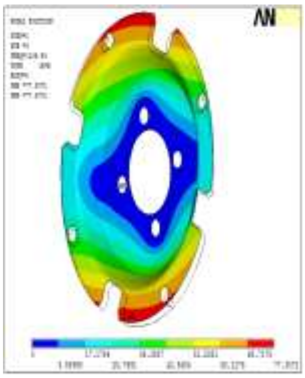


**Fig-5 Third mode shape**

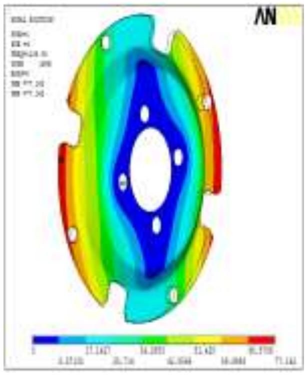


**Fig-6 Fourth mode shape**

Figure 5 and 6 shows third and fourth mode shapes of wheel disc and there natural frequency values are 1106.9 Hz and 1108.0Hz.

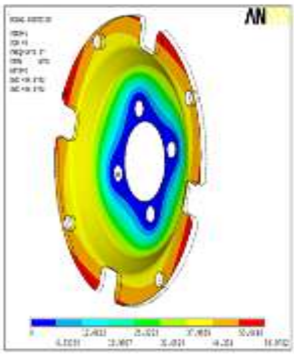


**Fig-7 Fifth mode shape**

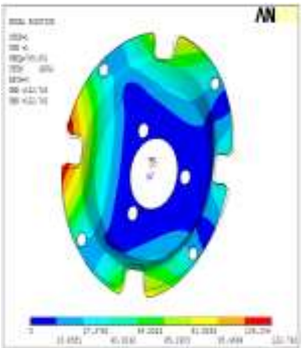
Figure 7 shows fifth mode shape of wheel disc and its natural frequency value is 1673.6 Hz.

**Modal analysis of wheel disc with thickness 3.2 mm and 3 holes for bolting**

For modal analysis of wheel disc with 3 holes, the boundary condition is used that inner edge is fixed and outer edge is free and bolt holes are constrained in all degree of freedom. Table 2 contain natural frequency of wheel disc of thickness 3.2 mm and 3 holes for bolting. Figure 8 to 12 shows respective mode shapes of wheel disc.

**Table-2 Natural frequency of wheel disc with three bolting holes and thickness 3.2 mm**

| Sr. No. | Mode | Natural frequency (Hz) |
|---|---|---|
| 1 | 1st | 705.83 |
| 2 | 2nd | 765.36 |
| 3 | 3rd | 1053.6 |
| 4 | 4th | 1069.4 |
| 5 | 5th | 1467.3 |



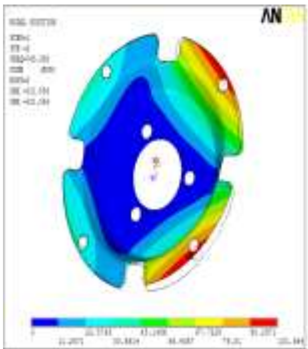
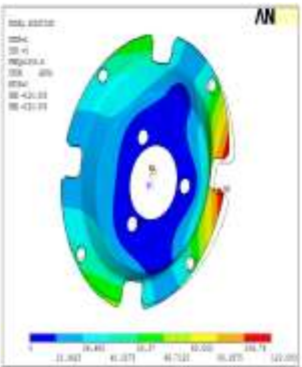


**Fig-8 First mode shape** **Fig-9 Second mode shape**

Figure 8 and 9 shows first and second mode shape of wheel disc of 3 holes and there natural frequency values are 705.83 Hz and 765.36 Hz.



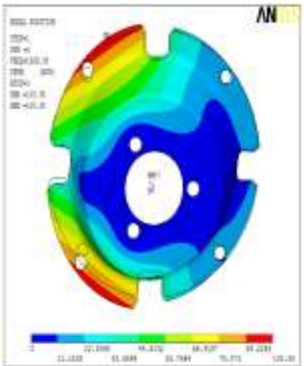


**Fig-10 Third mode shape** **Fig-11 Fourth mode shape**

Figure 10 and 11 shows third and fourth mode shape of wheel disc of 3 holes and there natural frequency values are 1053.69 Hz and 1069.4 Hz.

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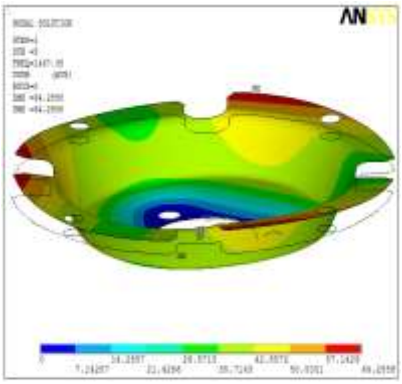

**Fig-12 Fifth mode shape**

Figure 12 shows fifth mode shape of wheel disc of 3 holes and its natural frequency value is 1467.3 Hz.

## III.PERFORMACE ANALYSIS

### Introduction

In performance analysis the results obtained from FEA analysis is compared to reach the conclusion. Differences in results are compared for same ratio of the inner to outer diameters, but different number of holes for bolting of wheel disc at inner edge clamped and outer edge free boundary condition. From comparison of results it clearly show that natural frequency reduced when structural parameter is changed that from 4 hoes to 3 holes. Comparison of vibration results of natural frequencies is shown in table 3 and figure 11 below.

**Table-3 Comparison of FEA results by reduction in wheel disc hole**

| Sr. No. | Natural frequency (Hz) wheel disc with 4 holes | Natural frequency (Hz) Wheel disc with 3 holes |
|---|---|---|
| 1 | 777 | 705.83 |
| 2 | 971 | 765.36 |
| 3 | 1106 | 1053.6 |
| 4 | 1108 | 1069.4 |
| 5 | 1676 | 1467.3 |

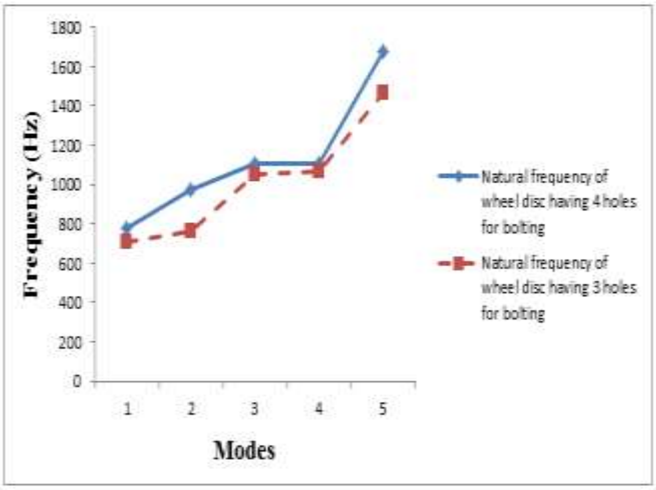


**Fig-13 Comparison of FEA results by reduction in wheel disc holes for bolting from 4 to 3**

## IV.CONCLUSION

The FEA results clearly shows, the difference in mode shapes of wheel disc with four and three holes for bolting. Mode shapes are deformed differently with respective frequencies of four and three holes of wheel disc. Natural frequency of wheel disc is directly proportional to the number of wholes for bolting.

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