Optimization of a Braking Rotor of Two Wheeler Using ANASYS

Mr. Nitin Meghraj Gaikwad, Asst. Prof. Surendra C. Patil
PG Student, Assistant Professor
Department Of Mechanical Engineering
Shri Shivaji Institute of Engineering & management studies
Parbhani, Maharashtra, India.

Abstract— Abstract— **The knowledge of natural frequencies of components is of great interest in the study of response of structures to various excitations. Hence a brake disc plate with central hole, fixed at inner edge and free at outer edge is chosen and its dynamic response is investigated. The objective of current dissertation work is to analyze the vibration characteristics as natural frequency, mode shapes of brake disc with different dia. of cooling holes, weared thickness & enlarged bolt hole diameter but with same ratios of inner to outer radius for inner edge clamped and outer edge free boundary condition. FEM software package is used for vibration analysis of brake discs with same conditions .Thus, results obtained are to be compared. This thesis deals experiences on finding natural frequency and the mode shape of disc brake. The disc brake is modeled using commercial computer aided design (CAD) software, Ansys.**

Index Terms—**Brake Disc, Natural Frequency, ANSYS 12.0, Mode Shape. FEM Analysis.**

INTRODUCTION

Disc brake noise and vibration are known to involve structural coupling between such components as the rotor, pads, caliper, and knuckle. 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 brakes of only a few percent of new vehicles exhibit sufficient noise and vibration to generate significant customer complaints, but the volume and expense of remediation efforts, in addition to the perception of reduced product-line quality, place pressure on brake noise and vibration.

An acute problem is called as “squeal" noise, which is typically defined as that occurring within the range 1.5 to 20 kHz at one or more of the rotor's natural frequencies and its harmonics. For ventilated and solid core designs, rotors have the distinction of being structural elements, members of the disc-pad friction pair, and efficient radiators of sound because of their large surface area. The study of the dynamic behavior of brake disc is important, as several machine components. It can be considered as annular plates with radial holes for the purpose of analysis. This study is fundamental for high-risk plants.

In each case, the rotor comprises the “disc" element which is in frictional contact with the pads during operation, and the hat element which provides the geometric offset necessary for mounting the rotor to the vehicle. The thickness, inner and outer diameter of the disc; and the numbers and spacing of the cooling vanes and mounting studs are some of the geometric parameters that set the rotor's natural frequency spectrum and vibration modes.

OBJECTIVES

i) To find natural frequency by FEM (Ansys software)
ii) To find mode shapes by FEM (Ansys software)
iii) Compare & conclude natural frequency & mode shape error due to optimization.

METHODOLOGY

Dissertation research papers are discussed dealing with the vibration analysis of the disc brakes which includes the increasing application of vibration analysis concepts in design has prompted researchers to gain an understanding of the dynamic behavior of structures. Here dynamic properties of brake discs are investigated using the FEM analysis software (ANSYS) and discussion of mode shapes by meshing them. Discussions on FEM results will be done here to get the conclusions as per variables applied on brake discs**.**

MATERIAL PROPERTIES AND SOLID MODELING

Brake discs of Bajaj pulsar of alloy steel is chosen for optimization with same b/a ratio i.e. aspect ratio (Inner to outer radius ratio).Following are the material properties for the specimen plates. Young’s modulus (E) = 2.1×10^{11} N/m^2 , Poisson’s ratio (γ) = 0.3, Density of material (ρ) = 5833 N/m^{3,} Specimen dimensions tabulated in table shows variables. **Aspect ratio b/a=**0.5416, **Inner diameter =**130 **mm, Outer diameter = 240mm**

Specimen	**Disc thickness at friction area**	**Dia. of hole of holding wheel hub**	**Dia. of 36 air cooling holes**
1st Disk	4	10.5	8
2nd Disk	3.20	10.5	8
3rd Disk	3.20	13	8
4th disc	3.20	13	9

Table Comparison of FEM Natural frequencies of disc brakes

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[Bajaj pulsar,Freq.Hz]			
4mm thickness (sample 1)	3.2 mm thickness (sample 2)	Disc Holder hole dia.13mm (sample 3)	Air ventilation hole dia.9mm (sample 4)
1741	1794	1741	1645
1752	1812	1752	1657
1752	1812	1753	1657
1770	1845	1761	1671
1771	1845	1771	1672
1778	1860	1778	1676
2772	2795	2771	2677
2929	2885	2929	2831
2930	2886	2930	2832
3394	3168	3394	3294

Different mode shape of annular disk brake

Mode shape of annular disk brake:-

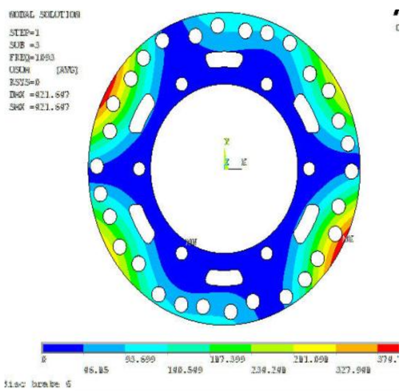

Fig. FEM mode shape (0, 2)

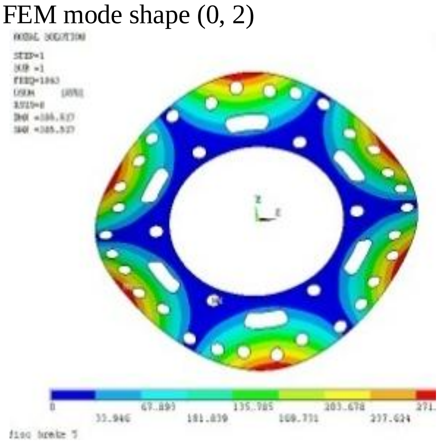

Fig. FEM mode shape (0, 3)

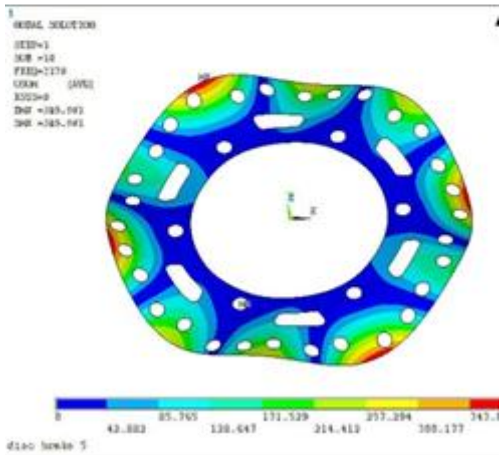

Fig. FEM mode shape (0, 10)

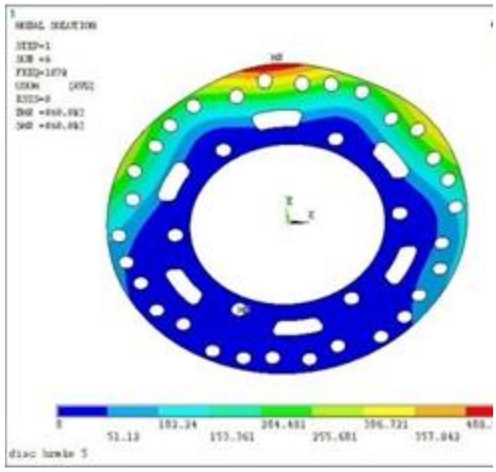

Fig. FEM mode shape (1, 0)

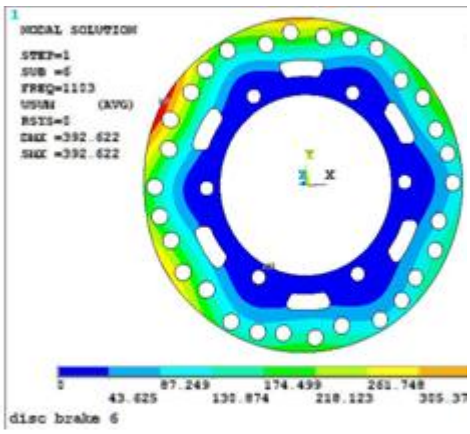

Fig. FEM mode shape (1, 0)

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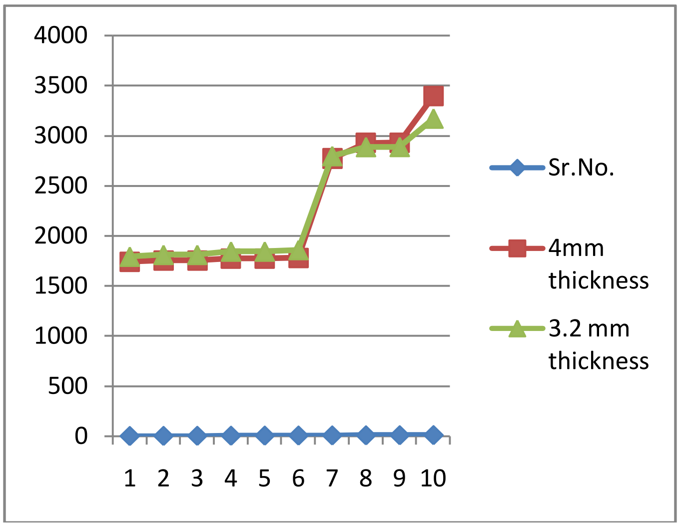
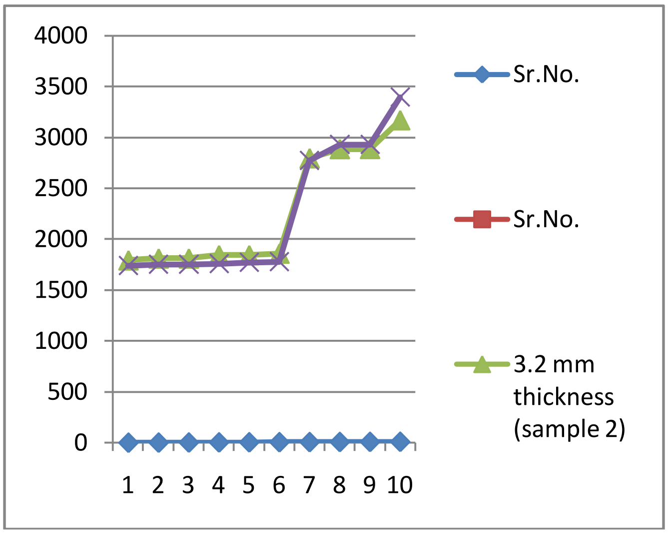
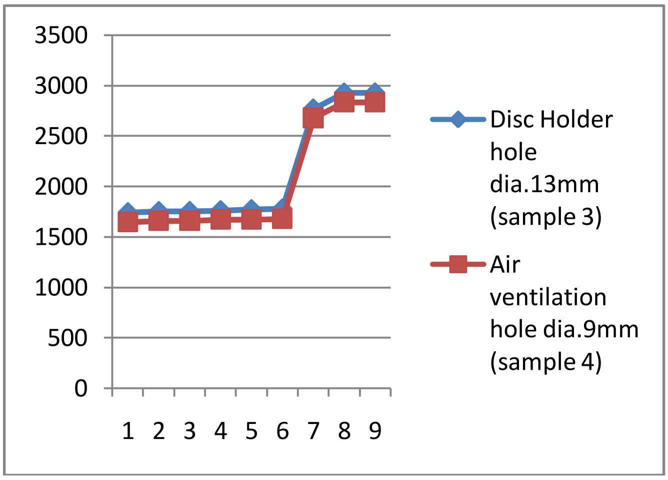


Graph Effect of wear of brake disc on FEM natural frequency.

<u>Remark:</u> Natural frequencies of disc brake of bike increases as the disc thickness decreases till first six natural frequencies.



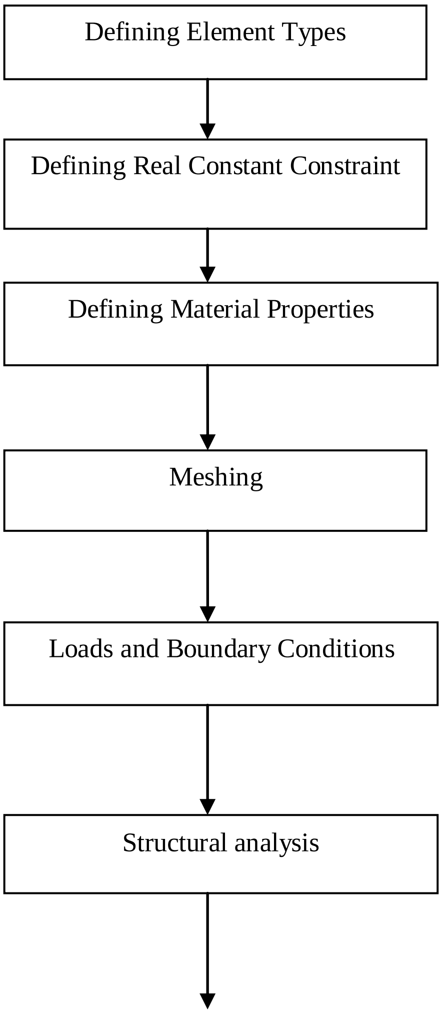
Graph Effect of increased diameter of brake disc holder hole.**<u>Remark:</u>** Natural frequencies of disc brake of bike decreases as the brake disc holder hole diameter increases



Graph Effect of increased air ventilation hole diameter on natural frequency of brake disc.

<u>Remark:</u> Natural frequencies of disc brake of bike decreases as the air ventilation hole diameter increases.

Finite Element Analysis Procedure



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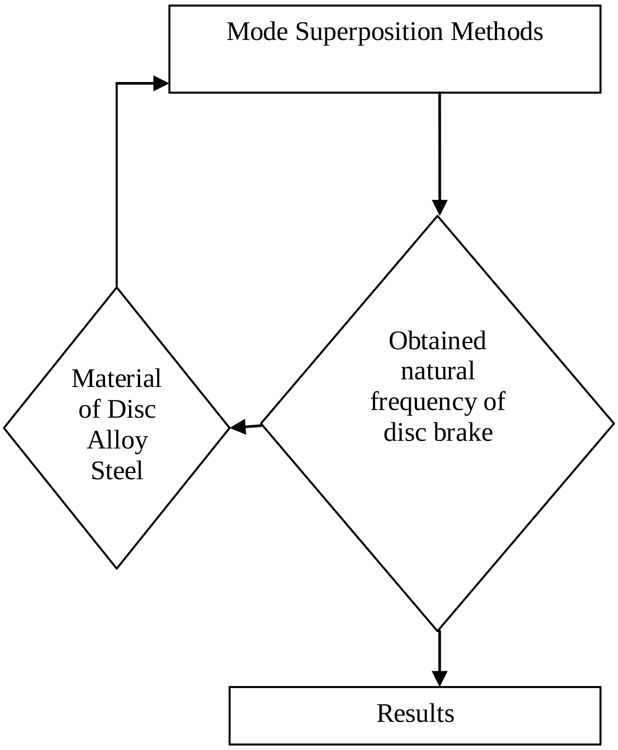

Flow Chart Of Finite Element Analysis Procedure

CONCLUSIONS

- No. of nodal diameter decreases as natural frequencies increases all the six samples of disk brakes.
- Natural frequencies of disc brake of bike increases as the disc thickness decreases
- Natural frequencies of disc brake of bike decreases as the brake disc holder hole diameter increases
- Natural frequencies of disc brake of bike decreases as the air ventilation hole diameter increases.

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FUTURE SCOPE

Although the aim of this dissertation is fulfill by finding natural frequency, mode shapes of annular brake disc with different holes & patterns with same ratios of inner to outer radius for inner edge clamped in shaft and outer edge kept free still further investigation can be carried out on dynamic behavior of disc brake such as rotor ,caliper.

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