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A RESEARCH PAPER ON SHAPE OPTIMIZATION OF CLUTCH DISC OF A PASSANGER CAR USING FEA AND IMPACT HAMMER TEST

Mr. Utpat Shriram Sureshrao
Research Scholar, Department of Mechanical Engineering,Vidya Pratishan'S Kamalnayan Bajaj Institute Of Engineering & Technology Baramati , Savitribai Phule Pune University

Mr.Dadasaheb Rupanwar
Assistant Professor and project guide, Department of Mechanical Engineering,Vidya Pratishan'S Kamalnayan Bajaj Institute Of Engineering & Technology Baramati , Savitribai Phule Pune University

Mr.Pravin Vijay Dhandore
Assistant Professor and project co-guide , Department of Mechanical Engineering,Vidya Pratishan'S Kamalnayan Bajaj Institute Of Engineering & Technology Baramati , Savitribai Phule Pune University

ABSTRACT:
This work represents the statement of computing stresses and the deformations and the vibration characteristics of a rigid clutch disc. Newer models for this rigid clutch disc has been recommended the material will remain the same however the shape of disc has been varying. The outcome of the newly recommended models has been recorded and compared with the reference model. 3D-CAD modeling of this clutch disc is created using CATIA-V5R20. The software used to determine total deformation and equivalent stress is ANSYS Version 19.0 in clutch disc. The experimental enquiry has been done by using the strain gauge process and the UTM. Relative analysis of FEA & Data-based results are carried out for the validation of work.

INTRODUCTION
A common application of the clutch is in automotive vehicles where it is used to connect the engine to the gearbox. It acts as a mechanical connection between the engine and the transmission; it concisely disconnects the engine from drivetrain to smoothly change gears. In simple terms we can say that clutches links and di-links two rotating shafts. The research work to be carried out requires a comprehensive survey of literature to know and gain knowledge about recent studies and researches carried out in the said area.

OBSERVATION THROUGH LITERATURE SURVEY
The literature review helped in setting the hypothesis for the research work and to quantify the proposed methodology of the work.

METHODOLOGY
1. Literature Survey
2. Identification of Need
3. Solid Modeling of Component
4. Software analysis of the Component
5. Fabrication of Component
6. Experimentation of Component
7. Validation of Idea

3D Modeling Of Clutch Disc
3D modeling has been carried out in CATIA-V5R20 figures below shows the representation of the disc and plate modeling carried out for the analysis purpose.

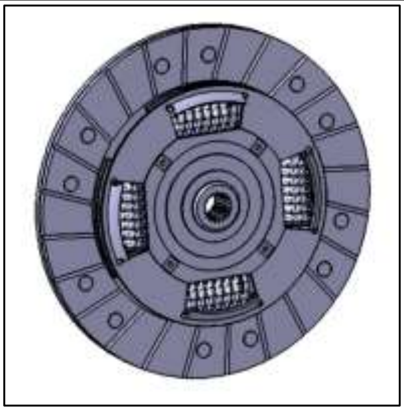


Fig. Clutch disc

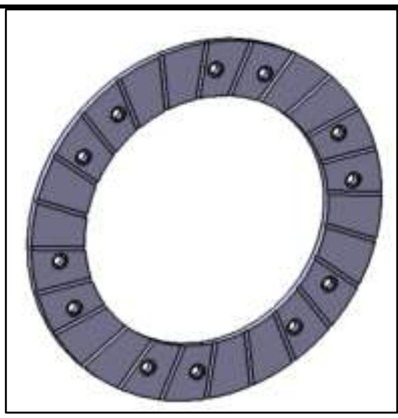


Fig. Friction plate

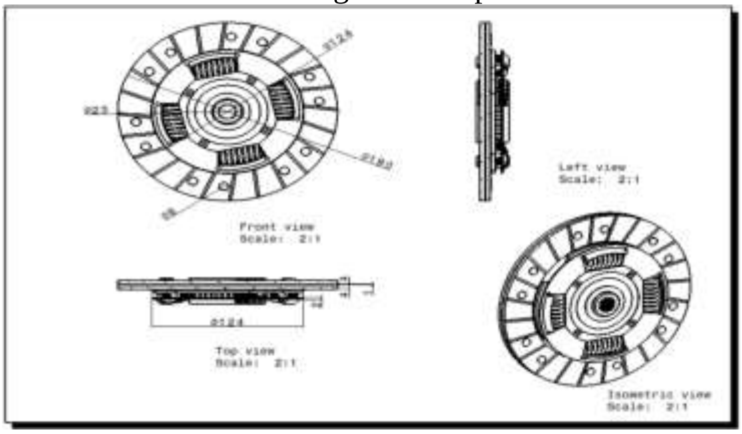


Fig. Drafting of cad model

Modal Analysis Of Existing Clutch Disc:

The next step in research is to carry out the analysis part of the component, it has been done using ANSYS 19.0 and figures below shows the analysis results.

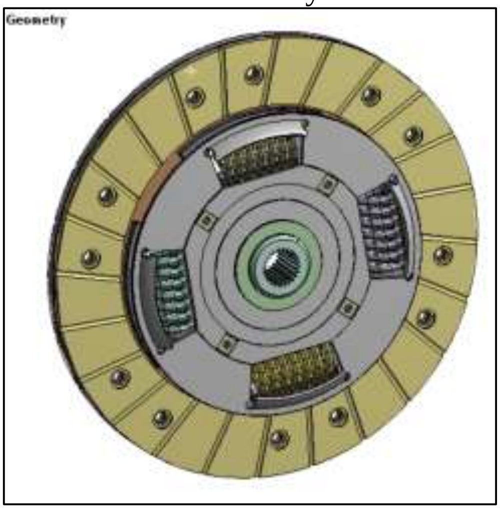


Fig. Existing clutch disc

Nodes	281803
Elements	141740

Fig. Meshing details

Boundary Condition-

A boundary condition for any model is the set of a familiar amount for the displacement or an associated loading. For a particular node researcher will be capable to set either load or displacement but not both. The principal kinds of loading available in FEA include the force, the pressure and the temperature. These can be applied to the points or surfaces or the edges or nodes and the components or distantly offset from the feature. The figures below shows the modal analysis of different shapes.

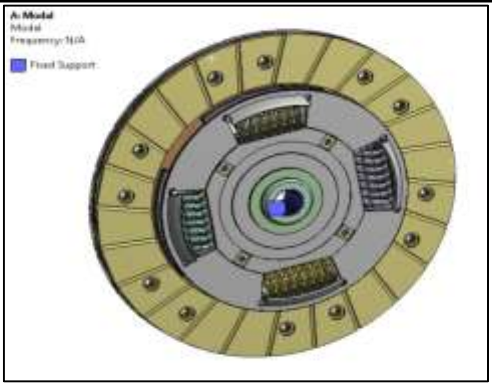
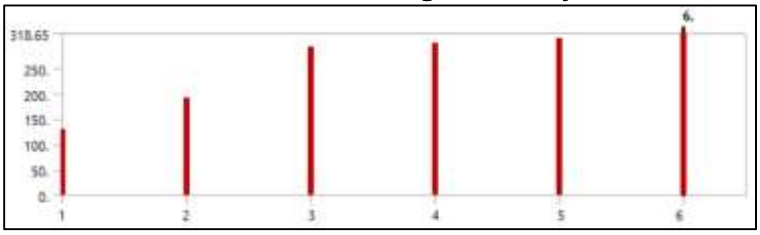


Fig. Boundary condition



	Mode	Frequency [Hz]
1	1.	129.13
2	2.	191.89
3	3.	292.14
4	4.	299.45
5	5.	309.44
6	6.	318.65

Fig. Modal analysis result

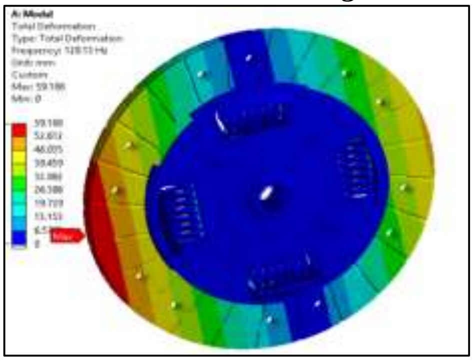


Fig. Mode shape 1

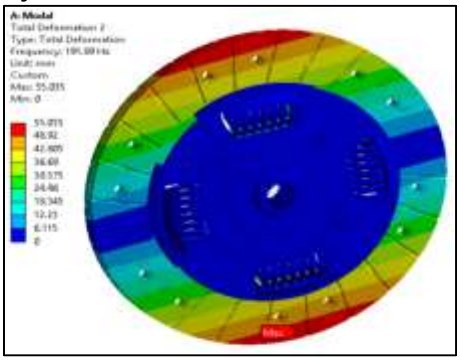


Fig. Mode shape 2

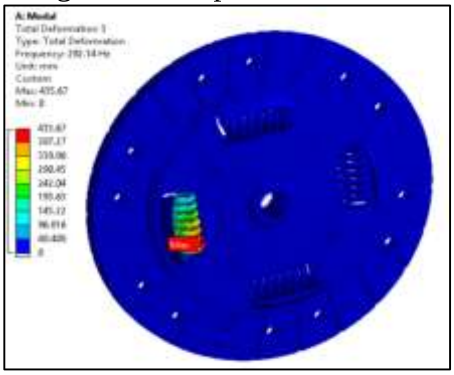


Fig. Mode shape 3

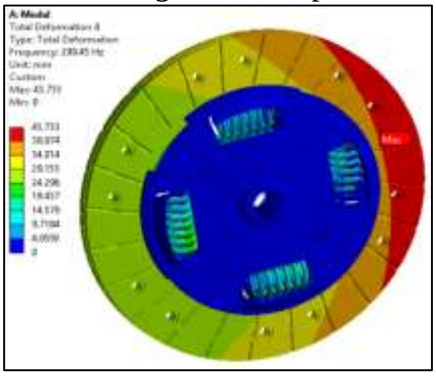


Fig. Mode shape 4

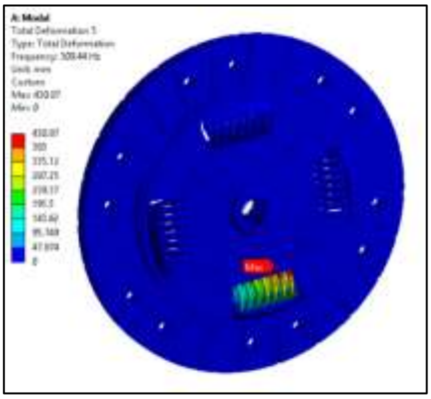


Fig. Mode shape 5

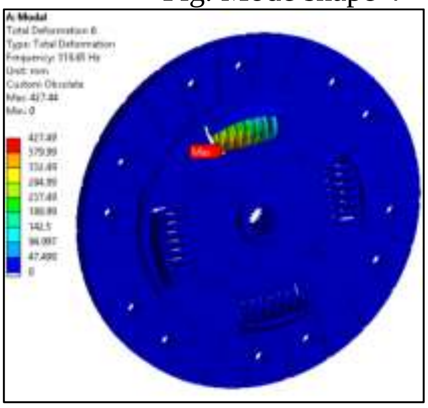


Fig. Mode shape 6

Clutch Disc Shape Optimization Analysis:

In this section we can find the shape optimization analysis of the model.

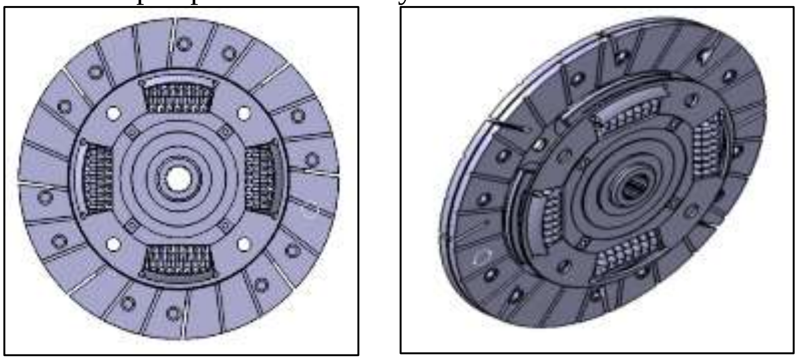


Fig. Optimized model

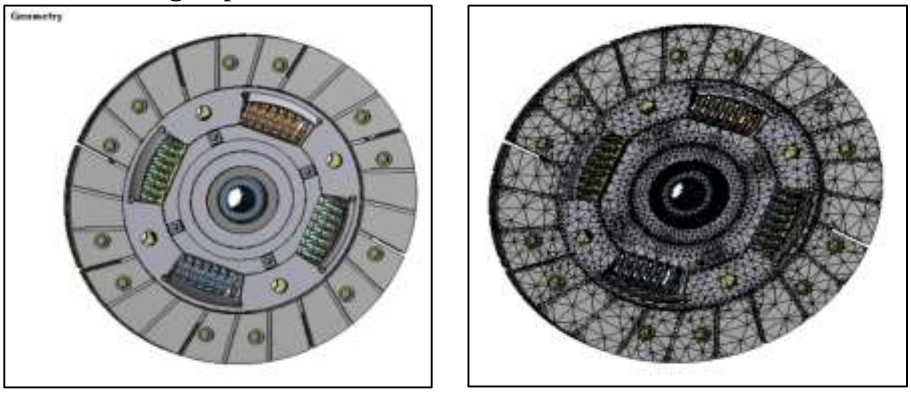


Fig. Geometry

Statistics	
Nodes	380207
Elements	192845

Fig. Meshing details

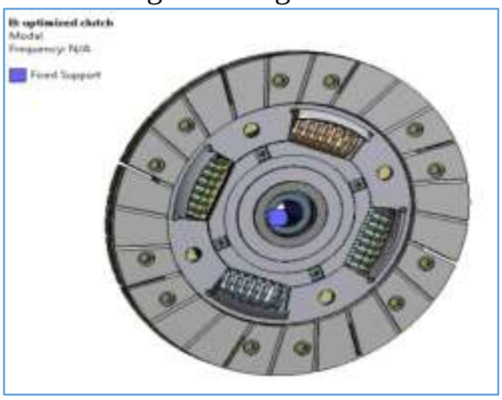


Fig. Boundary condition

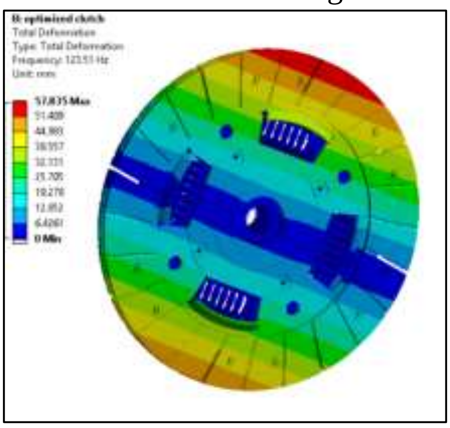


Fig. Mode shape 1

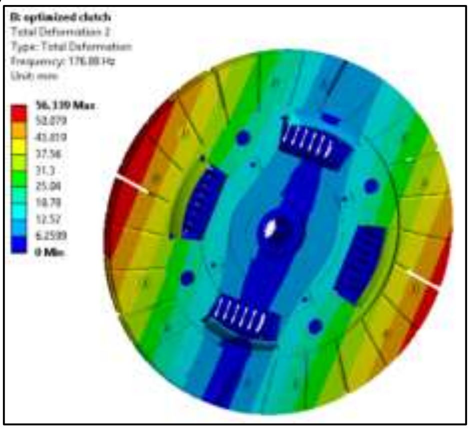


Fig. Mode shape 2

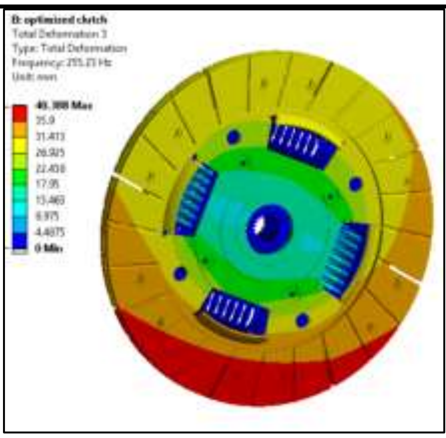


Fig. Mode shape 3

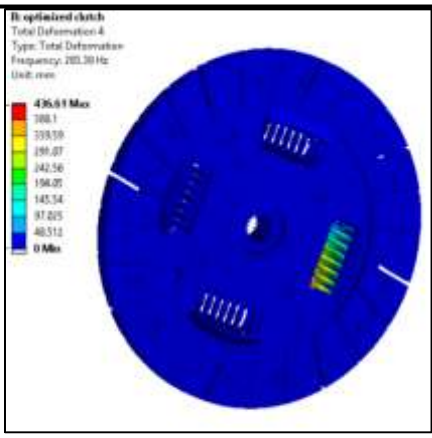


Fig. Mode shape 4

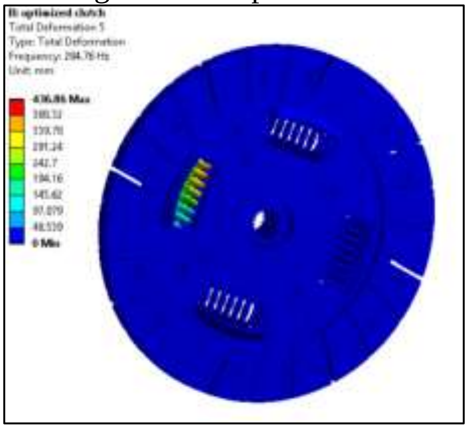


Fig. Mode shape 5

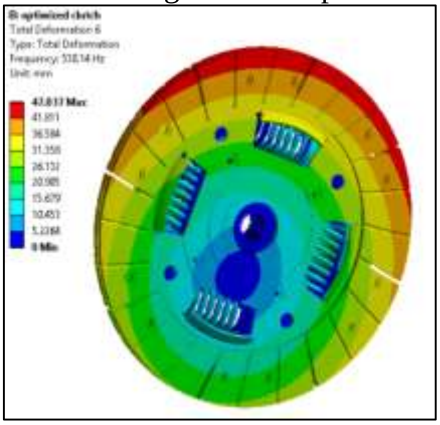
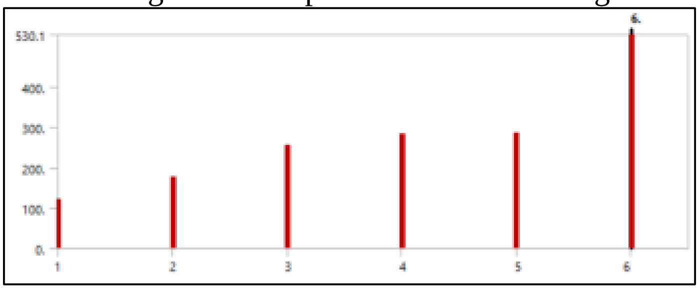


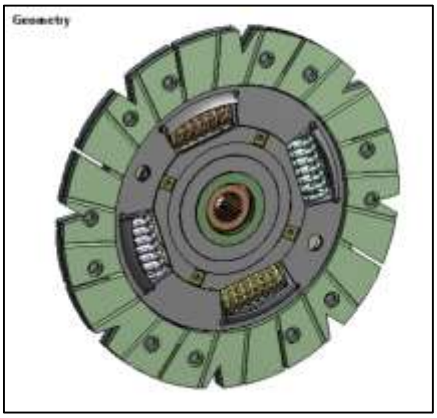
Fig. Mode shape 6



	Mode	Frequency [Hz]
1	1.	123.51
2	2.	176.88
3	3.	255.23
4	4.	283.38
5	5.	284.76
6	6.	530.14

Fig. Modal analysis result

Clutch Disc Optimized Model 2



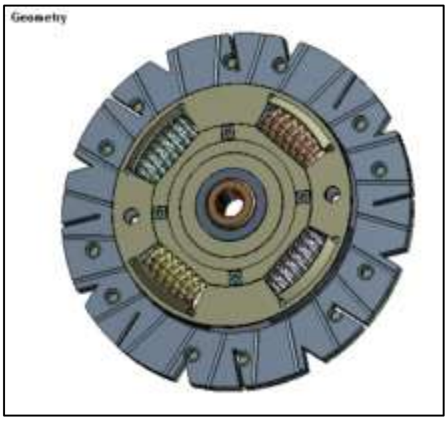
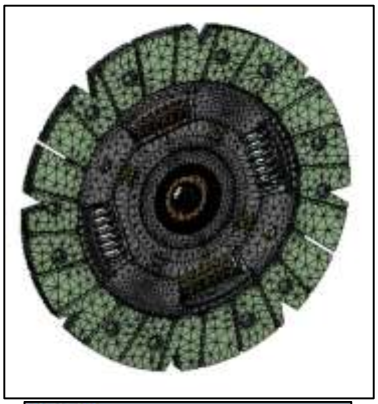


Fig. Optimized model



Statistics	
Nodes	373319
Elements	186912

Fig. Meshing details

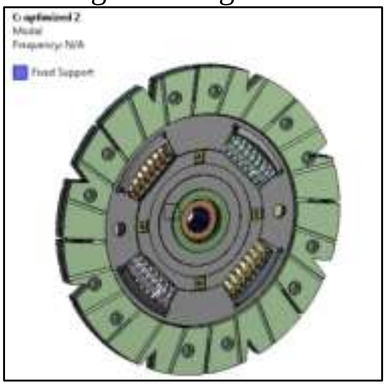


Fig. Boundary condition

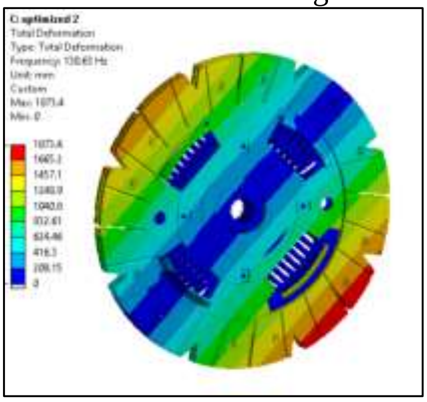


Fig. Mode shape 1

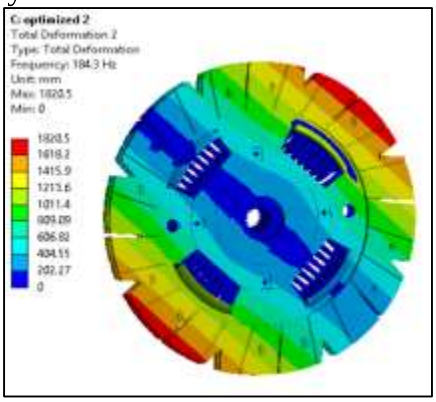


Fig. Mode shape 2

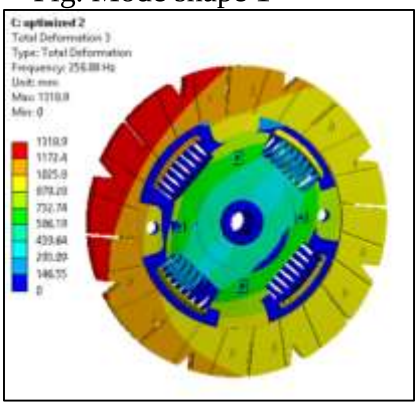


Fig. Mode shape 3

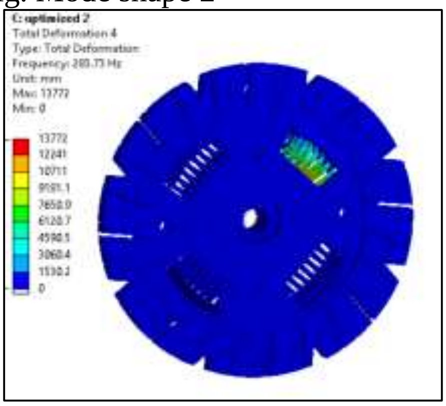


Fig. Mode shape 4

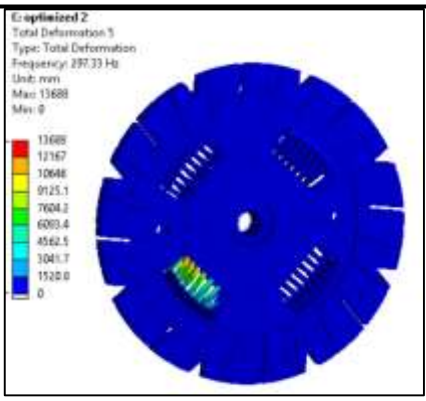


Fig. Mode shape 5

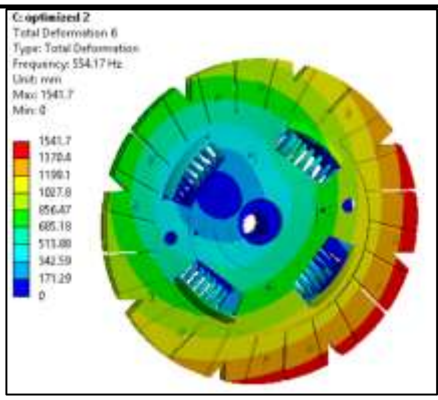
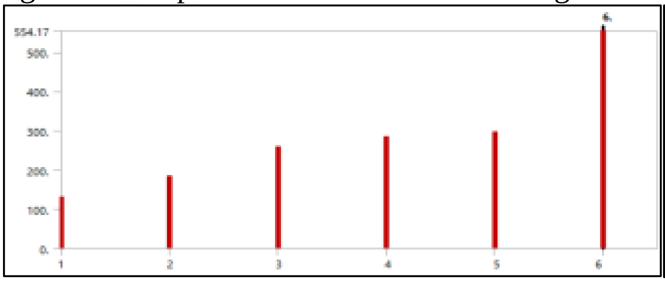


Fig. Mode shape 6



	Mode	Frequency [Hz]
1	1.	130.63
2	2.	184.3
3	3.	258.88
4	4.	283.73
5	5.	297.33
6	6.	554.17

Fig. Modal analysis result

Clutch Disc Optimization results:

Following figures shows the optimization results viz, before and after optimization

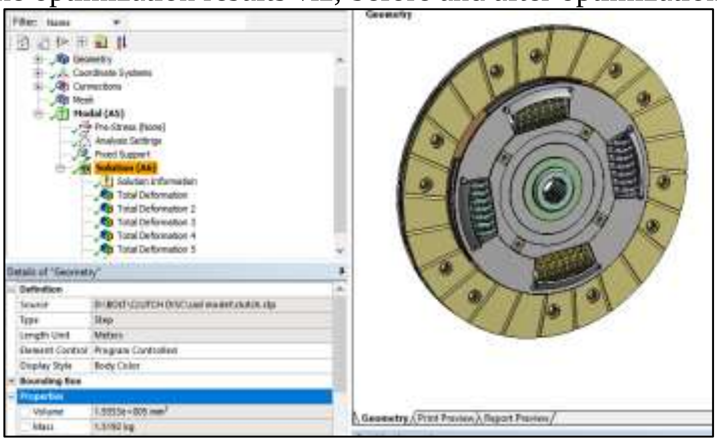


Fig. Existing disc with 1.52 kg weight

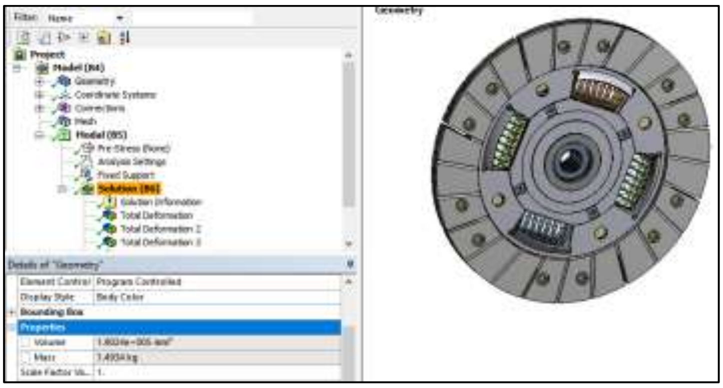


Fig. Optimized 1 disc with 1.49 kg weight

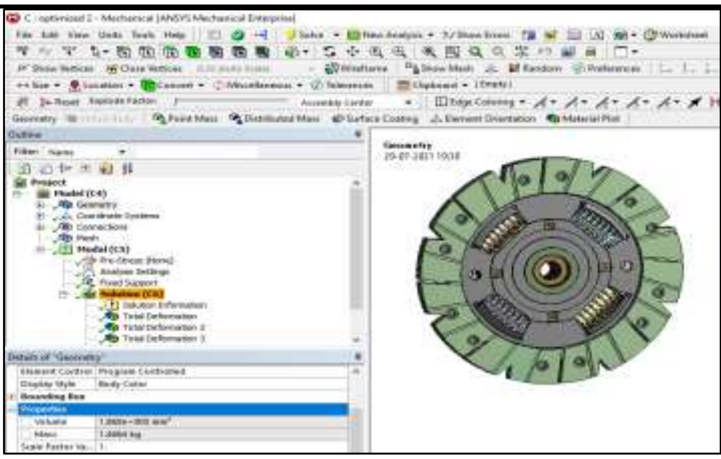


Fig. Optimized 2 disc with 1.46 kg weight
Weight reduction is 4 % with comparison

Experimental Testing:

The experimental validation is done by using FFT (Fast Fourier Transform) analyzer. The FFT spectrum analyzer considers the input signal, calculate the order of magnitude of its sine and the cosine division, and show the spectrum of those calculated frequency components. The vantage of this technique is nothing but the speed. Because this FFT spectrum analyzer computes or measure all the frequency components at the identical time, the technique offers possibleness of being hundreds of times quicker than conventional analog spectrum analyzers.

Impact Hammer Test

Impact excitation is one of the most common methods used for experimental modal testing. Hammer impacts produce a broad banded excitation signal ideal for modal testing with a minimal amount of equipment and set up. Furthermore, it is versatile, mobile and produces reliable results. Although it has limitations with respect to precise positioning and force level control, overall its advantages greatly outweigh its disadvantages making it extremely attractive and effective for many modal testing situations.

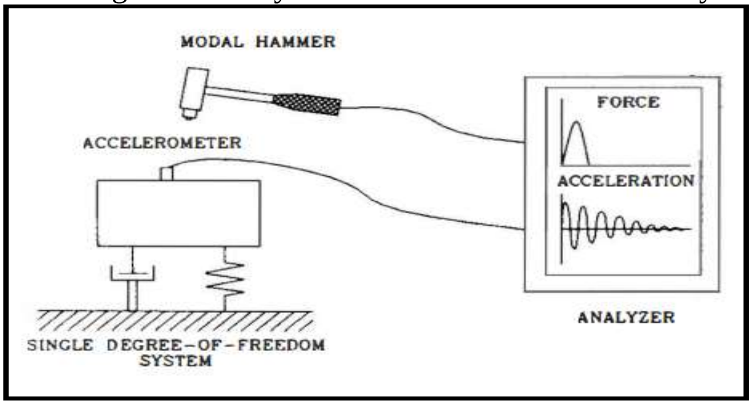


Fig : FFT construction

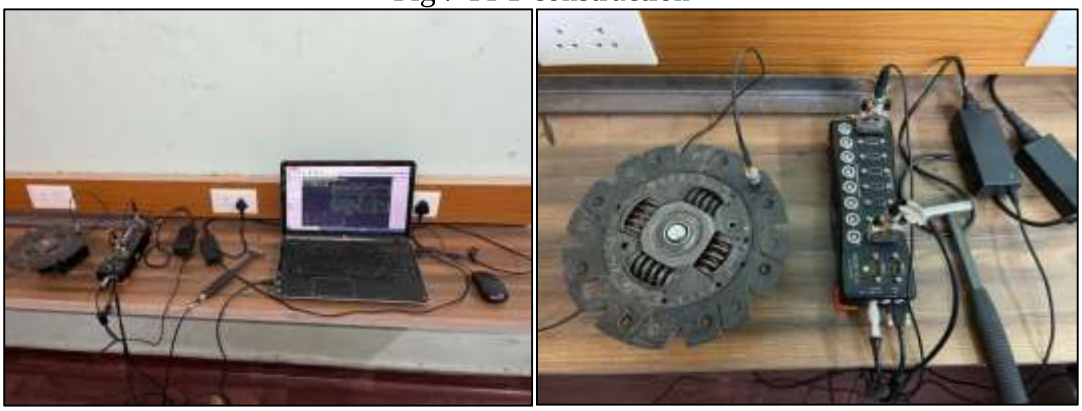


Fig. Experimental testing setup

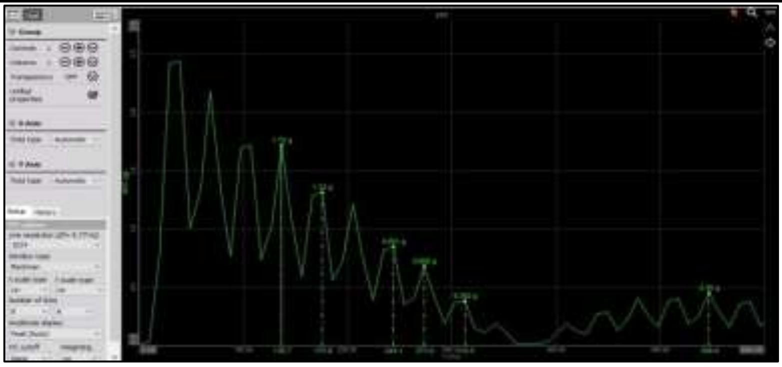


Fig. Experimental testing result

RESULT AND DISCUSSION

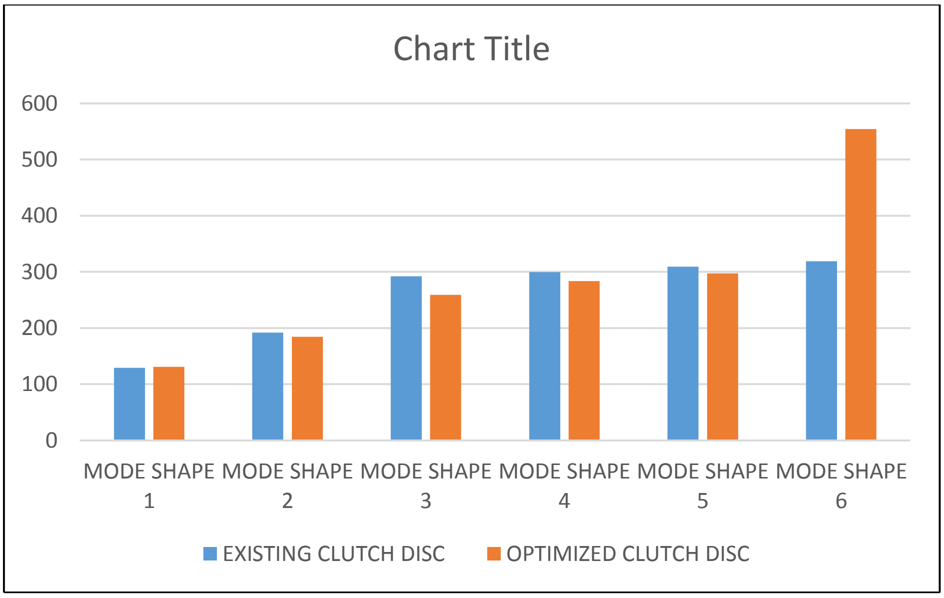
- ✓ Optimization of the clutch disc done by using CATIA software and analysis of the clutch disc completed using ANSYS software.
- ✓ Find out natural frequency of the clutch disc using modal analysis with the help of Ansys software.
- ✓ The main aim is to weight optimization of the clutch disc without affecting the fundamental frequency of the disc.

SR NO	MODE SHAPE	EXISTING CLUTCH DISC	OPTIMIZED CLUTCH DISC
1	MODE SHAPE 1	129.13	130.63
2	MODE SHAPE 2	191.89	184.3
3	MODE SHAPE 3	292.14	258.88
4	MODE SHAPE 4	299.45	283.73
5	MODE SHAPE 5	309.44	297.33
6	MODE SHAPE 6	318.65	554.17

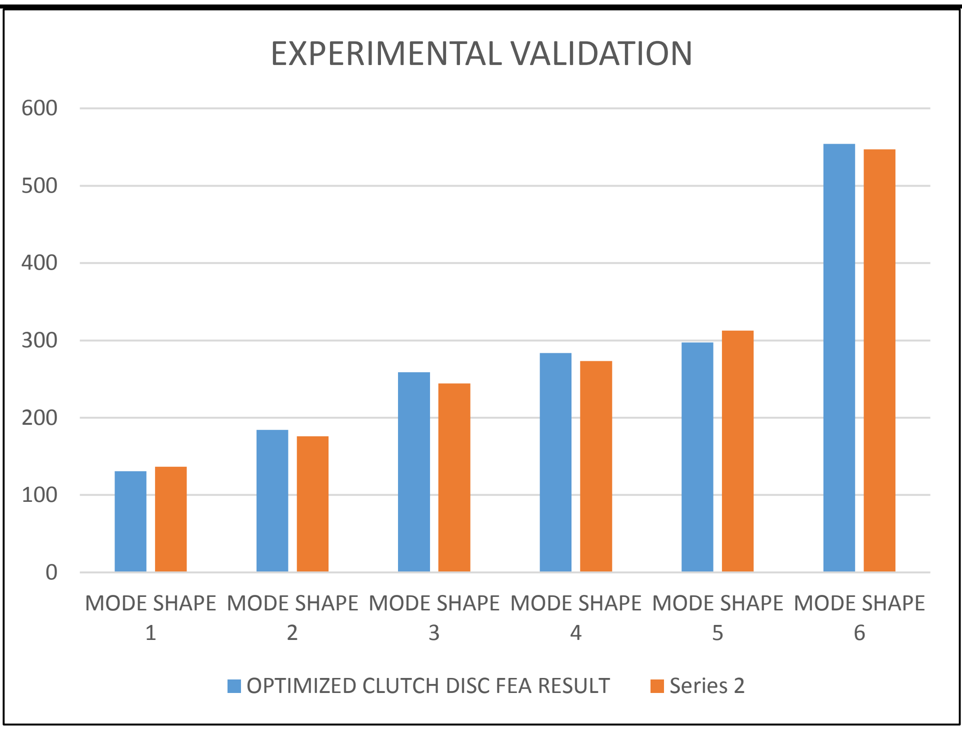
Table. Comparison between existing and optimized model

SR NO	MODE SHAPE	OPTIMIZED CLUTCH DISC FEA RESULT	OPTIMIZED CLUTCH DISC EXPERIMENTAL RESULT
1	MODE SHAPE 1	130.63	136.7
2	MODE SHAPE 2	184.3	175.8
3	MODE SHAPE 3	258.88	244.1
4	MODE SHAPE 4	283.73	273.4
5	MODE SHAPE 5	297.33	312.5
6	MODE SHAPE 6	554.17	546.9

Table. Comparison between FEA and experimental result



Graph. Existing and optimized comparison



Graph. Experimental validation

CONCLUSION

- In this project authors completed 2 optimized design using CATIA software for the weight optimization.
- The vibration analysis of the existing and optimized model completed using ANSYS software. The fundamental frequency of the existing clutch disc is 129.30 Hz. And the weight of existing clutch disc is 1.59 kg.
- Iteration 1 - The fundamental frequency of the optimized clutch disc is 123.31 Hz with the weight 1.50 kg.
- Iteration 2 - The fundamental frequency of the optimized clutch disc is 123.31 Hz with the weight 1.46 kg.
- The weight reduction using topology optimization technique is 130 gram, which is 8.17 %.

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