Modal Analysis of Original and Optimized Clutch Fork using ANSYS Workbench

Kamlesh U. Waghmare[1], Balaji D. Kshirsagar[2], Rutuja S. Bhangale[3]

[1]PG Student, Dept. of Mechanical Engineering, JSPM's Rajarshi Shahu College of Engineering, Maharashtra, India
[2]Professor, Dept. of Mechanical Engineering, JSPM's Rajarshi Shahu College of Engineering, Maharashtra, India
[3]Professor, Dept. of Mechanical Engineering, Pimpri Chinchwad Polytechnic, Maharashtra, India

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Abstract - *Clutch Fork is an Important Element of a Clutch system. The topology optimization is performed to reduce the material of a clutch fork. The Effects of topology optimization on the frequency of clutch fork are to be determined by comparing the frequency of the original clutch fork and optimized clutch fork by using modal analysis using ANSYS 19 software.*

Key Words: **Modal Analysis, Topology Optimization, Frequency, Clutch Fork, ANSYS**

1.INTRODUCTION

The clutch is an essential part of the vehicle. The clutch system is consists of components such as Pedal, Master cylinder, Slave cylinder, Clutch fork, Throw-out bearing, Pressure plate, Clutch disc, flywheel. To transfer motion from pedal to clutch fork is done by using a hydraulic system or a cable. The function of the clutch fork is to push the throw-out bearing on the pressure plate i.e diaphragm spring (Belleville spring) to disengage the clutch plate from the engine shaft flywheel, To perform gear shifting or stoping the vehicle. The default position of the clutch fork is engaged. The weight of the clutch fork system also adds to the overall weight of the vehicle so it is necessary to reduce the weight of the components if possible. Topology optimization can reduce the weight of a component keeping equivalent stresses in check.

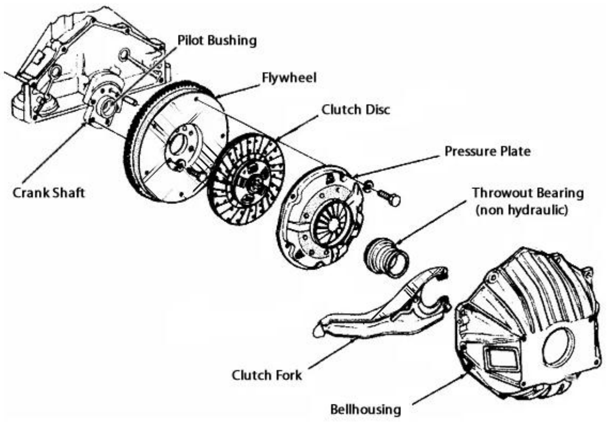

Fig -1: General assembly of Clutch

1.1 Objective

The main objective of this study is to compare the natural frequencies of the original and optimized clutch fork and study the effect of topology optimization on the same clutch fork frequencies.

1.2 Methodology

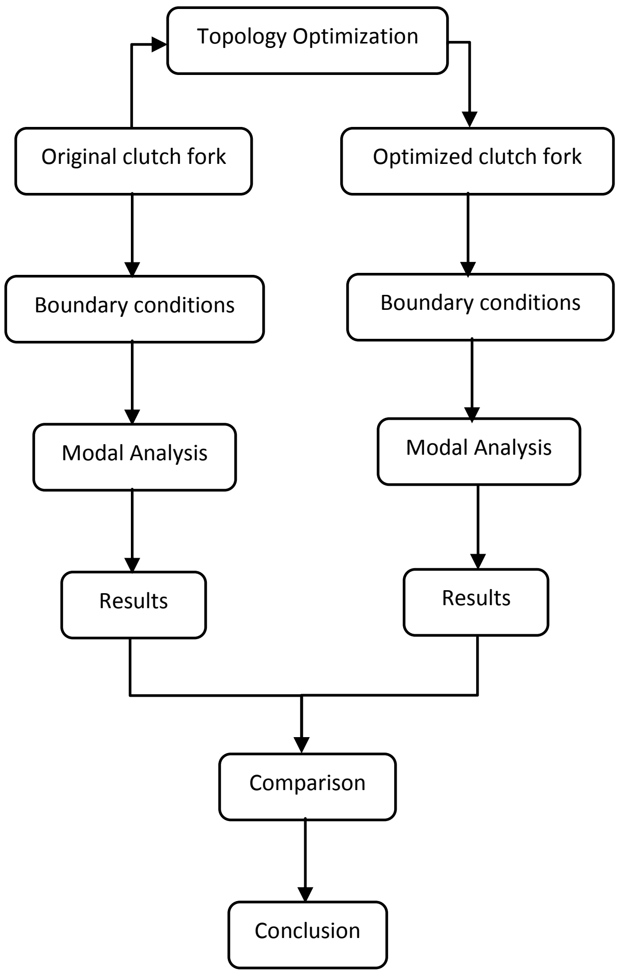

Fig -2: Methodology

2. MODAL ANALYSIS

In Dynamic systems, the modal analysis is used to get the frequency of vibration and mode shapes. A mode shape is nothing but the deformation at a specified natural frequency. Using ANSYS Workbench the modal analysis of the component or a system can be easily done. The modal analysis gives mode shapes and corresponding natural frequencies, it also gives a graph of mode shape and corresponding frequency.

1.1 Original clutch fork

Boundary conditions

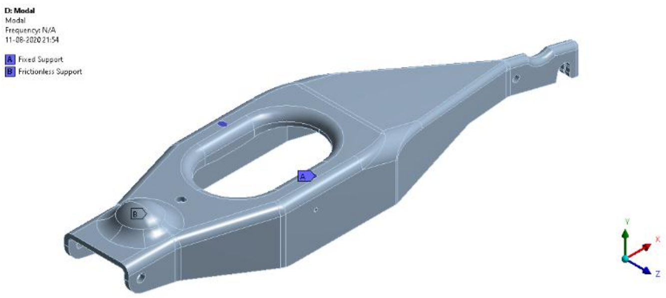

Fig -3: Original CAD model with boundary conditions

The initial-boundary conditions are the same as static structural analysis, only load/force is removed. The types of support given here are frictionless support at the dimple as it fits in spherical pivot support and fixed support is given where throwout bearing seats. The pre-stress given is zero.

Mode Shapes

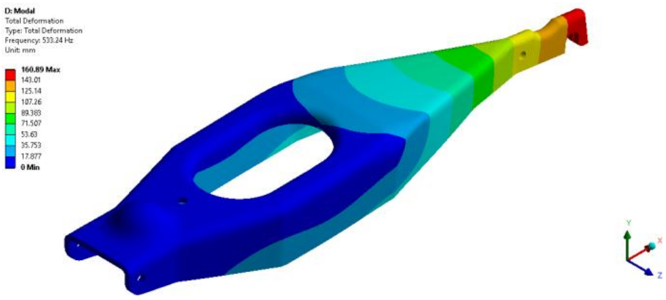

Fig -4: Mode Shape 1

Fig 4, gives us the first mode shape with maximum total deformation 160.89 mm and corresponding natural frequency of 533.24 Hz.

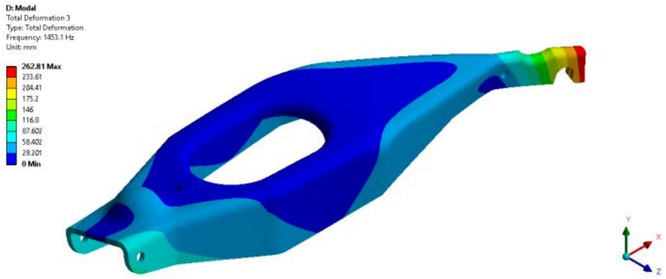

Fig -5: Mode Shape 2

Fig 5, gives us the second mode shape with maximum total deformation 169.42 mm and corresponding natural frequency of 1186.8 Hz.

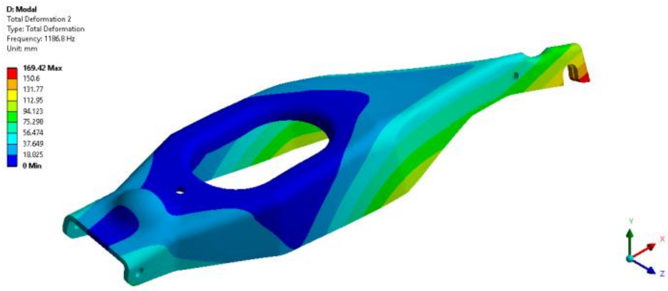

Fig -6: Mode Shape 3

Fig 6, gives us the third mode shape with maximum total deformation 262.81 mm and corresponding natural frequency of 1453.1 Hz.

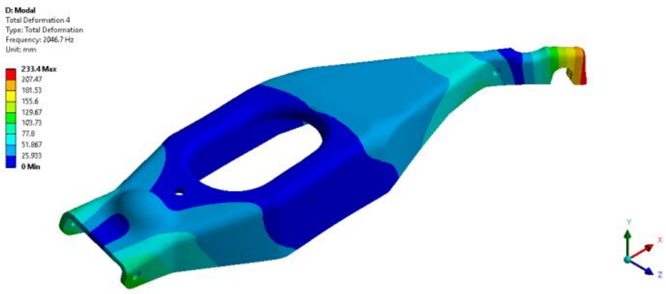

Fig -7: Mode Shape 4

Fig 7, gives us the fourth mode shape with maximum total deformation 233.4 mm and corresponding natural frequency of 2046.7 Hz.

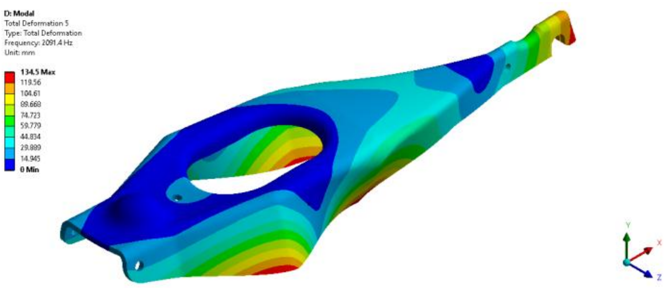

Fig -8: Mode Shape 5

Fig 8, gives us the fifth mode shape with maximum total deformation 134.5 mm and corresponding natural frequency of 2091.4 Hz.

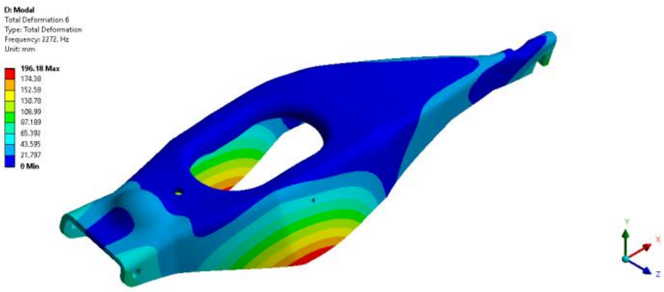

Fig -9: Mode Shape 6

Fig 9, gives us the sixth mode shape with maximum total deformation 196.18 mm and corresponding natural frequency of 2272 Hz.

1.2 Optimized clutch fork

Boundary conditions

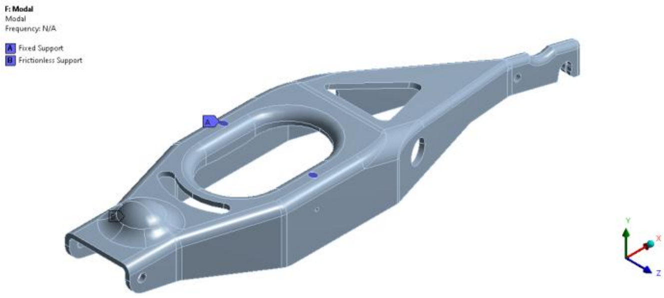

Fig -10: Optimized CAD model with boundary conditions

The initial-boundary conditions are the same as static structural analysis, only load/force is removed. The types of support given here are frictionless support at the dimple as it fits in spherical pivot support and fixed support is given where throwout bearing seats. The pre-stress given is zero.

Mode Shapes

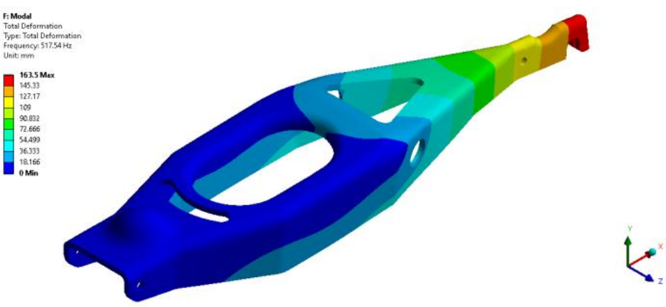

Fig -11: Mode Shape 1

Fig 11, gives us the first mode shape with maximum total deformation 163.5 mm and corresponding natural frequency of 517.54 Hz.

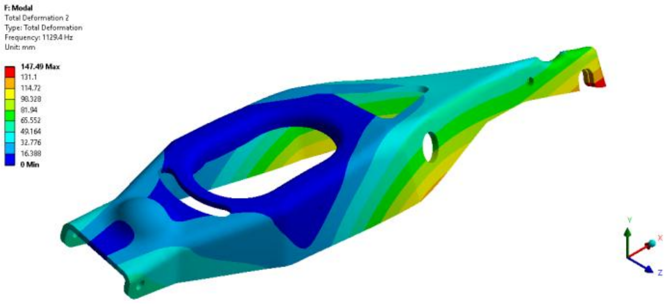

Fig -12: Mode Shape 2

Fig 12, gives us the second mode shape with maximum total deformation 147.49 mm and corresponding natural frequency of 1129.4 Hz.

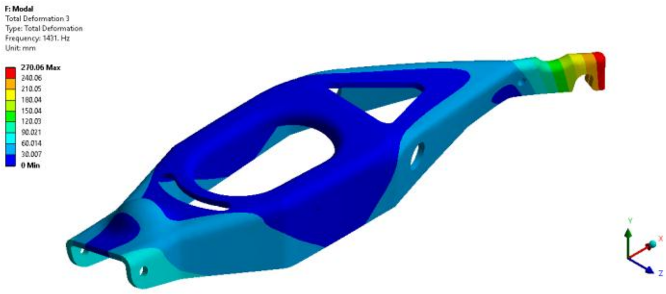

Fig -13: Mode Shape 3

Fig 13, gives us the third mode shape with maximum total deformation 270.06 mm and corresponding natural frequency of 1431 Hz.

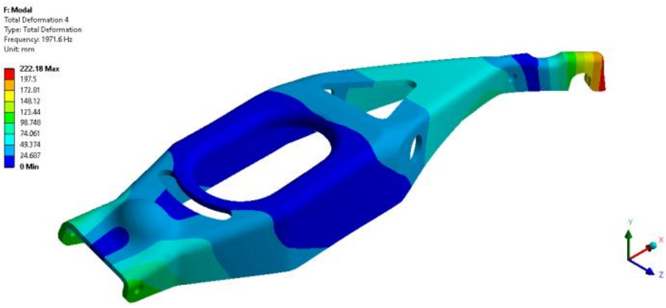

Fig -14: Mode Shape 4

Fig 14, gives us the fourth mode shape with maximum total deformation 222.18 mm and corresponding natural frequency of 1971.6 Hz.

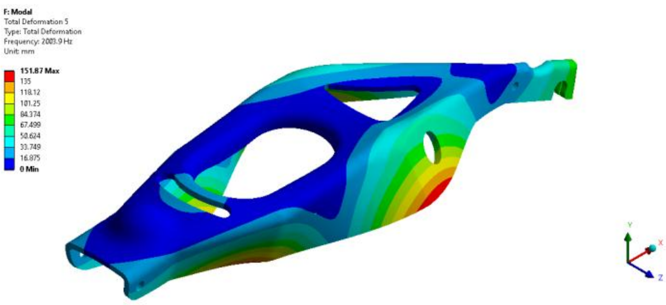

Fig -15: Mode Shape 5

Fig 15, gives us the fifth mode shape with maximum total deformation 151.87 mm and corresponding natural frequency of 2003.9 Hz.

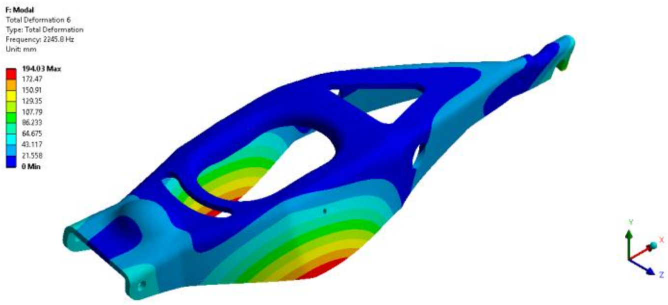

Fig -16: Mode Shape 6

Fig 16, gives us the sixth mode shape with maximum total deformation 194.03 mm and corresponding natural frequency of 2245.8 Hz.

3. RESULTS

Table -1: Result Comparison table

Original Clutch Fork			Optimized Clutch Fork		
Mode Shape	Max. Total Deformation (mm)	Frequency (Hz)	Mode Shape	Max. Total Deformation (mm)	Frequency (Hz)
1	160.89	533.24	1	163.5	517.54
2	169.42	1186.8	2	147.49	1129.4
3	262.81	1453.1	3	270.06	1431
4	233.4	2046.7	4	222.18	1971.6
5	134.5	2091.4	5	151.87	2003.9
6	196.18	2272	6	194.03	2245.8

Table 1, gives us the mode shapes and their corresponding deformation as well as natural frequencies for both original and optimize clutch fork. From the result table, it is seen that there are no significant changes in deformation and the natural frequency of the optimized clutch fork.

4. CONCLUSION

After comparing the deformations and frequencies of the original and optimized clutch fork it is found that there is no significant increase in both deformation and frequency. The removal of material from the original clutch fork is possible from the vibration perspective also. Thus the optimized clutch fork is safe under vibrations.

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