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# Modal analysis of a 2-cylinder crankshaft using ANSYS

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**ABSTRACT**
Crankshaft is a relevant component in an I.C. engine which transforms the reciprocating motion into rotational motion. This makes the crankshaft liable to vibrations due to different types of stresses and loads. Modal analysis when performed on crankshaft, gives the behavior of its structure through different mode shapes at different frequencies. It also helps to determine resonance frequencies. Modal analysis is the primary stage of many useful analysis like harmonic analysis and transient dynamic analysis, which give the dynamic behavior of the crankshaft.
***Keywords*** **-** ANSYS, Crankshaft, Modal, Vibration

## I. INTRODUCTION

The strong demand for high speed automobiles now-a-days, leads to the need of highly efficient I.C. engines. The efficiency of I.C. engine primarily depends on the crankshaft which converts the reciprocating motion into rotational motion. [1][2][3]. The crankshaft has to bear the load of combustion in the engine and sustain all the strokes of the piston for the engine to function smoothly. Various literatures have proved that, the centre of the crankpin is the most probable area of damage due to maximum stress and deformation occurring there, resulting in crankshaft failure. Modal analysis provides a means by which this deformation in the structure can be viewed while designing a crankshaft. Modal analysis gives different mode shapes by which the structure can be analyzed at different frequencies and resonance [4][5][6][7][8].

## II. LITERATURE REVIEW

Modal analysis gives the vibration characteristic of the structure. As vibration is dynamic in nature, it is very useful for dynamic analysis of the crankshaft. Any structure on which external force acts, can vibrate and this vibration can be at different frequencies[11][12][13][14][15]. When the effect of vibration is maximum, the structure is at high risk and this frequency of vibration is called, the resonance frequency. Modal analysis results in different mode shapes, that is the shape of the structure at different frequencies and at resonance. It gives the behaviour of the structure or the distortion in geometry when the structure is vibrated for a particular frequency range. Softwares like ANSYS when used for modal analysis provide accurate results for this analysis which extensively uses the expansion theorem.

## III. PROCESS

For performing modal analysis the following steps are to be followed.

### II.I IMPORT GEOMETRY

The geometry of the structure can be designed in any softwares like solidworks, CATIA-V5 etc, and imported to ANSYS.

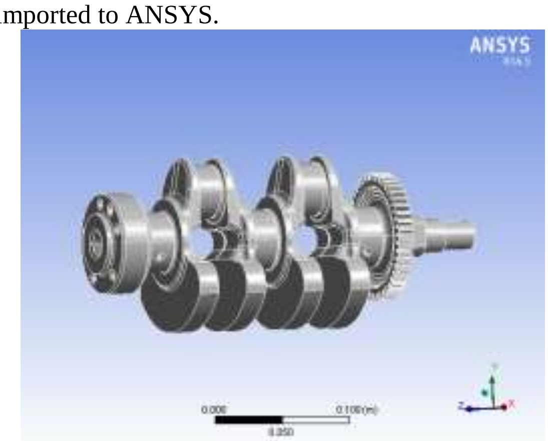


**Figure 1. The geometry of crankshaft imported in ANSYS**

### II.II MESHING

Finite element analysis is in which the structure is divided into finite number of elements. These elements are analyzed individually for stresses and deformation. Meshing is the first step of finite element analysis. We have divided the structure of our crankshaft into finite number of tetrahedrons which will be analyzed individually for deformation at different frequencies of a given frequency range. The following chart gives the details about the meshing of the geometry.

| | |
|---|---|
| Object Name | *Mesh* |
| State | Solved |
| **Sizing** | |
| Use Advanced Size Function | Off |
| Relevance Center | Coarse |
| Element Size | Default |
| Initial Size Seed | Active Assembly |
| Smoothing | Medium |
| Transition | Fast |
| Span Angle Center | Coarse |
| Minimum Edge Length | 9.3386e-005 m |
| **Inflation** | |
| Use Automatic Inflation | None |
| Inflation Option | Smooth Transition |
| Transition Ratio | 0.272 |
| Maximum Layers | 5 |
| Growth Rate | 1.2 |
| Inflation Algorithm | Pre |
| **Statistics** | |
| Nodes | 50281 |
| Elements | 28874 |
| Mesh Metric | None |

**Figure 2. Chart of details of the meshing performed in ANSYS**

The following figure shows the meshed geometry of the crankshaft. It is divided into 28874 elements.

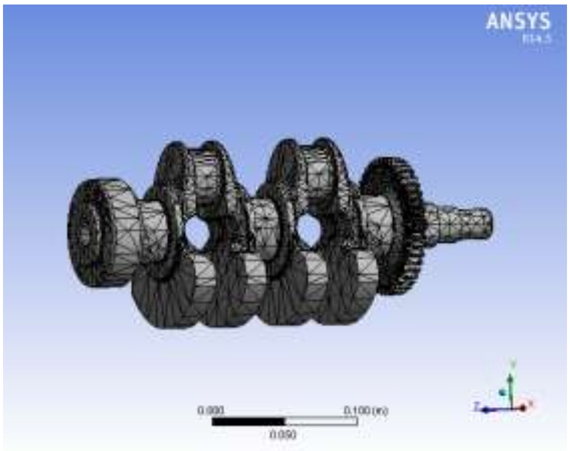

**Figure 3. Meshed geometry of crankshaft**

## II.III BOUNDARY CONDITIONS

Boundary conditions play an important role in any analysis. Here, in modal analysis, boundary conditions decide the part of the geometry which is fixed.

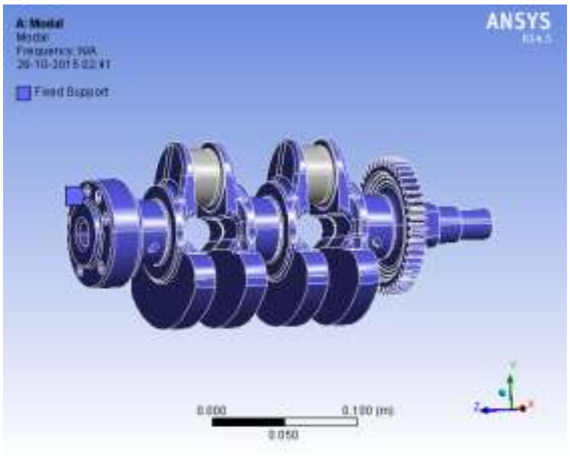

**Figure 4. Boundary conditions applied on crankshaft**

## II.IV TOTAL DEFORMATION

After executing modal analysis, we get the following modes showing deformation at mainly the centre of the crankpin of the crankshaft, which is the most damage prone part of the structure. The following chart gives the details of the modal analysis performed and the conditions and limits we have set for the number of modes and frequency. The pre-stress analysis is obtained usually from the static structural analysis.

**Table 1. Modes and their frequencies**

| Mode | Frequency [Hz] |
|---|---|
| 1. | 55.24 |
| 2. | 57.76 |
| 3. | 61.133 |
| 4. | 62.507 |
| 5. | 65.739 |
| 6. | 71.15 |
| 7. | 72.509 |
| 8. | 72.731 |
| 9. | 73.112 |
| 10. | 76.942 |

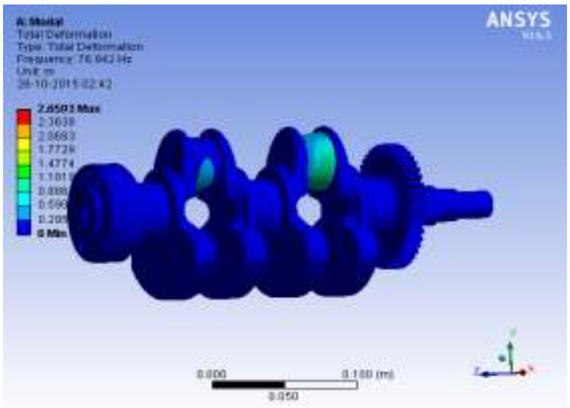

**Figure 5. Mode Shape 1**

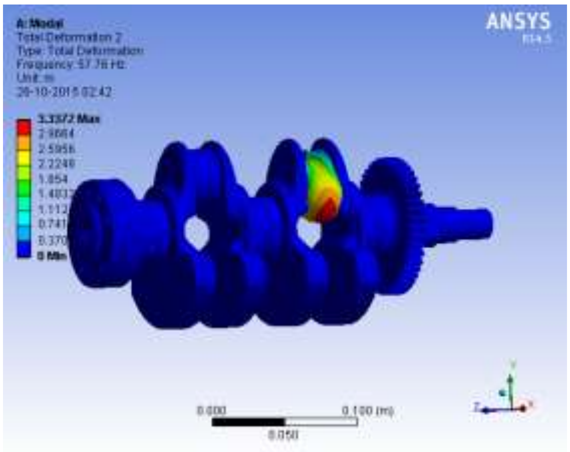


**Figure 6. Mode shape 2**

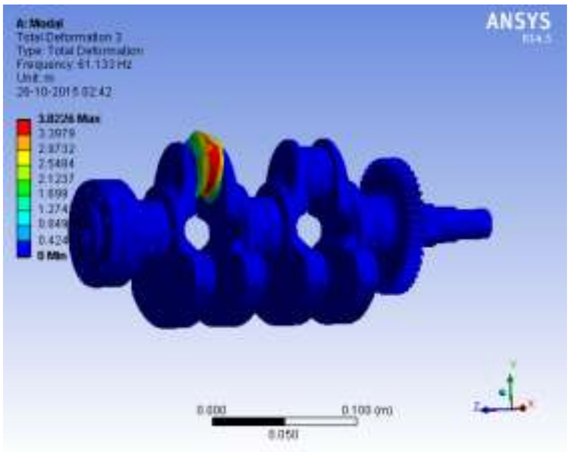


**Figure 7. Mode shape 3**

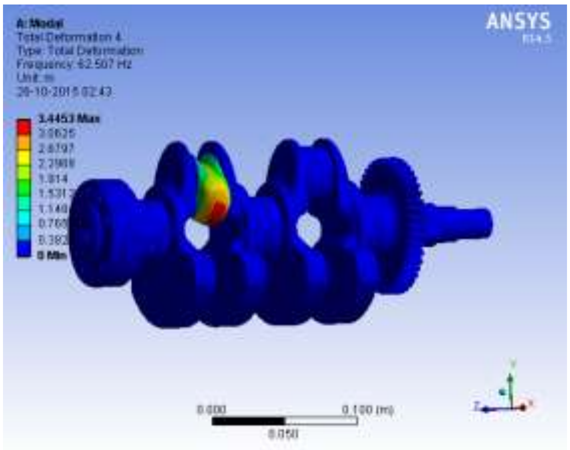


**Figure 8. Mode shape 4**

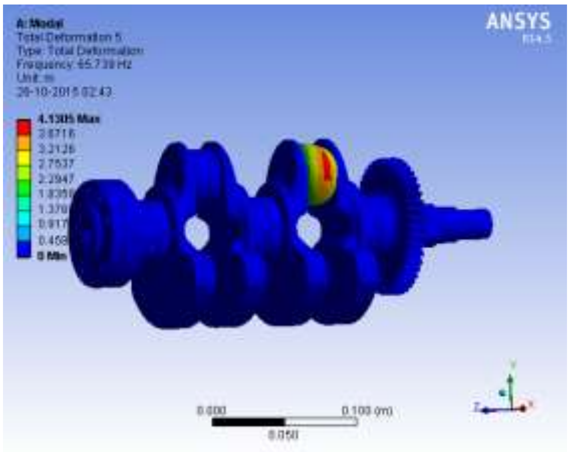


**Figure 9. Mode shape 5**

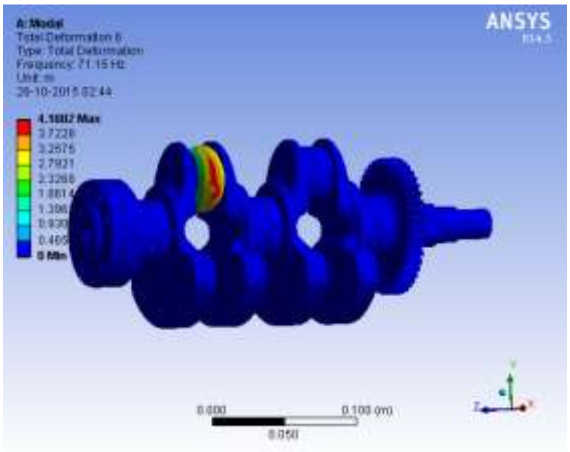


**Figure 10. Mode shape 6**

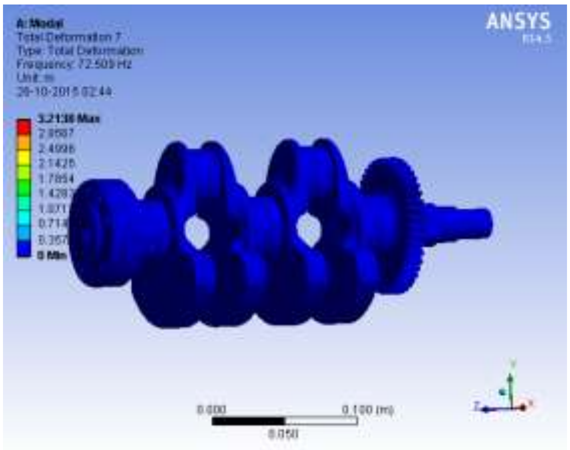


**Figure 11. Mode shape 7**

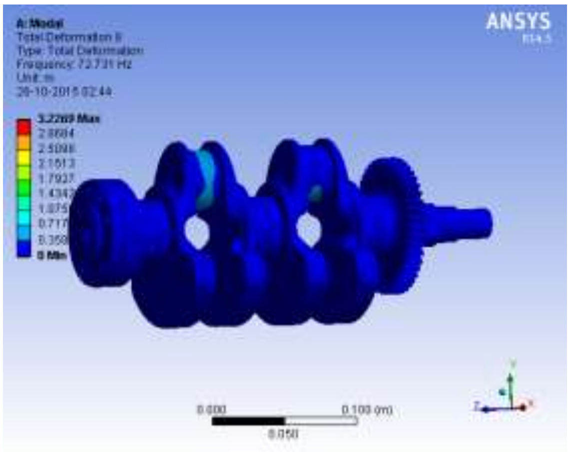


**Figure 12. Mode shape 8**

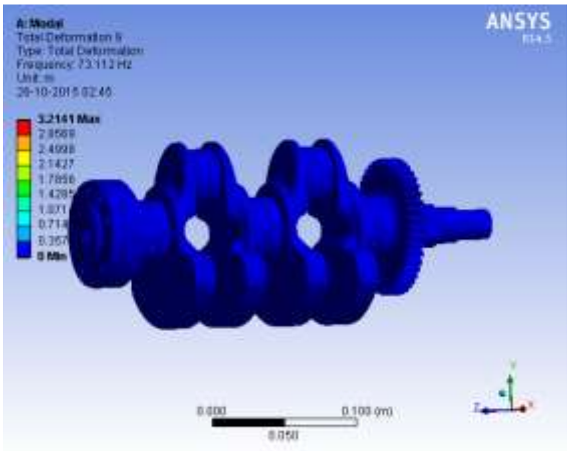


**Figure 13. Mode shape 9**

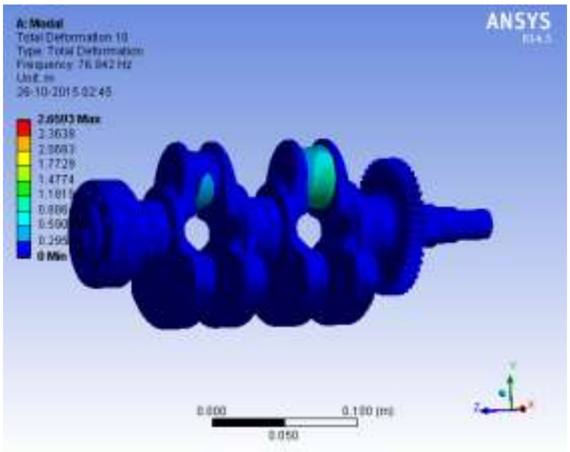


**Figure 14. Mode shape 10**

As it is seen from the figures, different modes of vibration at different frequencies can be seen and according to the results, the maximum vibration occurs in mode 6, at a frequency of 71.15 Hz with the deformation of 4.18m.

## IV. CONCLUSION

Thus, it can be concluded that modal analysis gives the relation of frequency and the vibration characteristics of the crankshaft. The results of modal analysis are extremely important as the resonance frequency or the frequency at which the effects of vibration are maximum is provided. The modal analysis also provides the starting point for harmonic and transient dynamic analysis where, the details of these mode shapes with their frequencies are useful.

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