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MODAL ANALYSIS OF CRANKCASE FOR SINGLE CYLINDER HIGH SPEED DIESEL ENGINE

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Abstract -The single cylinder engines are extensively used in agricultural areas for several purposes such as water pumping, harvesting machines, spraying of pesticides etc. The use of diesel as fuel and having only one cylinder makes them an economic alternative due to their low investment cost and limited fuel consumption. Therefore these engines are important auxiliary agricultural tool for rural areas. Because of excessive usage and overloading in field applications more failures are reported on different engine components. Crankcase is located at the bottom of the cylinder block. It can be molded as a part of a block or bolted on separately. . The failure investigation includes visual inspection, chemical composition analysis, microstructure examination, hardness determination, static analysis as well as dynamic analysis (modal and harmonic analysis). In this paper, failure investigation has been conducted on crankcase of single cylinder high speed diesel engine by modal analysis. Modal analysis determines the vibration characteristics (natural frequency and mode shape) of crankcase.
Keyword - Crankcase, Modal Analysis, Natural frequency, Mode shape.

1. INTRODUCTION.

Dynamic analysis of three-dimensional structural systems is a direct extension of static analysis. The elastic stiffness matrices are the same for both dynamic and static analysis. It is only necessary to lump the mass of the structure at the joints. The addition of inertia forces and energy dissipation forces will satisfy dynamic equilibrium. The dynamic solution for steady state harmonic loading, without damping, involves the same numerical effort as a static solution.

All real physical structures behave dynamically when subjected to loads or displacements. The additional inertia forces, from Newton's second law, are equal to the mass times the acceleration. If the loads or displacements are applied very slowly, the inertia forces can be neglected and a static loads analysis can be justified. Hence, dynamic analysis is a simple extension of static analysis.

In addition, all real structures potentially have an infinite number of displacements. Therefore, the most critical phase of a structural analysis is to create a computer model with a finite number of mass less members and a finite number of node (joint) displacements that will simulate the behavior of the real structure. The mass of a structural system, which can be accurately estimated, is lumped at the nodes. Also, for linear elastic structures, the stiffness properties of the members can be approximated with a high degree of confidence with the aid of experimental data. However, the dynamic loading, energy dissipation properties and boundary (foundation) conditions for many structures are difficult to estimate. Because of the large number of computer runs required for a typical dynamic analysis, it is very important that accurate and numerically efficient methods be used within computer programs.

There are three commonly used dynamic analysis types in ANSYS: (i) modal analysis, (ii) harmonic analysis, and (iii) transient analysis. The results related to these types of analyses can be reviewed in both postprocessors (General Postprocessor and Time History Postprocessor), The General Postprocessor is used to review results over the entire model at specific times or frequencies while the Time History Postprocessor allows the user to review results at specific nodes in the model over the entire time or frequency range.

2. MODAL ANALYSIS.

If the structural vibration is of concern in the absence of time-dependent external loads, a modal analysis is performed. Because the structural frequencies are not known a priori, the finite element equilibrium equations for this type of analysis involve the solution of homogeneous algebraic equations whose eigenvalues correspond to the frequencies, and the eigenvectors represent the vibration modes.

The following steps are used in a typical modal analysis in ANSYS.
Build the model.
Apply loads and obtain the solution.

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Expand the modes.
Review the results.
In certain cases, especially if the model has of a large number of degrees of freedom, it is advantageous to define Master Degrees of Freedom (MDOF). This procedure condenses the full matrices describing the structure into a smaller size, thus reducing the computational cost significantly. The only boundary conditions that are permissible in modal analysis are zero displacements. Any constraints/loads that are non-zero are ignored in the analysis. Once the modal analysis is complete, the solution is expanded to find results related to the complete structure—not just the MDOF. The results include natural frequencies, mode shapes, and corresponding parametric (relative) stress fields.

3. MODAL ANALYSIS OF CRANKCASE FOR SINGLE CYLINDER HIGH SPEED DIESEL ENGINE

First, I have Prepared Assembly in CATIA for crankcase of single cylinder diesel engine and Save as this part as IGES for Exporting into ANSYS Workbench Environment as shown in figure 1. Import IGES Model in ANSYS Workbench Simulation Module
Apply Material for Crankcase (FG260 Gray cast iron).

Material Details:
Material Type: - Gray cast iron
Designation : - FG260
Modulus of Elasticity: - 128520N/mm^2.
Ultimate tensile strength (Mpa):- 850
Elongation (%):- 13
Poisson ratio: - 0.26

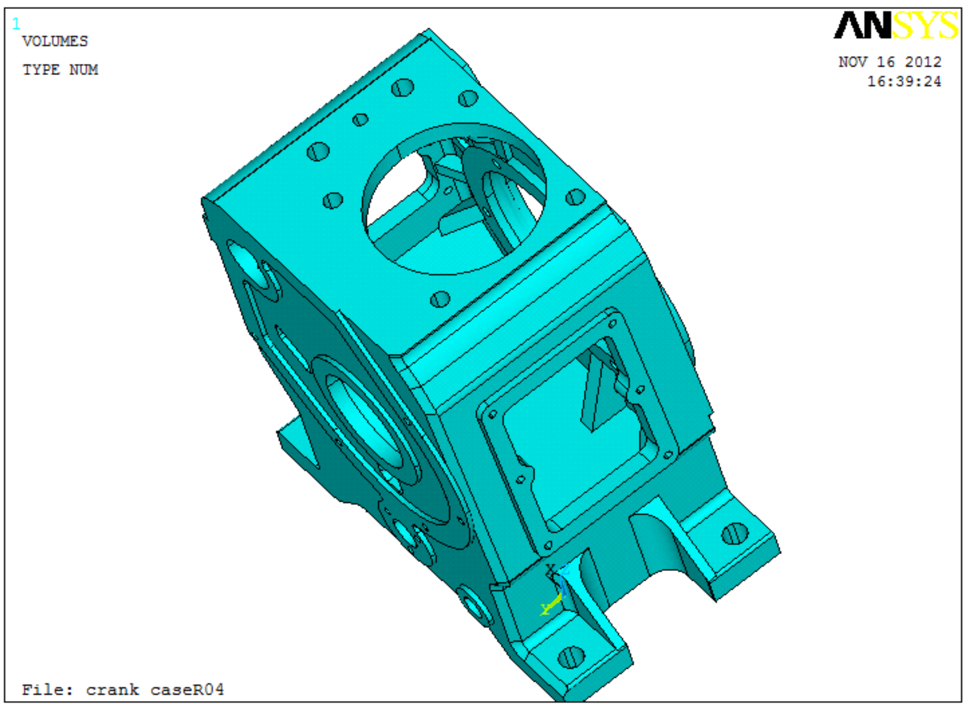

Figure 1: Crankcase of single cylinder diesel engine in ANSYS.

Mesh the existing model of Crankcase of single cylinder four stroke diesel engine as shown in figure 2.

Mesh Statics:
Type of Element: Tetrahedrons (10 Noded)
Number of Nodes: 469434.
Number of Elements: 270070

Statistics	
Nodes	469434
Elements	270070

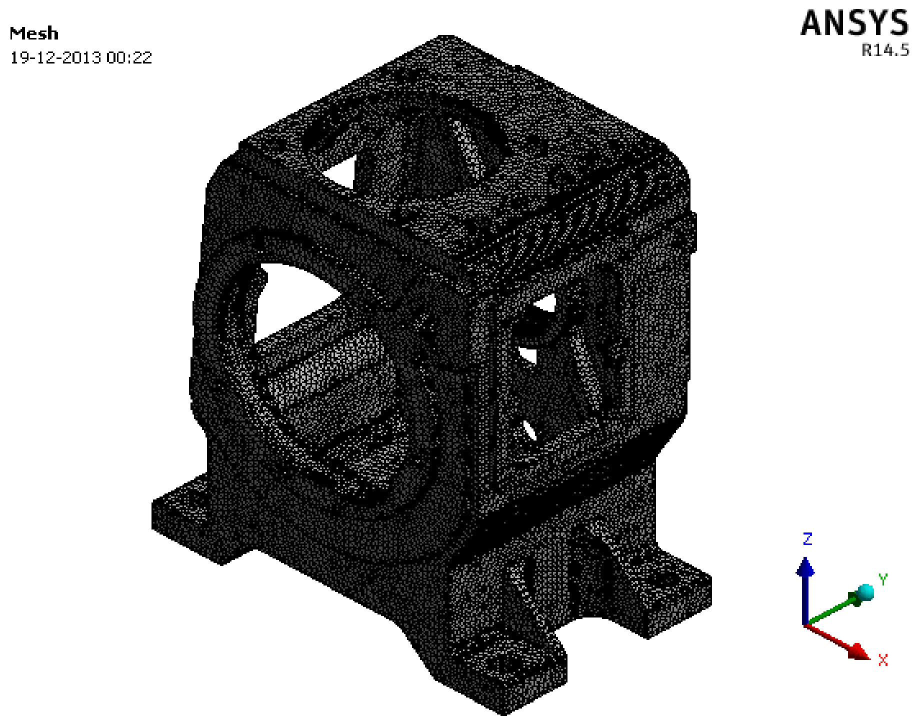

Figure2: Meshed existing Model of Crankcase of a single cylinder diesel engine.

4. MODAL ANALYSIS OF EXISTING MODEL OF SINGLE CYLINDER CRANKCASE.

Table 1 – The first six model parameters of model of crankcase.

No of Modes	Natural Frequency(Hz)	Types of modes
1	485.99	Bending
2	682.28	Bending
3	1044.7	Bending
4	1210.4	Bending
5	1662.1	Torsion
6	1857.6	Bending.

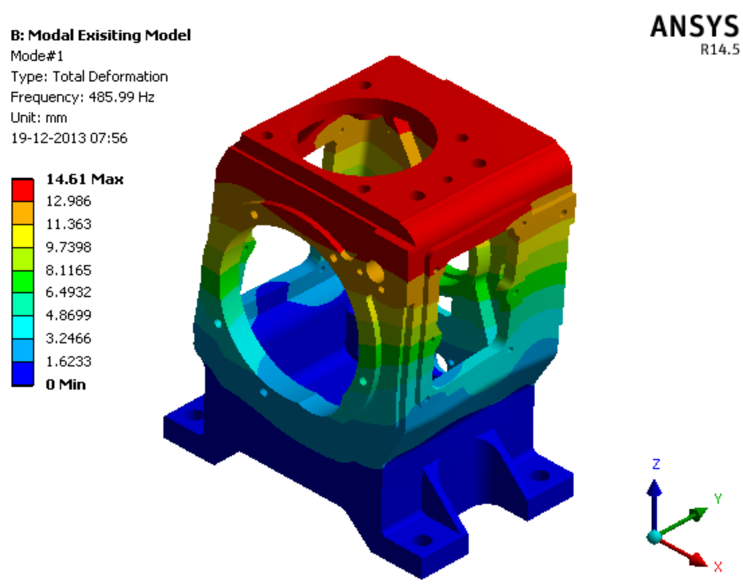

Figure 3 -Mode shape of crankcase for first frequency 485.99 Hz

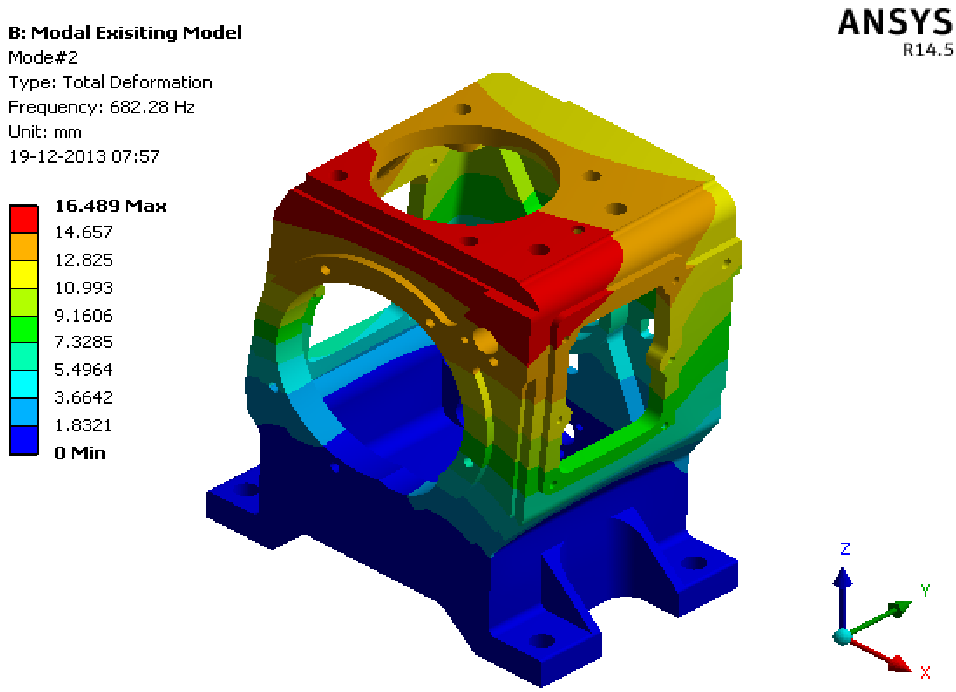

Figure 4 -Mode shape of crankcase for second frequency 682.28 Hz

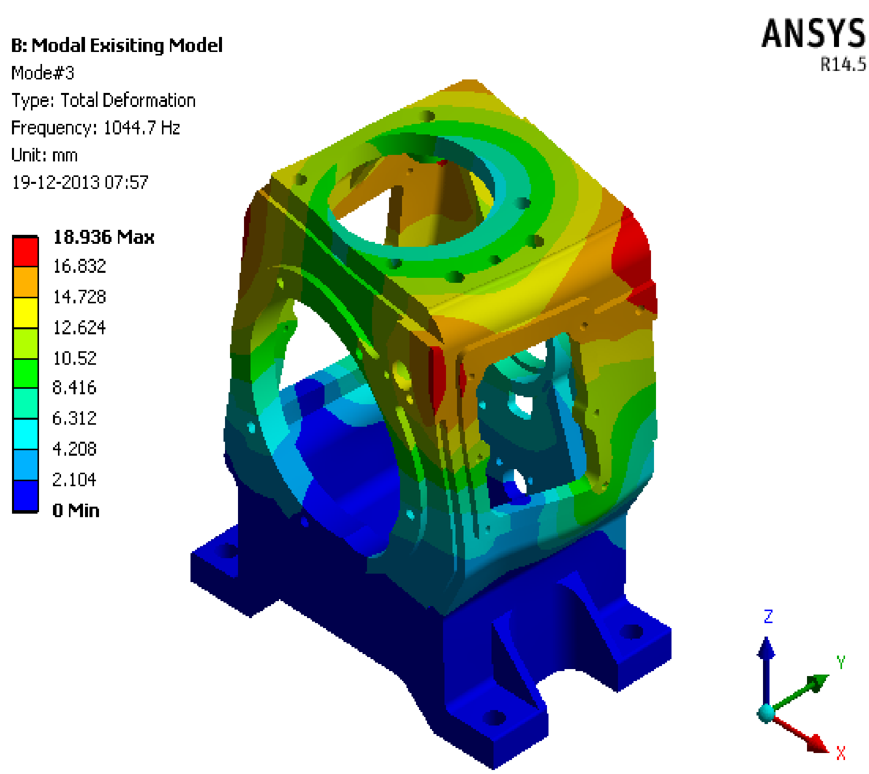

Figure 5. -Mode shape of crankcase for third frequency 1044.7 Hz.

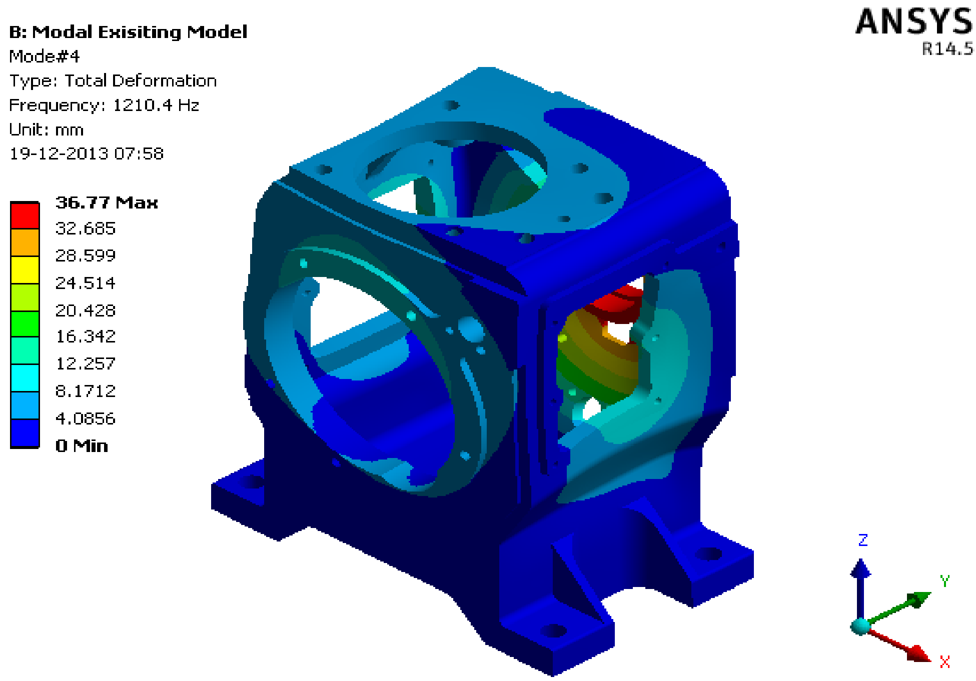

Figure 6 -Mode shape of crankcase for forth frequency 1210.4Hz

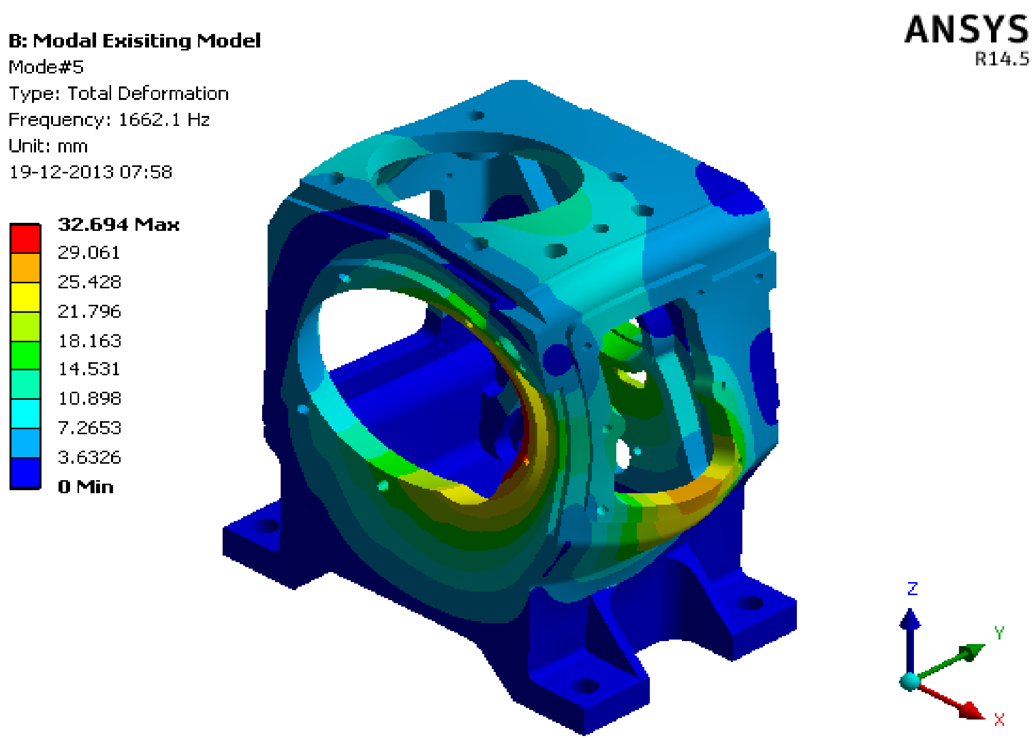

Figure 7 -Mode shape of crankcase for Fifth frequency 1662.1Hz

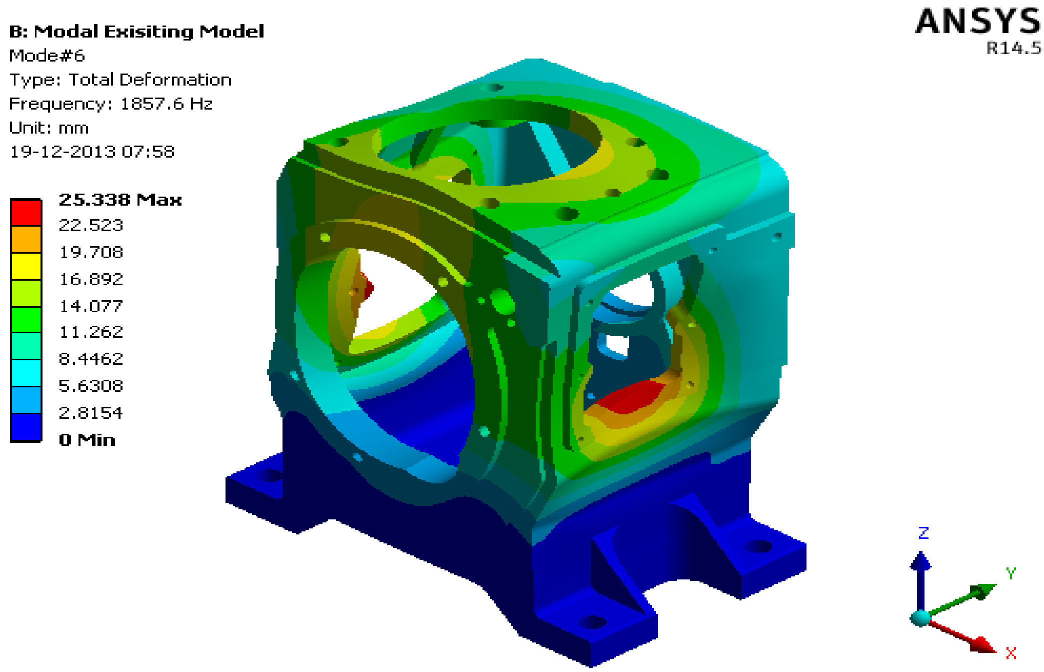

Figure 8 -Mode shape of crankcase for sixth frequency 1857.6 Hz.

5. CONCLUSION.

Because of crankshaft has rotational movement torsion mode are much more important than the bending moment .As it mentioned only 5th mode is torsion mode and so it is important. Natural frequency of fourth mode in this state 1662.1 Hz and lowest rotational speed is 24931.5 rpm. Maximum rotational speed of single cylinder four stroke diesel engines is 2600 rpm. So it is quite clear that the crankcase has no resonances phenomenon (no resonance occurs).

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Appendix A: Natural frequency of crankcase of four stroke diesel engine by using critical Speed equation.

No of mode	**Natural Frequency**	**Types of Mode**	**ω Critical q=1/2**	**ω Critical (rpm) q=1**	**ω Critical q= 1 1/2**	**ω Critical q=2**	**ω Critical q=3**	**ω Critical q=4**
1	485.99 Hz	Bending	58200.	29159.4	19439.6	14579.7	9719.66	7289.85
2	682.28 Hz	Bending	81873.6	90936.8	27291.2	20468.4	13645.6	10234.2
3	1044.7 Hz	Bending	125364.	62682.	41788.	31341.	20894.	15670.5
4	1210.4Hz	Bending	145200.	72600.	48400.	36300.	24200.	18150.
5	**1662.1 Hz**	**Torsion**	**199452.**	**99726.**	**66484.**	**49863.**	**33242.**	**24931.5**
6	1857.6 Hz	Bending	222912.	111456.	74304.	55728.	37152.	27864.