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Comparison of Static and Dynamic Analysis of Crank Shaft Made of EN9 with other Materials

S.V.Aparna, P.Santhosh Kumar

***Abstract*— Crankshaft experiences a complex loading due to the motion of the connecting rod, which transforms two sources of loading to the crankshaft. In this paper, static & dynamic analysis was done at various speeds to study the stress concentrations at critical locations of crankshaft. The main objective here is calculating natural frequency and resonance of the object and selection of the best materials for crankshaft. These improvements result in lighter and smaller engines with better fuel efficiency and higher power output. Crankshaft must be strong enough to take the downward force of the power stroke without excessive bending.**

***Index Terms*— Design, Analysis, Comparison of Materials.**

I. INTRODUCTION

Statics analysis was conducted on a nickel chrome steel and structural steel crank shafts from a single cylinder four stroke engine. Finite elements analysis was performed to obtain the variation of stress magnitude at critical locations. Three dimensional model of crankshaft was created in Pro/E soft ware. The load was then applied to the FE model and boundary condition where applied as per the mounting conditions of the engine in the ANSYS Workbench [1]. The relationship between the frequency and the vibration modal is explained by the modal analysis of crankshaft. The results would provide a valuable theoretical foundation for the optimization and improvement of engine design [2].

Dynamic analysis of the crankshaft results show more realistic whereas static analysis provides an overestimate results. Accurate stresses and deformation are critical input to fatigue analysis and optimization of the crankshaft. At mode 1 EN9 having 510.9 Hz (47.782 mm deformation) which is compared to other material is having very less deformation.

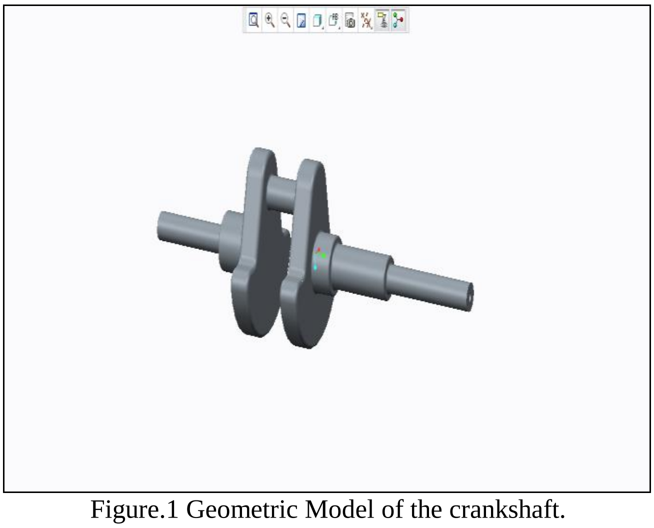

Figure.1 Geometric Model of the crankshaft.

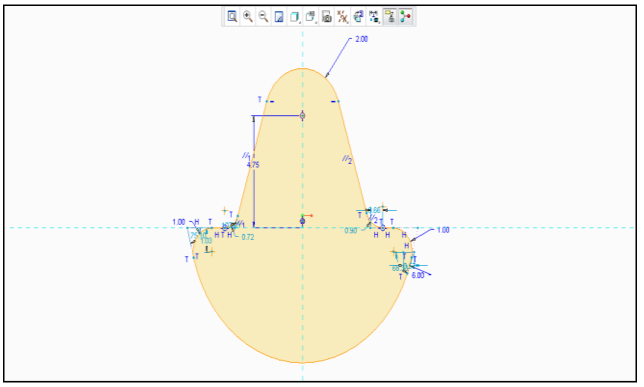

Figure.2 3D Model Developing

Mechanical Properties:

CAST –IRON:

E: 120 GPa
Poison ratio: 0.3
Density: 7200 Kg/m³
Yield strength: 195 MPa

STEEL:

E: 200 GPa
Poison ratio: 0.29
Density: 7850 kg/m³
Yield strength: 250MPa

NI-CAST IRON:

E: 90 GPa
Poison ratio: 0.33
Density: 7400 kg/m³
Yield strength: 220M pa

EN9:

E: 210 GPa
Poison ratio: 0.29
Density: 7850 kg/m³
Yield strength: 351MPa

II. STRUCTURAL ANALYSIS

Material: Cast iron

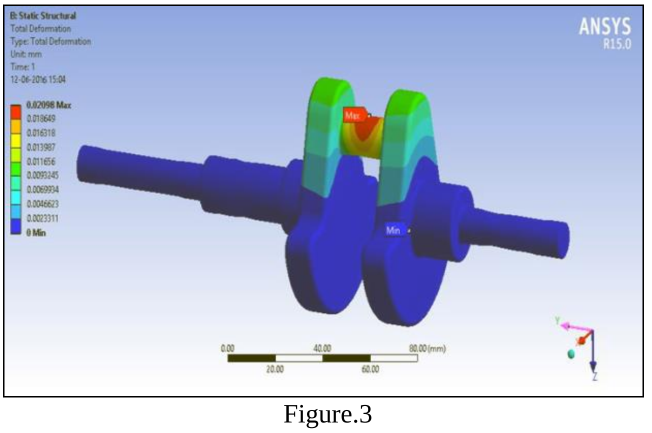

Figure.3

Figures3,4,5, 6 shows the deformation and equivalent stress of crank shaft when torque is 120N-m. It is observed that the deformation is less in EN9 material as compared to other (cast iron, Ni-cast iron, Steel). The stress induced in EN9 is more when compared to other materials.

Material: Ni-cast iron

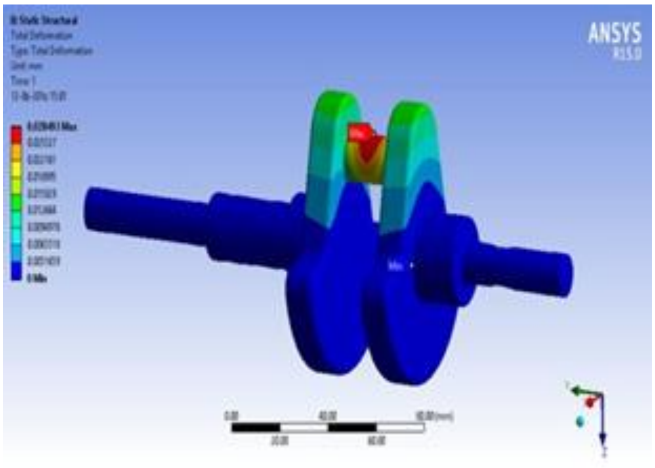

Figure.4

Material: Steel

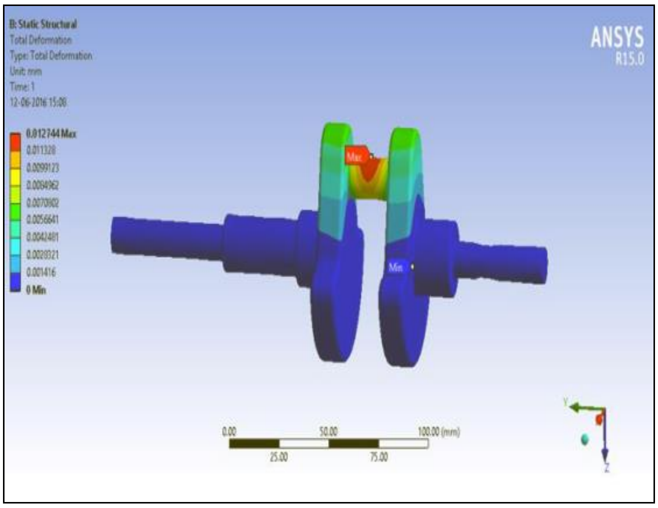

Figure.5

Material: EN9

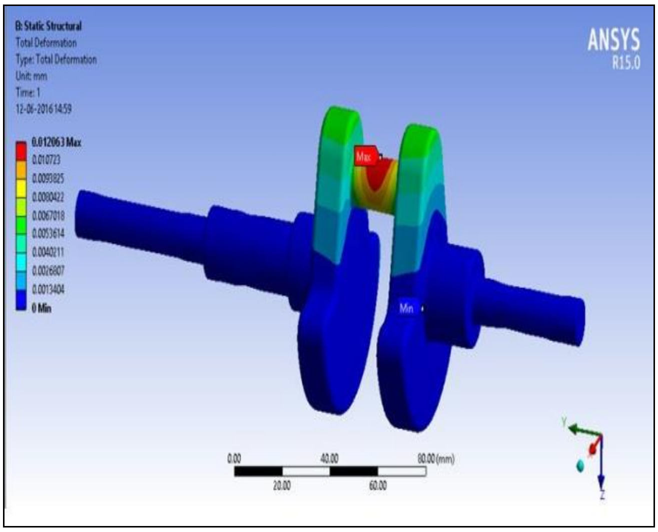

Figure.6

III. COMPARISION OF MATERIALS

Structural analysis gives results of materials (cast iron, Ni-cast iron, steel, EN9).The table.1 shows variation of deformation, equivalent stress and factor of safety.

Materials	Load(N-m)	Deformation, mm	Equivalent stress Mpa	Factor of safety
Cast iron	120	0.0233	256.59	0.79
NI-cast iron	120	0.029	256.56	0.9
Steel	120	0.014	256.65	0.81
EN9	120	0.011	256.67	1.4

Table.1 Variation of deformation, stress and factor of safety with constant load

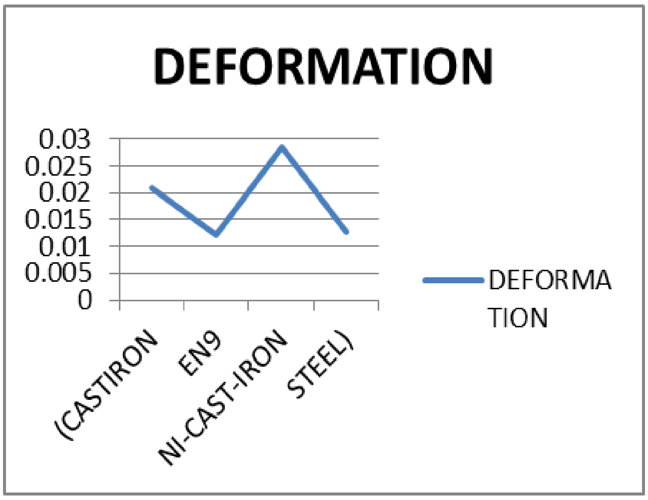

Figure.7 Load Vs Deformation of different materials

Figure.7 shows a Graph is plotted between Load Vs Deformation of all materials for constant load, the EN9 Material has less deformation compared to other materials (cast iron, Ni-cast iron, Steel).

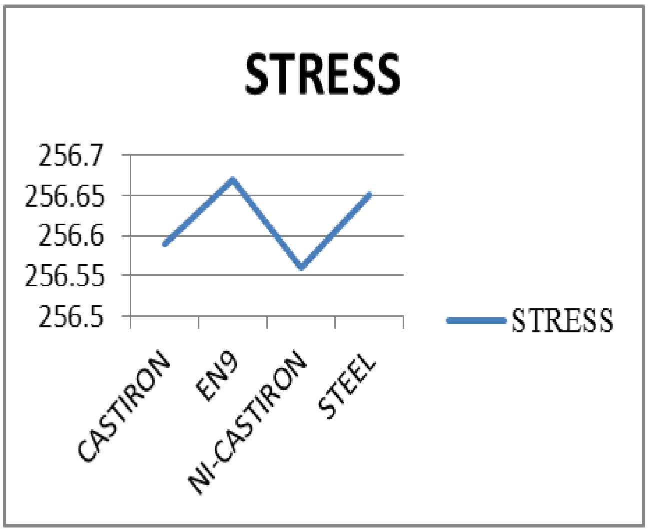

Figure.8 Stress variation for different materials

Figure.8 shows a Graph plotted between Stress variations for all materials for constant load, the EN9 Material has more stress value compared to other materials (cast iron, Ni-cast iron, Steel).

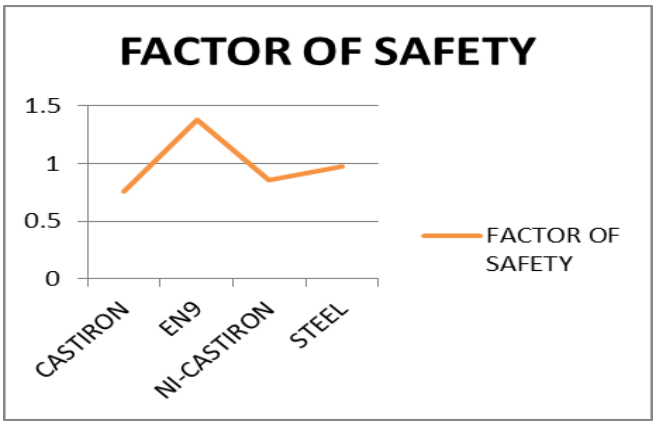

Figure.9 Variation of factor of safety for all materials

Figure.9 A Graph is plotted to show Variation of factor of safety for all materials for constant load, EN9 Material has more factor of safety value compared to other materials (cast iron, Ni-cast iron, Steel)

IV. MODEL ANALYSIS

It is used to calculate natural frequencies and mode shapes of a structural Model analysis need only boundary conditions, it is not associated with the load apply, because natural frequencies are resulted from the free vibrations. The figure shows the natural frequencies of cast iron, Ni-cast iron, steel and EN9 materials.

Material: Cast iron

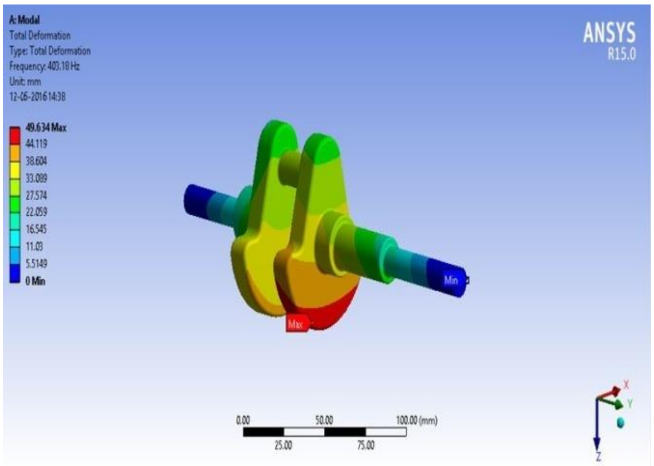

Figure.10

Material: Ni-cast iron

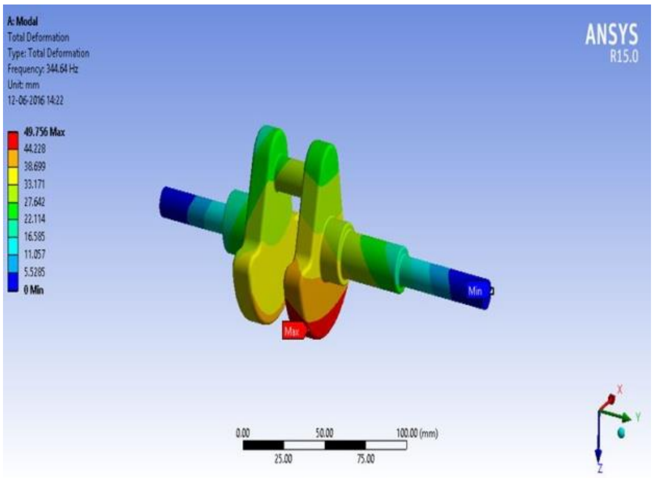

Figure.11

Material: Steel

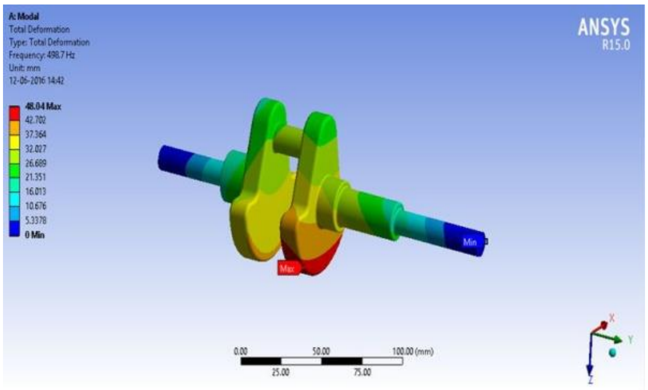

Figure.12

Material: EN9

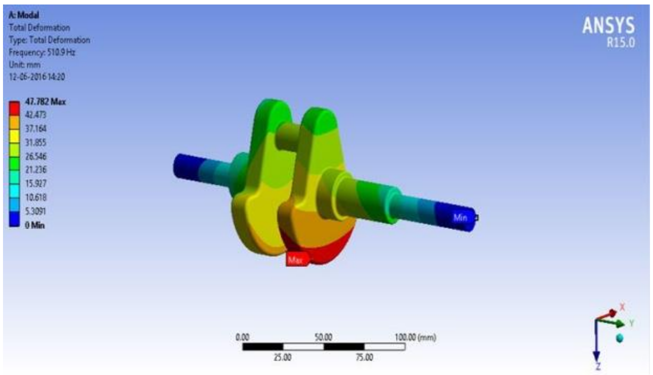

Figure.13

From Figures 10,11,12,13 it is observed that the Natural frequency of EN9 material when compared to Cast iron, Steel, Ni-Cast iron, frequency range is high.

Table.2 shows the Variation of Natural Frequencies for Different Modes for Different Materials:

Modes (HZ)	Cast iron	EN9	Nickel Cast iron	Steel
1	403.15	510.9	344.64	498.7
2	471.5	595.12	398.31	578.62
3	534.38	677.41	457.31	661.47
4	977.78	1234.9	827.5	1201.4
5	1533.9	1944.6	1313	1899
6	1827.3	2315	1561.1	2259.3
7	2665.7	3379.9	2282.6	3301
8	2671.9	3386.4	2285.2	3306.1
9	3330.3	4224.1	2855.1	4127.3
10	3798.9	4815.6	3251	4702.4

Table.2

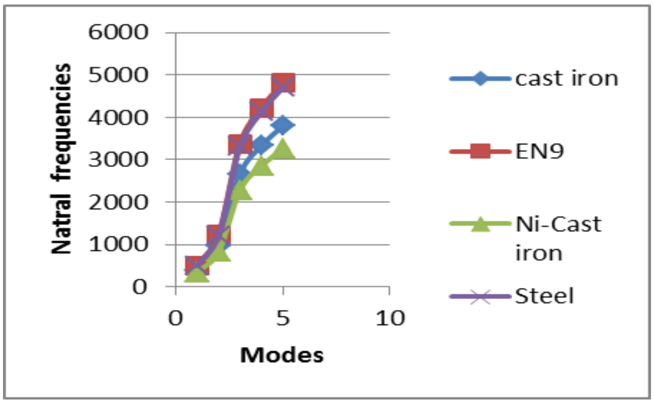

Figure.14 Natural frequencies of materials.

From Figure.14, it can be observed that the Material EN9 shows more frequencies when compared to other materials and material Ni-cast iron has less frequency.

V. CONCLUSION

In this paper, the single cylinder crankshaft model was created in creo-2 software and the model imported into ANSYS. By comparing all results in case1 (400rad/s, 6Mpa, 120N-m), EN9 material is having good strength and low stress values at high rotational velocity and high pressure and torque respectively. The factor of safety is 1.3831, von-mises stress 256.67 MPa.

The Value of Von-Misses Stresses that comes out from the analysis is far less than material yield stress so it can be concluded that the design is safe and further go for optimization to reduce the material and cost.
Dynamic analysis of the crankshaft results show more realistic whereas static analysis provides an overestimate results. Accurate stresses and deformation are critical input to fatigue analysis and optimization of the crankshaft. At mode 1 EN9 having 510.9 Hz (47.782 mm deformation) which is compared to other material is having very less deformation.

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