

STATIC ANALYSIS AND WEIGHT OPTIMIZATION OF CRANKSHAFT IN SINGLE CYLINDER FOUR STROKE DIESEL ENGINE

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Abstract – Reducing Weight is main problem in automobile industries. Since, if the vehicle weight is more the consumption of fuel is also more. And also if vehicle weight rises the cost also rises which indeed a main problem while buying an vehicle. The objective of the present work is to design and analyze the crankshaft with the material it is manufactured and also for the other metal alloys viz., EN9, SG700/2, SAE-1137. The solid model of the crankshaft was created in Solid Works. Model was imported in Altair Hyperworks for analysis by applying the normal load conditions. The model was tested for stress and deformation as the design constraints and also its frequency by performing modal analysis. After analysis a comparison is made between results of above materials mentioned in terms of deflections, stresses and frequency, to choose the best one.

Key Words: Crankshaft, EN9, SG700/2, SAE-1137, Solid Works, Hyperwork.

1. INTRODUCTION

The main work of the crankshaft is to transform the translational mechanical work of the piston being carried forward and backward by the pneumatic work due to pressure change as a outcome of the combustion response. Crankshafts are mass volume manufacturing engine part and they are widely used in automobile engine. In an internal combustion engine, the pistons linear reciprocating motion is transformed into rotary motion using the crankshaft. There are lots of further uses of a crankshaft which covers from tiny single cylinder engines to big size multi cylinder marine crankshafts. The part connects the piston to the crankshaft via the connector pin used for the transfer of this energy; the connector pin energy to the tiny part of crankshaft axel that is offset comes from the main axis results in the rotation about the primary crankshaft axis. The crankshaft is also attached to the pull-start by the pull-start connection cup. When the pull-start chord is pulled, the energy is transferred to rotational energy of the crankshaft.

The crankshaft has transform the translational mechanical work of the piston to rotational mechanical

work, its upcoming function is to convert this work to the driver pulley of the pulley-belt system. This is a important transfer of work due to its belt-pulley system that eventually replace this rotational mechanical work to the auger, causing it to rotate and collect the snow and additional material that is added by the auger. The movement that is related with the crankshaft is just this energy conversion. The crankshaft is located directly adjacent to the two-cycle gas engine, since it is attached to the piston by the connector pin.[5] This location further to the engine is a hot atmosphere that is caused by the convection of thermal energy off of the engine block's heat sink. The high temperatures in this atmosphere are cause for consideration when select the material for the crankshaft, which will be considered in the following section, with the help of geometry and appearance of the component.

2. GEOMETRIC MODELLING

To carry out CAE analysis of any component, the solid model of the same is essential. It is also called body in white. The CAD diagram shown in Fig. 1

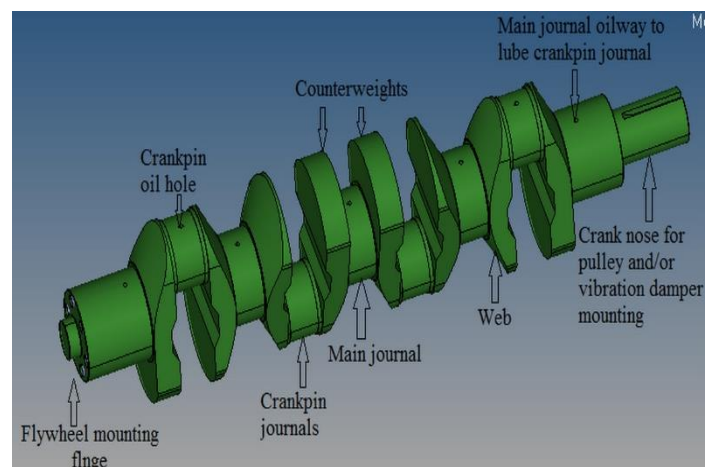


Figure 1- Crankshaft

2.1 MESHING

The creation of the FE-model initiates by importing the CAD model of the crankshaft from SOLID WORK to

Hypermesh. The assembled SOLID WORK model is exported to Hypermesh in .igs format. Meshing of CAD model is done by using solid elements. Whole crankshaft is meshed using solid element tetra4 with an average element size of 5mm.

Each node has displacement components and rotational degrees of freedom. Quality checks are made in order to eliminate coincident nodes and coincident elements. A standard mesh sensitivity analysis is carried out in order to confirm that the results achieved are effectively not altering to the size of the elements used. Figure 2 shows the complete meshed model of crankshaft.

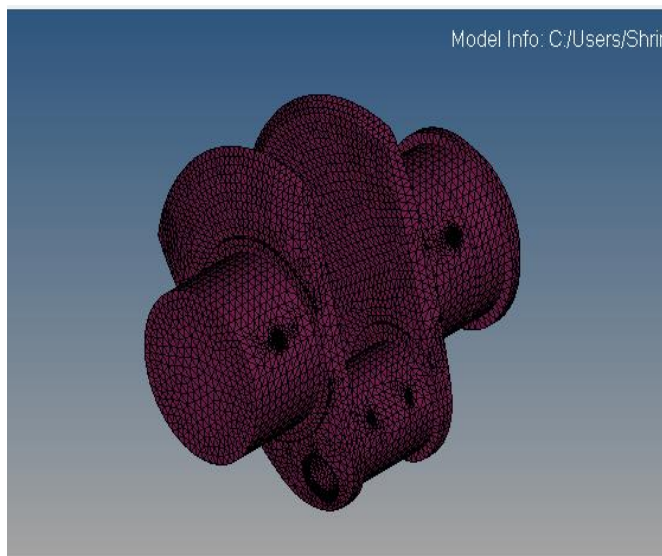


Figure 2: Meshed model of Crankshaft

Table 1: Types and number of elements

Total No. of Nodes	23305
Total No. of Elements	105613
Tria3 Elements	-----
Quad4 Elements	-----
Tetra4 Elements	105613
Hexa8 Elements	-----

2.2 MATERIALS AND PROPERTIES

Material properties need to be selected from standard material handbook. Most of the crankshafts are generally made of steel. Also the different materials with different compositions can be used for crankshafts which are shown in below table 2.

Table 2: Materials and properties

Material Description	Young's Modulus (E) MPa	Yield Strength (s) MPa	Poisson's ratio	Density ton/mm3
EN9	2.06e5	355	0.28	7.89e-9
SG700/2	1.72e5	471	0.28	7.15e-9
SAE-1137	2e5	435	0.285	7.8e-9

2.3 BOUNDARY CONDITIONS

The boundary condition is the applying of a load and/or constraint. In Hypermesh, boundary conditions are saved within a collector called load collectors. The function of the boundary conditions is to create and define constraints and loads on finite element models.

Constrained positions are showed in below figure 8.2. The load application is the major part in the analysis of a component. There are several kinds of loads like Point Load, Uniformly Varying Load and Uniformly Distributed Load.

The present crankshaft carries the UDL throughout its crankpin length. Where the total applied load is 39485.92N which is distributed along the length of the crankpin as well as the crankshaft is constrained at the both ends. Length of the pin is 40 mm. The total load and constrained applied on the crankshaft is as shown in below figure 3.

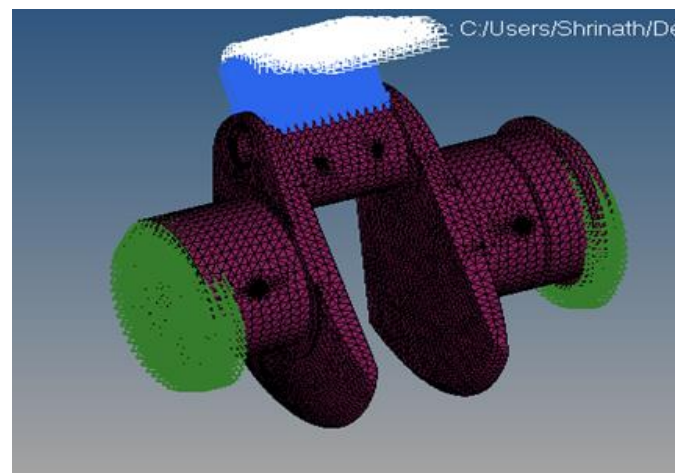


Figure 3: Boundary conditions.

3. SIMULATION AND RESULTS

Simulation is the processes of product validation where the product is tested with defined boundary conditions and assumed parameters. The process of simulating anything starts with model development; this model indicates the main function, characteristics or behaviors of the chosen physical process. The model represents the system itself, whereas the simulation represents the operation of the system over time.

In this paper we are taken a crankshaft and by changing its material properties the simulations are carried out. And finally the results of the simulations were compared.

3.1 EN9

For EN9 material, static analysis results are maximum displacement is 0.02128mm and maximum von-misses stress is 146.7Mpa. For free-free modal analysis frequency is 8378.6Hz and for constrained frame frequency is 6281.8Hz. The result images are shown in figure 4, 5, 6 and 7.

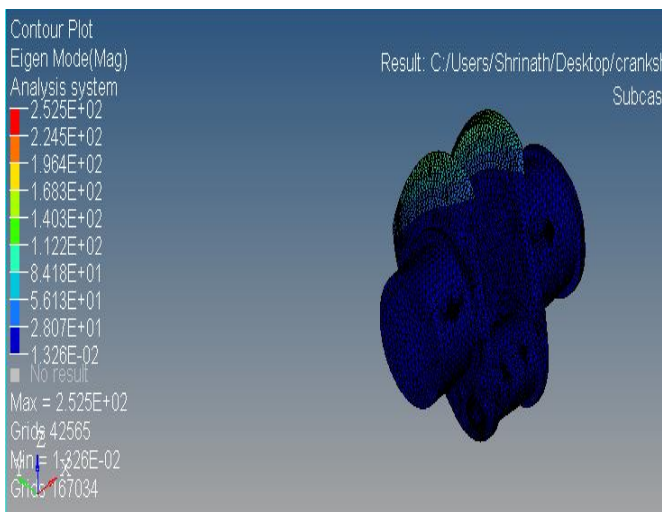


Figure 4: Free-Free Modal Analysis For EN9

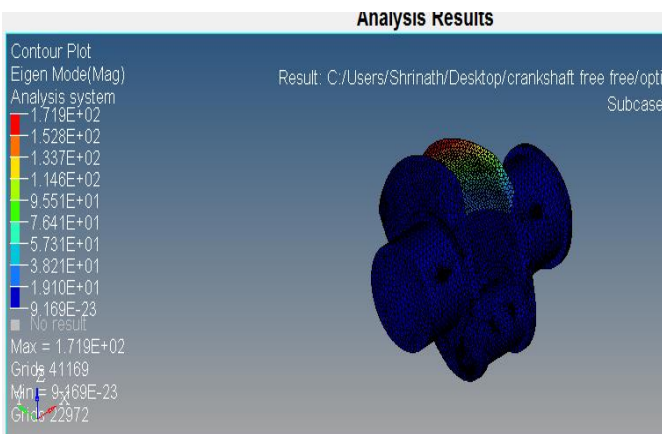


Figure 5: Constrained Modal Analysis For EN9

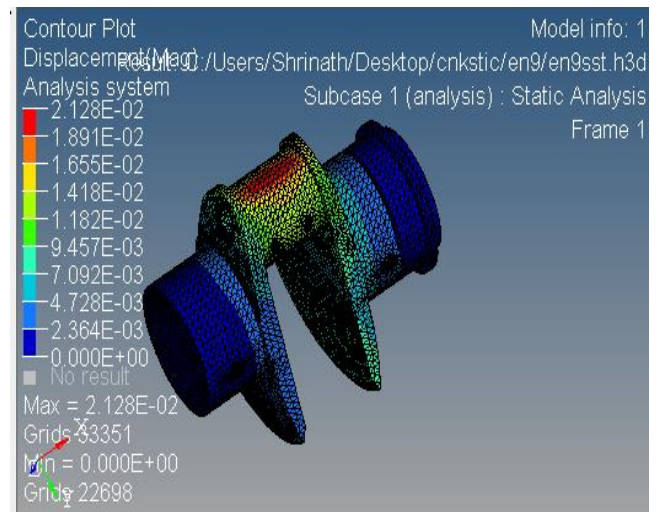


Figure 6: Displacement For EN9

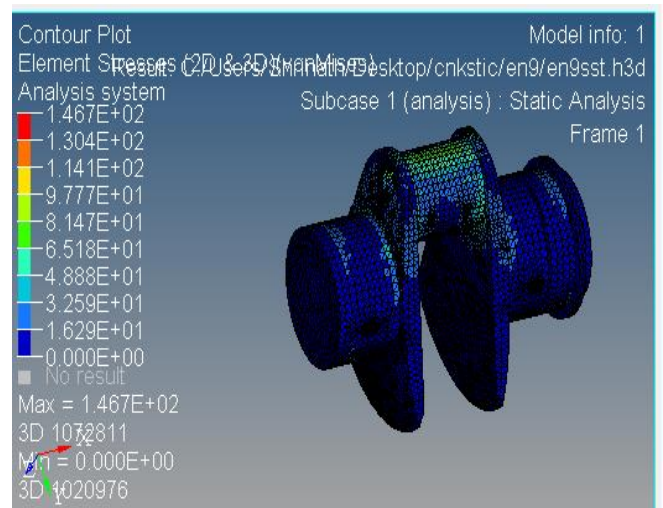


Figure 7: Von-Misses Stress For EN9

3.2 SAE-1137

For SAE-1137, static analysis results are maximum displacement is 0.02188mm And maximum von-misses stress is 146.1Mpa. For free-free modal analysis frequency is 8321.3Hz and for constrained frame frequency is 6239.4Hz. The result images are shown in figure 8,9,10 and 11.

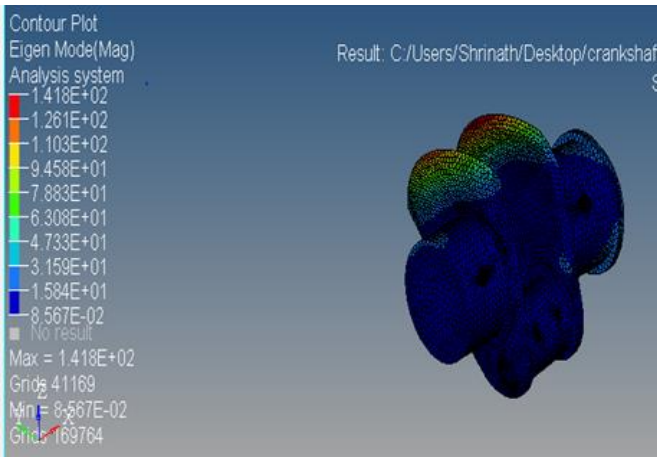


Figure 8: Free-Free Modal Analysis For SAE-1137

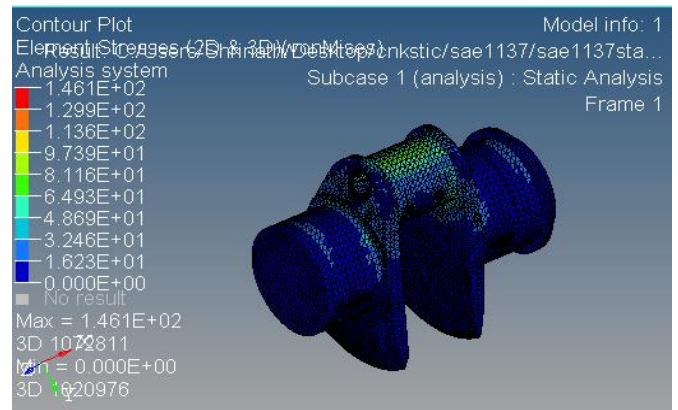


Figure 11: Von-Misses Stress SAE-1137

3.3 SG700/2

For Low alloy steel SG700/2, static analysis results are maximum displacement is 0.0254-mm and maximum von-misses stress is 146.7Mpa. For free-free modal analysis frequency is 8023.7Hz and for constrained frame frequency is 6014.6Hz. The result images are shown in figure 12, 13, 14, and 15.

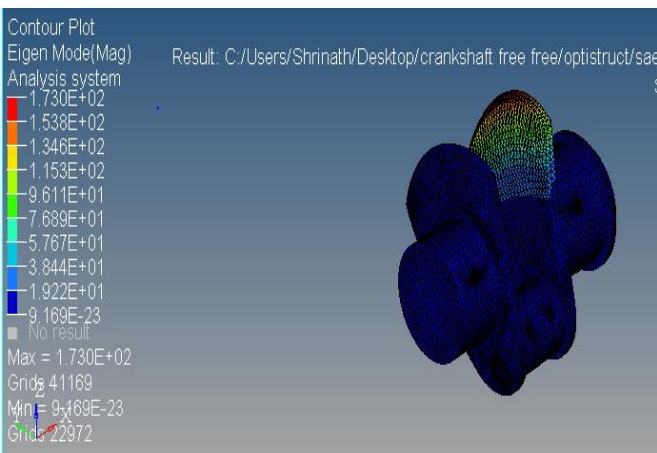


Figure 9: Constrained Modal Analysis For SAE-1137

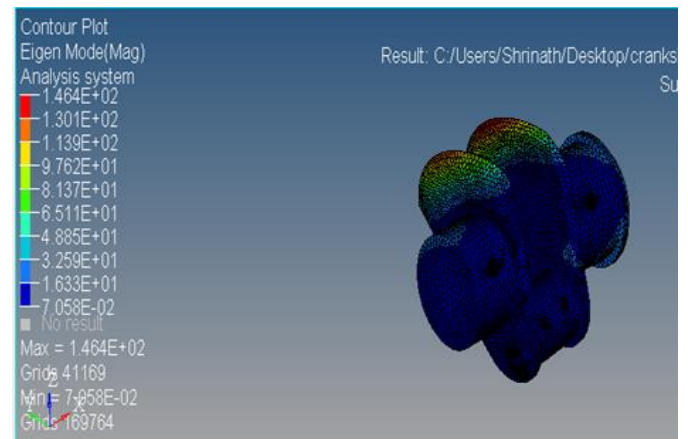


Figure 12: Free-Free Modal Analysis For SG700/2

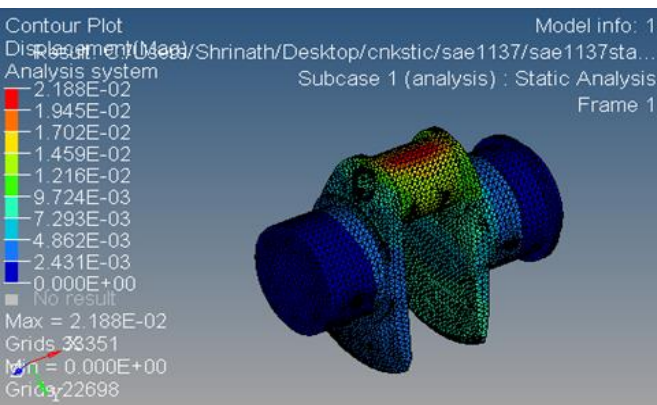


Figure 10: Displacement SAE-1137

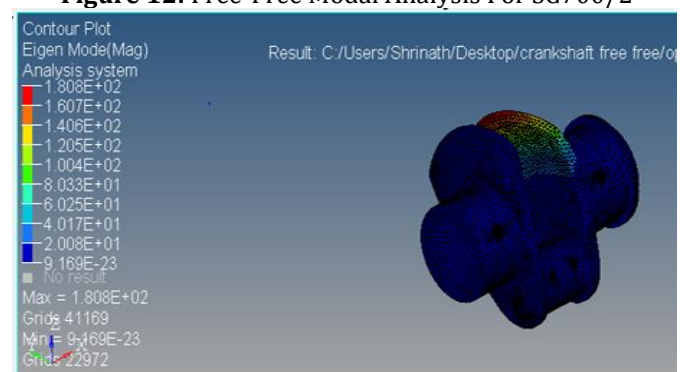


Figure 13: Constrained Modal Analysis For SG700/2

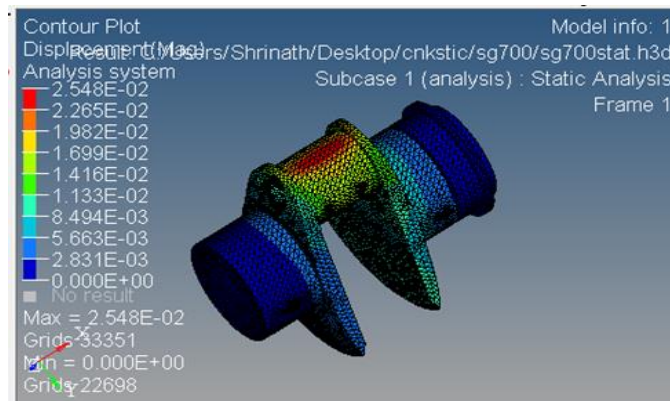


Figure 14: Displacement For SG700/2

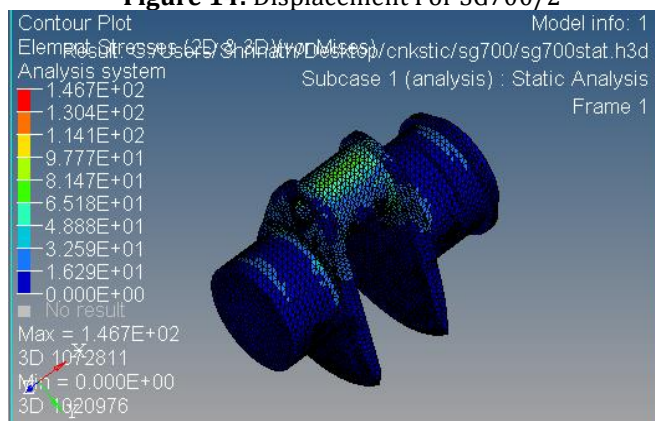


Figure 15: Von-Misses Stress For SG700/2

4. SUMMARY OF RESULTS

In this section we will discuss and compare the results of above simulations. The table 8.1 shows the summary of simulation results. The table shows the comparison between the simulation results of ladder chassis frame with different materials.

Table 3: Summary of Results

Materials	Static Analysis		Modal Analysis		Weight (kg)	Price (INR/kg)
	Displacement (mm)	Stress (MPa)	Free-free	Constrained		
			Frequency (Hz)	Frequency (Hz)		
EN9	0.02128	146.7	8378.6	6281.8	2.826	
SG700/2	0.0254	146.7	8023.6	6014.6	2.5609	43.15
SAE-1137	0.02188	146.1	8321.3	6239.4	2.794	47.45

5. CONCLUSIONS

In this project work, simulation is carried out on crankshaft with different materials. Here Altair Hypermeshv11.0 tool is used for meshing the complete model and passed the quality criteria's such as Quality Index, Skewness, Warpaga, Jacobian etc. The FE model is successfully analyzed using RADIOSS and OPTISTRUC software. After completing the simulations displacement, stress and frequency results are compared. From the comparison of simulation results we can concluded that:

1. The displacement is less i.e. 0.02128mm in EN9 material compared to other materials.
2. The von misses stresses are found almost same in all the three materials (EN9, SG700/2, SAE-1137) i.e. 146.7MPa under given boundary conditions.
3. The crankshaft made of SG700/2 material has less weight of 2.5609kg compared to other materials analyzed.
4. 10% weight reduction is observed by using SG700/2 with respect to EN9.
5. As compared to the cost of the SG700/2 is having the lower with compared to other material.
6. The frequency seen for material SG700/2 in free-free analysis is 8023.6Hz which is relatively lower and comparable with other materials.
7. The frequency seen for material SG700/2 in constrained analysis is 6014.6Hz which is relatively lower and comparable with other materials.
8. The percentage of weight reduction is 10% in single cylinder engines where as it would be even lower for four cylinder engine crankshaft.

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