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Research Paper

STRESS ANALYSIS AND OPTIMIZATION OF CRANK SHAFT USING CAE TOOLS

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Crankshaft is one of the most important parts in internal combustion engine, which converts the reciprocating displacement of the piston to a rotary motion with a four link mechanism.The objective of this paper was to suggest the optimum design parameter of the existing crankshaft by changing the design variables like journal diameter, crankpin diameter, fillets and counterweights etc. Here crankshaft of a four cylinder diesel engine was taken as case study. In the present paper, model of crankshaft was designed in the ANSYS Workbench and then Finite Element Analysis was carried out under the same loading conditions. Here, static analysis was done to find the maximum deformation and maximum stress point. Apart from this strain, shear stress and total deformation contours are also plotted. The results obtained are compared with the existing results and the crankshaft with optimum design was selected.

Keywords: Internal combustion engine, Finite element method, crankshaft analysis, ANSYS Workbench

INTRODUCTION

The crankshaft, sometimes casually abbreviated to crank, is a key component of an engine which translates reciprocating linear piston motion into rotation. The strength of the crankshaft affects the reliability and life of internal combustion engine largely (Haats and Wambach, 1999). During working stroke,when ignition of the fuel takes place, the flue gases develop high pressure inside the cylinder. This high pressure transmits to the crankshaft through the connecting rod. This pressure forces the crankshaft to rotate in a set of supporting bearings (main bearings). Due to this, crankshaft is subjected to bending and torsional stress and leads to the bending and torsional deformation. So crankshaft should be ofsufficient strength to bear these stresses, inertia and centrifugal forces.

In the present paper, crankshaft of a four cylinder diesel engine (Sun Lianke *et al.,* 2007) was taken for static analysis. The FEM (Nitin S Gokhale and Sanjay S Deshpande, 2008) software ANSYS Workbench was used to analyze the crankshaft model. The results of the equivalent (Von Mises) stress and directional deformation (Y-direction) were obtained and compared with the existing results (Gu Yingkui and Zhou Zhibo, 2011). For the optimized crankshaft, it was shown that the

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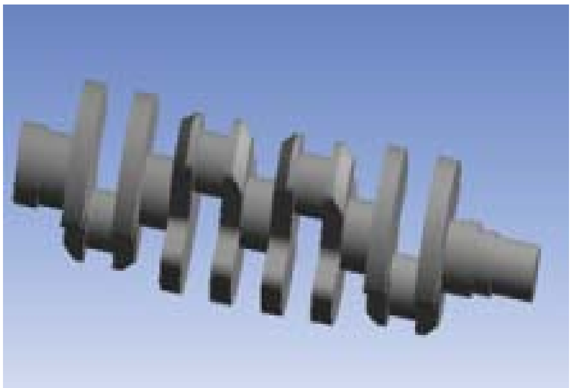
obtained results are better than the existing results. Apart from this, total deformation, equivalent elastic strain and equivalent shear stress were also plotted.

CRANKSHAFT MODEL AND BOUNDARY CONDITIONS

In the present research, the four-cylinder engine crankshaft is about 514 mm in length, it has four crankpins and five main bearing journals. In our investigations the real crankshaft was represented by a model whose structure details, such as chamfer, were ignored. The crankshaft model was created and analyzed by ANSYS Workbench. The model of four-cylinder crankshaft is shown in Figure 1.

Figure 1: 3-D Entity Model of Crankshaft



According to the structure of crankshaft, the crankshaft model was meshed by solid92 which was one of ANSYS solid type. The chamfer of the crankshaft was tessellated. The finite element mesh of the 3-D crankshaft model using ANSYS Workbench is shown in Figure 2. The material of crankshaft is QT800. The physical parameters used in the crankshaft simulation are listed in Table 1.

Figure 2: Meshed Model of Crankshaft

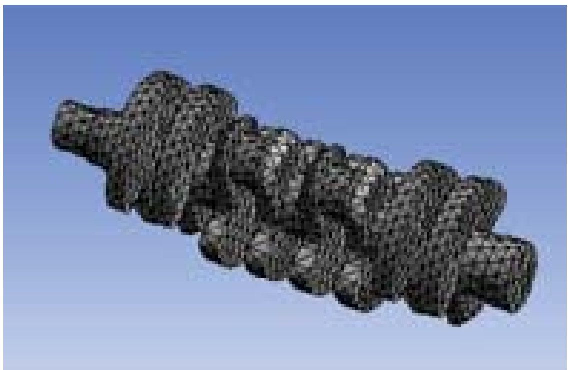


Table 1: Physical Parameters for Crankshaft

Material Selected	Structural Steel (QT800)
Young's Modulus,(E)	2.1 X 10^5 MPa
Poisson's Ratio	0.277
Ultimate Tensile strength	460MPa
Yield Strength	250MPa
Density	7800kg/m3
Behavior	isotropic

Under the similar conditions, the load on each crankpin is 20000N.Cylindrical supports are provided to the crankshaft which are free in radial direction and fixed in tangential and axial direction.

MODEL ANALYSIS

The modal analysis was carried out using the ANSYS Workbench software. For optimized crankshaft the results are shown by the Figures 3, 4, 5, 6 and 7 respectively.

The Figure 3 shows the Von Mises contour of crankshaft under the normal load of 20000 N. The maximum stress is found to be 166.93 MPa at the knuckle of centre journal shaft. The value of maximum stress is well below the yield

Figure 3: Equivalent (Von Mises) Stress

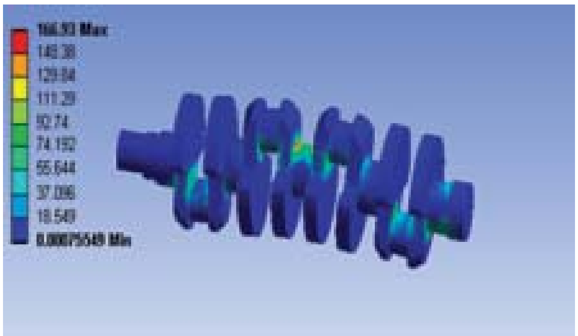


Figure 4: Directional Deformation

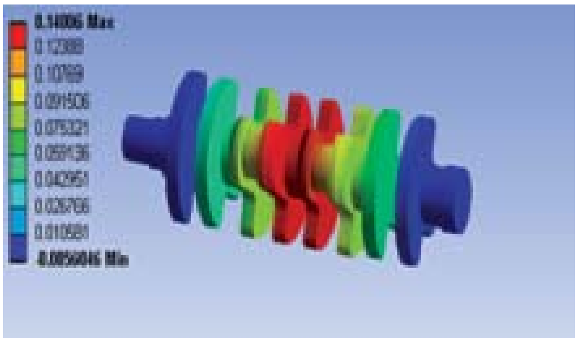
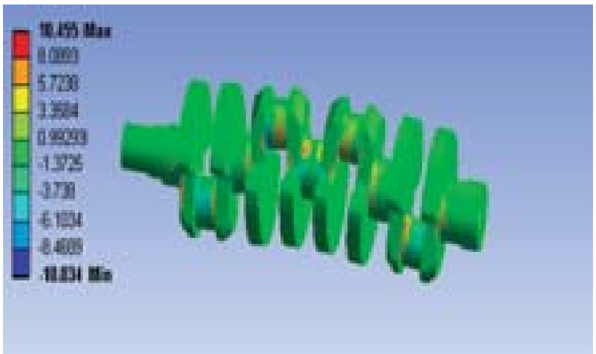


Figure 5: Equivalent (Von Mises) Shear Stress



stress 250 MPa for the structural steel. Figure 4 shows the directional deformation (Y-direction), which is found to be maximum at the centre (0.14006 mm). Both, maximum stress and directional deformation are less than the existing results. Figures 5 and 6 shows the maximum shear stress and the maximum strain which are found to be 10.455 and 7.95e-4 respectively. Total deformation is also determined which is shown by the Figure 7. So crankshaft design lies under the permissible limit.

Figure 6: Equivalent (Von Mises) Elastic Strain

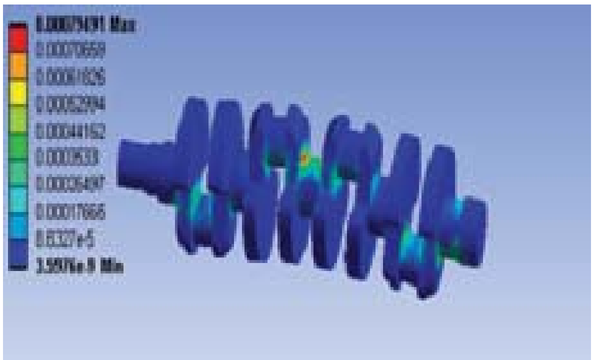
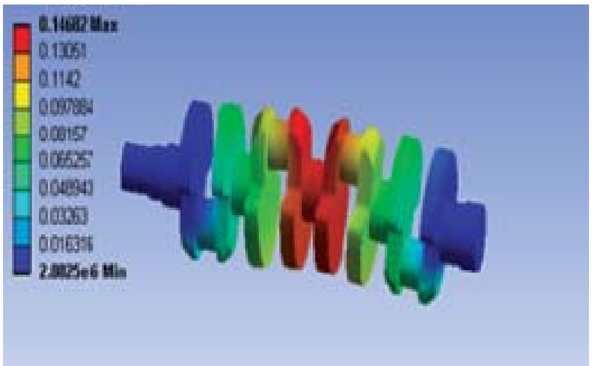


Figure 7: Total Deformation



RESULT COMPARISON

The FEA results are in close agreement with the experimental results. The variation in the Von-Mises stress is 20.88%. The variation in the directional deformation is 33.2%. So the FEA results are better than the existing one. Comparison of results is shown by the Table 2.

Table 2: Result Comparison for Static Analysis

S. No.	Parameters	Existing Result for Normal load (20 kN)	FEA Result for Normal load (20kN)
1.	Equivalent von-Misses stress	211 MPa	166.93 MPa
2	Directional deformation	0.211 mm	0.14006 mm

CONCLUSION

The following conclusions can be drawn from the analysis conducted in this study:

1. On the basis of the current studies performed, it can be concluded that the design parameter of connecting rod can be modified in such a way so that sufficient improvement in the existing results can be obtained.
2. During the design optimisation, weight of the crankshaft is also reduced by 193 gm which results in reduction in inertia and centrifugal forces.
3. It was found that the maximum stress point region was at the knuckle of the centre main journal shaft and crank arm.

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