Design and Analysis of Cast Stainless Steel Crankshaft in Solidworks Software

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Abstract - *The **crankshaft** is an important part of the **IC engine** that transforms the piston's reciprocating motion through the connecting rod into **rotary motion**. A crankshaft should have adequate strength to endure the moments of bending and twisting it is exposed to. The load added in **SOLIDWORKS** to the FE model. According to the engine mounting conditions, simulation boundary conditions are applied. In the study, stress variation over the engine cycle and the impact of torsion and bending load are discussed. Theoretically, Von-misses stress is measured using SOLIDWORKS software.*

Key Words: crankshaft, IC Engine, Rotary Motion, Solidworks, FE model.

1. INTRODUCTION

The crankshaft plays a vital role in all Internal Combustion Engines[1]. The crankshaft changes the direct movement of the cylinders into a rotational movement that is transmitted to the heap[2].Crankshaft is a large part consisting of bearing plates as the crank webs and balancing mass in the engine with a complex geometry, which transforms the piston's reciprocating displacement into rotating motion. This research was performed on a four-stroke diesel engine with a single cylinder. The crankshaft must be sturdy enough to bear the downward force without undue bending during the power stroke. The efficiency and life of the internal combustion engine is therefore largely dependent on the crankshaft's power. The crankshaft is the component of large volume production; an optimized design is therefore an efficient way to increase the engine's fuel efficiency and overall cost. When a power impulsion reaches a crankpin at the front of the engine, the torsional vibration occurs and the power stroke stops. It can break the crankshaft if not managed.

Crankshaft is a mechanical component with a complex geometry which transforms reciprocating motion into rotary motion[3]. The crankshaft has to sustain all the stress and the power strokes due to the gas combustion for unobstructed functioning of the engine[4]. Since the crankshaft experiences a large number of load cycles during its service life, fatigue performance and durability of this component has to be considered in the design process[5]. Design developments have always been an important issue in the crankshaft production industry, in order to manufacture a less expensive component with crankshaft production industry, in order to manufacture a less expensive component with requirements. These improvements result in lighter and smaller engines with better fuel efficiency and higher power output. Strength calculation of the crankshaft becomes a key factor to ensure the life of the engine. Beam and space frame models were used to calculate the stress of crankshaft usually in the past. But the number of nodes is limited in these models. With the development of computers, more and more design of crankshaft has been utilized in the finite element method (FME) to calculate the stress of crankshaft.

2. PROBLEM STATEMENT

Crankshaft is a large component with a complex geometry in the engine which converts the reciprocating displacement of the piston to a rotary motion. The crankshaft consists of three parts: crank pin, crank web, shaft. The big end of the connecting rod is connecting to the crank pin. The crank web connects the crank pin to the shaft portion this project will concentrate on the study of maximum stresses on a four-stroke IC engine steady state cast stainless steel crankshaft resulting from engine combustion pressure when the engine is started. The crankshaft torsional vibrations are caused by cyclic changes in gas pressure within the cylinder. The crankshaft torsional vibration is the leading cause of its failure. . At the root of the fillet areas stress concentrations exist and these high stress range locations are the points where cyclic loads could cause fatigue crack initiation leading to fracture[6].

2.1 Main Objectives

- Ø To perform static evaluation in solidworks simulation software.
- Ø To assess the von misses strain and shear stress.

2.2 Modeling and Meshing of crankshaft:-

According to the structure of the crankshaft, the main dimension parameters are considered while preparing the model in SOLID WORKS[7].

Table -1: Material Properties

Material Type	Cast stainless steel
Yield Strength (N/m2)	3.51571e+008
Tensile Strength (N/m2)	4.20507e+008
Poisson's Ratio	0.29
Elastic Modulus (N/m2)	2e+011
Density (kg/m3)	7900
Shear Modulus (N/m2)	7.7e+010

The integral crankshaft should be applied when conducting finite element analysis, depending on the complex crankshaft structure. There are more fillets and fine oil holes in the construction of the crankshaft. In view of these variables in the establishment process, the crankshaft finite element mesh becomes very thick, the amount of node equation increases significantly. The solution period would be extended by these variables, the unit form would become unsatisfactory and the accumulative error would be exacerbated. This will lower the precision of the simulation.

3. METHODOLOGY

3.1 Static Analysis Procedure

Firstly I have prepared the whole assembly of crankshaft in solidworks and then apply for the material of crankshaft in Simulation module.

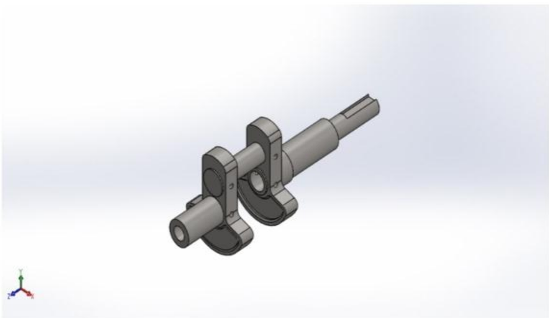

Figure 1:- Three dimensional model of crankshaft

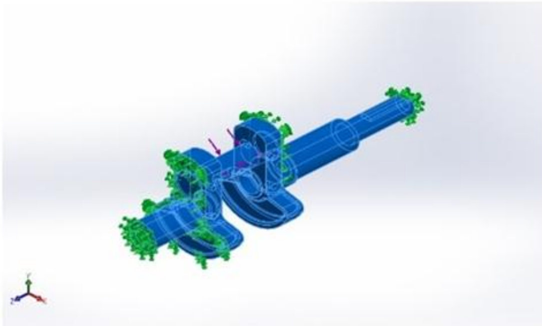

Figure 2:- Simulation module of crankshaft

3.2 Mesh the Crankshaft

Table -1: Mesh Statistics

Mesh Type	Solid mesh
Total nodes	24257
Total elements	14651
Element Size	3.6176 mm
Tolerance	0.183588 mm
Jacobian points	4

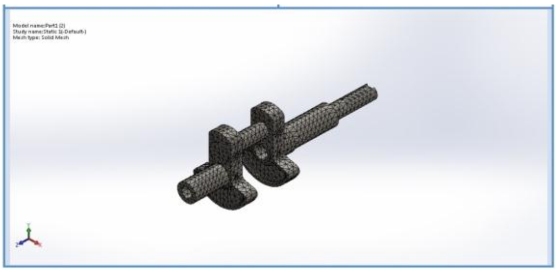

Figure 3: Meshed model of crankshaft

3.3 Define For Analysis Boundary Condition

Boundary conditions play an important role here in the measurement of finite elements; I have taken both remote displacements for repairing bearing supports. The figure is shown under the application of remote displacement for supporting bearings and has only one degree of freedom (Rotational).

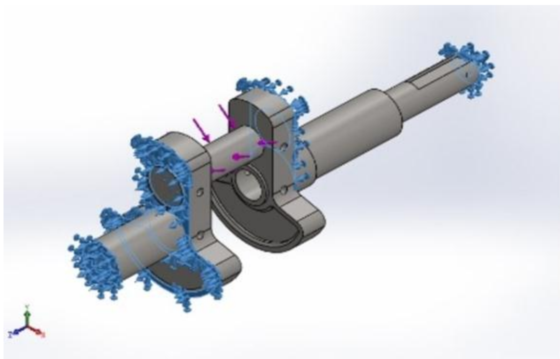

Figure 4: Loads and boundary conditions for crankshaft

3.4 Static Structural Analysis:

The technique of finite elements is a method of numerical analysis to obtain an approximate solution to a wide range of engineering problems. For several engineering problems, analytic mathematical solutions can not be obtained. A mathematical expression that gives the values of the desired unknown quality at any position in a body is an analytical solution. The engineer resorts to numerical methods that provide approximate but appropriate solutions for issues involving complex material properties and boundary conditions. The next step is to conduct a structural analysis of the crankshaft after the application of pressure and forces. We are particularly concerned with the deformation and stresses on the crankshaft in this structural analysis (von-misses stresses). The slight deformation occurs, when the pressure and forces are applied and stresses in the crankshaft are also present. The initial crankshaft deformation is shown in Fig. The crankshaft deformation is not the same overall. The red portion indicates that the deformation in that region is maximum, and the blue portion indicates that the deformation in that region is minimal.

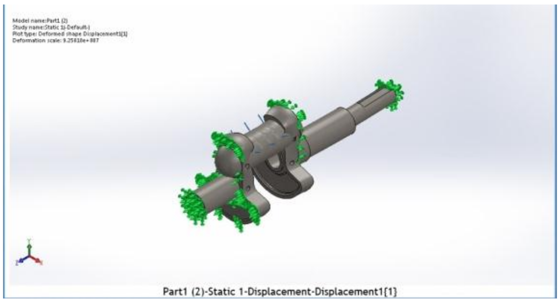

Figure 5: Deformed shape of crankshaft

Then, Run the Analysis

3.5 Get the Analysis

Output of Analysis

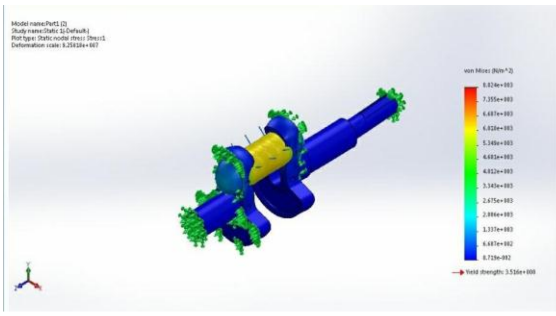

Figure 5: Von Misses Stress of crankshaft

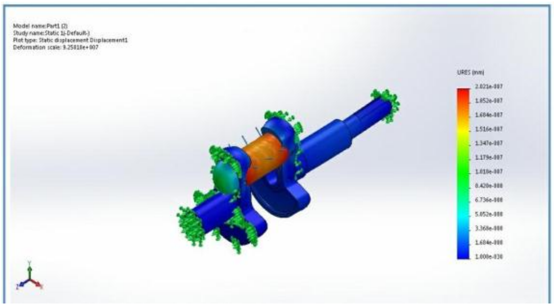

Figure 6: Static displacement of crankshaft

4. FUTURE SCOPE

With these considerations we can also do modal analysis to give the study about dynamic properties of crankshaft in the frequency domain. By this frequency domain we can get to know about the bending of crankshaft at different modes. We can also consider doing the thermal analysis on the crankshaft which leads to know the difference in properties of cast stainless steel crankshaft at different temperatures. We can also change the material of the crankshaft like forged steel, cast iron, tungsten etc. for getting better properties for the crankshaft.

5. CONCLUSIONS

1) For this particular engine, the highest load occurs at the crank angle of 355 degrees. Only a bending load is applied to the crankshaft at this angle.

2) The Von-Misses stresses resulting from the study are much lower than the stress of material yield, so our design is secure and we can optimize to reduce the material and expense.

3) The regions corresponding to the interface between the shaft and the web and the web and the pin that result in high stress concentration variables are important stress positions on the crankshaft geometry.

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