

# Design and Fatigue Analysis of Crankshaft

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**ABSTRACT:** A crankshaft is a fundamental feature in a vehicle's engine. It is the prime mover which is responsible for the conversion of linear energy into rotational energy. The crankshaft changes the piston motion with the help of connecting rods which in turn enable the engine to run. Hence, crankshaft is the most critical part of any assembly and its life can be improved if maintained properly. This paper deals with the material composition and the manufacturing processes usually followed for crankshafts and also the possible causes of failure and their analysis. In this regard, a model of the crankshaft has been prepared using NX CAD 8.5 version and with the help of an analysis workbench, ANSYS (the premier CAE tool since forty years), we were able to analyze the stress distribution and deformation for two different materials. Finally, on the basis of the results acquired, suggestions with regard to the improvement in design have been made.

**KEYWORDS:** Crankshaft, Modelling, Analysis, NX CAD, ANSYS, Suggestions, Failure

## I. INTRODUCTION

Crank shaft is a large component with a complex geometry in the engine, which converts the reciprocating displacement of the piston to a rotary motion with a four link mechanism. Since the crank shaft 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. Design developments have always been an important issue in the crankshaft production industry, in order to manufacture a less expensive component with the minimum weight possible and proper fatigue strength and other functional requirements. These improvements result in lighter and smaller engines with better fuel efficiency and higher power output. This study was conducted on a four cylinder four stroke cycle engine.

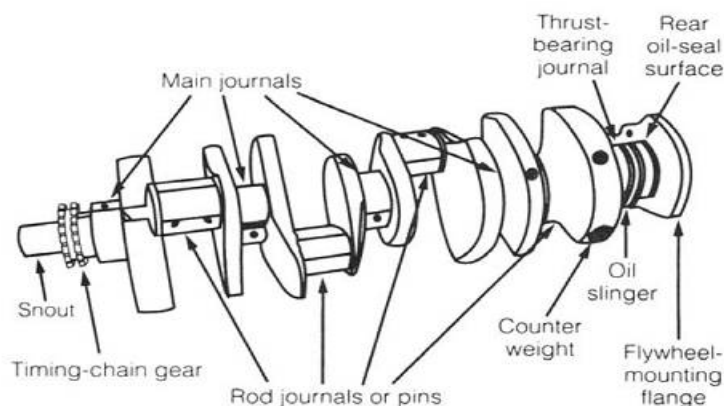


Figure 1.1 Typical crankshaft with main journals that support the crankshaft in the engine block. Rod journals are offset from the crankshaft centerline (Halderman and Mitchell, 2001).

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Figure 1.1 presents a typical crankshaft with journals which actually act as supporters for the crankshaft. The crank shaft, connecting rod, and piston constitute a four bar slider-crank mechanism, which converts the sliding motion of the piston (slider in the mechanism) to a rotary motion. Since the rotation output is more practical and applicable for input to other devices, the concept design of an engine is that the output would be rotation. In addition, the linear displacement of an engine is not smooth, as the displacement is caused by the combustion of gas in the combustion chamber. Therefore, the displacement has sudden shocks and using this input for another device may cause damage to it. The concept of using crankshaft is to change these sudden displacements to a smooth rotary output, which is the input to many devices such as generators, pumps, and compressors.

Paper is organized as follows. Section II describes related information about crankshaft, section III lists out various materials and manufacturing processes for crankshafts especially single cylinder ones whereas section IV presents the experimental results and section V presents conclusion.

## II. RELATED INFORMATION

Crank shaft experiences large forces from gas combustion. This force is applied to top of the piston and since the connecting rod connects the piston to the crank shaft, this force will be transmitted to the crank shaft. The magnitude of the force depends on many factors which consist of crank radius, connecting rod dimensions, and weight of the connecting rod, piston, piston rings, and pin. Combustion and inertia forces acting on the crankshaft cause two types of loading on the crankshaft structure; torsional load and bending load. There are many sources of failure in the engine. They could be categorized as operating sources, mechanical sources, and repairing sources. One of the most common crankshaft failures is fatigue at the fillet areas due to bending load caused by the combustion. Even with a soft case as journal bearing contact surface, in a crankshaft free of internal flaws one would still expect a bending or torsional fatigue crack to initiate at the pin surface, radius, or at the surface of an oil hole.

This study was motivated by a need for a comparative study of analysis of crankshaft made of aluminum and its alloys which are some of the mostly used materials to manufacture the crankshafts. It was desired to develop an optimized geometry, material, and manufacturing procedure, which will reduce the weight for fuel efficiency. This research was performed on crankshafts from single cylinder engines. However, since the basis of analysis are the same for multi-cylinder engines, the procedures used could be modified and implemented for crankshafts from other types of engines. Other studies on crankshafts from multi-cylinder engines are typically performed on a portion of the crankshaft consisting of two journal bearings and one crankpin bearing, which is similar to that of a single cylinder engine.

## III. MATERIALS AND MANUFACTURING PROCESSES

The major crankshaft material competitors currently used in industry are forged steel, cast iron and aluminum. Comparison of the performance of these materials with respect to static, cyclic, and impact loading are of great interest to the automotive industry. A comprehensive comparison of manufacturing processes with respect to mechanical properties, manufacturing aspects, and finished cost for crankshafts has been conducted by Zoroufi and Fatemi. This section discusses forging and casting processes as the two competing manufacturing processes in crankshaft production industry. Influencing parameters in both processes are detailed. Finally, the forged steel and the cast iron products are compared in terms of material properties and manufacturing processes.

Forging is the term for shaping metal by plastic deformation. Cold forging is done at low temperatures, while conventional hot forging is done at high temperatures, which makes metal easier to shape. Cold forgings are various forging processes conducted at near ambient temperatures, such as bending, cold drawing, cold heading, coining, and extrusion to produce metal components to close tolerances and net shape. Warm forging is a modification of the cold forging process where the workpiece is heated to a temperature significantly below the typical hot forging temperature, ranging from 500° C to 750° C Compared with cold forging, warm forging has the potential advantages of reduced

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tooling loads, reduced press loads, increased steel ductility, elimination of need to anneal prior to forging, and favorable as-forged properties that can eliminate heat treatment . The use of the lower temperatures in cold and warm forging processes provides the advantages of reducing and even substantially eliminating

## IV. EXPERIMENTAL RESULTS

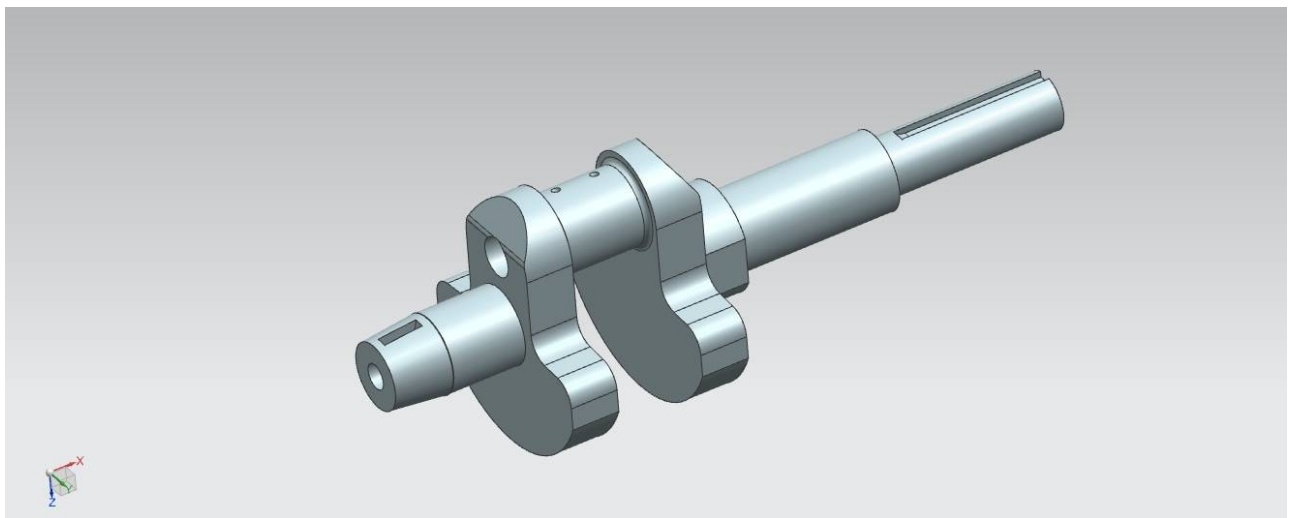


Fig 2: NX CAD model of crankshaft

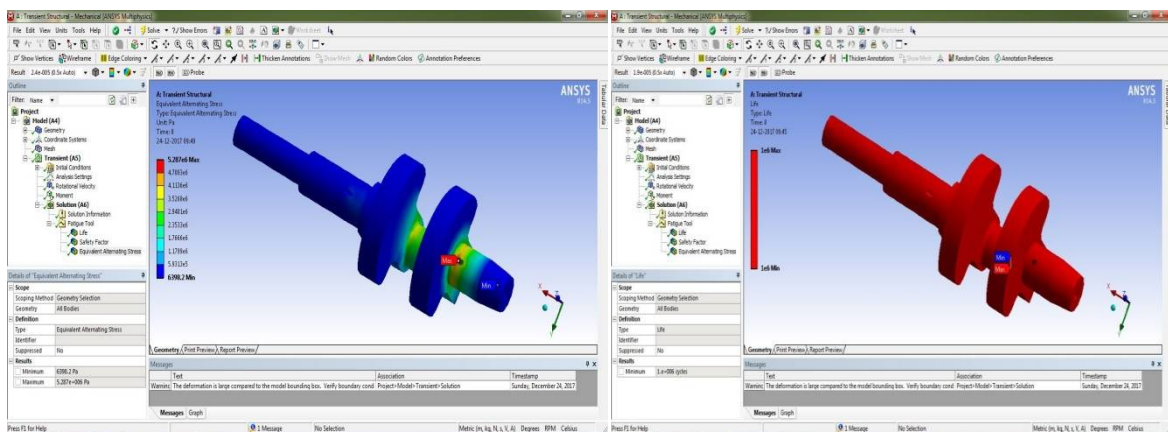


Fig 3 Steel Material

Fig 4 Steel Material

Static structural analysis has been conducted on the crankshaft by applying two different materials, Steel and Grey cast iron. Based on the stress distribution and maximum deformation results, we get to know which material suits better for the crankshaft and thus, fatigue life can be calculated.

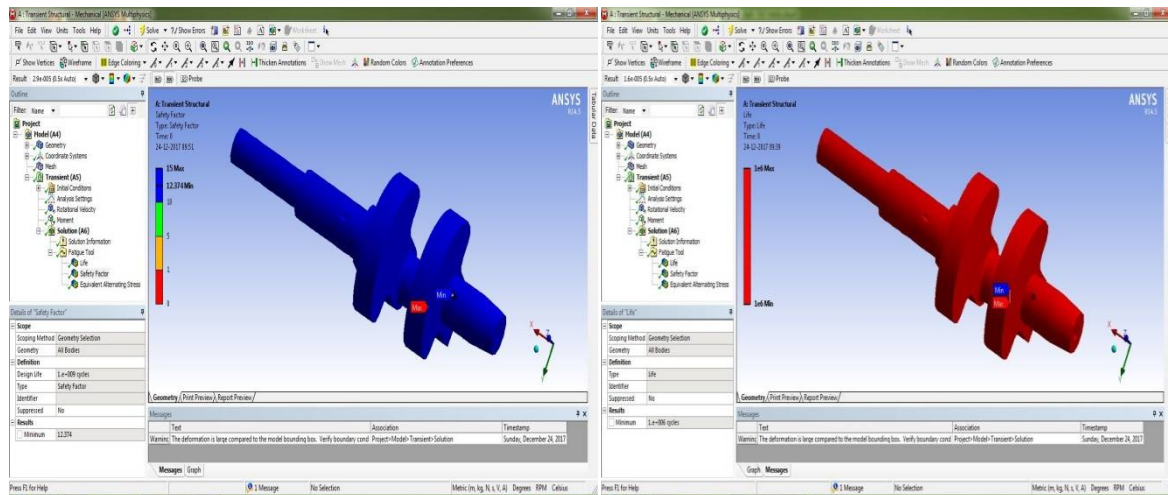


Fig 5 Grey Cast Iron

Fig 6 Grey Cast Iron

Figure 2 presents the CAD model of the crankshaft designed using NX CAD software and the corresponding figures Fig. 3, Fig. 4, Fig. 5 & Fig. 6 explain the results attained on successful completion of the static structural analysis. Hence, on the basis of the results obtained, conclusion has been derived.

## V. CONCLUSION

In our project from the above analysis, we observe that there has been considerable increase in the von mises stress (max.) for Grey Cast Iron. We can also derive that the maximum deformation value is  $5.572e-3$ mm for Grey Cast Iron as compared to  $5.821e-3$ mm with Steel. Hence, fatigue life will be more for Grey Cast Iron than that of Steel.

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