DESIGN AND STRUCTURAL ANALYSIS OF AN CRANKSHAFT USED IN AUTOMOBILE ENGINE

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ABSTRACT

The main objective of this is to study was to investigate the stresses induced in crankshaft manufactured of forged steel and an aluminium alloy (7076-T6). A comparative analysis was made to study the behaviour of materials. Crank shaft is one of the most important moving parts with a complex geometry in internal combustion Engine. It converts the reciprocating displacement of the piston into a rotary motion. When combustion takes place in the engine, there by high temperature and pressure will be developed inside the engine cylinder. Due to high speed and at high loads, the piston is subjected to large structural stresses, which influences on the crank. The forces induced at the pin joints and inertia forces obtained from the dynamic analysis were used as input for further analysis

Keywords: Stress analysis, Fatigue analysis, CATIA, ANSYS, steel and Aluminum

INTRODUCTION

Crankshaft 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 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. 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.

1.1 Function of Crankshafts in IC Engines

The function of the crankshaft is to translate the linear reciprocating motion of a pistons into the rotational motion required by the automobile. The crankshaft, connecting rod, and piston constitute a four-bar slider-crank mechanism, which converts the sliding motion of the piston 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.

1.2 Stress on crankshaft

The various forces acting on the shaft but failure takes place in two positions, bending and twisting. Firstly, failure may occur at the position of maximum bending; this may be at the center of the crank or at either end. In such a condition the failure is due to bending and the pressure in the cylinder is maximal. Second, the crank may fail due to twisting, so the connecting rod needs to be checked for shear at the position of maximal twisting. The pressure at this position is the maximum pressure, but only a fraction of maximal pressure.

1.3 Service Loads and Failures Experienced by Crankshafts

Crankshaft experiences large forces from gas combustion. This force is applied to the top of the piston and since the connecting rod connects the piston to the crankshaft, the force will be transmitted to the crankshaft. 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.

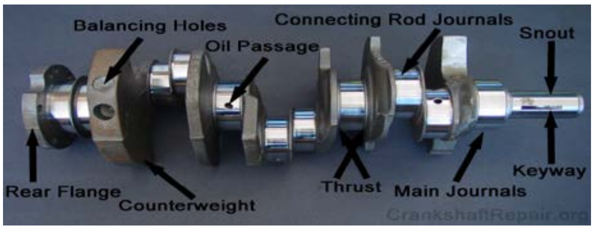


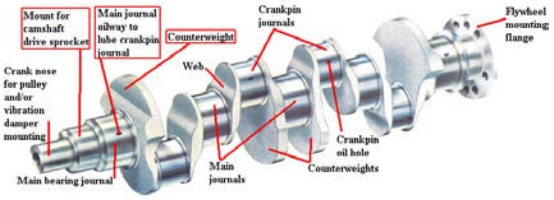
Fig 1.1 crankshaft

1.4History of crankshaft

The earliest evidence, anywhere in the world, for the crank combined with a connecting rod in a machine appears in the late Roman Hierapolis sawmill from the 3rd century AD and two Roman stone sawmills at Gerasa, Roman Syria, and Ephesus, Asia Minor (both 6th century AD).On the pediment of the Hierapolis mill, a waterwheel fed by a mill race is shown powering via a gear train two frame saws which cut rectangular blocks by the way of some kind of connecting rods and, through mechanical necessity, cranks. The accompanying inscription is in Greek.

1.5Dynamic stress analysis of the Crankshaft

The crankshaft experiences a complex loading due to the motion of the connecting rod, which transforms two sources of loading to the crankshaft. The main objective of this study was the optimization of the forged steel crankshaft which requires accurate magnitude of the loading on this component that consists of bending and torsion. The significance of torsion during a cycle and its maximum compared to the total magnitude of loading should be investigated to see if it is essential to consider torsion



2D input of missile piston

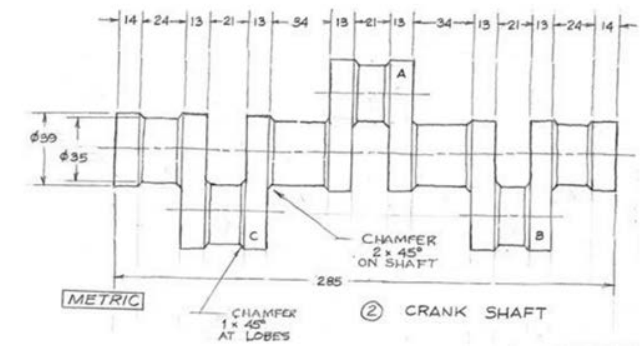


Fig 3. 2D input Of crankshaft of automobile

3D model is designed by using CATIA software.

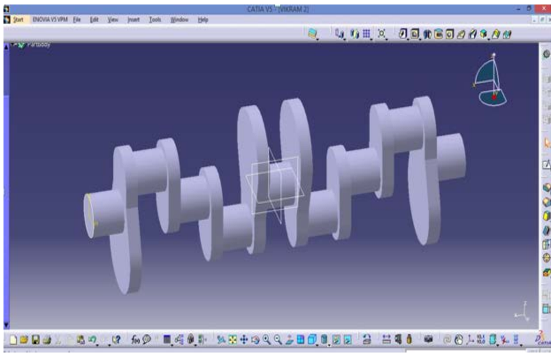


Fig 4. 3D modeling of missile pistion

Methodology used in the project:

- Develop a 3D model from the available 2D drawings of the Crankshaft.
- The 3D model is created using Catia V5 software.
- The 3D model is converted into Parasolid and imported into ANSYS to do static analysis by applying the pressure.
- Calculate stresses and deflections of the original model and check if the component is withstanding for the operating pressure.
- stresses and deflections on the modified model.

Import the geometry model

After importing the file just double click on the geometry it will open in another window.This window is opened select desired unit in meter and click on ok button.

Step 1: Importing the model

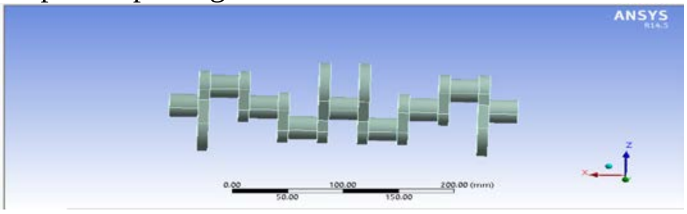


Fig 4.2 importing the model

4.9 Mesh Generation

In finite element analysis the basic concept is to analyse the structure, which is an assemblage of direct pieces called element, which are connected together at a finite number of points called nodes loading boundaries condition are then applied to this elements and a network of this elements is known as mesh.FEA analysis was performed on both crankshafts for the dynamic load analysis, as well as for the test setup. Since boundary conditions of dynamic FEA and test setup FEA are different, separate FE models were needed. In this section, meshing of both dynamic FEA and test setup FEA are presented for the forged steel and aluminium alloy crankshafts.

FINITE ELEMENT ANALYSIS OF A CEANKSHAFT

Aluminum Alloy

TABLE 1

Unit System	Metric (m, kg, N, s, V, A) Degrees rad/s Celsius
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Celsius

FIGURE 1

Model (A4) > Static Structural (A5) > Force

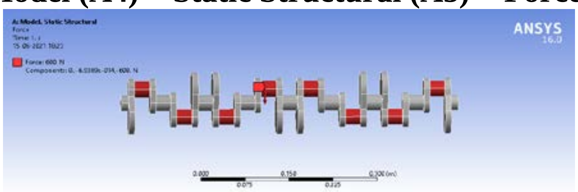
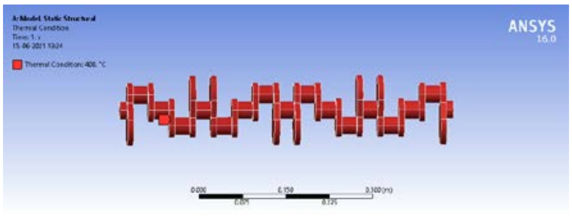


FIGURE 2

Model (A4) > Static Structural (A5) > Thermal Condition



Stainless Steel NL

FIGURE 3

Model (A4) >Static Structural (A5) > Solution (A6) > Total Deformation

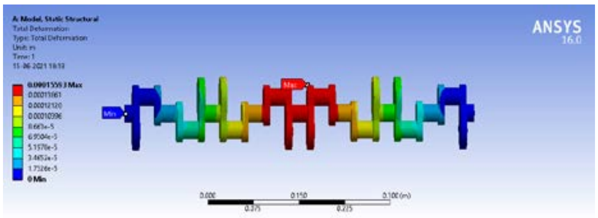
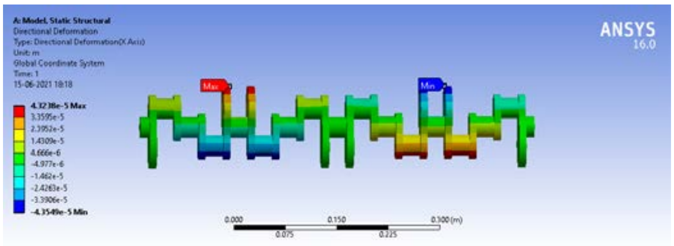


FIGURE 4

Model (A4) > Static Structural (A5) > Solution (A6) > Directional Deformation



CONCLUSION:

A forged steel and an aluminium alloy crankshaft were chosen for this study, both of which belong to similar single cylinder four stroke air cooled gasoline engines. First, both crankshafts were digitized using a CMM machine. Load analysis was performed based on dynamic analysis of the slider crank mechanism consisting of the crankshaft, connecting rod, and piston assembly, superposition of stresses from unit load analysis in the FEA.

The following conclusions can be drawn from the analysis:

1. Dynamic loading analysis of the crankshaft results in more realistic stresses whereas static analysis provides over estimated results. Accurate stresses are critical input to fatigue analysis and optimization of the crankshaft.

2. There are two different load sources in an engine; inertia and combustion. These two load source cause both bending and torsional load

on the crankshaft. The maximum load occurs at the crank angle of 355 degrees for this specific engine. At this angle only bending load is applied to the crankshaft.

3. Considering torsional load in the overall dynamic loading conditions has no effect on von Mises stress at the critically stressed location. The effect of torsion on the stress range is also relatively small at other locations undergoing torsional load. Therefore, the crankshaft analysis could be simplified to applying only bending load.

4. Superposition of FEM analysis results from two perpendicular loads is an efficient and simple method of achieving stresses for different loading conditions according to forces applied to the crankshaft from the dynamic analysis.

5.Stress and FEA results showed close agreement, within 7%difference. These results indicate non-symmetric bending stresses on the crankpin bearing, whereas using analytical method predicts bending stresses to be symmetric at this location. The lack of symmetry is a geometry deformation effect, indicating the need for FEA modeling due to the relatively complex geometry of the crankshaft.

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