Modelling and Assessment of Crankshaft through SOLIDWORK Program

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***Abstract*— In an internal combustion engine, many parts synchronize such as piston, connecting rod and crankshaft to convert thermal energy to mechanical energy, the crankshaft rotates in varying speeds to convert the reciprocating displacement of the piston to rotary motion, crankshaft complex geometry, radial force and tangential force effect on the crankshaft.**

This study aims to carry out study static Von mises stress, deformation and strain by modelling crankshaft in SOLIDWORKS program, to compare between tow materials alloy steel and malleable cast iron (Von mises), deformation and fatigue failure analysis of two designs existing model and modified model by applying resultant bearing load equal to 16066.5 N to the small end of connecting rode, this load results of (1089 N) tangential force and (3539 N) as radial force. The results show that there are no severe changes in the studied parameters and that both materials bear the applied load without failure.

***Keywords*— Crankshaft, SOLIDWORKS software, Von mises stress, deformation and strain.**

I. Introduction

In internal combustion engines, the crankshaft is one of the important part in the engine components, because of complex shape geometry of crankshaft and it converts the reciprocating motion of piston as a result of engine stroke to a rotary motion during engine stroke cycles during its service life. Number of pistons indicates the rod bearing journals that attach to the crankshaft connecting rod, the end of crank connects to the flywheel flange, all engine parts associated with crankshaft to achieve synchronized motion lead to vehicle to run. Crankshaft supported by more than one bearing, these bearings located in the bottom of the cylinder from the top and crankcase from the bottom. Figure (1) shows the crankshaft components.

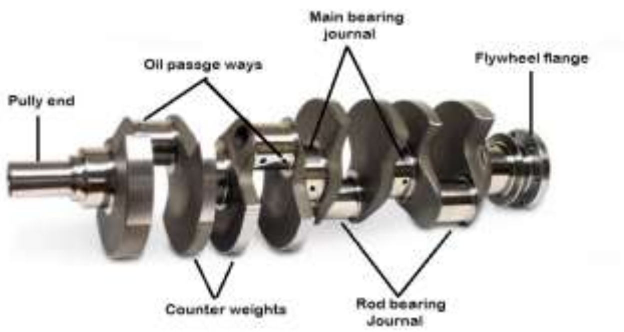

Figure (1) Crankshaft Components

Many parameters must be considered such as generated stresses on main and rod journals, fatigue life and durability. In the dynamic loading and the optimization of internal combustion engine optimum design of the shaft diameter satisfies the requirement of the engine performance to reach optimum crankshaft size design [1]. All ways the researches study effective parameters in the crankshaft with analyse the different types of load and stresses to reach the minimum weight with proper strength as well as long service life, which lead to improve the engine efficiency by increasing the power output with lowest specific fuel consumption. The life and reliability of internal combustion engine depends on crankshaft life, the crankshaft must be strong enough to bear the download force as generated the ignition stroke without failure in the bearings and journals. As the crankshaft rotates the torsional vibration increase by increasing the crankshaft rotation and power impulse hits crankpin, the weak point crankpin can be broken if proper diameter and material not used [2]. Inertia of rotating components and force applied as result of gas combustion in the cylinder are the forces acting the crankshaft, the inertia of rotating components such as connecting rod applies forces to the rod bearing depends on the rotating speed of crankshaft, and the variation of angular position of rod bearing, while the second force results of gas combustion depends on the dimensions of mechanism. Torsion and bending lead to the application of two forces on the crankshaft [3].

In this paper, Von mises stress, deformation and strain analyses carried out on the model of the crankshaft using SOLIDWORKS program, to compare between two metals results that used in modelling of crank shaft, alloy steel and malleable cast iron.

II. EXPERIMENTAL BY ANALYSES

A. *Mathematical Model for Crankshaft and Force Evaluation*

Crankshaft of diesel engine type studied, four crank throws design modelled adopted in the study, also the model contain three main journal in the structure of crankshaft with four rod journal bearing as shown in table I.

TABLE 1
MAIN PHYSICAL DIMENSIONS OF CRANKSHAFT

Physical Parameters	Values	Units
Diameter of Crankpin	*20*	*mm*
Length of Crankpin	*30*	*mm*
Diameter of Main Journal	*25*	*mm*
Length of Main Journal	*30*	*mm*
Thickness of Crank Web	*20*	*mm*
Length of Crankshaft	*473*	*mm*

The force effected on the crankshaft from the gas combustion can be calculated from equation (1).

$$F_p = \frac{\pi D^2}{4} \times P_{max} \quad (1)$$

Where D bore diameter and *P* maximum combustion pressure, and the tangential force can be calculated from equation (2).

$$F_T = K\ sin\ (\emptyset + \beta) \quad (2)$$

Where k thrust force, ∅ crankshaft when angle rotate 30° from the TDC and β connecting rod inclination.

B. *Material Properties and Modelling of Crankshaft*

Properties of the two materials studied as shown in the table II, the prepared dimensions are considered in the model of SOLIDWRKS program.

TABLE. II
MATERIALS FOR CRANKSHAFT

Item	Cast Alloy Steel	Malleable Cast Iron
Yield Strength MPa	*241.28*	*275.742*
Poisson's Ratio	*0.26*	*0.27*
Young's Modulus (MN/m2)	*1.9e5*	*1.9e11*
Density (kg/m3)	*7300*	*7300*

Under the boundary conditions, the two ends of crankshaft restricted, while the inertia and tangential forces applied to the four rod bearing journal, to analyse parameters by SOLIDWOK program.

1) CAD-Models:

Fig. (2) Model of Crankshaft

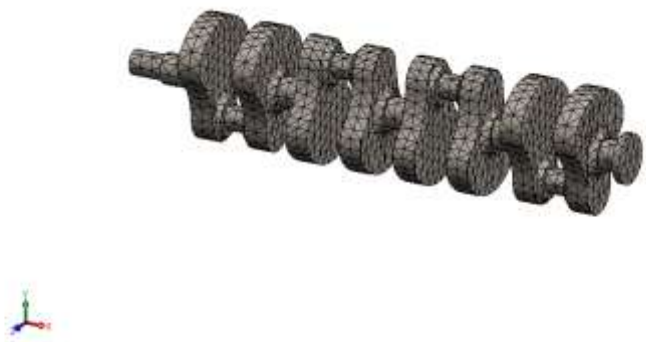

Fig. (3) Meshing the Crankshaft Model

Fig. (4) Boundary Conditions of the Designed Model

2) Results of Crankshaft using Malleable Cast Iron

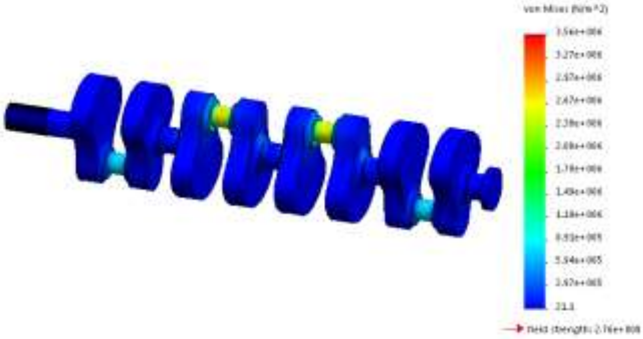

Fig. (5) Von-Mises Stress of the Model Crankshaft

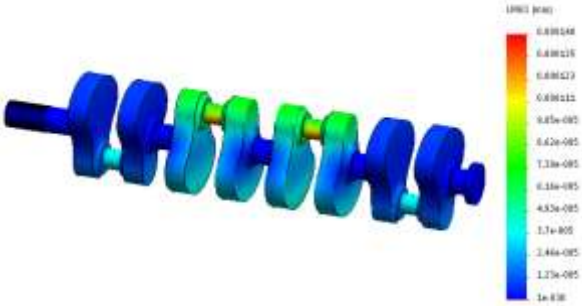

Fig. (6) Deformation of the Model Crankshaft

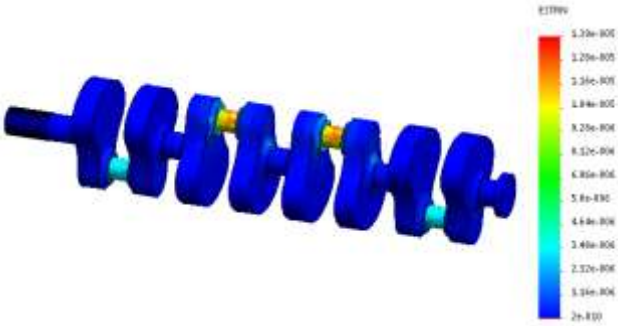

Fig. (7) Strain of the Model Crankshaft

3) Results of Crankshaft using Cast Alloy Steel

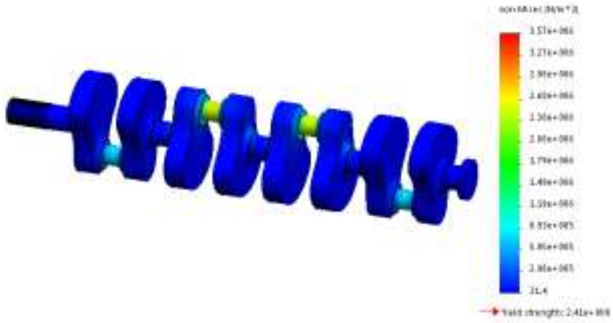

Fig. (9) Deformation of the Model Crankshaft

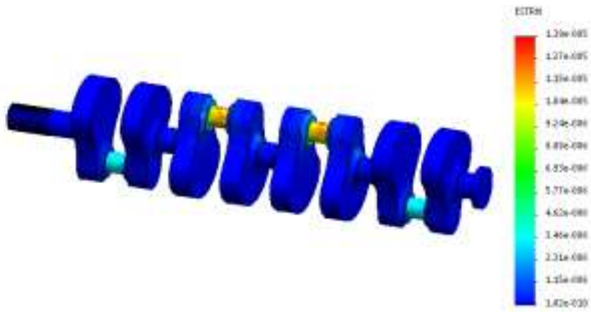

Fig. (10) Strain of the Model Crankshaft

TABLE III
MAX. AND MIN. RESULTS OF VON MISES, STRAIN, AND DEFORMATION OF CAST ALLOY STEEL

Weight kg	Von Mises N/m^2	Deformation mm	Strain	No.
7.73	*3.57e+006*	*0.000147*	*1.39e-005*	*Max*
	21.4	*1e-030*	*1.82e-010*	*Min.*

TABLE IV
MAX. AND MIN. RESULTS OF VON MISES, STRAIN, AND DEFORMATION OF MALLEABLE CAST IRON

Weight kg	Von Mises N/m^2	Deformation mm	Strain	No.
7.73	*3.56e+006*	*0.000148*	*1.39e-005*	*Max.*
	21.1	*1e-030*	*2e-010*	*Min.*

III. RESULTS AND DISCUSSION

Finite Element analysis of the four-cylinder crankshaft was conducted with the FEA SOLID WORKS software. Two materials had been chosen (Malleable Cast Iron & Cast Alloy Steel), strain, deformation and Von mises values were examined for the same weight of these two materials as shown in the table III and IV respectively. There is a small change in the minimum value of strain values for about 0.18e-010, but there is so small change in the maximum value of deformation for about 0.000001 mm, also there is so small change in the minimum and maximum values of Von mises for about 0.3 N/m^2, 0.01e+006 N/m^2 respectively. The results show that there are not severe changes in the parameter values, so both materials bear the applied load and works in the safe region.

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