Modeling And Fatigue Analysis of A Cast Iron Crankshaft

Walid Roundi[1]
1PhD Student, Department of Mechanical Engineering, Moroccan Laboratory of Innovation and Industrial Performance (LaMIPI) , Higher School of Technical Education of Rabat, Mohammed V Souissi University, Rabat, Morocco

Abdellah El Gharad[2]
[2]Professor, Department of Mechanical Engineering, Moroccan Laboratory of Innovation and Industrial Performance (LaMIPI) , Higher School of Technical Education of Rabat, Mohammed V Souissi University, Rabat, Morocco

Abstract— The objective of the paper is a fatigue and stress analysis of a cast iron crankshaft and the determination of its probable mechanical behavior using Finite Element Method. For this reason we modeled the mechanism and then we applied loads on him to have the results of strain, displacement, and stress.
The modeling and fatigue analysis of any solid component consists of geometry generation, applying material properties, meshing the component, defining the boundary constraints, and applying the proper load type.

Keywords—Fatigue; Stress; Crankshaf; Displacement; Material.

I. INTRODUCTION

The crankshaft is component of an engine, he convert reciprocating linear piston motion into rotation. The crankshaft is often connected to the flywheel thus reducing the pulsation of the four-stroke cycle. In some recent models, the crankshaft is attached to the crankshaft sensor; 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.

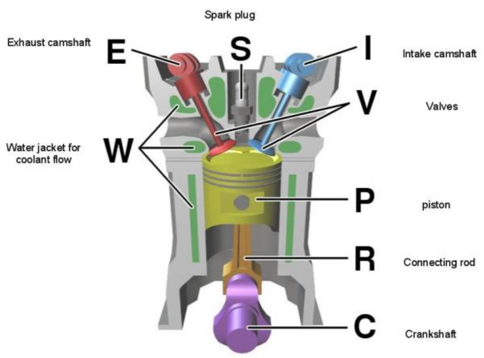

Fig .1.Thermal engine

The Principe 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.

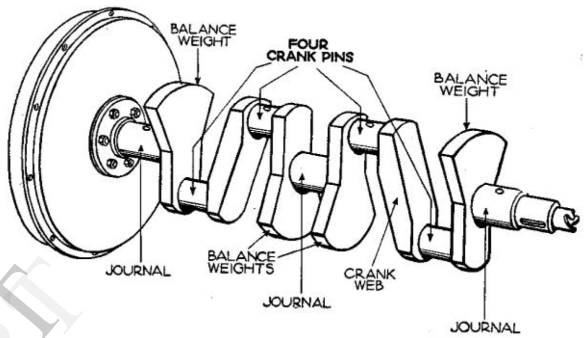

Fig .2 . Example of a Crankshaft

So it is estimated that 50-90% of structural endommagement is due to fatigue, thus there is a need for quality fatigue design tools. This is why many designers and analysts use "in-house" fatigue programs which cost much time and money to develop. It is hoped that these designers and analysts, given a proper library of fatigue tools could quickly and accurately conduct a fatigue analysis suited to their needs. Finite element modeling of any solid componentconsists of geometry generation, applying material properties, meshing the component, defining the boundary constraints, and applying the proper load type. These steps will lead to the stresses and displacements in the component. In this study, analysis procedure was performed for cast iron crankshaft.
The focus of fatigue and stress analysis is to provide useful information to the design engineer when fatigue failure may be a concern, fatigue results can have a convergence attached.

II. MODELING OF THE CRANKSHAFT

In this study a simulation was conducted on an actual cast iron crankshaft. The Finite element analysis was performed to obtain the variation of stress magnitude at critical locations.
The below figure shows the geometry of the crankshaft for Analysis, the crankshaft created by CAD software for further analysis.

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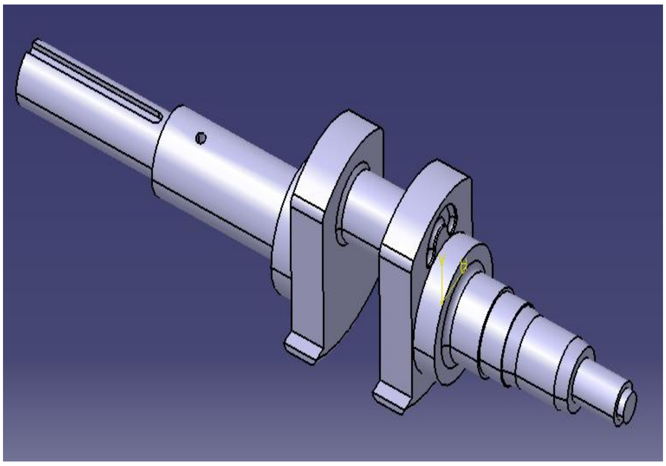

Fig .3. Modeling of the crankshaft in 3D

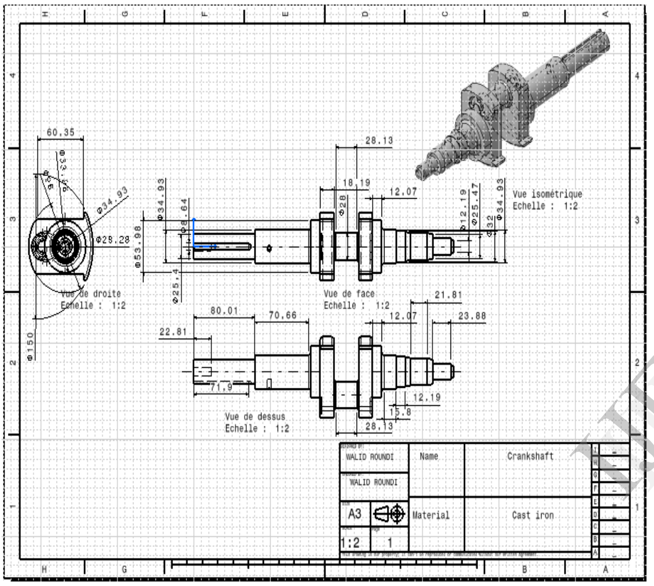

Fig .4. Drawing of the cast iron crankshaft with measured dimensions noted (mm)

A. *Apply Material for crankshaft (cast iron)*

The most crankshaft material competitors currently used are forged steel, and cast iron. Comparison of the performance of these materials with respect to static, cyclic, and impact loading are of great interest to the automotive industry. In this study, analysis procedure was performed for cast iron crankshaft.

TABLE 1. material property (Cast iron)

Material	Cast Iron
Density	7,25 g/cm^3
Mass	2,9182 kg
Area	56736,5 mm^2
Volume	402511 mm^3
Center of Gravity	x=181,78 mm y=0,000637031 mm z=3,05179 mm

III. BONDARY CONDITIONS:

The boundary conditions are the critical factors for the correctness of calculation. The boundary conditions in the crankshaft model consist of load boundary condition and restriction boundary condition. So the load applying on the crankpin neck surface becomes the critical factor of load boundary condition. The load applying on the crankpin surface is supposed as distributed load. The uniform pressure of 0.5 Mpa is applied on the crankpin neck which is indicated by the yellow arrows and as shown in Figure 5 the both sides that have been fixed.

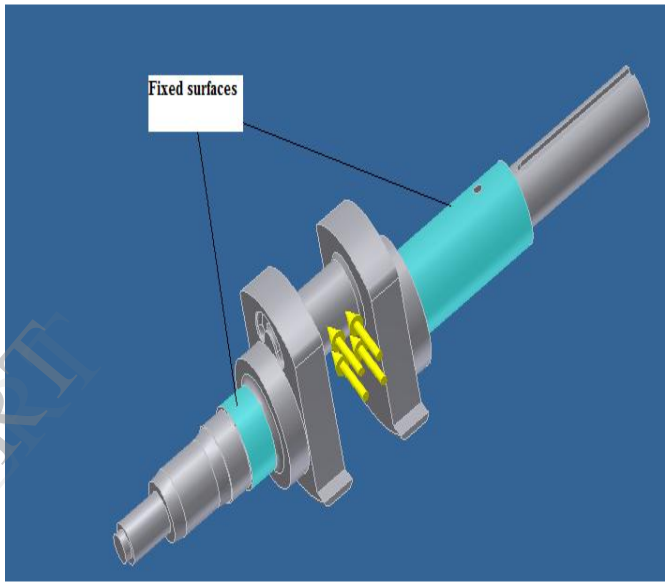

Fig.5 .Loading and boundary conditions on the crankshaft

IV. RESULTS AND DESCUSSION

A. *Von Mises Stress*

The von Mises stress is often used in determining whether an isotropic and ductile metal will yield when subjected to a complex loading condition. This is accomplished by calculating the von Mises stress and comparing it to the material's yield stress, which constitutes the von Mises Yield Criterion, we can define the von mises stress as:

$$\left[\frac{(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2}{2}\right]^{1/2}=\sigma_v$$

where σ_v is von Mises stress in MPa, σ_1, σ_2, σ_3 are principal stresses in MPa So as a failure criterion engineer can check, whether Von Mises stress induced in the material exceeds yield strength (for ductile) of the material.

Figure 6 show the distribution of Von mises stresses induced within the crankshaft body. The maximum values of equivalent stresses are goes up 0.432 MPa.

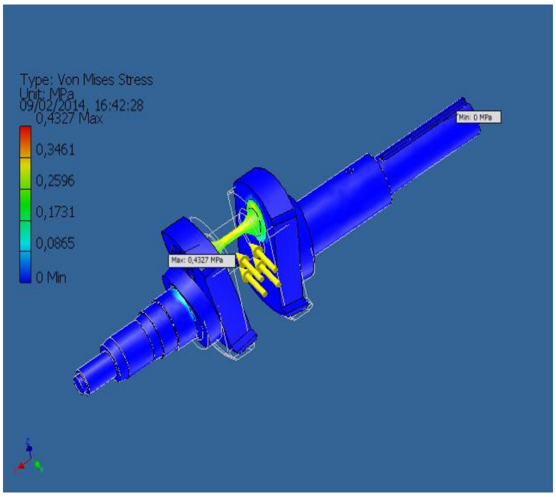

Fig.6 . Result of the Von Mises Stress

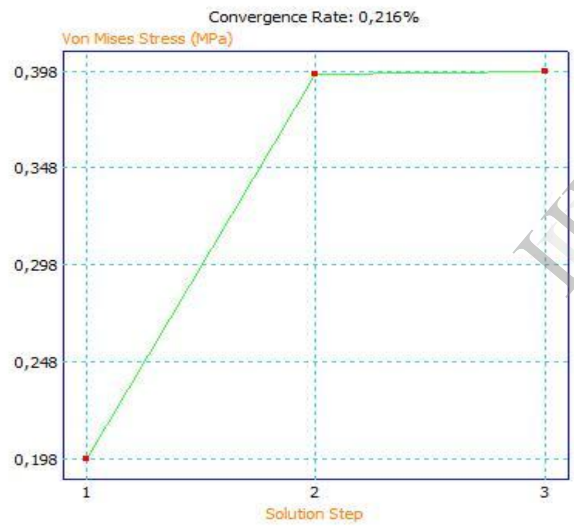

Fig.7 . Plot of The Von Mises Stress Convergence

B. *Displacement*

Figure 8 show the distribution of the displacement induced within the crankshaft body.

The maximum values of displacement are goes up to 4,905e-005 mm, which are highly localized and observed at the axe where the uniform pressure is applied.

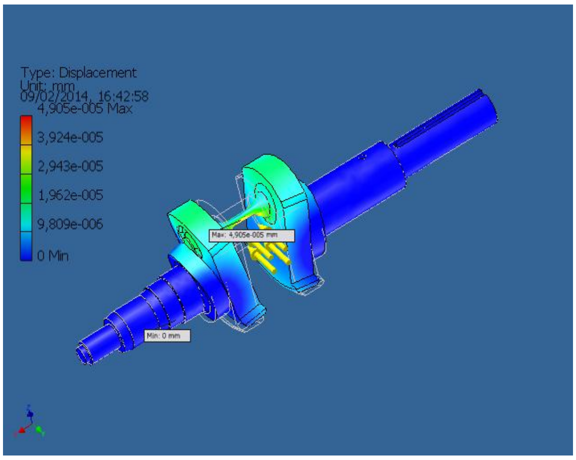

Fig.8 . Result of Displacement

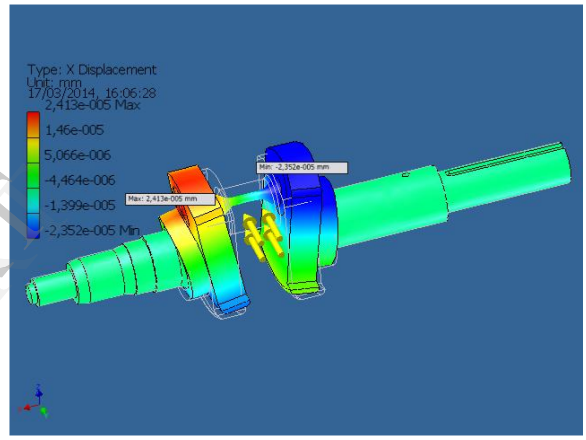

Fig.9 . Result of X Displacement

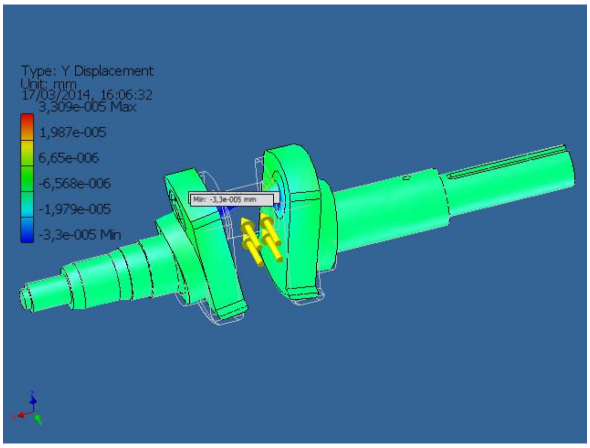

Fig.10 . Result of Y Displacement

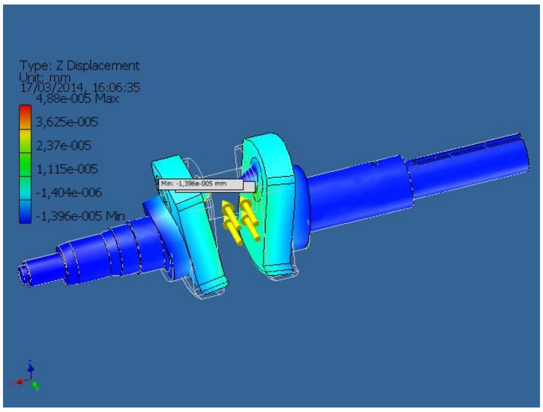

Fig.11 . Result of Z Displacement

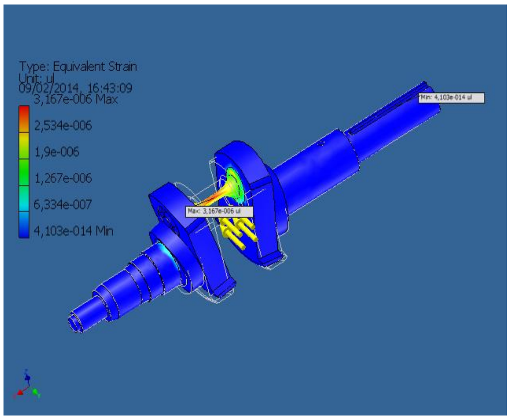

Fig.12 . Results of Strain

C. Strain

A strain is a normalized measure of deformation representing the displacement between particles in the body relative to a reference length.

A general deformation of a body can be expressed in the form

$$\mathbf{x} = \boldsymbol{F}(\mathbf{X})$$

Where x is the reference position of material points in the body. Such a measure does not distinguish between rigid body motions (translations and rotations) and changes in shape (and size) of the body.

A deformation has units of length. We could, for example, define strain to be:

$$\boldsymbol{\varepsilon} \doteq \frac{\partial}{\partial \mathbf{X}}(\mathbf{x} - \mathbf{X}) = \boldsymbol{F} - \mathbf{1}$$

Figure 12 show the distribution of the equivalent stress induced within the crankshaft body. The maximum values of the equivalent stress are goes up to 3,167e-006 ul, which are highly localized and observed at the axe where the uniform pressure is applied.

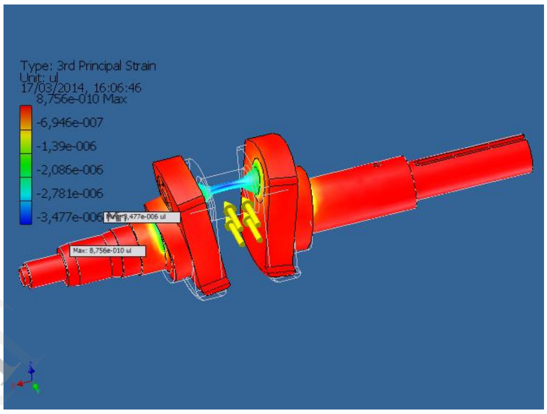

Fig.13 . Result of 3rd Principal Strain

TABLE 2**.** Result of analysis in four different locations in the Crankshaft

Von Mises stress (MPa)	Displacement (mm)	Equivalent Strain (ul)
0.0022	0	2.10 e -008
0.1377	4,00e-007	1.07 e -006
0.2598	1.80 e–oo5	1.94 e -006
0.3233	2.59 e -005	2.74 e -006

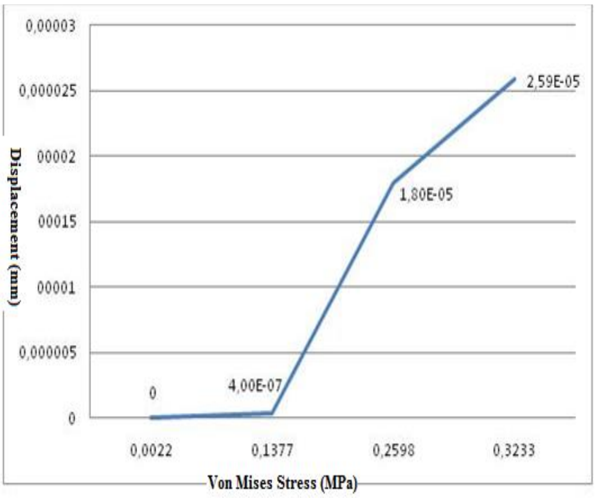

Fig. 14 .Plot The Variation of Displacement v/s Von Mises stress

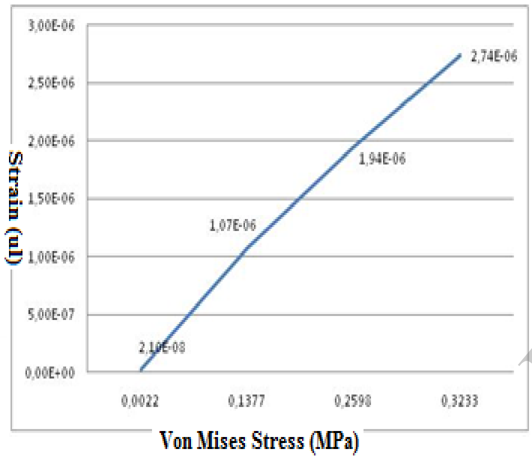

Fig. 15 .Plot The Variation of equivalent strain v/s Von Mises stress

V. CONCLUSON

In this present work and based on results obtained we can notice that the maximum deformation appears at the centre of crankshaft surface. The maximum stress appears at the fillets between the crankshaft journal and crank cheeks, and near the central point.

The crankshaft deformation was mainly bending deformation under the lower frequency. And the maximum deformation was located at the link between main bearing journal and crankpin. So this area prone to appear the bending fatigue crack.

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