ANALYSIS OF 4-CYLINDER DIESEL ENGINE CRANKSHAFT USING ALUMINIUM ALLOY

Mr. Randhavan B M[1], Prof. Galhe D S [2]

[1] *PG Student, Mechanical Department, JCOE, Kuran, Maharashtra, India*

[2] *Professor, Mechanical Department, JCOE, Kuran, Maharashtra, India*

ABSTRACT

Crankshaft is an important component in an engine assembly. Crankshaft consists of two web sections and one crankpin, which converts the reciprocating displacement of the piston to a rotary motion with a four link mechanism. This paper is related to design and finite element analysis of crankshaft of 4 cylinder diesel engine of heavy vehicle like truck. Engine capacity is 3785.1cc. The finite element analysis in ANSYS software by using three materials based on their composition viz. EN 8, EN 24 and Aluminum based alloy material. The parameter like von misses stress, deformation; equivalent elastic strain were obtained from analysis software. The results of Finite element shows that the Aluminum based alloy material showed best material properties among all from ANSYS R14.5

Keyword: - *ANSYS R14.5, von mises stress, crankshaft*

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1. INTRODUCTION

The crankshaft is a structural component which converts the linear piston movement into rotary motion while the force connecting rod is transformed to torque. Crankshaft consists of two web and crankpin on which connecting rod is connected. A crankshaft is subjected to several forces that vary in magnitude and direction (multiaxial loading). Bending stress and shear stress due to twisting are also common stresses acting on crankshafts. The crankshaft main journals rotate in a set of supporting bearings (main bearings), causing the offset rod journals to rotate in a circular path (translation movement) around the main journal centers. The diameter of that path is the engine stroke when the piston moves up and down in its cylinder. Failure of crankshafts are mainly due to fatigue failure. In this paper we studied different materials like EN8, EN 24 and aluminum alloy for crankshaft. Analysis of for this three materials are carried using ANSYS 14.5.

2. LITERATURE REVIEW

Hong-Seok Park, Xuan-Phuong Dang (2013) this work studies the in-line induction heating process before hot forging of an automotive crankshaft to find the potential solutions for improving the energy efficiency. We optimized the process parameters and proposed an insulating system to reduce the radiation and convection losses at the open spaces between adjacent heaters. The results obtained from the analytical model of the heat transfer show that using insulating covers can roughly reduce 9% of heat losses compared to the energy stored in the workpiece. Approximately additional 6% of energy can be saved by process parameters optimization. [1]

Xiaoping Chen, Xiaoli Yu, Rufu Hu, Jianfen (2014) Crankshaft fatigue problem has long been a headache and frequent phenomenon in combustion engine which attracts various efforts especially including fundamental fatigue experimental data. In this paper, the rational experimental method is employed to study the crankshaft fatigue phenomenon based on a customized experiment platform, mimicking the real-world crankshaft working condition physically. Then, based on the experiment data, the statistical regression analysis of eight commonly used hypothesis distributions is conducted. The degrees of fitting effects of the chosen statistical model are evaluated individually. Results show that the three-parameter Weibull distribution model fits the data best which may be used as the fundamental model in future analysis. This study provides a solid foundation for better understanding the mechanism of crankshaft fatigue phenomenon. [2]

G. Zucca, A. Mocci, J. Tirill´o, M. Bernabei, F. De Paolis (2015) a trainer military aircraft, equipped with alternative internal combustion engine, experienced an over speed during preflight operations. In the aftermath, maintenance personnel performed magnetic particles NDT and found two cracks on the crankshaft. These were located at the front support of the part and were both about 46 ÷ 48 mm long. The crankshaft is a critical item for the engine and in order to prevent other similar incidents a technical investigation took place. Therefore, this report shows the results obtained by Fractographic, metallographic, chemical analysis and numerical simulation: the root cause of the cracks was the embrittlement of material due to an excessive hydrogen content. This made possible a fatigue fracture mechanism under normal operative cyclic loads. [3]

M. Fonte, P. Duarte, L. Reis, M. Freitas, V. Infante (2015) in this paper investigation is carried on two damaged crankshafts of single cylinder diesel engines used in agricultural services for several purposes. Recurrent damages of these crankshafts type have happened after approximately 100 h in service. The root cause never was imputed to the manufacturer. The fatigue design and an accurate prediction of fatigue life are of primordial importance to insure the safety of these components and its reliability. This study firstly presents a short review on fatigue power shafts for supporting the failure mode analysis, which can lead to determine the root cause of failure. The material of these damaged crankshafts has the same chemical composition to others found where the same type of fracture occurred at least ten years ago. A finite element analysis was also carried out in order to find the critical zones where high stress concentrations are present. Results showed a clear failure by fatigue under low stress and high cyclic fatigue on crankpins. [4]

3. MODELLING AND COMPUTATIONAL ANALYSIS

The materials used for the crankshaft are five which are based on their composition. Building an accurate and reliable calculating model is one of the key steps of analysis with finite element analysis. During the model development, the geometry of the finite element model should be built according to the real one as close as possible. However, if the structure of the object is complex, it can be very difficult to build the model in accordance with the real one. In the model built below crankshaft is simplified. The model was created using Creo 2.0 software.

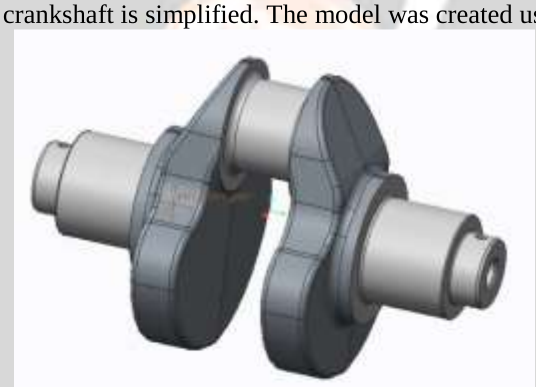

Figure 1. 3D Model of Crankshaft

3.1 Finite Element Analysis

Finite element method is a numerical procedure for solving continuum mechanics of problem with accuracy acceptable to engineers. Finite element method is a mathematical modelling tool involving discretization of a continuous domain using building-block entities called finite elements connected to each other by nodes for once and moment transfer. This process includes finite element modelling and finite element analysis.

1) Analysis of crankshaft- EN 8 Material:

We select material EN 8 for analysis following are the properties of material for structural analysis,

Material: - EN 8
Poisson ratio: - 0.300
Density: - 7850 kg/mm^3
Young’s Modules: - 210 Gpa

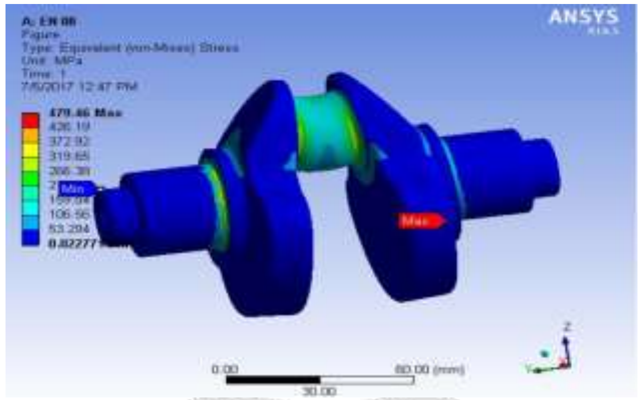

Figure 2. Von Misses Stress Distribution (EN 8) of Crankshaft

For the given load conditions the range of Equivalent Von- Mises stress is observed from 0.022777 MPa to 479.46MPa.

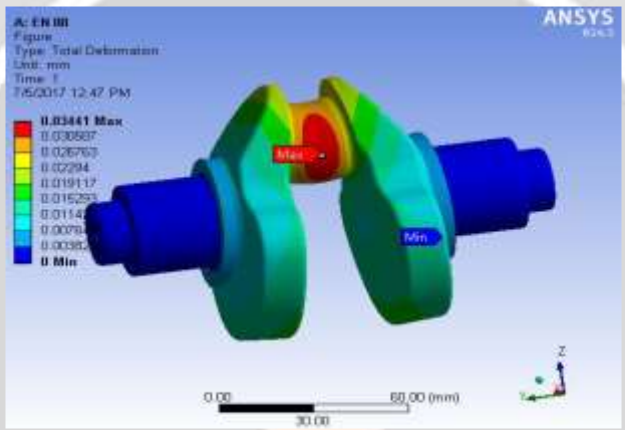

Figure 3. Deformation of (EN 8 material) crankshaft

From the above result for material EN 8 maximum deformation occurs at the centre. Maximum deformation is noted as 0.03441mm.

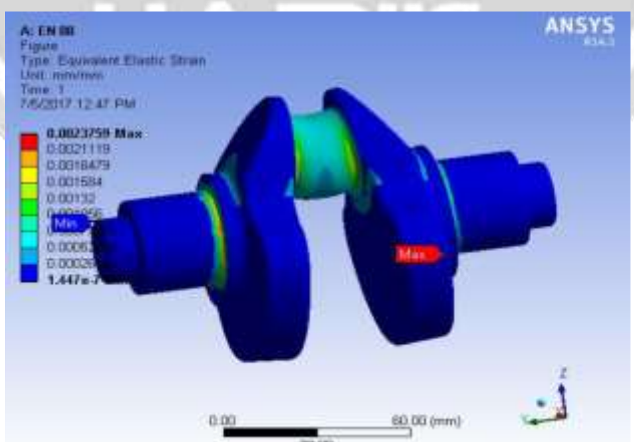

Figure 4. Equivalent Elastic Strain (EN 8) of Crankshaft

From the above results the Equivalent elastic Strain for the given load conditions is observed from 1.447e-7 to 0.0023575.

2) Analysis of crankshaft- EN 24 Material:

We select fourth material EN 24 for analysis following are the properties of material for structural analysis,

Material: - EN 24

Poisson ratio: - 0.300
Density: - 7800 kg/mm3
Shear Modules: - 205 Gpa

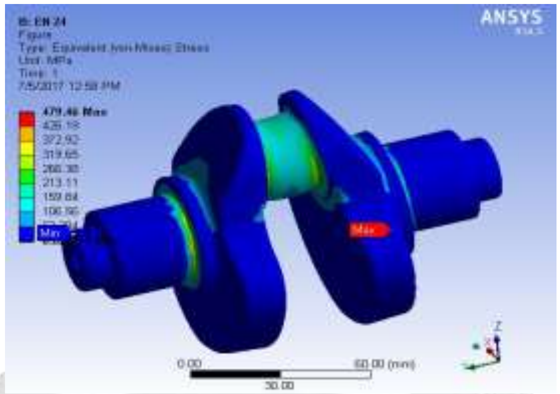

Figure 5. Von Misses Stress Distribution (EN 24) of Crankshaft

For the given load conditions the range of Equivalent Von- Mises stress is observed from 0.022777 MPa to 479.46MPa.

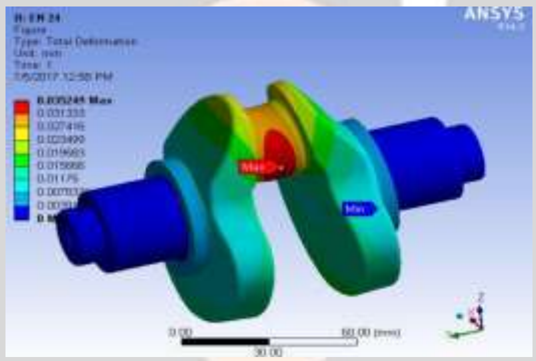

Figure 6. Deformation of (EN 24 material) Crankshaft

From the above result for material EN 8 maximum deformation occurs at the centre. Maximum deformation is noted as 0.035249mm.

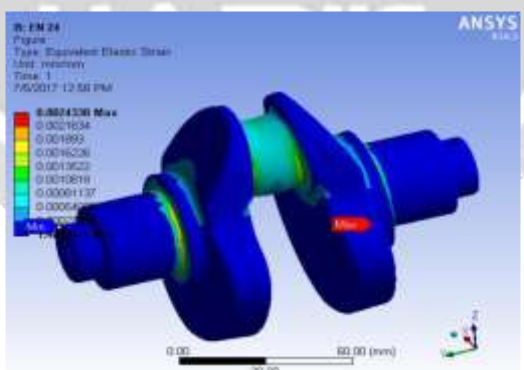

Figure 7. Equivalent Elastic Strain (EN 24) of Crankshaft

From the above results the Equivalent elastic Strain for the given load conditions is observed from 1.48e-7 to 0.0024338.

3) Analysis of Crankshaft- Aluminium Alloy Material:

We select fifth material Aluminium Alloy for analysis following are the properties of material for structural analysis,

Material: - Aluminium Alloy
Poisson ratio: - 0.32
Density: - 3100 kg/m3

Young's Modulus: - 72Gpa

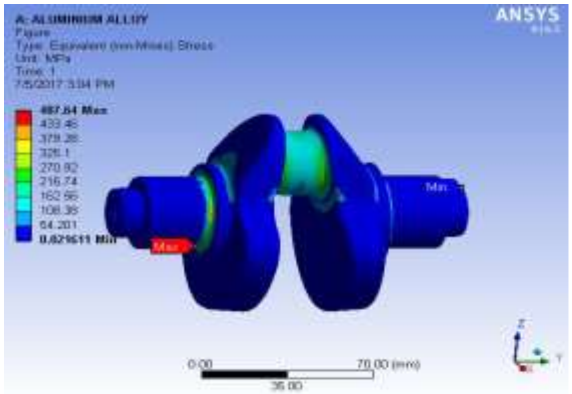

Figure 8. Von Misses Stress Distribution (Aluminum Alloy) of Crankshaft

For the given load conditions the range of Equivalent Von- Mises stress is observed from 0.021611 MPa to 487.64 MPa.

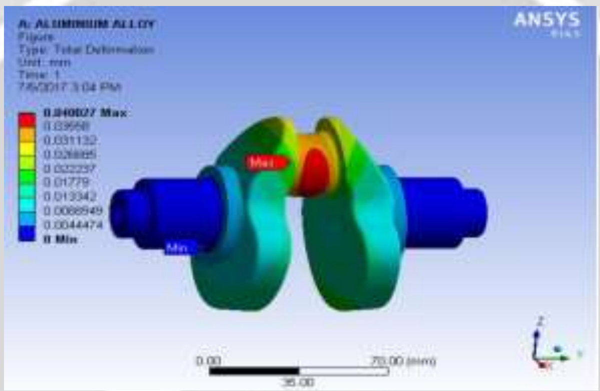

Figure 9. Deformation of (Aluminum Alloy) Crankshaft

From the above result for material EN 8 maximum deformation occurs at the centre. Maximum deformation is noted as 0.040027mm.

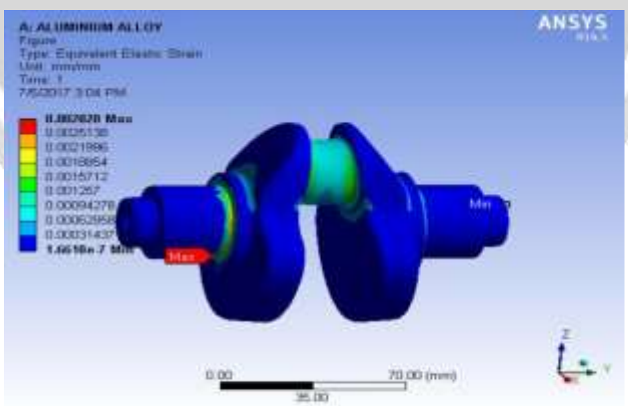

Figure 10. Equivalent Elastic Strain (Aluminum Alloy) of Crankshaft

From the above results the Equivalent Elastic Strain for the given load conditions is observed from 1.6618 e-7 to 0.00282.

4. CONCLUSIONS

The maximum deformation appears at the centre of the crankpin neck surface. Though it is not confirming the minimum available deformation, the difference between the minimum deformation available and the deformation when aluminium alloy is used, which is too less & can be ignored. The maximum stress appears at the fillet areas between the crankshaft journal and crank cheeks and near the central point journal.

5. ACKNOWLEDGEMENT

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6. REFERENCES

[1] Wei Li, Qing Yan, Jianhua Xue, "Analysis of a crankshaft fatigue failure", Engineering Failure Analysis 55 (2015) 139–147.

[2] M. Fonte, P. Duarte, V. Anes, M. Freitas, L. Reis, "On the assessment of fatigue life of marine diesel engine Crankshafts", Engineering Failure Analysis (2015).

[3] M. Fonte, V. Anes, P. Duarte, L. Reis, M. Freitas, "Crankshaft failure analysis of a boxer diesel motor", Engineering Failure Analysis (2015).

[4] M. Fonte, P. Duarte, L. Reis, M. Freitas, V. Infante, "Failure mode analysis of two crankshafts of a single cylinder diesel engine", Engineering Failure Analysis (2015).

[5] B. Kareem, "Evaluation of failures in mechanical crankshafts of automobile based on expert opinion", Case Studies in Engineering Failure Analysis 3 (2015) 25–33.

[6] Xiaoping Chen, Xiaoli Yu, Rufu Hu, Jianfeng Li, "Statistical distribution of crankshaft fatigue: Experiment and modeling", Engineering Failure Analysis 42 (2014) 210–220.

[7] A. Ktari, N. Haddar, H.F. Ayedi, "Fatigue fracture expertise of train engine crankshafts", Engineering Failure Analysis 18 (2011) 1085–1093.

[8] J.A. Becerra, F.J. Jimenez, M. Torres, D.T. Sanchez, E. Carvajal, "Failure analysis of reciprocating compressor crankshafts", Engineering Failure Analysis 18 (2011) 735–746.

[9] Gustavo Rocha da Silva Santos, Guilherme Vinícuis França dos Santos, "Design of a Crankshaft for Internal Combustion Engine by Using Topology Optimization", 20th International Congress of Mechanical Engineering (2009).

[10] M. Fonte, M. de Freitas, "Marine main engine crankshaft failure analysis: A case study", Engineering Failure Analysis 16 (2009) 1940–1947.