Optimization of Two Wheeler Crankshaft using FEA Analysis

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Abstract— The crankshaft is also called as crank. In a reciprocating engine, it translates reciprocating linear piston motion into rotational motion. In a reciprocating compressor, it converts the rotational motion into reciprocating motion. It is one of the most critically loaded components. It experiences cyclic loads in the form of bending and torsion during the working. Here the failure of crankshafts for two wheelers mostly occurs in the crankpin. Thus the crankpin is an important component that mostly decides the life of the crankshaft. The crankshaft considered here is of Scooty ES. The analysis is done for finding critical location in crankshaft. It is a petrol engine crankshaft. Abnormal sound was heard in crankshaft while it is in operation. It was identified as failure of crankshaft. Severe wear has been observed at crankpin bearing location where the oil hole is provided. Here the analysis of the two wheeler crankshaft was done. Its results are then compared and verified numerically, then by the use of ANSYS software. The results compared here are Von Mises Stresses and the strain occurring on the crankshaft.

Key words: Crankshaft, Strain, Stress, Force, Bending Moment

I. INTRODUCTION

A. *Crankshaft:*

Crankshaft fails due to many reasons and these are failure due to absence of lubrication oil, shaft misalignment, vibrations which are caused by bearing, due to improper geometry, due to high temperature of engine, and overloading. It experiences large forces due to combustion of gas. Crankshaft consists of main bearings, the crankpins, connecting rods and the crank arms. The crankshaft having shaft which rotates in the bearing. When the linear reciprocating motion of the pistons is converted into a rotational output, the crankshaft undergoes bending and torsion.

II. STRESS CALCULATIONS OF CRANKSHAFT

A. *Scooty ES*

Engine Displacement= 59.9 cc
Bore × Stroke = (42.6 × 42.0) mm
Maximum Power = 3.5 ps @ 5500 rpm
Maximum Torque = 4.5 Nm @5500 rpm

B. *Pressure Calculation:*

Density of Petrol (C18 H18):

$$\varrho = 750 \text{ kg/m}^3 = 750 \times 10^{-9} \text{ kg/mm}^3$$

C. *Operating Temperature:*

$$T = 20^0C = 20+273 = 293^0K$$

As, Mass= Density × Volume

D. *Molecular weight of petrol:*

$$M = 114.228 \times 10^{-3} \text{ kg/mole}$$

E. *Gas constant for petrol:*

$$R = \frac{8314.3}{114.228\times 10-3}$$

$$R = 72.7868 \times 10^3 \text{ J/kg/mol.K}$$

As, PV = mRT

$$P\times 59.9\times 10^3 = 0.044925 \times 72.7868 \times 10^3 \times 293.15$$

P= 16.0030 MPa / N/mm^2

F. *Design Calculations*

1) *Gas Force (Fp):*

Fp= Pressure (P) X Cross-section area of piston (A)

$$Fp = 16.003 \text{ x } [\frac{\pi}{4} \times (42.6)^2]$$

$$Fp = 22.809 \text{ x } 10^3 \text{ N}$$

2) *Moment of Crank-Pin (Mmax)*

$$M_{max} = \frac{Fp}{2} \times \frac{lc}{2}$$

lc = Length of crank-pin = 34.9 mm

$$M_{max} = \frac{22.809}{2} \text{x}10^3 \text{ x } \frac{34.9}{2}$$

M_{max}= 199.008 x 10^3 N. mm

3) *Section Modulus of Crank-pin (Z)*

$$Z = \frac{\pi}{32} \text{ x } dc^3$$

dc= Diameter of Crank-pin = 13 mm

$$Z = \frac{\pi}{32} \text{x}13^3$$

$$Z = 215.68 \text{ mm}^3$$

Torque obtained at Maximum Power of given Engine

$$P = \frac{2\pi NT}{60}$$

$$3.5 \text{ x } 10^3 = \frac{2\pi\times 5500\times T}{60}$$

$$T = 6.076 \text{ x } 10^3 \text{ N. mm}$$

4) *Von Mises Stresses induced*

Equivalent Bending Moment:

$$M_{ev} = \sqrt{(Kb \times Mmax)^2 + 0.75 \times (Kt \times T)^2}$$

$$M_{ev} = \sqrt{(1 \times 199.008 \text{ x}10^3)^2 + 0.75 \times (1 \times 6.076 \times 10^3)^2}$$

$$M_{ev} = 199.077 \text{ x } 10^3 \text{ N. mm}$$

Thus, $\sigma von = \frac{Mev}{Z}$

$$\sigma von = \frac{199.007 \text{ x } 10^3}{215.68}$$

$\sigma = \sigma von = 923.69 \text{N/mm}^2$

$$\text{Strain} = \frac{\sigma}{E}$$

$$\text{Strain} = \frac{923.69}{200\times 10^3}$$

$$\text{Strain} = 4.6134 \text{ x } 10^{-3}$$

The material medium carbon steel property of the crankshaft is given below in table format.

Density	2340 kg/m^3
Yield Tensile Strength	685 MPa
Ultimate Tensile Strength	885 MPa
Poisson's ratio	0.3

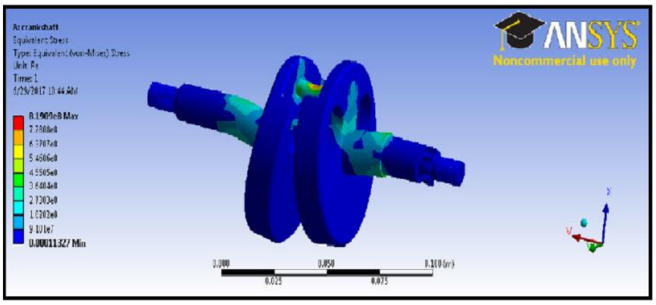
III. ANSYS RESULT

A. FEM Analysis of Existing Crankshaft

The Results of existing Crankshaft are described as below:

B. Von-misses stress or Equivalent stress

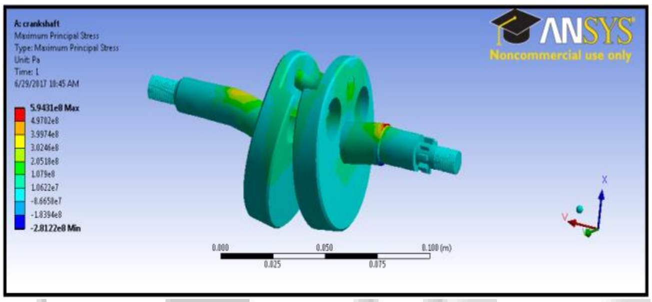
Figureshows the maximum Equivalent (Von-Misses) stress on the crankshaft which is 819 MPa.



Maximum Equivalent (Von-Misses) stress

C. Maximum Principal stress of Crankshaft

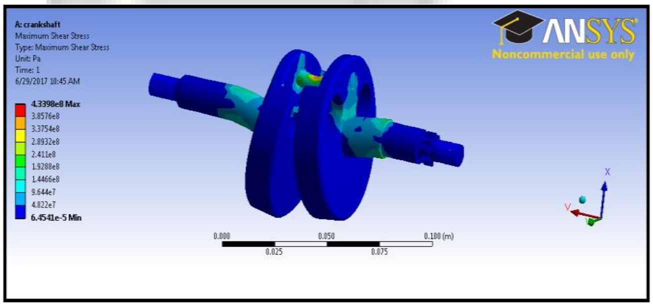
Figure shows the maximum principal stresses on shaft which are 594.31 MPa



Equivalent Elastic Strain of Crankshaft

D. Maximum shear stress on Crankshaft

Figure showsthe maximum shear stress on the crankshaft which is 433.98 MPa



The maximumshear stress on the Crankshaft

E. The Factor of Safety of Crankshaft

Figure showsthe Factor of Safety of Crankshaft which is 0.10524

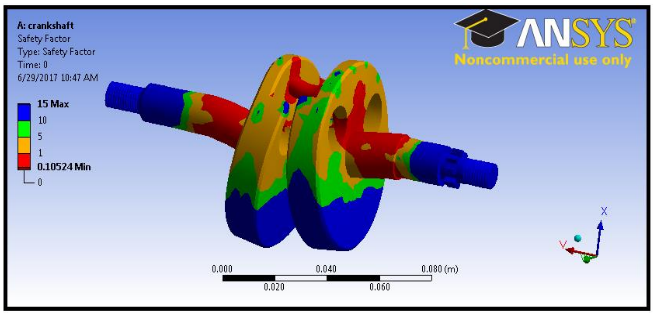
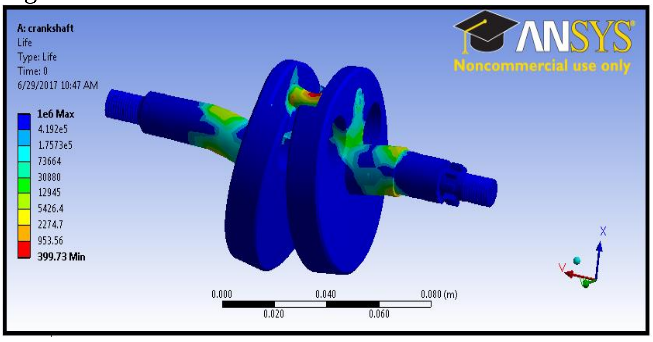


Fig.3.7 The Factor of Safety of Crankshaft

F. The Life of the Crankshaft

Figure shows life of the crankshaft which is 399.73.

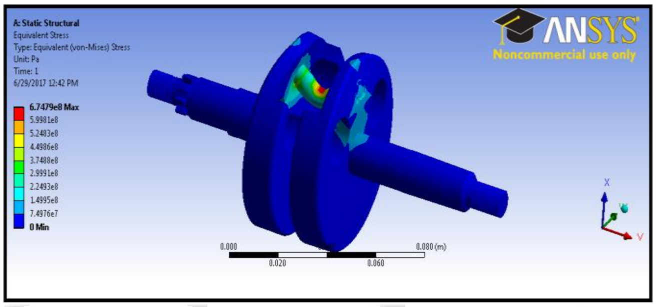


The Life of the Crankshaft

G. FEM Analysis of Proposed Crankshaft

Von-misses stress or Equivalent stress

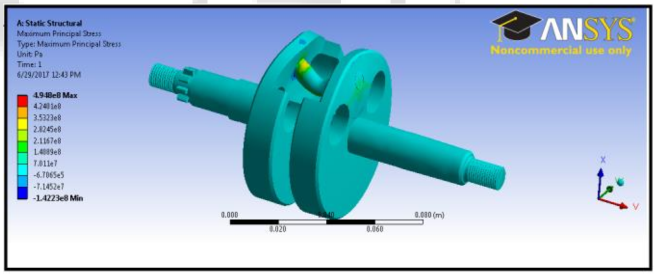
Figureshows the maximum Equivalent (Von-Misses) stress on the crankshaft which is 674.79 MPa.



Maximum Equivalent (Von-Misses) stress

H. Maximum Principal Stress of Crankshaft

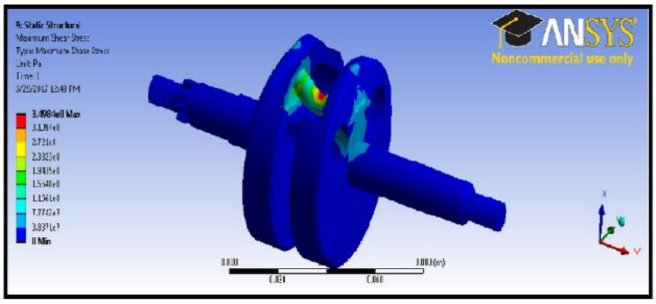
Figure shows the maximum principal stresses on shaft which are 494.8MPa



Equivalent Elastic Strain of Crankshaft

I. Maximum shear stress on Crankshaft

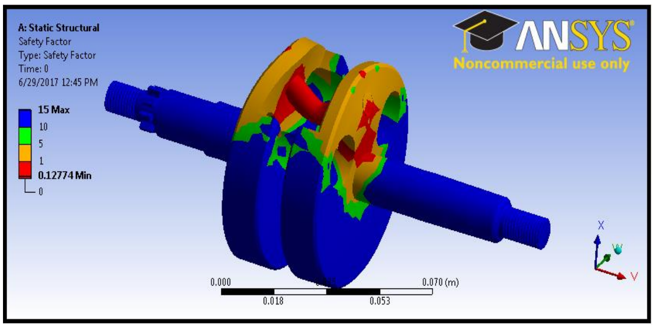
Figure showsthe maximum shear stress on the crankshaft which is 349.8MPa



The maximumshear stress on the Crankshaft

J. The Factor of Safety of Crankshaft

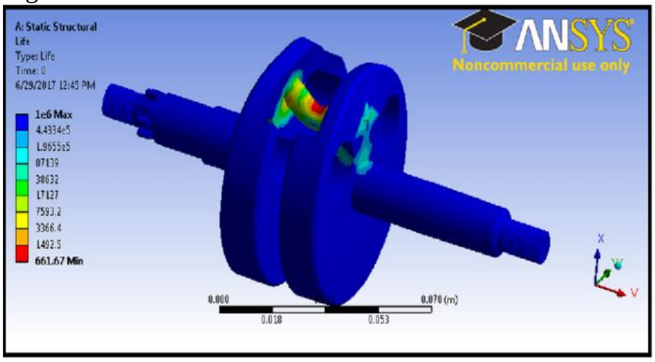
Figure shows the Factor of Safety of Crankshaft which is 0.12774



The Factor of Safety of Crankshaft

K. The Life of the Crankshaft

Figure shows life of the crankshaft which is 661.67



The Life of the Crankshaft

Parameters	Existing Crankshaft	Modified Crankshaft
Maximum principal stress	5.9431×10^8Pa	4.948×10^8 Pa
Maximum shear stress	4.3398×10^8 Pa	3.4984×10^8 Pa
Equivalent stress	8.19×10^8 Pa	6.7479×10^8 Pa
Life	899.73×10^6	661.67×10^6
Factor of Safety	0.105	0.1277

Table II: Static Analysis comparison of existing and proposed crankshaft

IV. CONCLUSION

In this paper, the crankshaft model was created by CATIA V5 for modeling the crank shaft. Then, the created model was import into ANSYS software for static structural analysis. The comparison of analysis results of the materials will show the effect of stresses on the material. The experimental and theoretical calculation matches with the ansys result. The analysis of the crank shaft was done using material SAE 4340(Cr Ni Mo Steel).

REFERENCES

[1] Mr. Anant B. Khandkule “Comparative analysis of crankshaft in single cylinder petrol engine crankshaft by numerical and analytical method” INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY [IJIERT] ISSN: 2394-3696 VOLUME 2, ISSUE 4APR.-2015

[2] Rajkumar Ashok TekalePatil, D. D. Date “Optimization through CAE Practices for Forged Crankshaft of a Two - Wheeler to Effect Mass Reduction” International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

[3] Park, H., Ko, Y. S., and Jung, S. C., 2001, “Fatigue Life Analysis of Crankshaft at various Surface Treatments,” SAE Technical Paper No. 2001-01-3374, Society of Automotive Engineers, Warrendale, PA, USA.

[4] Farzin H. Montazersadgh, “Optimization of a Forged Steel Crankshaft Subject to Dynamic Loading”, „SAE International‟, Paper No 2008-01-0432, (2008).

[5] Rinkle Garg, Sunil Baghla, “Finite Element Analysis and Optimization of Crankshaft Design”, „International Journal of Engg.and Management Research‟, ISSN: 2250-0758, vol-2, Issue-6, (2012), pp: 26-31.

[6] C.M.Balamurugan, R.Krishnaraj, Dr.M.Sakthivel, “Computer Aided Modeling and Optimization of Crankshaft”, „International Journal of Scientific & Engineering Research‟, ISSN 2229-5518, Issue 8, vol.2, (2011).pp.1-6

[7] Ms. Jagruti K. Chaudhari,”Experimental And Numerical Analysis Of Crankshaft Used In Hero Honda Splendor Motorcycle”,InternationalJournal.of New Technology and Research (IJNTR) ISSN:2454-4116, Volume-2, Issue-7, July 2016 Pages 83-94

[8] KishorRaskar,”Optimization of Two Wheeler Crankshaft using Finite Element Analysis”, ”nternational Engineering Research Journal Page No 1054-1061”

[9] P.N.Rohini, S.Nagu,” Design and Optimization of IC Engine Crankshaft”,” INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY” ISSN: 2277-9655(2014)

[10] M. Senthilkumar, Dr.S.Ragunathan, M.Suresh, V.R.Srinivashan,” A Study of Crankpin Failure in I.C. Engine”, “Mechanical Engineering:An International Journal(MEIJ),Vol 1No. 3(2014).

[11] Prof. Nilesh B. Totla, Mr. ShindeAjitRajendra,” COMPARATIVE ANALYSIS OF CRANKSHAFT OF PULSAR 180 DTS-I”,” International Journal of Engg.and Management Research”ICRTES-16 ISBN:978-93-86171-06-1.