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COMPARATIVE ANALYSIS OF CRANKSHAFT IN SINGLE CYLINDER PETROL ENGINE CRANKSHAFT BY NUMERICAL AND ANALYTICAL METHOD

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ABSTRACT

The crankshaft is also referred as crank. It is responsible for conversion between reciprocating motion and rotational motion. 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. 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 Pulsar 180 DTSi. It is a petrol engine crankshaft made from Alloy steel 41Cr4.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 is 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.

Keywords: Crankshaft, Crankpin, Strain, Stress, Force, Moment

INTRODUCTION

1. Crankshaft

The crankshaft, also referred as crank, is responsible for conversion between reciprocating motion and rotational motion. In a reciprocating engine, it translates reciprocating linear piston motion into rotational motion, whereas in a reciprocating compressor, it converts the rotational motion into reciprocating motion. In order to do the conversion between two motions, the crankshaft has "crank throws" or "crankpins", additional bearing surfaces whose axis is offset from that of the crank, to which the "big ends" of the connecting rods from each cylinder attach.

The crankshaft main journals rotate in a set of supporting bearings also called as main bearings. They cause the offset rod journals to rotate in a circular path around the main journal centers, the diameter of which is twice the offset of the rod journals. The diameter of that path is the engine "stroke": the distance the piston moves up and down in its cylinder. The big ends of the connecting rods also called as conrods, contain bearings (rod bearings) which ride on the (offset) rod journals.

Fig 1: Single Cylinder Petrol Engine Crankshaft

2. Forces Acting On The Crankshaft

A major source of forces imposed on a crankshaft, namely Piston Acceleration. The combined weight of the piston, ring package, wristpin, retainers, the conrod small end and a small amount of oil are being continuously accelerated from rest to very high velocity and back to rest twice each crankshaft revolution. Since the force it takes to accelerate an object is proportional to the weight of the object times the acceleration (as long as the mass of the object is constant), many of the significant forces exerted on those reciprocating components, as well as on the conrod beam and big-end, crankshaft, crankshaft, bearings, and engine block are directly related to piston acceleration. Combustion forces and piston acceleration are also the main source of external vibration produced by an engine.

These acceleration forces combine in complex ways to produce primary and secondary shaking forces as well as primary and secondary rocking moments. The combinations of forces and moments vary with the cylinder arrangement. Here in this case piston force is considered.

3. Material Composition Of The Crankshaft

The material composition of the crankshaft is given below in table format.

Components	**Symbol**	**Percentage %**
Iron	Fe	97.3 – 98.1
Chromium	Cr	0.7 – 0.9
Carbon	C	0.38 – 0.43
Silicon	Si	0.15 – 0.53
Sulphur	S	0 – 0.04
Phosphorous	P	0 – 0.035

4. Calculations For The Project

4.1 Engine Specifications:

i) Capacity: 178.6cc

ii) Type: 4 stroke, DTS-i, air cooled, single cylinder

iii) Bore x Stroke: 63.5 x 56.4 (in mm)

iv) Maximum Power:

17.02 @ 8500 (ps @ RPM)

12.518 @ 8500 (kW @ RPM)

v) Maximum Torque: 14.22 @ 6500 (Nm @ RPM)

4.2 Pressure Calculations:

Density of petrol (C_8H_{18}):

$$\rho = 750 \text{ kg/m}^3 = 750\times10^{-9} \text{ kg/mm}^3$$

Operating Temperature:

$T = 20^{O}C = 273.15+20 = 293.15^{O}K$

As Mass = Density × Volume

Then $m = 750\times10^{-9} \times 178.6 \times 10^{3}$

$= 0.13395$ kg

4.3 Molecular Weight of Petrol:

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

4.4 Gas Constant for Petrol:

$R = \frac{8314.3}{114.228 \times 10-3} = 72.7868 \times 10^{3}$ J/kg/mol K

As $pV = mRT$

$p \times 178.6 \times 10^{3} = 0.13395 \times 72.7868 \times 10^{3} \times 293.15$

Thus $p = 16.003$MPa $= 16.003$ N/mm^2

4.5 Design Calculations

1) Gas Force (F_P):

F_P = Pressure (P) × Cross Section Area Of Piston (A)

$F_P = 16.003 \times \frac{\pi}{4} \times 63.5^2$

$= 50.6802 \times 10^{3}$ N

2) Moment On The Crankpin

$$M_{max} = \frac{FP}{2} \times \frac{lc}{2} \qquad (1)$$

By the given dimensions of the crankpin,

Diameter of the crankpin = (d_c) = 30 mm

Length of the crankpin = (l_c) = 53.7 mm

$$\text{Thus } M_{max} = \frac{50.6802 \times 10^3}{2} \times \frac{53.7}{2}$$

$$= 680.3816 \times 10^3 \text{ Nmm}$$

3) Section Modulus Of Crankpin

$$Z = \frac{\pi}{32} \times dc^3 \qquad (2)$$

$$= \frac{\pi}{32} \times 30^3 = 2650.7188 \text{ mm}^3$$

4) Torque Obtained At Maximum Power Of Given Engine

$$P = \frac{2\pi NT}{60} \qquad (3)$$

$$12.518 \times 10^3 = \frac{2 \times \pi \times 8500 \times T}{60}$$

$$T = 14.0633 \text{ Nm}$$

$$= 14.0633 \times 10^3 \text{ Nmm}$$

5) **Von Misses Stresses Induced**

Torque (T) = 14.0633×10^3 Nmm

Bending Moment (M_{max}) = 680.3816×10^3 Nmm

K_b = Combine shock, fatigue factor for bending = 1

K_t = Combine shock, fatigue factor for torsion = 1

Equivalent Bending Moment:

$$Mev=\sqrt{(Kb \times Mmax)^2 + (\frac{3}{4} \times (Kt \times T)^2)} \qquad (4)$$

$$= \sqrt{(1 \times 680.3816 \times 10^3)^2 + (\frac{3}{4} \times (1 \times 14.0633 \times 10^3)^2)}$$

$$= 680.4905 \times 10^3 \text{ Nmm}$$

$$\text{Thus } \sigma_{von} = \frac{Mev}{Z} \qquad (5)$$

$$= \frac{680.4905 \times 10^3}{2650.7188} = 256.805 \text{ N/mm}^2$$

$$\sigma = \sigma_{von} = 256.805 \text{ N/mm}^2$$

6) Strain

$$\epsilon = \frac{\sigma}{E} \qquad (6)$$

$$= \frac{256.805}{200 \times 10^3} = 1.284 \times 10^{-3}$$

ANSYS RESULT

Here the ANSYS simulation is done. In this case, Von Mises stresses and Strain is obtained. For this scenario, Gas force of 50.6802×10^3 N. From this case, the following results are obtained.

5.1 Assumptions:

Parameters	***Values***
Combine shock, fatigue factor for bending = K_b	1
Combine shock, fatigue factor for torsion =K_t	1
Density = ρ (kg/m^3)	7700
Ultimate Tensile Strength = Sut (MPa)	1000
Yield Strength = Syt (MPa)	660

The assumption taken here is the crank web and the shafts are considered as fixed. The only critical component considered here is the crankpin.

5.2 Model

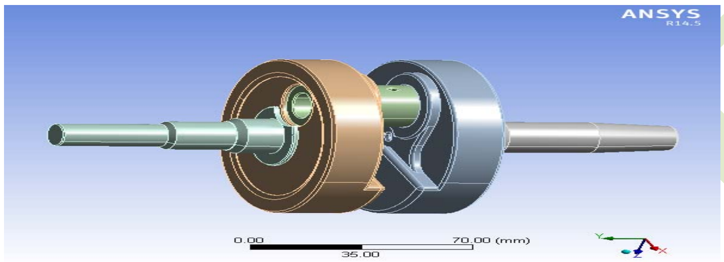

Fig 2 Crankshaft Model

5.2 Model Meshing

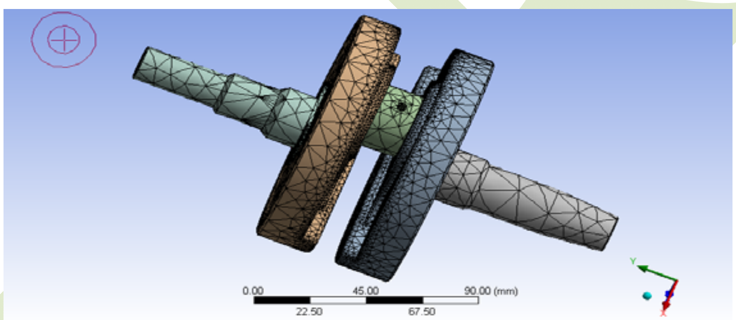

Fig 3 Meshed Model

5.3 Initial Conditions

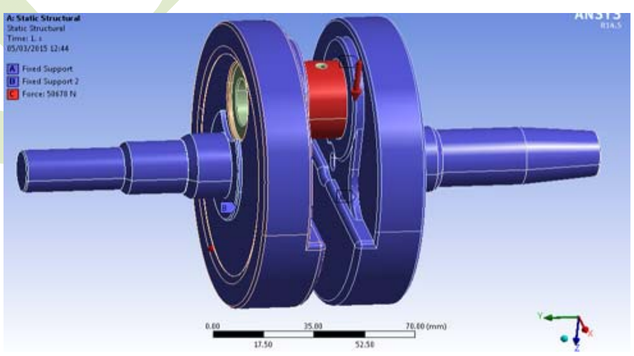

Fig 4 Initial Conditions

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5.4 Result

5.4.1 Von Mises Stresses

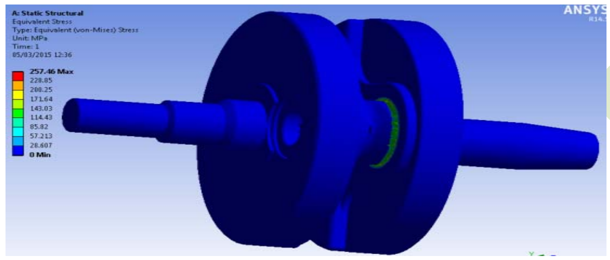

Fig 5 Von Mises Stresses

5.4.2 Total Deformation

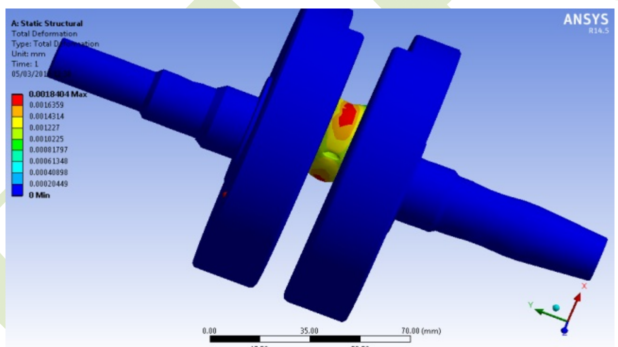

Fig 6 Total Deformation

CONCLUSION

Parameter	Numerical	Analytical	Error
Von Mises Stress (MPa)	256.805	256.47	0.13061%
Total Deformation (mm)	0.068	0.0018404	0.3694%

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