Analysis And Optimization of Crankshaft

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Abstract- *Crankshaft basic purpose is to generate power in engine from rotary motion. But it may fail after particular life cycle this occurs to its geometry, weight distribution etc. Major parameter here is stress concentration that is present at weak section. This paper explains various ways in which these critical stress values can be reduced. For this analytical calculations been done and those were compared with ANSYS for normal or standard crankshaft. Optimization been applied to crankshaft i.e. drilling a hole near critical stress location. Again results are obtained for optimized crankshaft. Furthermore, results are compared are percentage of difference and reduced weight are noted.*

Keywords- Crankshaft ,FEA, Optimization ,ANSYS

I. INTRODUCTION

In Internal Combustion engine crankshaft is major component responsible for power generation. It converts linear motion of piston into rotary motion. So its strength is also an important parameter for consideration. Crankshaft is subjected to cyclic loads in form of torsion and bending throughout its life. Crankshaft must tough and stiff to take the down force. Stress calculation becomes important factor to have better life of engine. [1]. Design as well as development of crankshaft is important concern in production.

To make it reliable weight is reduced up to possible limit and with optimum fatigue strength considering fulfillment of functional aspects. Crankshaft considered is 4-stroke TATA Indica Vista Quadrajet Which is diesel engine based.

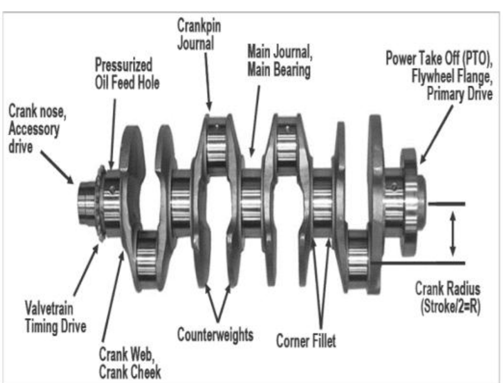

Fig .1 Standard crankshaft with nomenclature

II. LITERATURE REVIEW

Ms.Jagruti K. Chaudhari finds out the best material useful for crankshaft. Selection of suitable material is based upon various experimental test and numerical analysis. Comparing them identifying percentage error involved. [1]

V.C Shahane work is related to optimize the crankshaft in terms of weight reduction. To obtain the result various changes in geometry is done around 6 cases are considered. Out of which one obtained with less stress and frequency. Corresponding weight is the optimization. [2]

Ketan V.Karandikar obtained the result for different materials.Test is carried out , mathematically ,ANSYS and experimentally i.e UTM (Universal Testing Machine).From which the material performs the better than is consider best for crankshaft.[3]

K.Thriveni , Dr B.Jaya Chandraiah work is related to modal analysis of 4-stroke crankshaft for two cases free frequency and frequency analysis. Results were obtained for both cases. [4]

Technical Specifications of Engine

Number of Cylinders	4 Cylinder, SDE Common Rail,
Type of Engine (Inline engine)	1248 cc, Inline Diesel, 475IDI engine
Bore / Stroke (D/L)	69.6 / 82
Power @ speed	75 PS (55KW)@ 4000 rpm
Torque @ speed	190 Nm@ 1750 RPM
Compression ratio	17.6 :1
Engine type	Compressor Ignition (CI) Engine

Table 1 Standard Specifications of Engine

III. EXISTING MATERIAL DETAILS

Existing Material details are useful for the finite element analysis to find out fatigue life of crankshaft. Existing Material details of Tata Indica Vista engine is in table given below

Designation	40Cr4Mo3
Material	Forged Steel
Yield strength (MPa)	55 Kg/mm2 MIN
Ultimate Tensile strength (MPa)	83 Kg/mm2 MIN
Elongation	14% MIN
Poisson's Ratio	0.3

Table .2 Material Properties

IV. ANALTYICAL CALCULATION

The force acting on the center crankshaft at the top dead center. Force acting on crank pin

Now the piston force

Assuming maximum pressure 5 MPa

Piston Force Fp

Fp = Area of the bore x Max gas pressure
= (π/4) x D2 x Pmax
=(π/4) x (69.6)2 x 5
Fp = 19023 N

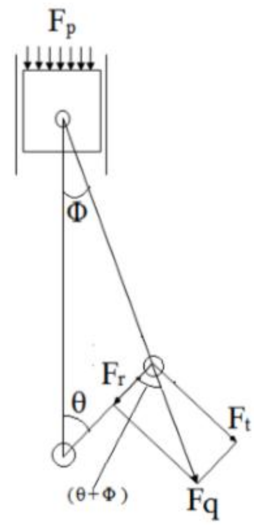

Fig. 2 Forces Acting on Crank

Moment on Crankpin:
By given dimensions of the crankpin,
Diameter of the crankpin (dc) = 40 mm
Length of the crankpin (lc) = 30 mm

Mmax = (Fp/2) x (lc/2)
= (19023/2) x (30/2)
=142672.55 Nmm

Section Modulus of Crankpin:
Z = (π/32) x (dc)3
= (π/32) x (40)3
= 6283.185 mm3

Torque obtained at maximum Power of given engine:
P = (2 π NT/60)
55 x 103= (2 π x4000 x T/60)
T =131302.82 Nmm

Von Misses Stresses Induced:
Torque =131302.82 Nmm
Bending moment (Mmax) = 142672.55 Nmm
Kb= Combine shock, fatigue factor for bending = 1
Kt= Combine shock, fatigue factor for torsion = 1

Equivalent Bending Moment :
Meq = [(Kb x Mmax)2 + (3/4)2(Kt x T)2]0.5
= 173358.543 N mm

Thus
σvon = Meq/Z
= 27.59 N/mm2

Equivalent Twisting Moment:

Teq = $(M_{eq}2+T2)0.5$

= 193896.588 N-mm

Teq = $\pi/16 \times dc3 \times \tau$

τ = 15.43 N/mm2.

Strain

ε = σ/E=27.59/2x105

ε = 1.3795x10-4

V. ANALYSIS OF CRANKSHAFT USING ANSYS

In this research paper the geometry of crankshaft is created in CATIA V5 R21 and analyzed showed in fig

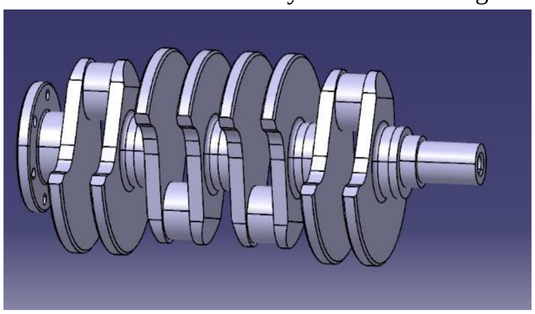

Fig. 3 Solid model of crankshaft using CATIA V5

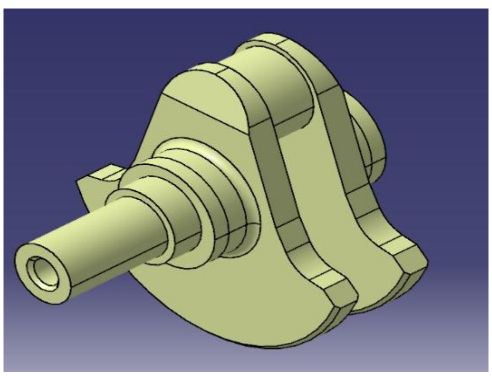

Fig.4 Solid model of 4 cylinder crankshaft

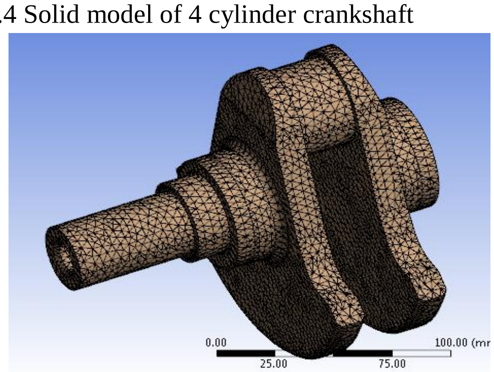

Fig.5 Meshing of single cylinder crankshaft with 2 mm element length size

Element type	3D Solid Element
Element Shape	Tetrahedral element
Elemental length size	2 m
Number of Element	39706
Number of Nodes	69778

Table 3 The element length sizes and types

VI. LOADING AND BOUNDARY CONDITIONS

Boundary conditions are applied by fixing the shaft present at both ends. Load is applied over the crankpin towards downward direction.

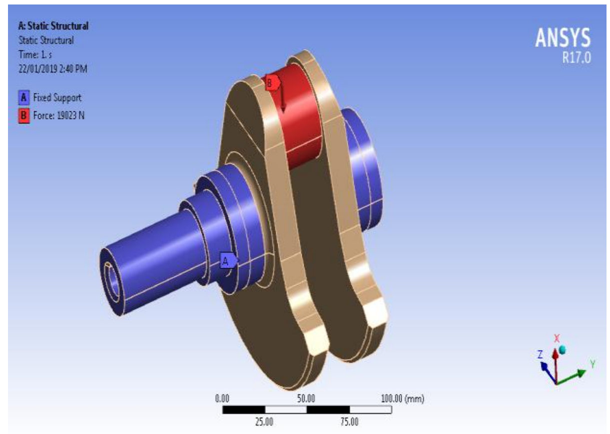

Fig.6 Boundary conditions for crankshaft

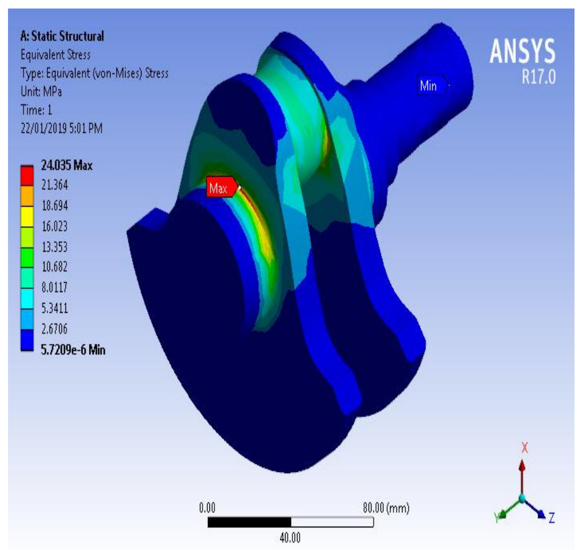

Fig.7 Von Mises Stress Maximum occurs near crankpin and main journal

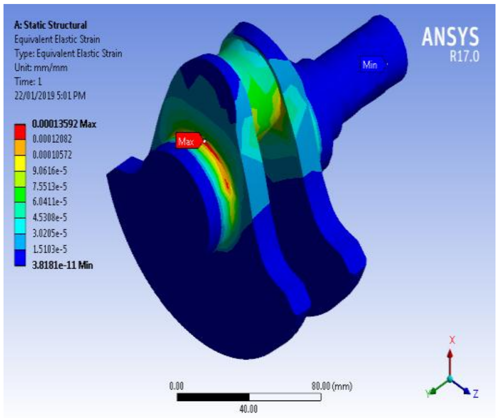

Fig.8 Von Mises Strain Maximum occurs near crankpin and main journal

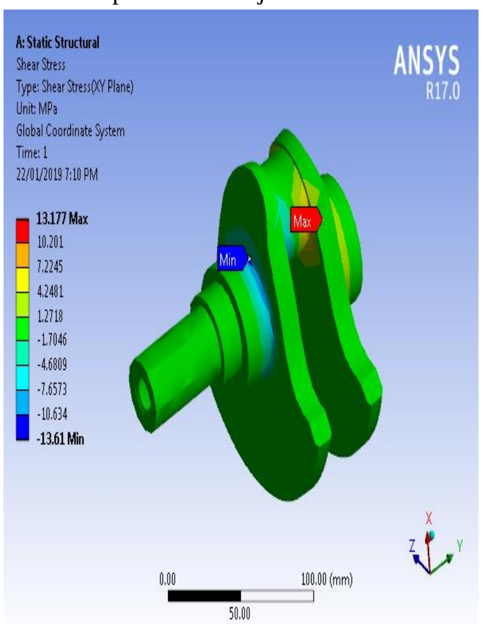

Fig.9 Shear Stress is Maximum near crankpin region

RESULT TABLE

Sr. No.	Type of stress	Theoretical	ANSYS results
1.	Von-misses stress(N/mm²)	27.59	24.035
2.	Von-misses strain	1.3795x10-4	1.3592x10-4
3.	Shear Stress (N/mm2)	15.43	13.177

OPTIMIZATION OF CRANKSHAFT

Optimization of crankshaft can be done by reducing stress at critical location and release stress at that point by providing hole closer to that region.

First, hole in made on crankpin axially parallel to shaft of diameter 6 mm.

This selection is made on basis of trial and error method to determine best suited size.

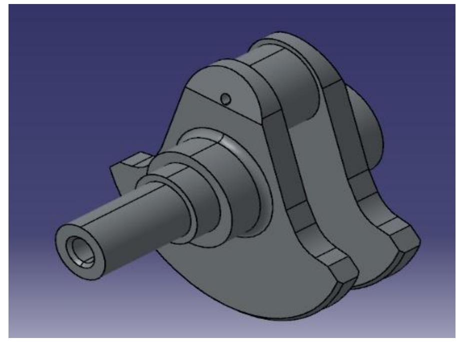

Fig.10 Solid model of single cylinder crankshaft with hole present axially along crankpin

Boundary conditions are same that of previous model.

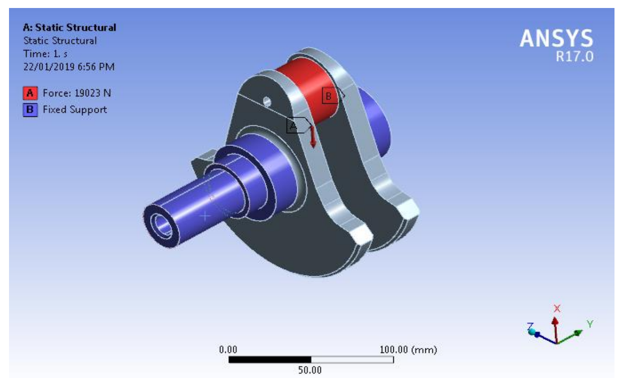

Fig.11 Boundary conditions of crankshaft with hole.

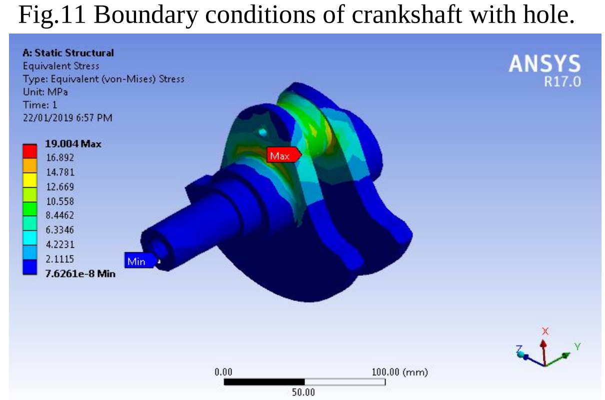

Fig.12 Von Mises Strain Maximum occurs near crankpin and main journal

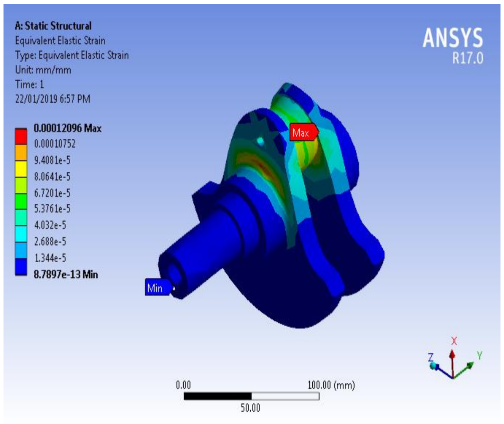

Fig.13 Von Mises Strain Maximum occurs near crankpin and main journal

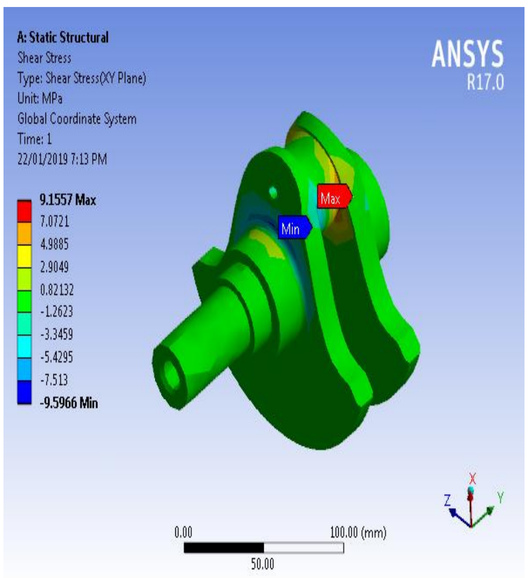

Fig.14 Shear Stress is Maximum near crankpin region

RESULTS AFTER OPTIMIZATION

Sr. No.	Type of stress	Before Optimization	After Optimization
1.	Von-misses stress(N/mm²)	24.035	19.004
2.	Von-misses strain	1.3592x10-4	1.2096x10-4
3.	Shear Stress	12.838	9.1557

VII. CONCLUSION AND FUTURE WORK

Analysis and optimization of crankshaft is done analytically and via ANSYS Workbench Results obtained.

It was observed that from stress analysis the maximum deformation in crankshaft occurs near main journal and crankpin region, where chances of failure are more. This is generally due to crank in cross section area and size variation.

This can be reduced to certain extent by hole at or near the region where stress concentration is more.

Value of diameter select is based upon trial and error method is the best suited diameter to be considered.

Additionally, it also acts as cooling medium by allowing the air pass through it which reduces the temperature.

In future modal analysis and its validation can be done by experiment i.e. fatigue test and vibration testing, FFT analyses etc.

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