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MODELLING OF CRANKSHAFT BY CAD TOOL AND FINITE ELEMENT ANALYSIS USING ANSYS SOFTWARE

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ABSTRACT

Crankshaft is the complex geometry in the Internal Combustion Engine with large volume production component. This converts the reciprocating motion of the piston in to a rotary motion. An attempt is made in this paper to study the Static structure analysis on a crankshaft. The modelling of the crankshaft is created by using Solidworks 16 Software. Finite element analysis (FEA) is uses to analysis variation of stress at critical locations of the crankshaft to use the ANSYS software. The results ofVon-misses stress on the crankshaft is 6.52Mpaand shear stress on the crankshaft is 3.367Mpa. The Theoretical results are obtained on von-misses stress is 10.99Mpa, shear stress is 2.9Mpa. Then approved of model is compared with the Theoretical and FEA results for Von-misses stress and shear stress are within the limits.

Keywords: Crankshaft, solidworks, finite element analysis (FEA), ANSYS Software, Static Analysis

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1. INTRODUCTION

Crankshaft is the complex geometry in the Internal Combustion Engine with large volume production component, which converts the reciprocating displacement of the piston to a rotary motion. The crank pins to which the big end of the connecting rod are connected, there are crank arms or webs which connect the crank pins and shaft parts. In addition, the linear displacement of an engine is not smooth; as the displacement is caused by the combustion chamber therefore the displacement has sudden shocks. The concept of using crankshaft is to change these thrust displacements to as smooth rotary output, which is use in many devices such as generators, pumps and compressors. It should also use for a flywheel helps in smoothing the shocks. Crankshaft experiences large forces of gas combustion in engine. This force is start to the top of the piston and since the connecting rod connects the piston to the crankshaft, this force will be transmitted to the crankshaft. The magnitude of the forces depends on many factors such as consist of crank radius, connecting rod dimensions, and weight of the connecting rod, piston, piston rings, and pin. Combustion and inertia forces acting on the crankshaft. Torsional load and Bending load. Crankshaft must be strong to take the downward force of the power stroke without bending, so the reliability and life of the internal combustion engine depend on the strength of the crankshaft. The crank pin is as a built in beam with a distributed load along its. Length that varies with crank positions. Each web is as like a cantilever beam subjected to bending and twisting. Bending moment which causes tensile and compressive stresses and Twisting moment causes shear stress on crankshaft. There are many parts of failure in the engine, one of the most common crankshaft failure is fatigue at the fillet areas due to the bending load. On the moment of combustion, the load from the piston is transmitted on the crankpin, and causing a large bending moment on geometry of the crankshaft.

2. LITERATURE REVIEW

Rinkle garg and Sunil Baghl. [1] Had constructed crankshaft model on Pro/E Software and then analysed on ANSYS software. As the maximum limits of stress, strain and total deformation reduced, there had improved in the strength of the crankshaft. The weight of the crankshaft had reduced .There by, reduces the inertia force. As the weight of the crankshaft decreased this would decreased the cost of the crankshaft and increase the I.C engine performance.

C.M. Balamurugan et al [2] has been compare the fatigue performance of two competing manufacturing technologies for automotive crankshafts. Studied the Computer aided Modelling and Optimization of crankshaft. Namely use forged steel and ductile cast iron. The analysis performed in ansys software and the 3D model of crankshaft is created by the solid edge. . The new optimised geometry had compatible with the new engine. Without changing connecting rod and engine block. Fillet rolling and results in increased fatigue strength and reduced cost of the crankshaft.

Gu Yingkui, Zhou Zhibo. [3] Have been using the PRO/E software to create and discussed the 3D model of diesel engine’s crankshaft. it shows that the high stress region mainly on crank arm, the main journal, the crank arm and connecting rod journal ,that why, the area most easily broken.

Abhishekchoubey, and Jamin Brahmbhatt. [4] Have been Analysis and made 3D model of crankshaft, for the analysis ANSYS software is used and modelling software is solidworks. Maximum deformation appears on the crankpin neck surface and the maximum stress appears on crankshaft journals, crank cheeks, and near the central point journal. High stress appears in edge of main journal.

R. J. Deshbhratar, and Y.R Suple. [5] Have been using the PRO/E software to create and discussed the 3D model of diesel engine’s crankshaft. it shows that the high stress region mainly on crank arm, the main journal, the crank arm andconnecting rod journal. Maximum deformation take place on the centre of crankshaft surface.High stress appears in edge of main journal.

3. OBJECTIVE

An attempt in this paper, the crankshaft is modelled by using SOLIDWORKS software, and static analysis is done by using ANSYS Workbench software. To evaluate the von-misses stress and shear stress.

4. MATHEMATICAL MODEL FOR CRANKSHAFT

Configuration of the Engine to which the crankshaft belongs, Delta Integrale 2.0 16V engine

Crank pin radius	18.5 mm
Shaft Diameter	40 mm
Thickness of the Crank web	15 mm
Bore diameter	55 mm
Length of the crank pin	40 mm
Maximum pressure	35 bar

Force on the piston

Bore diameter (D) = 55 mm, FQ= Area of the bore ×Max. Combustion pressure

$= \frac{\pi}{4} \times D^2 \times Pmax$ =8.315 KN

In order to find the Thrust Force acting on the connecting rod (FQ), and the angle of inclination of the connecting rod with the line of stroke (i.e. angle Ø).

$sin\emptyset = \frac{sin\theta}{\frac{L}{R}} = \frac{\sin 35°}{4}$=

Which implies, $\emptyset = 8.24°$

We know that thrust Force in the connecting rod,

$F_Q = F_p/\cos\emptyset$

=8.401KN

From we have

Thrust on the connecting rod

Thrust on the crankshaft can be split into tangential component and radial component.

1. Tangential force on the crankshaft,

$F_T = F_Q \sin(\theta + \emptyset) = 5.69$ KN

2 .Radial force on the crankshaft,

F_R = FQ cos (θ+ Ø) = 6.057 KN

Reactions at bearings due to tangential force is given by

$H_{T1} = H_{T2} = F_T/2 = 2.81$ KN

Similarly, reactions at bearings due to radial force is given by

$H_{R1} = H_{R2} = F_R/2 = 3.0285$KN

Design of crankpin

Let d= diameter of crankpin in mm

We know that bending moment at the centre of the crankshaft

$M_C = H_{R1} \times b_2 = 83.1887$ KN-MM

Twisting moment on the crankpin

$T_C = H_T$ x R = 51.985KN-mm

From this we have equivalent twisting moment

$T_e = \sqrt{{M_C}^2 + {T_C}^2}$ =97.985 KM-mm

The von Mises stress induced in the crank-pin

$M_{ev} = \sqrt{(K_b * M_c)^2 + 3/4\ (k_t * T_c)^2}$

=179.55KN-mm

$$M_C = \frac{\pi}{32} * d^3 * \sigma$$

σ= 10.99 N/mm^2

Shear stress:

$$T_C = \frac{\pi}{16} * d^2 * \tau$$

τ= 2.9 N/mm^2

5. MODELING AND MESHING OF THE CRANKSHAFT

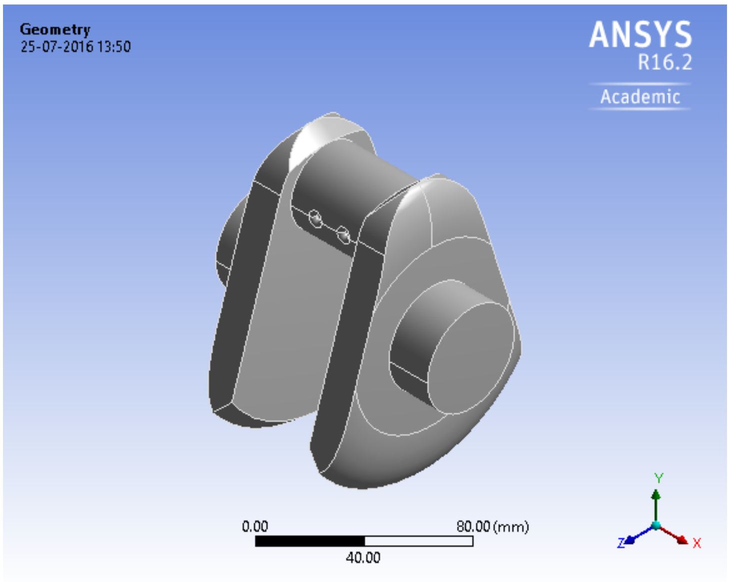

Figure 1.1 Model of the crankshaft

Mesh Statics:

Type of Element : Tetrahedrons
Number of nodes : 4443
Number of Elements: 2541

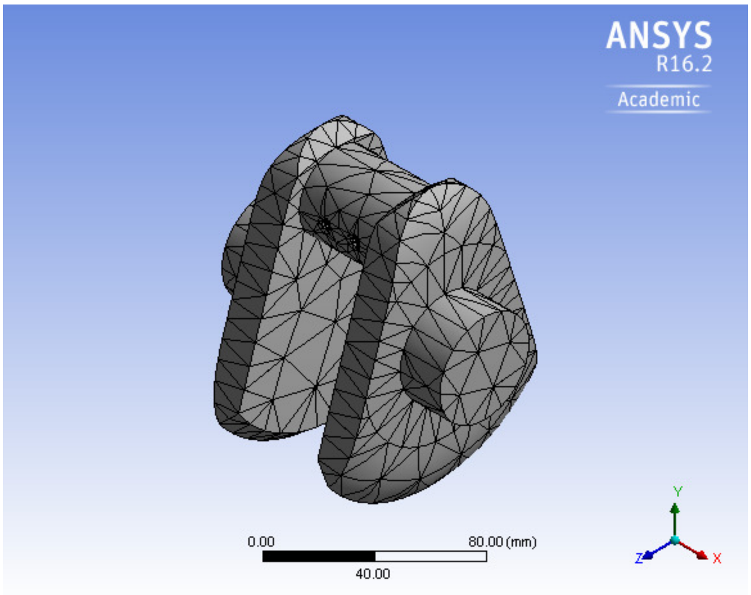

Figure 1.2 Meshed model of the crankshaft

Introduction to FEA:

The basis of FEA relies on the decomposition of the domain into a finite number of sub-domains (elements) for which the systematic approximate solution is constructed by applying the variation or weighted residual methods. In effect, FEA reduces problem to that of a finite number of unknowns by dividing the domain into elements and by expressing the unknown field variable in terms of the assumed approximating functions within each element. These functions (also called interpolation functions) are defined in terms of the values of the field variables at specific points, referred to as nodes. The finite element method is a numerical procedure that can be used to obtain solutions to a large class of engineering problems involving stress analysis, heat transfer, electro-magnetism, and fluid flow.

ANSYS is general-purpose Finite Element Analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user designed size) called elements. The software implements equations that govern the behaviour of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. The ANSYS Workbench environment is an intuitive up-front finite element analysis tool that is used in conjunction with CAD systems and/or Design Model. ANSYS Workbench is a software environment for performing structural, thermal, and electromagnetic analyses. The Workbench focuses on attaching existing geometry, setting up the finite element model, solving, and reviewing results.

Static Analysis: Used to determine displacements, Stresses, Strain, Deformation etc. under static loading conditions in both linear and nonlinear static analysis. Nonlinearities include plasticity, stress stiffening, large deflection, large strain, hyper elasticity, contact surfaces, and creep. Apply Material for crankshaft (cast iron).

Material Type:

Castiron Young modulus: 1.78e+005Mpa

Poisson’s ratio: 0.3

Density: 7.197e-006kg/mm^3

6. RESULTS AND DISCUSSION

Analysis of crankshaft-cast Iron

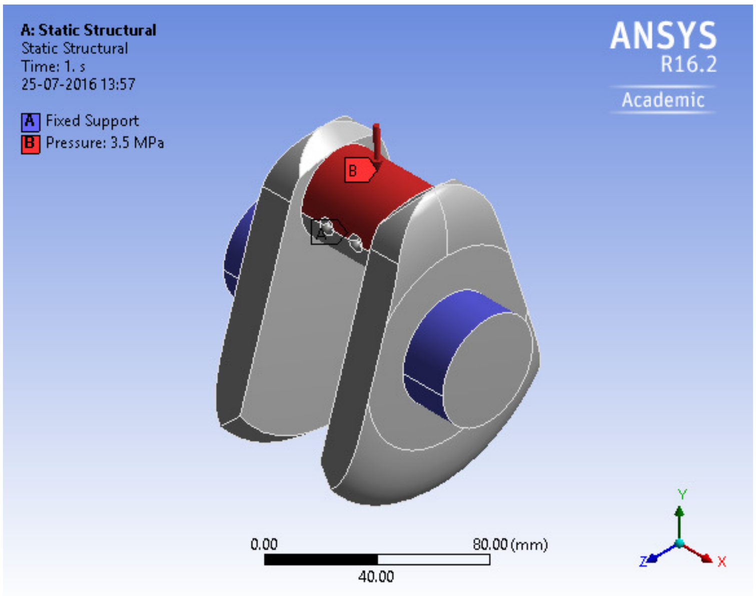

Figure 1.3 Apply Boundary conditionthe crankshaft

The two ends of the crankshaft is to be fixed, the load 3.5 Mpa is applied on the top of the crankpin surface.

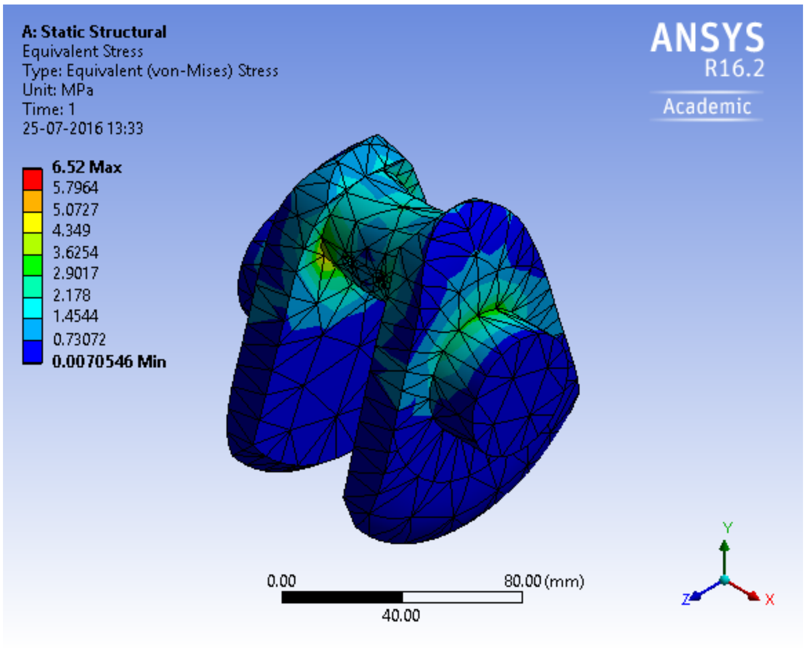

Figure 1.4 crankshaft von-misses stress

The maximum stress induced in the crankshaft is 6.52 Mpa at the crankpin neck surface.

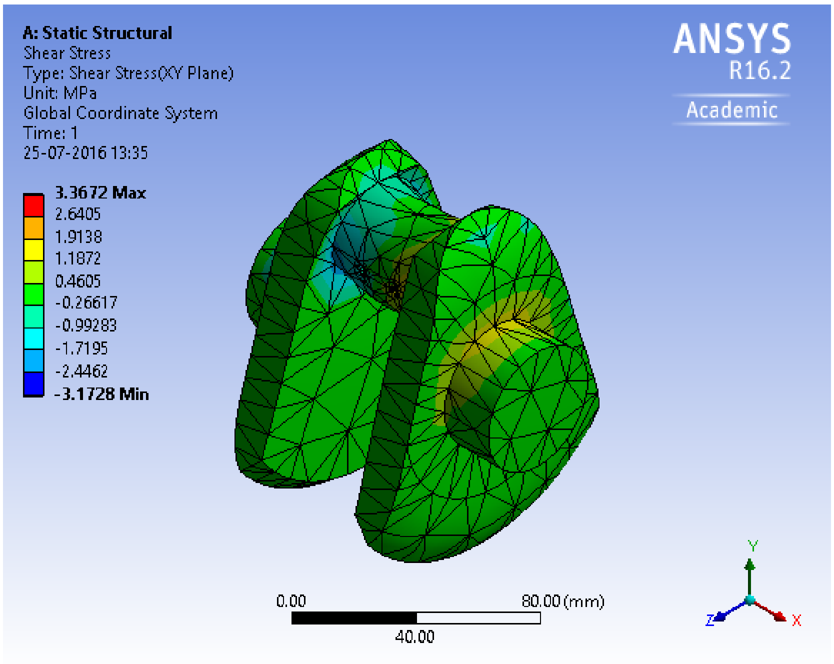

Figure 1.5 Maximum shear stress in the crankshaft.

The Maximum shear stress induced in the crankshaft is 3.369 8Mpa.

S.No.	Type of stress	Theoretical	ANSYS results
1	Von-misses stress(N/mm²)	10.99	6.52
2	Shear stresses (N/mm²)	2.9	3.369

1. The centre of the crankpin neck surface obtain maximum deformation.
2. The fillet area between the crankshaft journal and near the central point journal obtain maximum stress.
3. Our design is safe for the condition of the value of von-misses stresses that comes out from the analysis is far less than material yield stress.

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