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Static analysis of crankshaft of a single cylinder petrol engine

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ABSTRACT

A crankshaft is used to convert reciprocating motion of the piston into rotary motion. Crankshaft is one of the critical components of an IC engine. Failure of the crankshaft leads to a drastic disaster in IC engines. The load of cylinder gas pressure is transmitted to crankshaft through connecting rod. The dynamic load and rotating system exerts repeated bending and shear stress due to torsion, which are common stresses acting on crankshaft and mostly responsible for crankshaft fatigue failure.

In this paper, static analysis of crankshaft for four stroke single cylinder petrol engine is carried out. Initially the crankshaft is designed and then 3D model of crankshaft was developed in CATIA. Based on analytical calculations, load acting on crankshaft is obtained. This model is then imported to ANSYS to perform static analysis to obtain the variation of stress magnitude at critical locations. Analysis is done by considering two materials and results are compared to select the best material.

Keywords: *Stress analysis, Crankshaft, Fatigue, ANSYS*

INTRODUCTION

Crankshaft is one of the largest components in IC engines. It is one of the most critically loaded components and experiences cyclic loads in the form of bending and torsion during its service life. Most of the failure is due to fatigue failure. Lot of parameters are involved and needs to be considered for fatigue life calculation.

Crankshaft experiences large forces from gas combustion. This force is transmitted to the crankshaft by connecting rod, which connects piston to the crank shaft. Combustion and inertia forces acting on the crankshaft exerts two types of load on crankshaft 1. Torsional load 2. Bending load. Crankshaft must be strong enough to take the downward force of the power stroke without excessive bending so the reliability and life of the internal combustion engine will be more. The crank pin is like a built in beam with a distributed load along its length that varies with crank positions. Each web is like a cantilever beam subjected to bending and twisting. 1. Bending moment which causes tensile and compressive stresses. 2. Twisting moment causes shear stress. There are many sources of failure in the engine one of the most common crankshaft failure is fatigue at the fillet areas due to the bending load causes by the combustion. At the root of the fillet areas stress concentrations exist and these high stress range locations are the points where cyclic loads could cause fatigue crank initiation leading to fracture.

In strength analysis, considering loads acting on the component, equivalent stresses are calculated and compared with allowable stresses to check if the dimensions of the component are adequate. Due to complexity of crankshaft structure and loads acting on it, classical calculation method has limitations to be used for strength analysis. Finite Element Method is a numerical calculation method used to analyze such problems. The crankpin fillet and journal fillet are the weakest parts of the crankshaft. Therefore these parts are evaluated for safety.

LITERATURE SURVEY

Rinkle Garg (2012) conducted a static analysis on a cast iron crankshaft from a single cylinder four

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stroke engine. In this paper, Finite element analysis was performed to obtain the variation of the stress magnitude at critical locations. Using ProE software three dimensional model of the crankshaft was created. The load was then applied to the FE model and boundary conditions were applied in the ANSYS. Later, optimization of the cast iron crankshaft is done based on the results obtained from the analysis. Based on the results obtained, it is concluded that the model presented here is safe and under permissible limit of stresses. After optimizing, results show the improvement in the strength and reduction of weight by 3934g.

Bhumesh J. Bagde1, Laukik P. Raut (2013) worked on the problem occurred in single cylinder engine crank shaft i.e. formation of cracks after certain time period. They modelled the crank shaft with dimensions and then simulated the crank shaft for static structural and fatigue analysis. The modeling software used is PRO-E wildfire 4.0 for modeling the crank shaft. The analysis software ANSYS was used for structural and fatigue analysis of crank shaft. The material for crank shaft is EN9 and other alternate materials on which analysis will be done are SAE 1045, SAE 1137, SAE 3140, and Nickel Cast Iron. The objective involves modeling and analysis of crank shaft, so as to identify the effect of stresses on crank shaft, to compare various materials and to provide possible solution.

Momin Muhammad Zia Muhammad Idris (2013) carried out strength analysis on crankshaft of a single cylinder two stroke petrol engine. The three dimensional model of crankshaft was developed in PRO/E and imported to ANSYS for strength analysis. A calculation method is used to validate the model. The paper also proposes a design modification in the crankshaft to reduce its mass. It is found that weakest areas in crankshaft are crankpin fillet and journal fillet. The reduction in mass obtained by design modification is 38%.

Shweta Ambadas Naik (2015) discussed the stress analysis and modal analysis of a 4-cylinder crankshaft using finite element method. The 3D model of crankshaft was developed in PRO/E and imported to ANSYS for strength analysis. In this study, failure analysis of a crankshaft was carried out. All crankshafts were failed from the same region. Failures had occurred in the first crankpin, the nearest crankpin to the flywheel. Dynamic analysis and finite element modelling were carried out to determine the state of stress in the crankshaft. Finite element analysis was performed to obtain the variation of stress magnitude at critical locations. The review of existing literature on crankshaft design and optimization is presented. The materials, manufacturing process, failure analysis, and design consideration of the crankshaft are reviewed here. The results would provide a valuable theoretical foundation for the optimization and improvement of engine design.

METHODOLOGY

Modelling

According to the dimensions, 3D model of crankshaft is prepared. For modelling, CATIA V5 software is used.

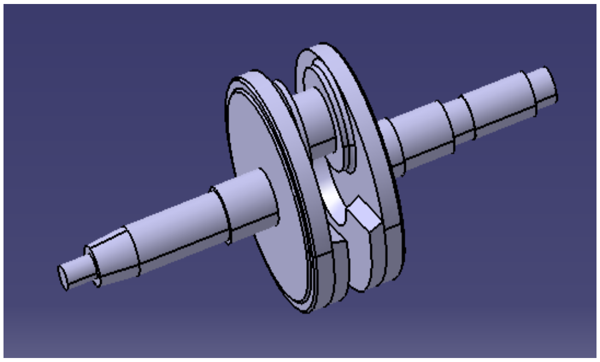

Fig 1 3D Model of Crankshaft

Material selection

In this paper, two materials are selected and compared for selecting the better material among them. Structural steel and cast iron is taken for the study

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Table 1 Material properties of Structural Steel

Density	**$7.85*10^{-6}$ kg/mm^3**
Poisson's ratio	0.3
Young's Modulus	$2*10^5$ MPa
Yield strength	250 MPa
Ultimate Strength	460 MPa

Table 2 Material properties of Cast Iron

Density	**$7.19*10^{-6}$ kg/mm^3**
Poisson's ratio	0.3
Young's Modulus	$1.7*10^5$ MPa
Yield strength	280 MPa
Ultimate Strength	450 MPa

Analysis

Static structural analysis is carried out using ANSYS 15.0 software by importing the modelled crankshaft. The amount of load acting on the crankshaft is calculated and the load obtained is 3180 N. The two journal bearings are fixed as shown in figure 2

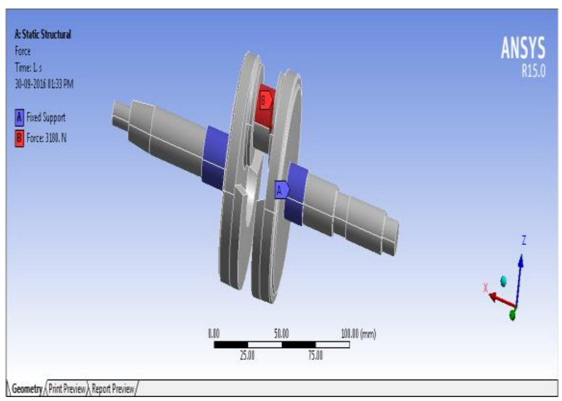

Fig 2 Loads and Boundary conditions

Analysis of Crankshaft using Structural steel material

Maximum Von-mises Stress is obtained at the crankpin and its value is 12.784 MPa shown in fig 3.

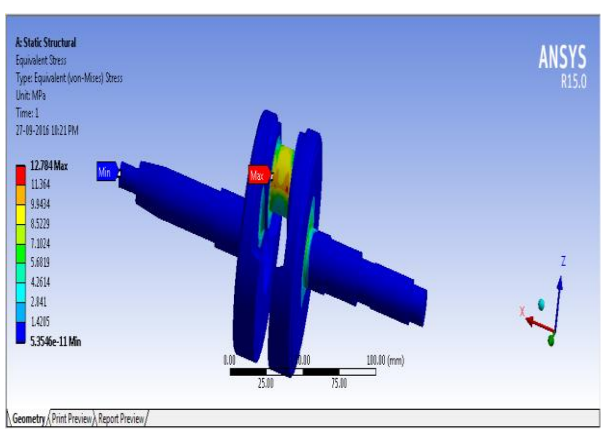

Fig 3 Von-mises Stress 12.784 MPa

As observed from the static analysis, maximum principal stress is appearing at the crankpin fillet as shown in below figure 4.

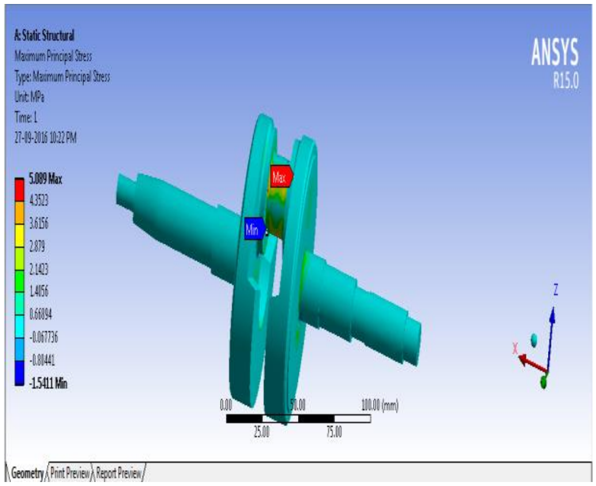

Fig 4 Principal Stress 5.089 MPa

Maximum elastic strain of $7.32e^{-5}$ is obtained at the crankpin fillet as shown in figure 5 below.

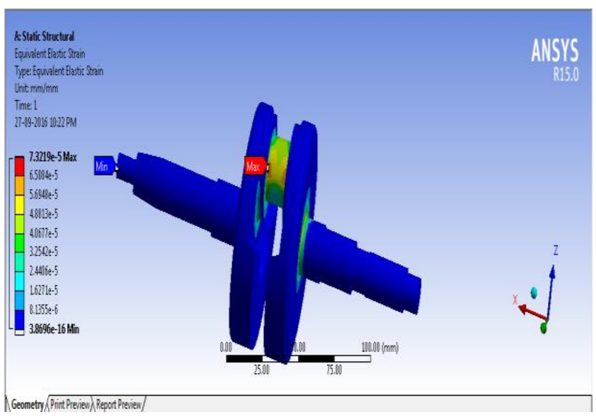

Fig 5 Elastic Strain $7.32e^{-5}$

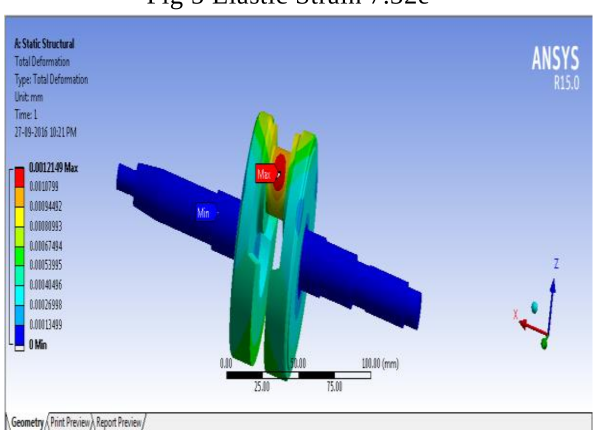

Fig 6 Deformation 0.00121 mm

Cast iron

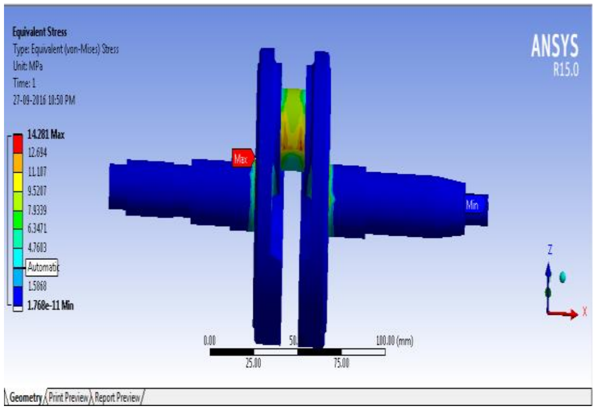

Fig 7 Von-mises Stress 14.28 MPa

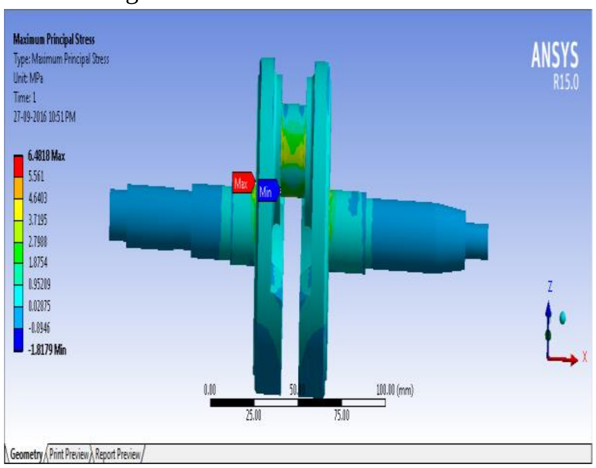

Fig 8 Principal Stress 6.48 MPa

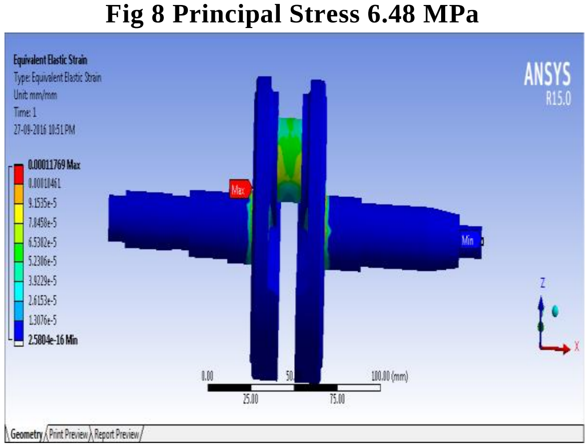

Fig 9 Strain 0.00011

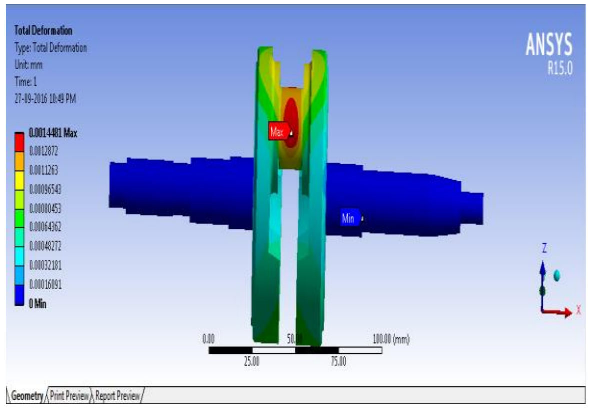

Fig 10 Deformation 0.00144 mm

RESULTS AND DISCUSSION

	Structural Steel	Cast Iron
Von-Mises Stress	12.784 MPa	14.28 MPa
Principal Stress	5.089 MPa	6.48 MPa
Strain	$7.32*10^{-5}$	0.00011
Deformation	0.00121 mm	0.00144 mm

CONCLUSION

From the above results obtained from analysis, it is concluded that structural steel is more efficient than cast iron material.

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