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STATIC STRESS ANALYSIS AND OPTIMIZATION OF A DIESEL ENGINE CRANKSHAFT USING FEA

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ABSTRACT
In recent years, there are many kinds or development of vehicle engine especially car and motorcycle engine. Each automotive company tried to develop their own engine to compete for new technology or invention in market. Internal combustion engine is one type of automotive engine in which fuel that run the mechanism is burned internally or burned inside the engine cylinder. There are two types in internal combustion engine which is reciprocating and rotary engine. The type of engine that usually used is two stroke and four stroke engine. In internal combustion engine, piston is one of the important part defined as cylindrical component that moves up and down in the cylinder bore by force produce during the combustion process. Static analysis is carried out in this paper to calculate stress, strain.

Keywords: *crank shaft, FEA, design, engine.*

INTRODUCTION

Crankshaft is a large component in an engine having complex geometry that converts linear reciprocating displacement of the piston to a rotary motion of the crank with a four link mechanism. Since the crankshaft experiences a large number of load cycles during its service life, its fatigue performance and durability has to be considered in the design process. Design developments have always been an important issue in the crankshaft production industry, in order to manufacture a less expensive component with minimum weight, proper fatigue strength, higher fatigue life and satisfying other functional requirements. Crankshaft is a highly stressed component in an engine and that is subjected to combined bending and torsional loads. The Crankshaft must be designed till last the life of the engine. In case of failure of the crankshaft, it would result catastrophic damage to the engine. Considering the life of an engine in an automobile for example, this results in requirement for an infinite life of fatigue situation. Because of the long life and high stresses, as well as the need for weight reduction, material and manufacturing process selection is important in crankshaft design. There is competition among materials and manufacturing processes due to cost, performance, and weight. This is a direct result of industry demand for components that are lighter, to increase efficiency, and cheaper to produce. While at the same time maintaining fatigue strength and other functional requirements.

TYPES OF CRANK SHAFT

A crankshaft (i.e. a shaft with a crank) is used to convert reciprocating motion of the piston into rotary motion or vice versa with a four link mechanism. The crankshaft consists of the shaft parts which revolve in the main bearings, the crankpins to which the big ends of the connecting rod are connected, the crank arms (cheeks) which connect the crankpins and the shaft parts.

The crankshaft, depending upon the position of crank, may be divided into the following two types:

1. Side crankshaft or overhung crankshaft
2. Centre crankshaft

Reasons for The Failure Of Crankshaft

i. Bearing misalignment: This can be detected earlier with the proper crankshaft deflection measurement. It leads to vibration of the engine.
ii. Engine power imbalance: It leads to fatigue failure due to cyclic loading. This can be caused by poor maintenance or monitoring of the engine power, or even poor quality fuel used.
iii. Incorrect geometry leads to stress concentration.

EXPERIMENTAL SETUP

The below figure shows the engine setup of Kirlosker TV1 single cylinder 4 stroke diesel engine. Experiment has been conducted on this engine to get the load variation on the piston, connecting rod and crankshaft for different crank angles.
c

Fig.1 Experimental Test Rig.

Table 1: Specification of Engine.

Sl. No	Description	Specification
1	Engine	Kirlosker TV1 Diesel Engine
2	Bore	87.5 mm
3	Stroke	110mm
4	Engine rpm taken for study	1500 rpm
5	Compression ratio	17.5:1
6	Test condition/Type	Water cooled
7	Max pressure at study rpm	73 bar

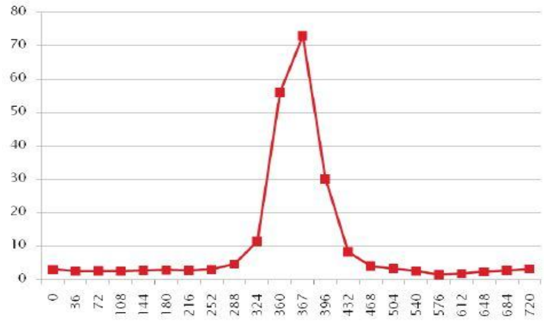

Fig.2 Pressure vs. crank angle plot

Pressure in Mpa is indicated on Y axis, and crank angle degrees along X axis as shown above chart. By this graph we can get the variation of gas pressure on piston with change in crank angle as follows. Then, the crank angle is converted from degrees to time in seconds using formula as below.
Engine rpm =1500 rev/min
= (1500 x 360 0) / 60 deg/sec
=9000 0 per second
Gas pressure is converted to force on piston using formula
Gas force= FG =A x P
Where, piston head surface area A = □r2 in m2 and P is gas pressure on piston in N/m2.

RESULT AND DISCUSION

Material selection

By the ANSYS WB14 analysis software got results like von-misses stress, maximum shear stress and total deformation on crankshaft by applying load of 11 MPa at the centre of crankpin when crankshaft is at dead centre. The results obtained on 4 different material types of crankshaft are compared for stresses, deformation and mass. The material which has low density induces low stress and deformation on a crankshaft has been selected as a suitable material in the analysis.

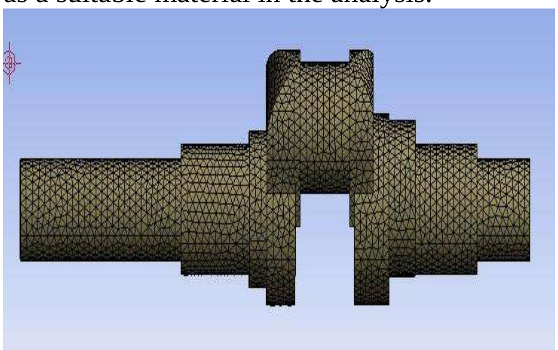

Fig 3: Meshed model of the present crankshaft

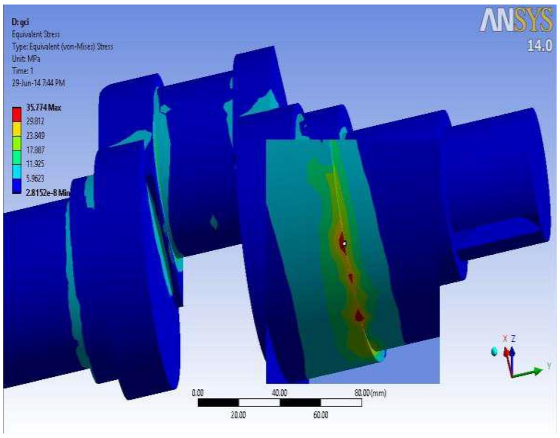

Fig 4: Equivalent von-mises stress of 35.774 MPa

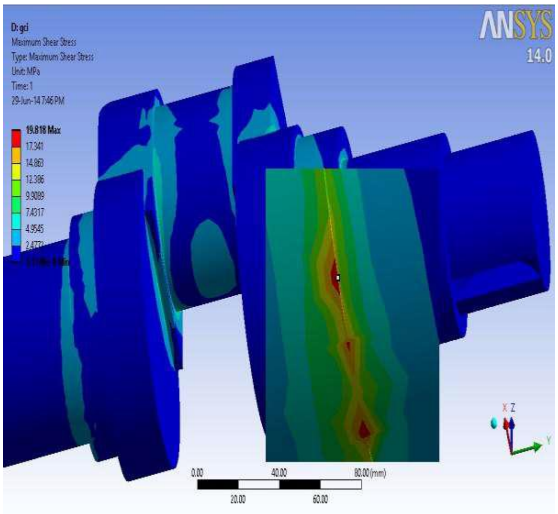

Fig 5: Maximum shear stress of 19.818 MPa

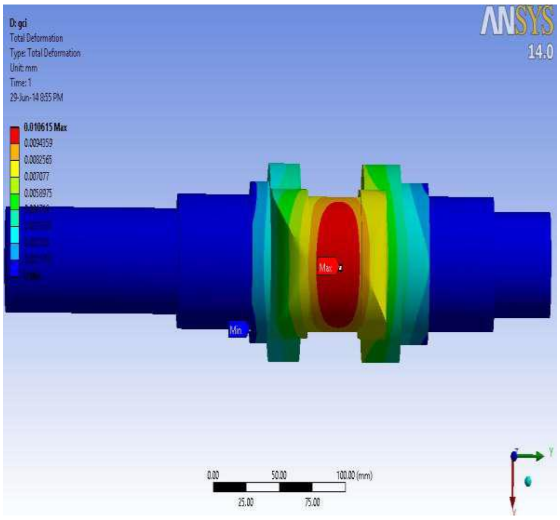

Fig 6: Total deformation of 0.010577 mm

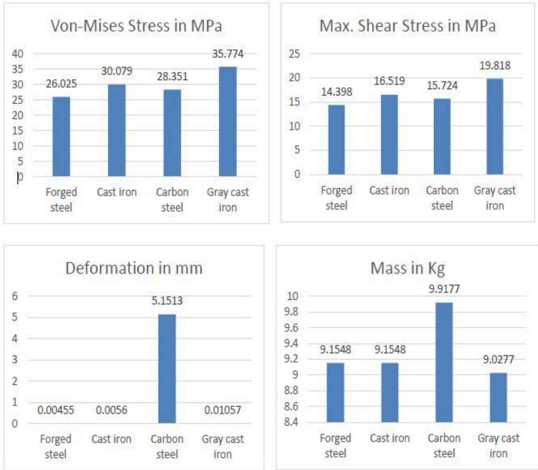

Fig 7.Variation of determinants on present model.

MODIFICATION TO THE PRESENT MODEL

Results obtained from the present crankshaft are compared one another and shows that there is a chance for reducing the mass. Fillet of 5 mm radius has been applied on the less critical sections as shown in fig. mass of about 65 grams has been reduced. So, optimization in mass of the component has been achieved.

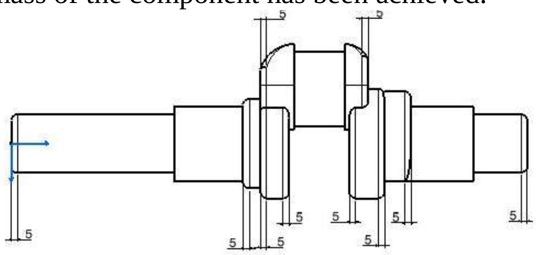

Fig 8: 2D view of the optimized model

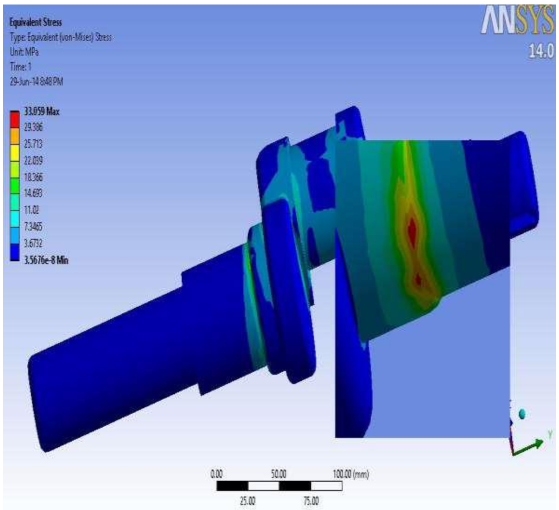

Fig 9: von-misses stress on optimized model of 33.059MPa

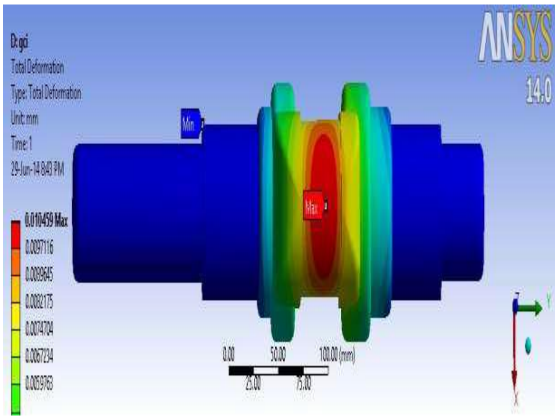

Fig 10.Total deformation on optimized model of 0.010459 mm

CONCLUSIONS

Finally, by comparing all the determinants like von-mises stress, shear stress, deformation and mass on all type material crankshafts, Gray cast iron crankshaft is best suitable from the study. Since, all the determinants are within safe limit and mass of the Gray cast iron crankshaft is about 9.0277 kg which is lesser amongst different material crankshafts.

For the present modal, fillet of 5 mm radius has been applied and 64 grams of material is reduced. Even though, all the determinants are within the allowable limit.

By considering the inertia effect of crankshaft in the engine, Gray cast iron crankshaft will impose less inertia effect.

SCOPE FOR FUTURE WORK

Further investigation has to be carried out by using suitable composite material for crankshaft which provides good stiffness and less weight with no increase in stress. In this work, we have discussed only the static analysis of crankshaft. Further, we can determine the von-misses stress and total deformation of crankshaft under dynamic loading condition.

Also, fatigue analysis can be carried out on the modified crankshaft and physical testing of the crankshaft can be done to confirm the analysis results before releasing for production. Also find that, is there any other optimization method by which we can still reduce the stress in crankshaft.

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