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Modelling and Optimization of I.Cengine Crank Shaft with Different Materials and Loads by Using Finite Element Analysis

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ABSTRACT:

Crankshaft is a component in an engine which converts the reciprocating motion of the piston to the rotary motion. Where as 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 design of a crankshaft is of 4 stroke single cylinder S.I engine. So that two revolution of crankshaft for each stroke. The peak pressure acting on the engine crankshaft. The crankshaft of the located model is designed using CAD SOFTWARE CATIA V5 with the accurate dimensions and material standards. CATIA V5 is one of the best design software in design tools were we can easily design components based on it dimensions and analysis in ansys with accurate results. In this project to compare the optimization of crank shaft on two different materials(steel alloy& aluminum oxide composite) .The results are taken and evaluated with the given load conditions and following deformation results are shown.

INTRUDUCTION:

1.1. Introduction to crankshaft

Today's automotive industries are faced with a number of issues, which require them to be responsive in order to be competitive. To be competitive, one has to produce components with low cost and high quality.

The advent of high performance computers, CAD tools and Optimization techniques has helped realize the demand of global market. With the help of Optimization techniques and numerical methods, one can design a component, create a solid model using CAD tools, simulate the operating conditions and find out if the component meets the expectations and feasibility before starting the actual production, thereby saving time and resources.

1.2. The general considerations in designing a crankshaft are

The type of loads and stresses caused by it, selection of material, motion of parts or kinematics of the crankshaft, form and size of parts, convenient and economical features like minimization of wear, and use of standard parts. Failure of the Crankshaft will result in the failure of the engine.

LITERATURE REVIEW:

2.1. Crank Materials and Construction

Essentially, the range of crankshaft materials runs as follows: billet steel, steel forgings, cast steel, nodular iron, malleable steel or (in some cases) cast iron. If we were to produce one crankshaft design and reproduce it in all these materials, the order of strength would approximately follow this same list. While cast cranks are typically less expensive than forgings, they can be produced in shapes not available with forgings.

But dollar for dollar, forged cranks tend to be the better method of manufacture, certainly with respect to high output durability. Often a subject of discussion and frequently believed to be critical in the design, modification and service life of a crankshaft, is how fillet radii are configured. If we were to perform a stress analysis test that included all other design features and conditions of a given crankshaft, fillet radii could be considered the most critical factor in overall design and/or modification procedure. There is belief among crankshaft manufacturers that the use of fillets of non-constant radius sometimes called non-circular contours is preferred over those of constant radius. Worst case, this is an area worth discussing with your engine builder or crankshaft manufacturer of choice.

2.2. Cranks Influence on Parts:

To increase crankshaft stroke this implies an increase in low- and mid-rpm torque is desirable. Therefore, so would the selection of an intake manifold camshaft and header system that favors torque output in the same range of engine speed. Similar to events from lengthening connecting rods (all else being equal), a stroke increase changes both the rate at which intake flow velocities are created (vs. crank angle). It also affects piston dwell around TDC and BDC. This suggests a re-think/adjustment of sparking timing (at least initial spark) when comparing engine applications of a stroked and un-stroked crank.If we decided to decrease, by whatever means, the inertial resistance of the crank you are using. That suggests an engine that will accelerate quicker and, likely, one that would benefit from an increase in compression ratio. Short of performing single-cylinder dynamic pressure analysis as a function of crank angle (perhaps with Engine Cycle Analysis or comparable in-cylinder measurements), it’s possible to re-coup some power lost to “retarded” rear cylinders by juggling rocker ratios that serve them. Consider what we do to improve higher rpm power with valve timing that is acting retarded maybe a shade higher ratio, for an initial test.

3.1. CRANKSHAFT DESIGN ISSUES:

In the world of component design, there are competing criteria, which require the engineers to achieve a perceived optimal compromise to satisfy the requirements of their particular efforts. Discussions with various recognized experts in the crankshaft field make it abundantly clear that there is no ‘right’ answer, and opinions about the priorities of design criteria vary considerably. In contemporary racing crankshaft design, the requirements for bending and torsional stiffness (see the Stiffness vs. Strength sidebar) compete with the need for low mass moment of inertia (MMOI). Several crankshaft experts emphasized the fact that exotic metallurgy is no substitute for proper design, and there's little point in switching to exotics if there is no fatigue problem to be solved.

High stiffness is a benefit because it increases the torsional resonant frequency of the crankshaft, and because it reduces bending deflection of the bearing journals. Journal deflection can cause increased friction by disturbing the hydrodynamic film at critical points, and can cause loss of lubrication because of increased leakage through the greater radial clearances that occur when a journal's axis is not parallel to the bearing axis. At this point, it is important to digress and emphasize the often-misunderstood difference between STIFFNESS and STRENGTH. Metal parts are not rigid. When a load is applied to a metal part, the part deflects in response to the load. The deflection can be very small Crankshaft, or it can be quite large (valve springs, etc). But to one degree or another, all parts behave like springs in response to a load. The ultimate strength of a material is a measure of the stress level which can be applied to a lab sample of the material before it fractures. The degree to which a given part resists deflection in response to a given loading is called stiffness.

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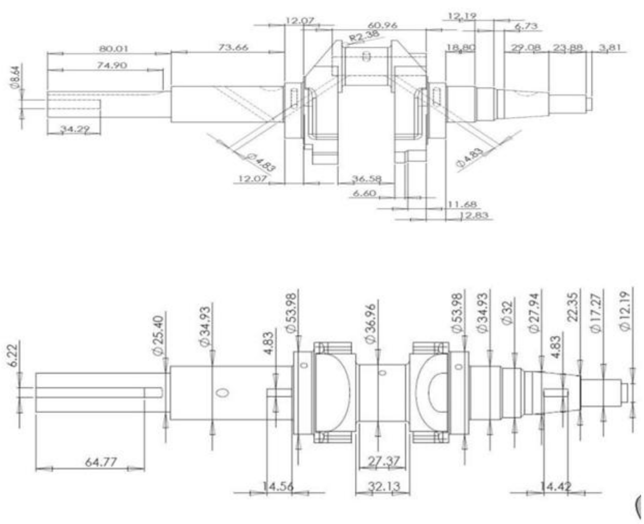
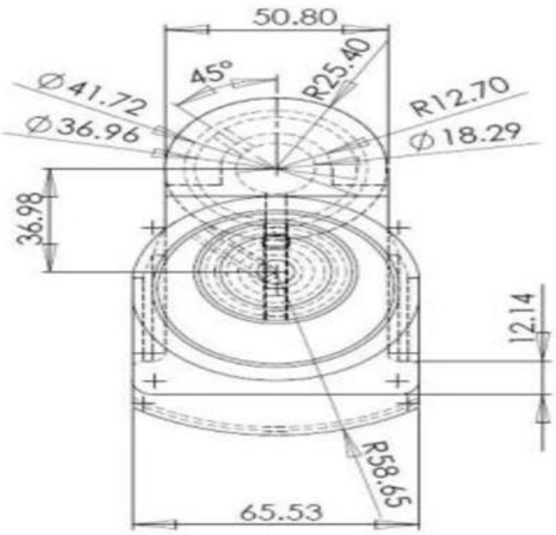
It is important to understand that the ultimate strength of a material has nothing whatever to do with stiffness. Stiffness is the result of two properties of a part: (1) the Young's Modulus of the material (sometimes called Modulus of Elasticity, but more appropriately named Modulus of Rigidity) and the cross-sectional properties of the part to which the load is applied. If suppose we have two components which are identical in all respects (same material, same dimensions) except the tensile strength to which those components have been heat-treated. If you apply an increasing load to each component, both will deflect the same amount for each load value, until the component with the lower strength permanently deforms (and breaks if it is loaded and constrained in a certain way) at a relatively low stress level. The component with the higher strength will continue to deform with increasing load until its yield stress is reached, at which point it too will permanently deform. Since the current crankshaft materials are alloy steels, the Young's Modulus is fairly constant. That means that altering the section properties of the highly-stressed portions of the crankshaft is the only way to increase stiffness. Of course, adding material works at cross-purposes to maintaining low MMOI.

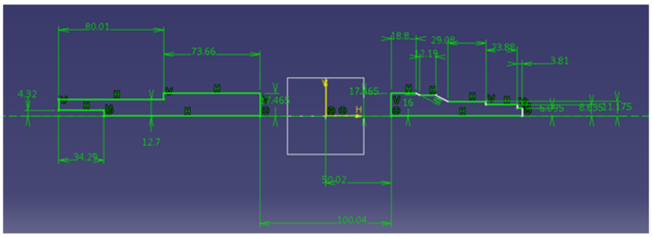
3.2. Dimensions of crank shaft :



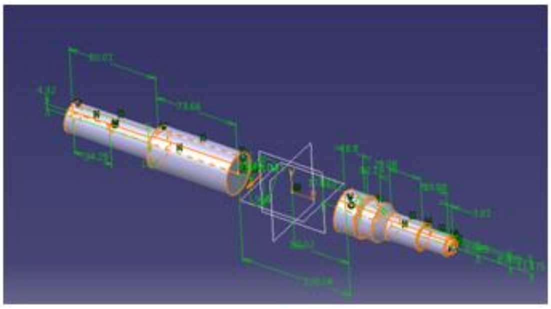


HOW TO DRAW CRANK SHAFT IN CATIA

SKETCH 1



SHAFT



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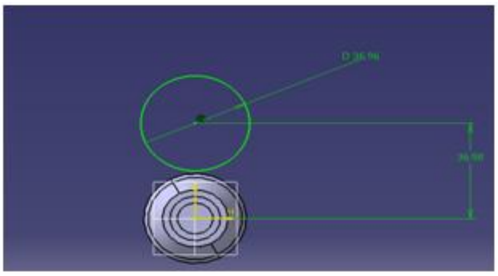

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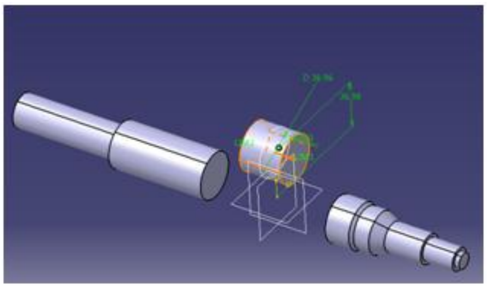

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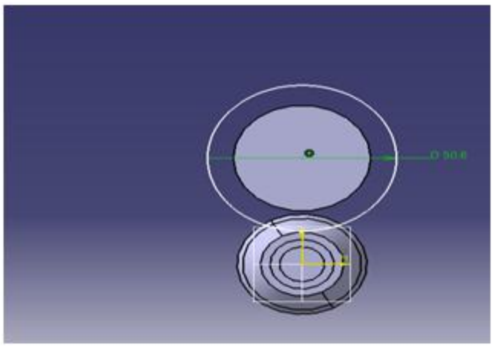

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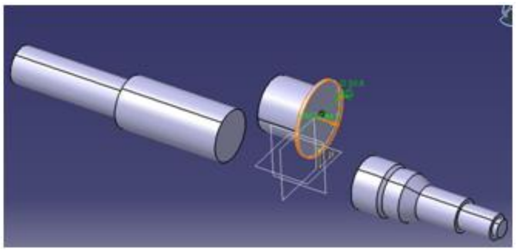
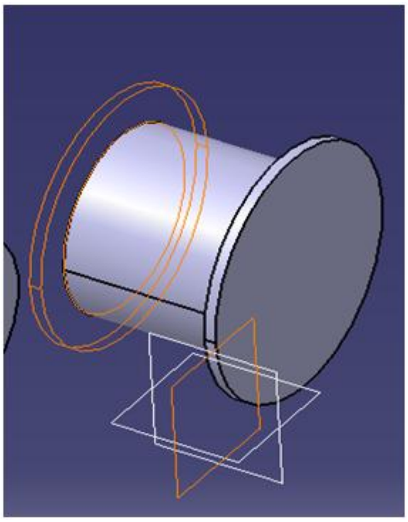
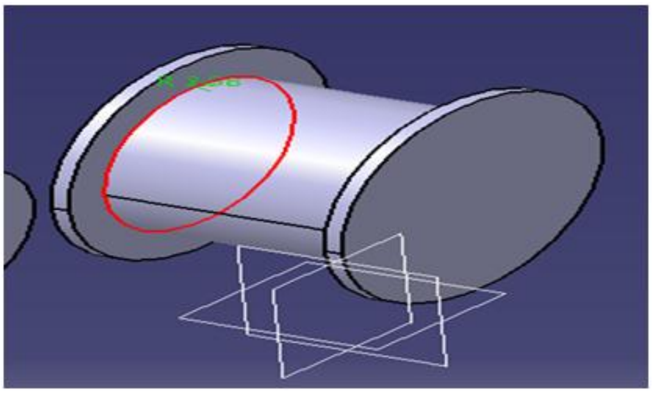


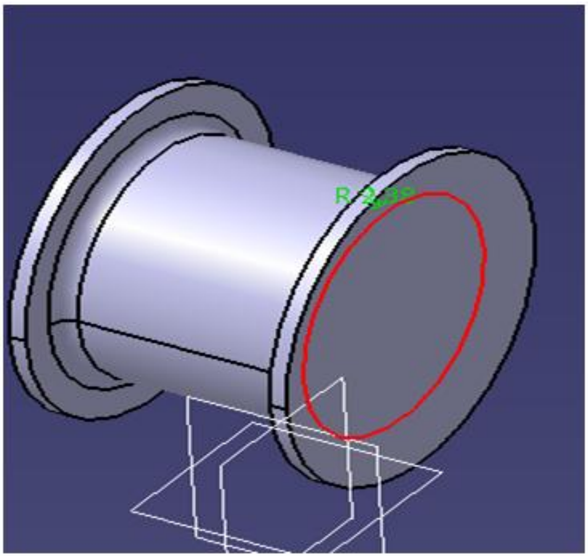
MIRROR



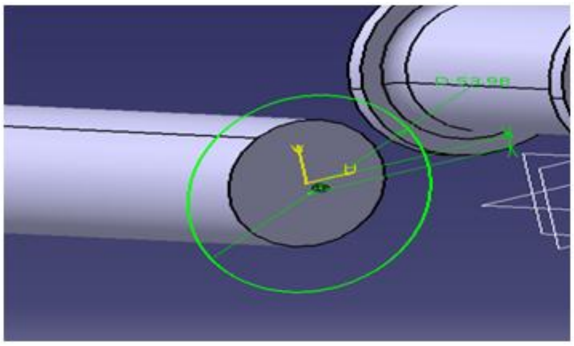
EDGE FILLET 1



EDGE FILLET 2



SKETCH 5



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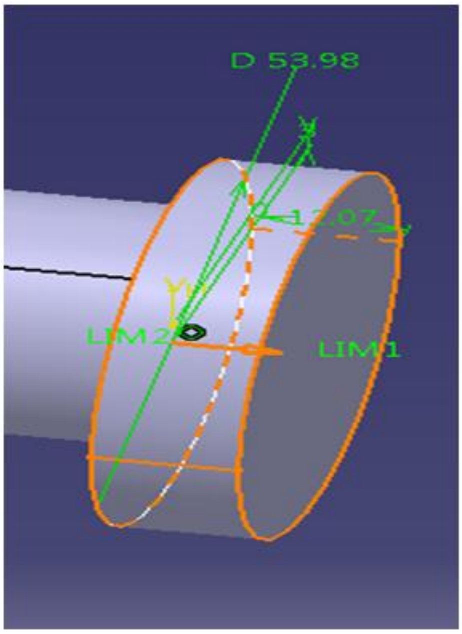
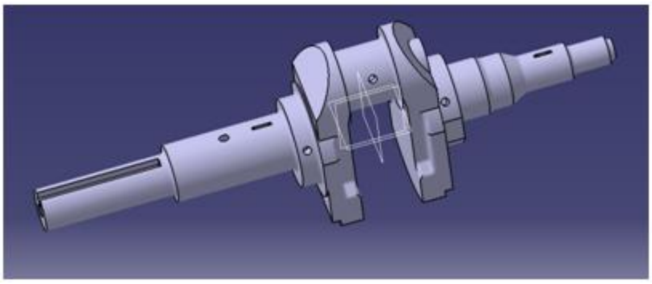


SKETCH 6

Final Crank shaft



- **Material Data**
  - Structural Steel

FIGURE 5
Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Elastic Strain > Figure

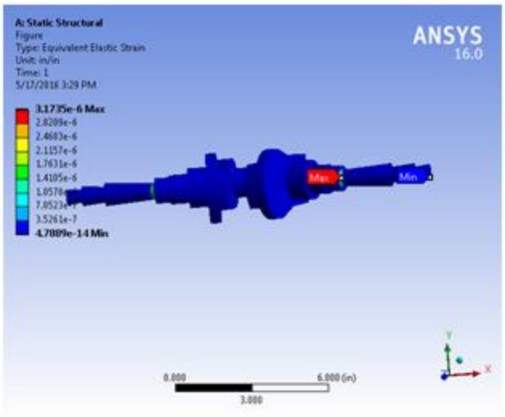
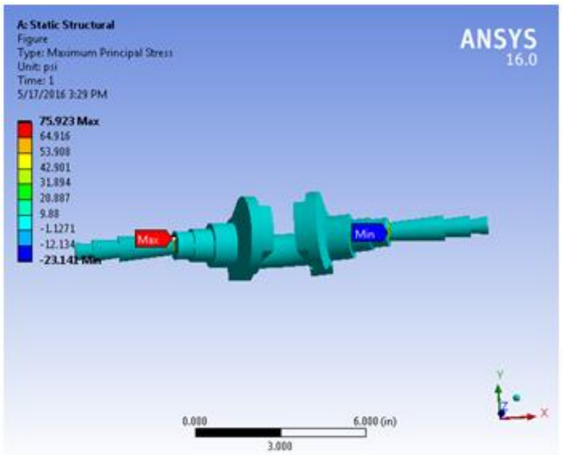


FIGURE 7
Model (A4) > Static Structural (A5) > Solution (A6) > Maximum Principal Stress > Figure



- **Material Data**
  - Aluminum Alloy

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FIGURE 3
Model (A4) > Static Structural (A5) > Solution (A6) > Total Deformation > Figure

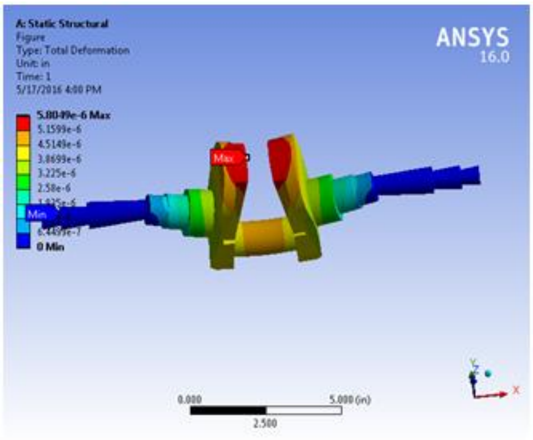
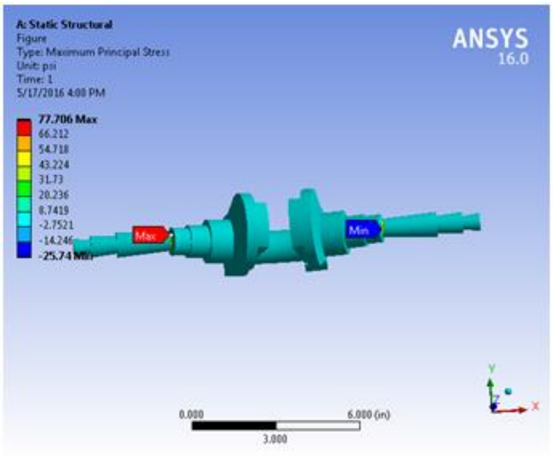


FIGURE 7
Model (A4) > Static Structural (A5) > Solution (A6) > Maximum Principal Stress > Figure



CONCLUSION AND FUTURE SCOPE:

According to the analysis the values of both the materials when comparison was done. Although the val-ues are high for aluminum oxide it is suitable for the Crankshaft de-sign because it can sustain with its strength then steel. Stresses induced by aluminium composite materials are less and within the limits. By using aluminium composite ($Al_2 O_3$) the weight of the crank shaft can be reduced , so the performance can be improve. The future scope of this project is to be done by using different materials (composites and some alloys) and may get good results which will be useful for high perfor-mance engines.

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