# Comparison of Materials for Crankshaft in ANSYS by using FEM Tool

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*Abstract*— Crankshaft is one of the vital components for the effective and precise working of Internal Combustion engine with the complex geometry; which converts the reciprocating displacement of the piston to a rotary motion. The crankshaft consists of three parts i.e. crank pin, crank web and shaft. In the present work, I have done a crankshaft analysis to choose the best material for the crankshaft. Firstly, I have prepared a crankshaft model in the CAD software SOLIDWORKS and them SOLIDWORKS file saved ion the STEP format because ANSYS software can only read the STEP file format. In the ANSYS software 3.5 MPa load apply on the crankshaft for analysis, three-time analysis is done of the crankshaft load was the same for three times but the material was changed. The three material used in this research from the survey is Aluminium Alloy, Alloy Steel, Structural Steel. Mainly two factors are found out stress and deformation for material comparison. Tetrahedron meshing method is used for the crankshaft meshing. After meshing the nodes of the crankshaft are 5664 and elements are 3118. Both the Rear and front main bearing journal are kept fixed and load is applied on the upper face of the main bearing journal. In the end, I have found out that if stress is the main factor for crankshaft failure then Aluminium Alloy is the best material for the crankshaft because in this material less stress produced as compared to the other materials.

***Keywords:*** Crankshaft, Static Structure Analysis, SOLIDWORKS, ANSYS, FEM Tool

## I. Introduction

Crankshaft is large volume production component with a complex geometry in the diesel engine. This converts the reciprocating displacement of the piston into a rotary motion of the crank. The crank shaft takes the power from piston which is generated due to combustion process inside the combustion chamber of the cylinder. During the power transmission process the load acts at a particular crank angle to the max and hence the connecting rod is analyzed for the stress developed, due to load conditions and the changes mentioned. The crankshaft, sometimes casually called the crank, is the part of an engine which translates the up and down motion of the pistons in the rotation. To transform the motion, the crankshaft has one or more offset shafts. The pistons are connected to the crankshaft with these shafts. When the piston travels up and down, it pushes the offset shaft. This, in turn, rotates the crankshaft [1]. The pistons create a pulsing impact in the rotation. A crankshaft usually connects to a flywheel. The flywheel smooth's out the rotation. Sometimes there is a torsion or vibration damper on the opposite end of the crankshaft. This helps decrease the vibrations of the crankshaft. Large engines usually have some cylinders. This helps to decrease pulsations from unique firing strokes. For some engines, it is important to provide counterweights. The counterweight is used to offset the piston and advance balance.

## II. Literature review

Becerra et al. [5] introduced that torsional dynamics controlled the stress level response of the crankshaft, with the values obtained higher than those found in a static analysis (due only to gas pressure in the compressor chamber). Critical speed had values within the operating range of the compressor and, as a result, this parameter always operates near resonance during common operation. Although the stress level estimated from the methodology described here could be inadequate from a quantitative point of view (as it did not include damping), the friction model could not be verified for the compressor (it was developed for alternative engines) and dynamic effects between the key and keyway could not be included. The results obtained from the FEM and forced response of the system analysis, like the high increment in the torsional displacement between DOFs 2 and 3, are representative of the system behavior. In this way, the accuracy of the estimated critical speed values is acceptable. Higher stresses are located in the keyway region, where the influence of the geometric stress concentration factor is very important. In this way, much of the broken crankshaft shows the failure surface crossing this zone.

Citti et al. [14] introduced that the steel analyzed is a typical biotitic grade with high mechanical characteristics that can substitute the traditional quenched and tempered steels in such projects which require high fatigue resistance property as automotive engines. The untreated material has got excellent fatigue results considering its mechanical properties (> than 50% of Rm). Moreover the fatigue crack propagates about 30% of the resistant section. The gas nit riding technique utilized to increase the fatigue property of this steel demonstrates good results about the nitrogen diffusion, but the expected values of fatigue results are against this fact. The fatigue limit increment compared to the untreated specimens is about 13%. Moreover during the staircase test of the nitride specimens a series of specimens broke in high cycles range (more than 4 millions) differently from the untreated specimens. This behavior could be associated with an increased embrittlement of the material which must be confirmed by fractography. Further investigations must be undertaken by looking also at the heat treatments cycle modification in order to increase the advantage in fatigue limit given by the nit riding treatment.

Deshbhratar et al. [15] proposed that the maximum deformation appears at the center of crankshaft surface. The maximum stress appears at the fillets between the crankshaft journal and crank cheeks, and near the central point. The edge of main journal is high stress area. The crankshaft deformation was mainly bending deformation under the lower frequency. And the maximum deformation was located at the link between main bearing journal and crankpin and crank cheeks. So this area prunes to appear the bending fatigue crack. Base on the results, we can forecast the possibility of mutual interference between the crankshaft and other parts. The resonance vibration of system can be avoided effectively by appropriate structure design. The results provide a theoretical basis to optimize the design and fatigue life calculation.

Fonte et al. [11] introduced that a review on the assessment of fatigue life of marine diesel engine crankshafts was presented. The main issues associated to the fatigue strength of marine diesel engine crankshafts are addressed, and these ones are similar to the other diesel engines. An example of catastrophic failure was presented and the root cause seems to be related with the shrinkage assembly of the semi-built crankshaft. Crankshaft design and its maintenance have a paramount importance on these dynamic components lifetime. The rules of Register of Shipping Society and Ship Classification Societies, as well as the FEA are mandatory. Regular deflections measurements and the comparison with the last readings can significantly improve the lifetime of crankshafts as well as the rules and recommendations of manufacturers.

## III. OBJECTIVE OF THE STUDY

1) To create 3D CAD model of the crankshaft in SOLIDWORKS 2017.
2) Study the effects of the loads acting on the crankshaft under the considered loading conditions.
3) Comparison of the materials in ANSYS by using FEM tool for chooses the best material for crankshaft.

## IV. METHODOLOGY

In our proposed work, we shall prepare the model of crankshaft in SOLIDWORKS and then save in the STEP format and perform statics structural analysis of crankshaft and evaluate the von-misses stress and deformation occurring in crankshaft. In our research composite element structural member is analyzed using the software called ANSYS. Normally as in all other analysis software the structure is created and property is allotted to the structure that you had created. Then the load is applied to the structural member as required. At the end best material is choose by comparison of results through graph. The software's which is used in this research the detail of software is given blow.

## V. GEOMETRIC MODELING AND FINITE ELEMENT ANALYSIS

### A. *Sketcher:*

Sketching is valuable for making unpredictable limits or for following with a digitizer. Determine the article type (line, polyline, or spline), augmentation, and resilience before sketching.

### B. *Modeling:*

SOLIDWORKS software is utilized to make crankshaft model. SOLIDWORKS is an intuitive PC supported structuring and assembling framework. The miscreant capacities robotize the typical building, plan and drafting abilities found in the present assembling organizations. Formation of a 3-D model in SOLIDWORKS can be performed utilizing three workbenches for example sketcher, displaying and assembly.

### C. *Finite Element Analysis:*

The finite element method (FEM), is a numerical method for taking care of issues of designing and mathematical material science. Common issue zones of intrigue incorporate basic examination, heat exchange, liquid stream, mass transport, and electromagnetic potential. The investigative arrangement of these issues for the most part requires the answer for limit esteem issues for halfway differential conditions. The finite element method definition of the issue results in an arrangement of logarithmic conditions. The method approximates the obscure capacity over the domain. To tackle the issue, it subdivides an extensive framework into littler, less complex parts that are called finite elements. The basic conditions that model these finite elements are then collected into a bigger arrangement of conditions that models the whole issue. FEM then uses variation methods from the analytics of varieties to estimate an answer by limiting a related mistake work.

### D. *Mesh Generation and Boundary Conditions*

ANSYS Meshing is a comprehensively valuable, watchful, automated world class thing. It makes the most appropriate work for exact, gainful multiphasic courses of action. A work fitting for a specific examination can be made with a single mouse click for all parts in a model. Full controls over the options used to make the work are open for the ace customer who needs to align it. The power of parallel dealing with is thus used to decrease the time you have to sit tight for work age. ANSYS Meshing thinks about the kind of game plans that will be used in the assignment and has the correct criteria to make the most fitting work. ANSYS Meshing is thus joined with each solver inside the ANSYS Workbench condition. For a smart examination or for the new and uncommon customer, a usable work can be made with a solitary tick of the mouse. ANSYS Meshing picks the most fitting decisions reliant on the examination type and the geometry of the model. The feet of the human body and base of the vehicle situate are kept fixed.

## VI. RESULTS AND DISCUESSIONS

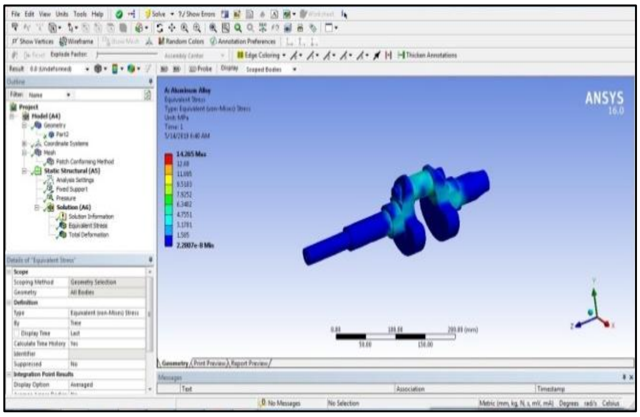


Fig. 1: Total stress produced in Aluminium Alloy material

From the figure 1, we noticed that the maximum stress produced in the crankshaft with Aluminium Alloy material is 14.265 MPa that is on the main journal bearing. The effect of stress is very small on the rear main bearing journal and front main bearing journal. The material may be fail of the crankshaft from the main bearing journal due to high stress effect. The scale shown in the figure 1, that shows the effect of stress reduce when the color of the scale goes change. At the red color the effect of stress is very high and at the blue color the effect of stress is very less.

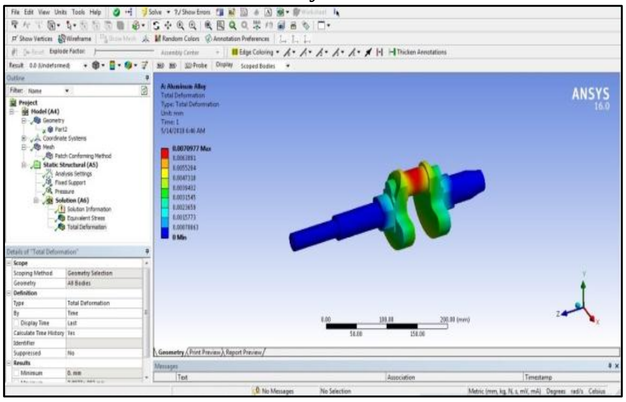

Fig. 2: Total deformation produced in Aluminium Alloy material

We noticed from the figure 2, the maximum deformation in the crankshaft occur on the 3.5 MPa load on the main bearing journal same as the stress. There is no deformation occurring on the rear and front main bearing journal due to theses journal are kept fixed. The maximum deformations occur on the crankshaft is 0.0070977 mm on the main bearing journal.

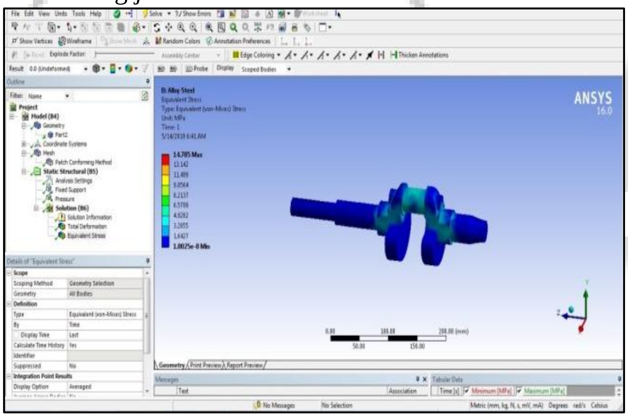

Fig. 3: Total stress produced in Alloy Steel material

We have noticed from the figure 3, the maximum effect of stress is on the main bearing journal. The maximum value produced of the stress in the Alloy Steel material is14.785 MPa. We have also noticed that the stress produced in this material is more as compared to the Aluminium Alloy material.

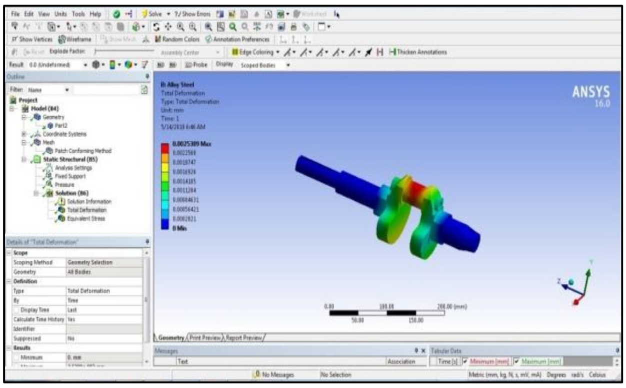

Fig. 4: Total deformation produced in Alloy Steel material

We have noticed from the figure 4, the maximum deformation occur in the crankshaft is 0.00253879 on the main bearing journal. The deformation produced in this material is less as compared to the Aluminium Alloy material.

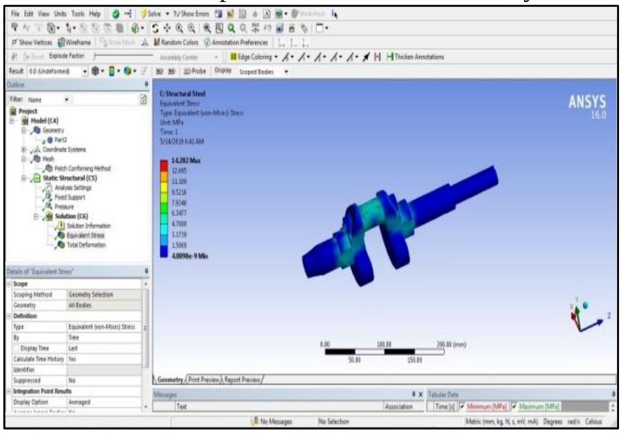

Fig. 5: Total stress produced in structural Steel material

We have noticed from the figure 5, the maximum effect of stress is on the main bearing journal an also minimum effect on the rear and front main bearing journal. In this material the maximum value of stress produced 14.282 MPa. The stress produced in the structural Steel material is less as compared to the Alloy Steel but high as compared to the Aluminium Alloy material. If the material selection is right then the life of the crankshaft may be increase. The scale shown in the *figure 5* shows the reduction in the stress. At the red color the effect of the stress is maximum and at the blue color the effect of the stress is minimum. From the main bearing journal to the rear and front main bearing journal the stress goes reduce due to the fixed support as shown in the figure 5, above.

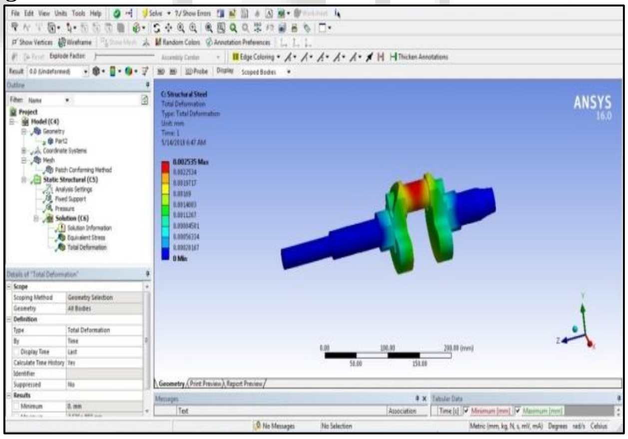

Fig. 6: Total stress produced in structural Steel material

We have noticed from the figure 6, the maximum deformation produced on the crankshaft is 0.002535 mm on the upper surface of the main bearing journal. The deformation produced in the structural steel material is less as compared to the Aluminium Alloy and Alloy Steel material. We have also noticed that maximum deformation occur in the Aluminium Alloy Material. The material of the crankshaft may be fail fr4omthe main journal due to the load. Stress and deformation are the two main factor on the basis we can selection of the material. Sometime stress will be the main factor only and some time the selection of the material will be on the deformation factor, Above we have discussed that the maximum stress produced in the Alloy Steel as compared to the other two material and the maximum deformation occur in the Aluminium Alloy as compared to the two other materials. Now, I have compared all the results through the graph by which we can easily see the difference between all the materials. If the material selection is wright then the life of the crankshaft may be increase.

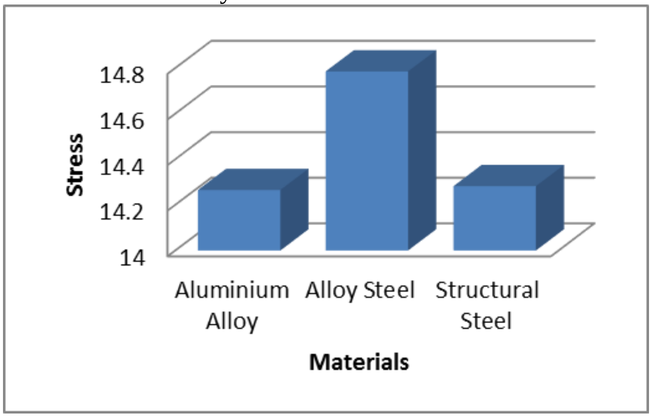


Fig. 7: Comparison graph of the Stress

The figure 7 shows the comparison of the stress. We can see in the Y- axis the stress vary and in the X- direction materials are defined. The minimum stress produced in the Aluminium Alloy and maximum stress produced in the Alloy Steel.

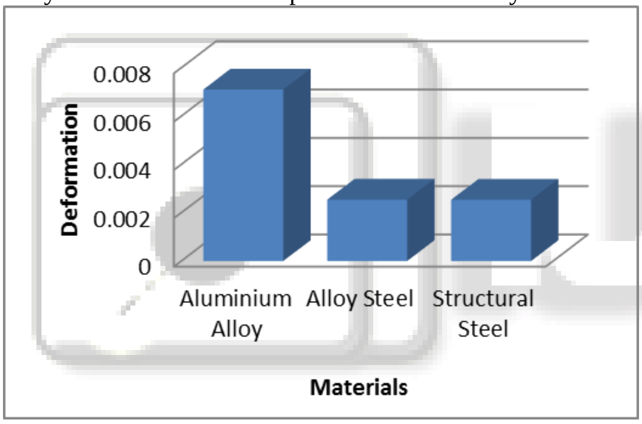


Fig. 8: Comparison graph of the Displacement

From the above figure 8, we have noticed that the maximum deformation occur in the Aluminium Alloy and the minimum deformation occur in the structural Steel. If we consider the deformation is main factor then the Structural Steel material is best for crankshaft production and some other important factor are discuss in next chapter.

## VII. CONCLUSION

1) The maximum stress produced in the Alloy Steel with value 14.785 MPa and the minimum stress produced in the Aluminium Alloy with value 14.665 MPa.
2) The stress produced in the Structural Steel material with value 14.282 MPa is less as compared to the Alloy Steel material and high as compared to the Aluminium Alloy material.
3) The maximum deformation occurs in the Aluminium Alloy material with value 0.0070977 mm and in the Alloy Steel material 0.0025389 mm deformation produced that is lea as compared to the Aluminium Alloy material. But the deformation produced in the Structural Steel material with value 0.002535 mm is less as compared to the Alloy Steel material.

We have noticed from the above discussion that if the stress is the main factor in material then I will prefer Aluminium Alloy material because in this material stress is produced less as compared to the other materials. If we have neglect stress and main factor is deformation then Structural Steel is the best material for the crankshaft.

### A. *Future Scope*

The present work can be extended in following directions:
1) The whole analysis can be repeated with more materials used for connecting rods.
2) The vibration analysis of connecting rod can be helpful for further study of the vibrations produced in the engine.
3) Transient structure can be done instead of static structure of the connecting rod.

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