Design and Analysis of Camshaft using FEA

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Abstract - *A camshaft is mechanical rotary element use in IC engines. Crankshaft is responsible for the rotation of camshaft with the help of various gear trains or idler gear. The main function of camshaft is to convert rotary motion of crankshaft into reciprocating motion and transfer it to opening and closing valve in order to supply fuel to combustion chamber. The performance of camshaft is mainly depends upon the proper design and material used in camshaft. So it is very important to select proper material for camshaft by which efficiency of IC engine can be improved. There are various materials used for camshaft hence the main aim of the project is to select the perfect material for camshaft by performing finite element analysis on it. The project is mainly focused on variation of stress on the camshaft on different materials. Comparison will be done at the end in order to find the best material for camshaft. Here the camshaft is for multi cylinder engine and solidworks is used as three dimensional modeling software to model the camshaft and once a CAD model is available, this model will be used in ANSYS for analysis.*

Key Words: **Design, Analysis, geartrain, idler gear, FEA, reciprocating motion, Solidworks, CAD, ANSYS, efficency, IC engines, camshaft.**

1. INTRODUCTION

A camshaft in an internal combustion engine makes it possible for the engine's valves to open and close. The camshaft is a cylinder that aligns with the engine's cylinders. The asymmetrical lobes of the camshaft correspond to the engine's valves. As the camshaft rotates, it opens and closes the engine's valves.

The camshaft is connected to the engine's crankshaft by the timing belt. The timing belt and the camshaft work together to open the valves in coordination with the stroking of the pistons. Timing belts must be checked and adjusted regularly. When a timing belt breaks, the camshaft stops spinning. When this occurs, pistons can strike a valve while it is closed, functionally destroying the engine.

Camshafts typically have variable speeds that shift as the speed of the engine changes. Most modern vehicles have dual overhead camshafts, with one camshaft assigned to the exhaust valves and a second to the intake valves. Typically, V-6 and V-8 engines have dual overhead camshafts, while smaller inline 4- or 6-cylinder engines have a single overhead camshaft. Dual camshafts make it possible to have more valves in the engine, which increases the flow of both intake and exhaust gases. This increased flow increases the engine's power.

Figure 01 Cam and Camshaft

2. CLASSIFICATION OF CAMS

Cams are classified in three ways:

a. In terms of their shape, such as wedge, radial, cylindrical, globoidal, conical, spheri-cal, or three-dimensional;
b. In terms of the follower motion, such as dwell-rise-dwell (DRD), dwell-rise-return-dwell (DRRD), or rise-return-rise (RRR);
c. In terms of the follower constraint, which is accomplished by either positive drive or spring load as mentioned previously.

Figure 02 Various types of cam

3. CAM TERMINOLOGY

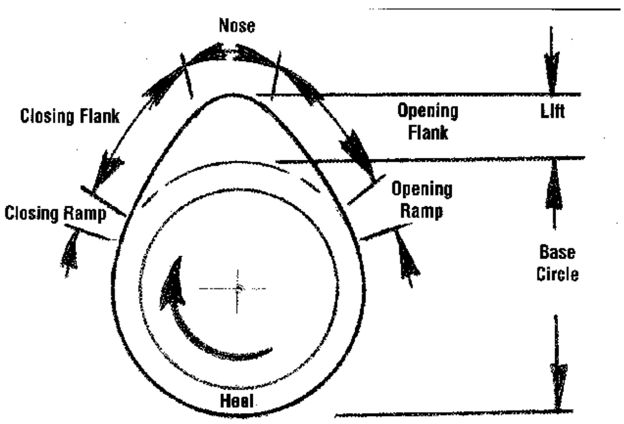

Figure 03 Single lobe

Heel- It is base circle of cam with no lift and concentric with the bearings.

Ramps- Ramps are used so the valves will seat gently and not bounce off the seat. There are two ramps namely opening ramp and closing ramp.

Flanks- In order to move the valve as quickly as possible with large velocity and acceleration the portion used is said to be flank.

Nose- The top portion of cam opposite to heel with minimum radius of curvature is known as Nose or Toe. Nose have the maximum lift.

Asymmetric lobe- The opening and closing side of the cam are different.

Core- The rough part of the camshaft between the lobes, bearings and gears is referred as core.

Lift- Total vertical distance produce by the cam is called as lift.

4. FINITE ELEMENT ANALYSIS

Finite element analysis is the very useful method which is used to solve the engineering problems and get numerical solution in wide range. When the problems involve complicated shapes and complex geometry then this tool is enough to handle any material under different loading and boundary conditions.

4.1Advantages of FEA:

Finite element analysis is most effective and widely adopted analysis. Divide and rule phenomenon is used in this process. It divides the finite element geometry into infinite small sections across the boundaries. The major outcome of this analysis is that it gives very much near to the practical results. Not only results but also it shows the section where the component is very weak so it can be modify further. When failure occurs. This analysis helps to determine the reason by which design was failed.

4.2 Limitations of FEA :

The main limitation of FEA is that the accuracy of the output result depends upon the skill of design engineer. Also in order to get fast results with complex geometry the processing power of the computer needs to be high so it increases the cost of computer system. As matter of fact we need to remember that finite element analysis is not fully accurate process.

4.3 Application of FEA:

In case of heat transfer problems heat flux or temperature distribution data can be obtain by FEA. FEA is also useful while solving the Eigen value problems in solid mechanics, structural problems or buckling load calculation. In fluid mechanics problem stability of fluid can be easily found with the help of finite element analysis. While solving the problems of electrical circuits FEA plays a very important role.

5. ANALYSIS PROCEDURE

Static structural Analysis

The Static structural analysis is mainly done by performing following steps,

5.1 Creating a model: A three dimensional modeling software is required in order to make model of camshaft. Solidworks is one of the most commonly used 3D modeling software used by modern industries. The basic geometry can be identified by means of visualizing the model in solidworks. Below figure shows the modeled camshaft with the help of solidworks.

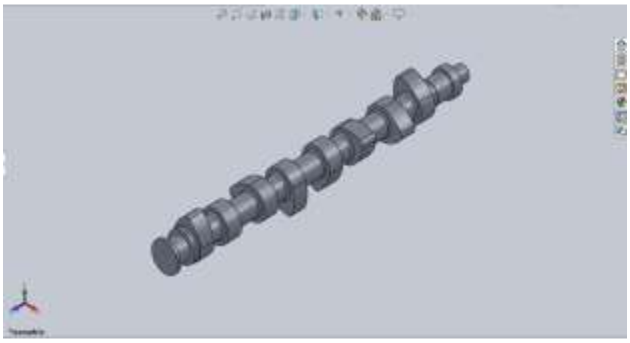

Figure 04 3D model of Camshaft

5.2 Material properties: After creating a 3D model in solidworks, the model is going to import in analysis software. Ansys V19.2 is going to be used as analysis software. Material properties like Modulus of Elasticity, Poisson's ration, density, etc needs to be inputted in the software for better results.

Materials	Elasticity (Pa)	Poisson's Ratio	Density (Kg m^-3)
Mild Steel (EN08)	2E + 11	0.3	7850
Grey CI	1.1E + 11	0.28	7200
Aluminum Alloy	7.1E + 10	0.33	2770

Table 1 Properties of Materials

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5.3 Mesh generation: In finite element analysis, mesh generation is the concept in which the model is divided into number of discrete parts known as elements which is connected by means of point said to be Nodes. Mesh size is directly proportional to the accuracy of result. Big size of nodes sometimes gives unexpected results which can lead to failure of the actual product.

Figure 05 Mesh Generation

5.4 Applying Boundary Conditions: After completing of mesh generation proper constrain must be applied to the model in order to set the limiting point. Load of turning moment is applied to the camshaft as it is a rotating member in IC engine. Proper ID must be given to loads and constrain so that it could be easy to identify the load.

5.5 Solution : After applying the loads and defining the boundary condition , according to the defined problem ,Solution phase deals with model. In this analysis the main concern is Total deformation, von mises stress and von mises strain.

5.6 Post Processing: The last step in Static structural analysis is post processing. With the help of different color graphics post processing program shows us the values of different factors varying from high to low. Clear idea of failure of material can be observed from the graphics.

Material: Mild Steel Grade EN08

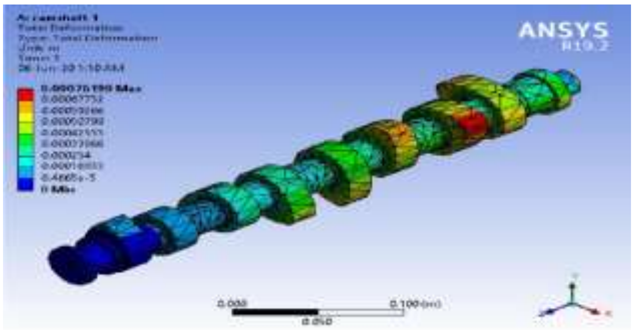


Figure 06 Total Deformation

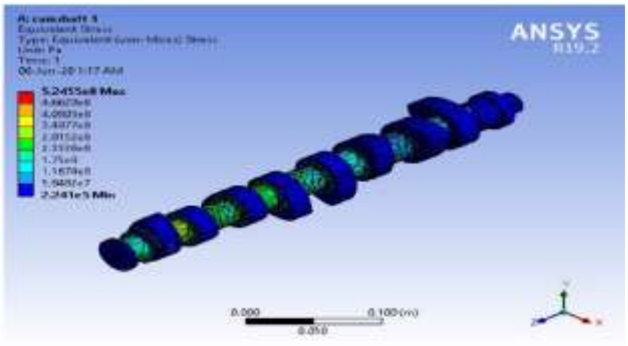


Figure 07 Equivalent (Von Mises) Stress

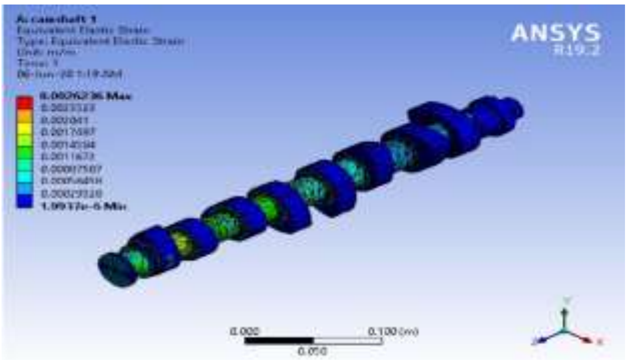


Figure 08 Equivalent (Von Mises) Strain

Material: Grey Cast iron

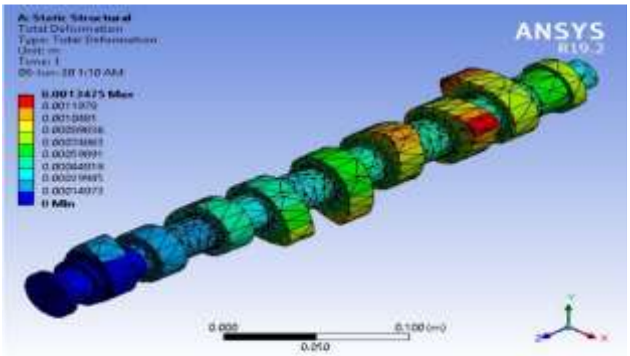


Figure 09 Total Deformation

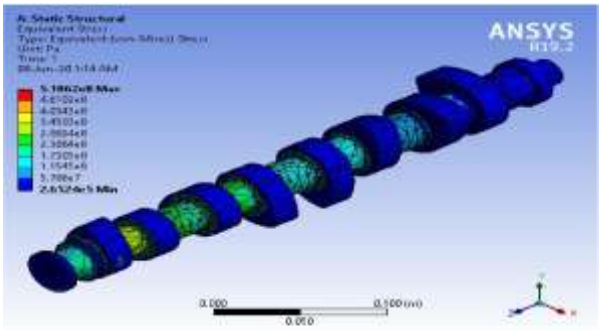


Figure 10 Equivalent (Von Mises) Stress

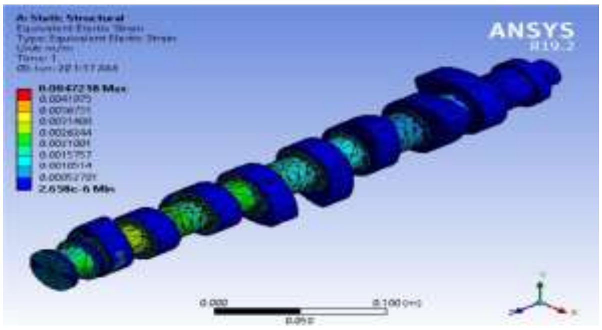


Figure 11 Equivalent (Von Mises) Strain

Material: Aluminium Alloy

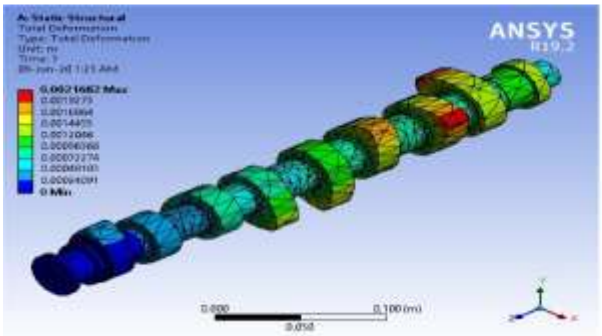


Figure 12 Total Deformation

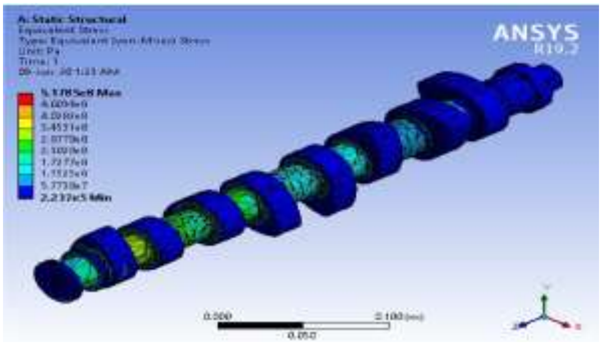


Figure 13 Equivalent (Von Mises) Stress

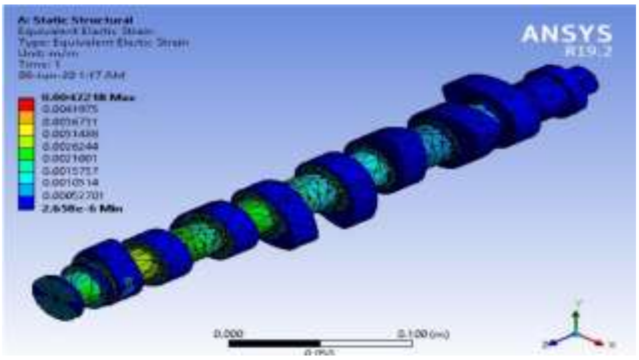


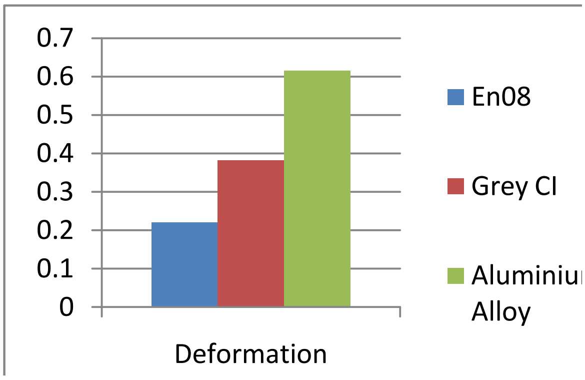
Figure 14 Equivalent (Von Mises) Strain

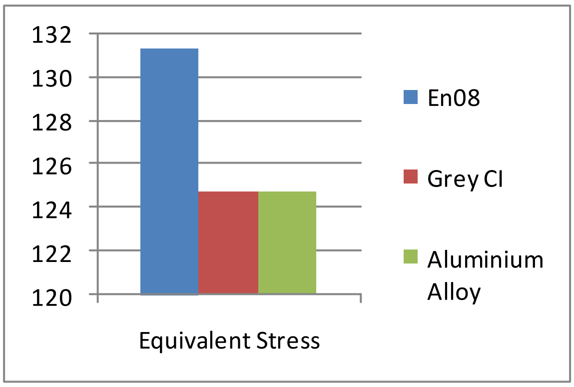
6. RESULTS

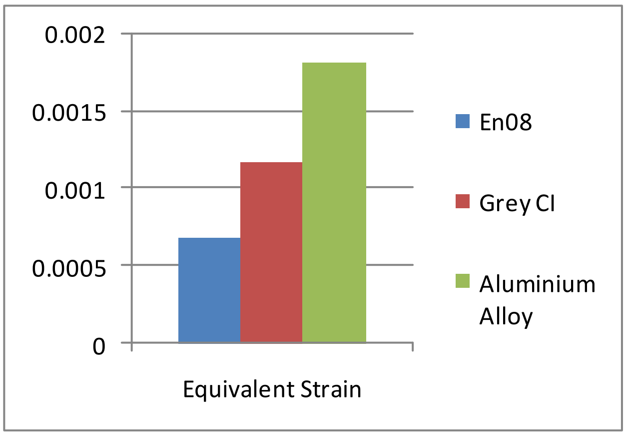
Material	Total Deformation (mm)	Equivalent Stress (MPa)	Equivalent Strain
EN 08	0.21965	131.4	0.0006828
Grey CI	0.38251	124.76	0.0011784
Al. Alloy	0.61551	124.77	0.0018254

Table 2 Results

Graphs :







7. CONCLUSION

Following conclusion can be derived from the performed finite element analysis: When we look at the results, as deformation point of view, it is clearly shown that the deformation in Aluminium alloy is highest as compared to the both and deformation in grey CI is greater than EN08. But when we look at the intensity of stress in all materials, the stress developed in EN08 has highest value whereas value of stress in remaining both materials is almost same from the result. Amount of strain in Aluminium is greater than strain generated in grey CI and strain in grey CI is greater than stain generated in EN08.

8. REFERENCES

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