
Stress Analysis of Engine Camshaft and Choosing Best Manufacturing Material

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Abstract

This paper presents the modeling and static structural analysis of engine camshaft. For the purpose of this analysis, finite element method is used. The Camshaft is one of the important parts in the engines of automobile and other vehicles. This camshaft rotates at high speeds causing stress and vibrations in the system. Camshafts are also subjected to varying contact fatigue loads due to the contact of the plunger on the cam. These exact values are needed to be determined to avoid failure in camshaft. The objective of the project is to do modeling and perform stress analysis of engine camshaft. In this project the standard engine camshafts is modeled and analyzed using Pro-E Wildfire 4.0 and ANSYS WORKBENCH 11.0 software respectively. The model is created by the basic needs of an engine. It is done with the available background, such as forces acting over the cam by means of a valve while running at maximum speed. Here the approach becomes fully CAE based. CAE based approach enriches the Research and limits the time duration. A study has been undertaken to predict the structural behavior of camshafts of different materials using three dimensional finite element stresses. Two Materials namely copper and cast Iron are taken into the consideration. The results of Stress and maximum displacement are calculated and compared for all the above materials. ANSYS values are compared with the theoretical values. The conclusion is to focus towards proper material for the camshaft to reduce maximum displacement and stress. The material Iron comes out to be the best material for the manufacture of camshaft based on the analysis.

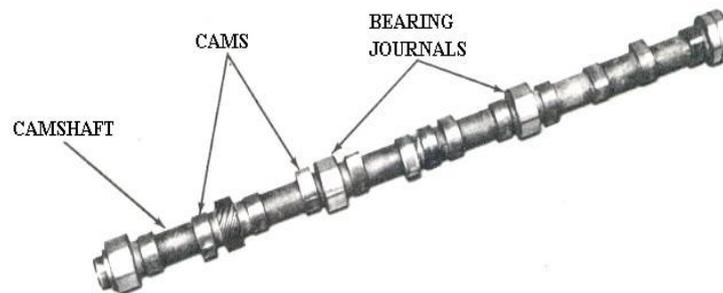
Keywords— Camshaft, Stress Analysis, Modal Analysis, Finite Element Analysis, ANSYS, PRO E

1.) INTRODUCTION

It is known that the Camshaft is considered to be the brain of the engine. It includes the cam lobes, journal bearings and a thrust face to restrict the to and fro motion of the Camshaft. The prime function of the camshaft is to operate the fuel injectors and poppet valves in the engine. The camshafts along with its components control the opening and the closing of two valves. The associated parts are push rods, rocker arms, the valve springs as well as tappet. The camshaft is driven with the help of a Crankshaft by the timing gears. The camshaft controls the valve train operation. Both the camshaft and crankshaft determines the order of firing of the engine. The fatigue failure of the associated components of the camshaft is initiated by the stress concentration and geometric features. Geometric features like holes, grooves and corners as well as the local plasticity and high cycle fatigue behavior are taken into considerations. Some of the common phenomena due to which the camshaft failure occurs are contact fatigue, insufficient lubrication, cam galling and dry wear. It is thus important that the fatigue analysis of the camshaft should be carried out. It will determine the conditions of the failure so that the failure can be avoided.

An important concern of the various engineers in the IC engine field is to predict and extend the service life of the camshaft. There are various variables on which the stress performance of the camshaft depends. They are cam material, the lift profile, valve train configuration and the various manufacturing processes. Many efforts in the manufacturing industry are undergoing in which the effect of grinding on the service lifetime of the camshaft is studied. The lobes of the Cam Shaft are ground to produce the required surface finish and lift profile. It is found by the manufacturers that the quality as well as the service life of the cam shaft is dependent on the way the camshaft is ground (Abusive, moderate or gentle) There are millions of parts involved in the mass production grinding of the camshafts. The output rates are limited by the detrimental

effect of the thermal damage to the camshafts. Thus it is imperative to have a link between the grinding process and the engineering design to have high rates of production of the camshafts as well as have an efficient design.



The Valve train: the Role of the Camshaft

The valve train includes a series of parts including the cams, followers, push rods, rocker arms, shafts, valves, springs, retainers, rotators and locks. The purpose of the complete system is to open and close the intake port and exhaust port which lead to the combustion chamber. The main function of the camshaft is to open and close the engine valves as and when required. The design of the camshaft is such that the valves are open and closed at the precise time. They are at the controlled rate with reference to the position of the piston. There are two lobes per cylinder in the camshaft. One lobe is to drive the intake valve and the other is to drive the exhaust valve. It is thus imperative that the V4 engine has a camshaft with 8 lobes. The valve train part which is in the direct contact with the cam is known as follower or the lifter.

III. ANALYTICAL PROCEDURE

A. Finite Element Modeling

In this work, the analysis was carried out on a camshaft. The 3D camshaft model was generated and analyzed. The model may be created in the pre-processor. It can be imported from another CAD drafting package via a neutral file format (IGES, STEP, ACIS, Para solid, DXF, etc.). The element should be best suited for the regular or irregular geometries and should provide fast results. The element should be able to be used for linear as well as nonlinear problems.

B. Applying Mesh

Mesh generation is the process of dividing the analysis continuum (Space) into a number of discrete parts or finite elements. The finer the mesh, the better are the results, but also longer is the analysis time. Therefore, a compromise between accuracy & solution speed is usually done. The mesh may also be created manually. In the manually created mesh we will notice that the elements are smaller at the joints. This is known as mesh refinement, and it helps the stresses to be captured at the geometric discontinuities. Manual meshing is a long & a tedious process for the models with any degree of geometric complication. With useful tools emerging in pre-processors, the task is becoming even easier. The mesh is created automatically by using a mesh engine. The only requirement is to define the mesh density along the model's edges and corners.

C. Apply loads and Boundary conditions

Some types of loads are usually applied to the analysis model. The loading may be in the form of a point load, a pressure (Stress) or a displacement in a stress (displacement) analysis, a temperature or a heat flux in a thermal analysis or a fluid pressure or velocity in a fluid analysis. The loads may be applied to a point, the

edge, and a surface or on a complete body. The loads should be in the same units as is the model geometry and material properties specified. If you apply a load to the model, then at least 1 constraint or boundary condition should be applied. Structural boundary conditions are usually in the form of zero displacement. Thermal BCs are usually the specified temperatures. Fluid BCs are usually given pressures. A boundary condition may be given to act in all directions (x, y, z), or in certain directions. The applications of correct boundary conditions (BC) are critical to the accurate solution of the design problem. At least 1 boundary condition has to be applied to every model and modal & buckling analyses with no loads applied.

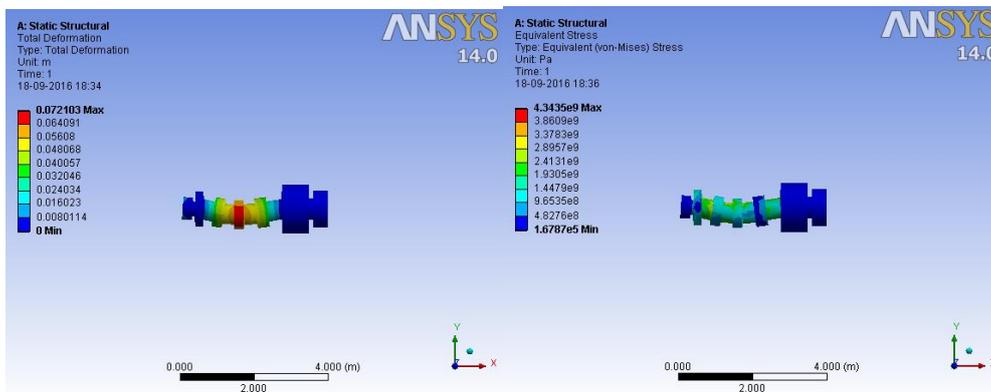
D. Solution

This part is generally fully automatic. The FE (Finite element) solver can be logically divided into 3 main parts, the pre-solver, the mathematical-engine, & the post-solver. The pre-solver reads in the model made by the preprocessor and formulates the mathematical representation of the model. All parameters defined in the preprocessing stage are used for this. If you left something out, chances are that the pre-solver will complain & cancel the call to the mathematical engine. If the model is correct then the solver proceeds to form the element-stiffness matrix for the problem. It calls the mathematical-engine which calculates the result (displacement, temperatures and pressures, etc.) The results are returned to the solver. The post-solver is used to calculate strains, stresses, heat fluxes, velocities, etc. for each node and key point.

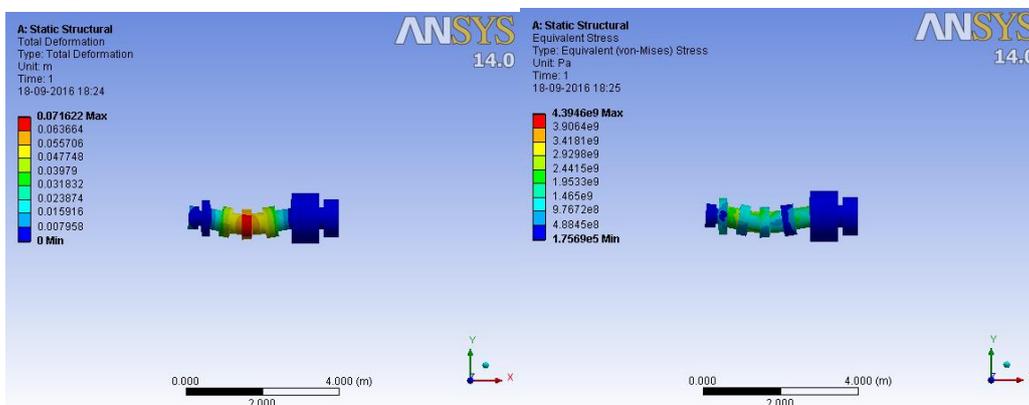
IV. RESULTS AND DISCUSSIONS

The Stress Distribution (Von Mises) and displacement profiles for the two materials are shown below:

1) Copper



2) Cast Iron

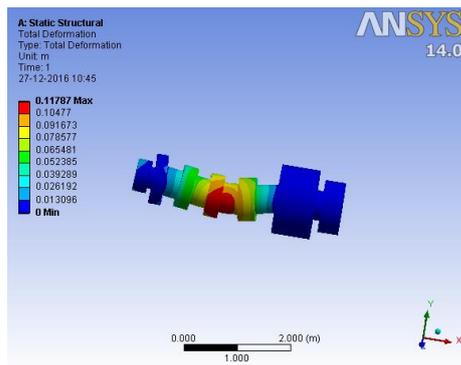
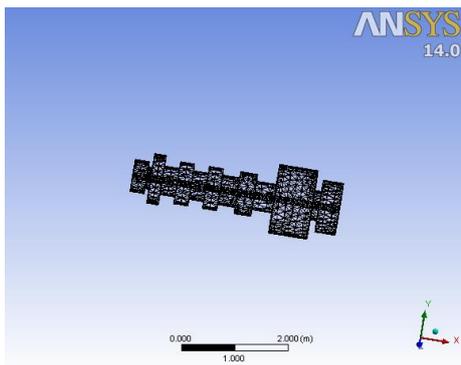


Thus, from the above results we can see that the maximum displacement is Minimum in the case of Iron material. Thus the best material for the cam shaft is steel and it should be manufactured in Iron material.

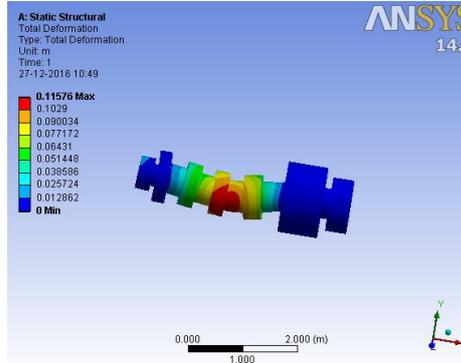
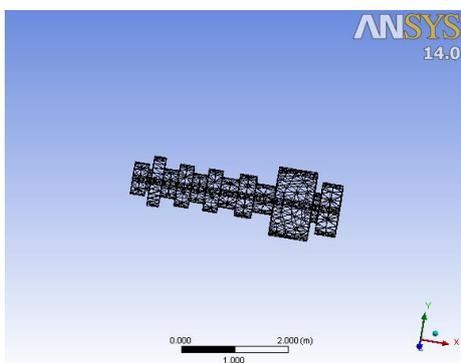
The above results have been validated with the previous works done by the researchers and our results are in close agreement with their results.

The Mesh Independency Test for one of the material is shown below:

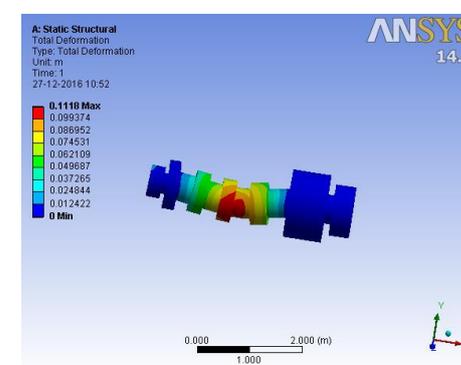
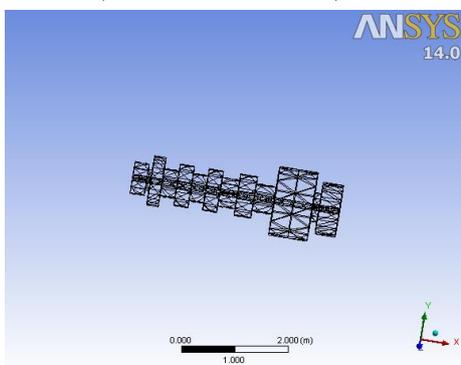
Case 1 (Fine Mesh Size)



Case 2 (Medium Mesh Size)



Case 3 (Coarse Mesh Size)



V CONCLUSION

Solid Modeling Software was used to model the cam shaft with accurate cam profile. Analysis was carried out to evaluate the design using traditional materials like Cast Iron and Copper. Static analysis is carried out to find the displacement and stress due to loads. The results are then tabulated and analyzed. The best material out of the 2 materials is chosen. According to the results obtained from the analysis, Iron (special grade for automotive parts) is the best choice for camshaft manufacturing.

7.REFERENCES

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