Design & Analysis of Cam Shaft in Automobiles

A.Swarajyam
PG student- Mechanical engineering, CAD/CAM specialization, Intell Engineering College Anatapur 515004, India

Abstract

A camshaft is a rotating cylindrical shaft used to regulate the injection of vaporized fuel in an internal combustion engine. These are occasionally confused with the crankshaft of the engine, where the reciprocating motion of the pistons is converted into rotational energy. Instead, camshafts are responsible for accurately-timed fuel injections required by internal combustion engines. Camshafts have multiple cams on them, which are used to open valves through either direct contact or pushrods. A camshaft is directly coupled to the crankshaft, so that the value openings are timed accordingly.

An engine camshaft can be made from many different types of materials. The materials used in the camshaft depend upon the quality and type of engine being manufactured. For most mass-produced automobiles, chilled cast iron is used. Not only it is cheap, but child cast iron is also extremely durable and reliable. This is because cold treating increases the strength and hardness of any metal that undergoes the process.

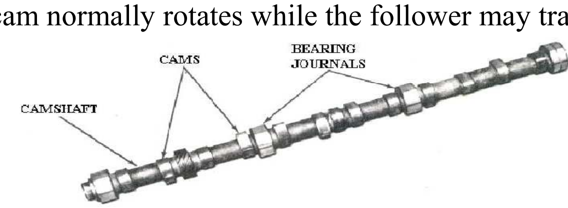
In this project, a cam shaft will be designed for a 150cc engine and modeled through pro/engineer. Present used material for camshaft is cast iron. In this work, the camshaft material will be replaced with steel and aluminum alloy. Structural analysis and model analysis will be done on cam shaft using cast iron, steel and aluminum alloy. Comparison will be done for the three materials to verify the better material for camshaft.

Modeling will be done using pro/Engineer software and analysis will be done using ANSYS.

KEYWORDS: Cam Shaft, Cams, follower, FEM, Pro/E,Ansys

INTRODUCTION

A cam is a mechanical device used to transmit motion to a follower by direct contact. The driver is called the cam and the driven member is called the follower. In a cam follower pair, the cam normally rotates while the follower may translate or oscillate.



Cam and Camshaft

Camshaft Operation:

The camshaft uses lobes (called cams) that push against the valves to open them as the camshaft rotates; springs on the valves return them to their closed position. This is a critical job, and can have a great impact on an engine's performance at different speeds.

Types of Camshafts:

Single Overhead Cam:

A single overhead cam has one cam per head. So if it is an inline 4-cylinder or inline 6-cylinder engine, it will have one cam; if it is a V-6 or V-8, it will have two cams (one for each head). On single and double overhead cam engines, the cams are driven by the crankshaft, via either a belt or chain called the timing belt or timing chain.

Double Overhead Cam:

A double overhead cam engine has two cams per head. So inline engines have two cams, and V engines have four. Usually, double overhead cams are used on engines with four or more valves per cylinder -- a single camshaft simply cannot fit enough cam lobes to actuate all those valves. The main reason to use double overhead cams is to allow for more intake and exhaust valves. More valves, means that intake and exhaust gases can flow more freely because there are more openings for them to flow through. This increases the power of the engine.

Camshaft Basics

The key parts of any camshaft are the **lobes**. As the camshaft spins, the lobes open and close the intake and exhaust valves in time with the motion of the piston. It turns out that there is a direct relationship between the shape of the cam lobes and the way the engine performs in different speed ranges.

To understand why this is the case, imagine that we are running an engine extremely slowly -- at just 10 or 20 revolutions per minute (RPM) -- so that it takes the piston a couple of seconds to complete a cycle. It would be impossible to actually run a normal engine this slowly, but let's imagine that we could. At this slow speed, we would want cam lobes shaped so that:

- Just as the piston starts moving downward in the intake stroke (called top dead center, or **TDC**), the intake valve would open. The intake valve would close right as the piston bottoms out.
- The exhaust valve would open right as the piston bottoms out (called bottom dead center, or **BDC**) at the end of the combustion stroke, and would close as the piston completes the exhaust stroke.

This setup would work really well for the engine as long as it ran at this very slow speed. But what happens if you increase the RPM? Let's find out.

When you increase the RPM, the 10 to 20 RPM configuration for the camshaft does not work well. If the engine is running at 4,000 RPM, the valves are opening and closing 2,000 times every minute, or 33 times every second. At these speeds, the piston is moving very quickly, so the air/fuel mixture rushing into the cylinder is moving very quickly as well.

When the intake valve opens and the piston starts its intake stroke, the air/fuel mixture in the intake runner starts to accelerate into the cylinder. By the time the piston reaches the bottom of its intake stroke, the air/fuel is moving at a pretty high speed. If we were to slam the intake valve shut, all of that air/fuel would come to a stop and not enter the cylinder. By leaving the intake valve open a little longer, the momentum of the fast-moving air/fuel continues to force air/fuel into the cylinder as the piston starts its compression stroke. So the faster the engine goes, the faster the air/fuel moves, and the longer we want the intake valve to stay open. We also want the valve to open wider at higher speeds -- this parameter, called **valve lift**, is governed by the cam lobe profile.

MATERIALS USED:

Camshafts can be made out of several different types of material. The materials used for the camshaft depends on the quality and type of engine being manufactured.

Existing Material:

Chilled iron castings:

This is a good choice for high volume production. A chilled iron camshaft has a resistance against wear .When making chilled iron castings, other elements are added to the iron before casting to make the material more suitable for its application.Chills can be made of many materials, including iron, copper, bronze, aluminum, graphite, and silicon carbide. Other sand materials with higher densities, thermal conductivity or thermal capacity can also be used as a chill. For example, chromate sand or zircon sand can be used when molding with silica sand.

Implemented Material:

Alloy Steel

Alloy steels are steels containing elements such as chromium, cobalt, nickel, etc. Alloy steels comprise a wide range of steels having compositions that exceed the limitations of Si, Va, Cr, Ni, Mo, Mn, B and C allocated for carbon steels.

MATERIAL	VON-MISES STRESS	DEFORMATION
STRUCTURAL STEEL	157.19	0.0056878
CHILLED CAST IRON	157.5	0.01043

Comparison of stress results of different materials

INTRODUCTION TO CAD/CAM

CAD is used to design and develop products, which can be goods used by end consumers or intermediate goods used in other products. CAD is also extensively used in the design of tools and machinery used in the manufacturer of components.CAD is used though out the engineering process from the conceptual design and layout, through detailed engineering and analysis of components to definition of manufacturing methods.

PRO/E

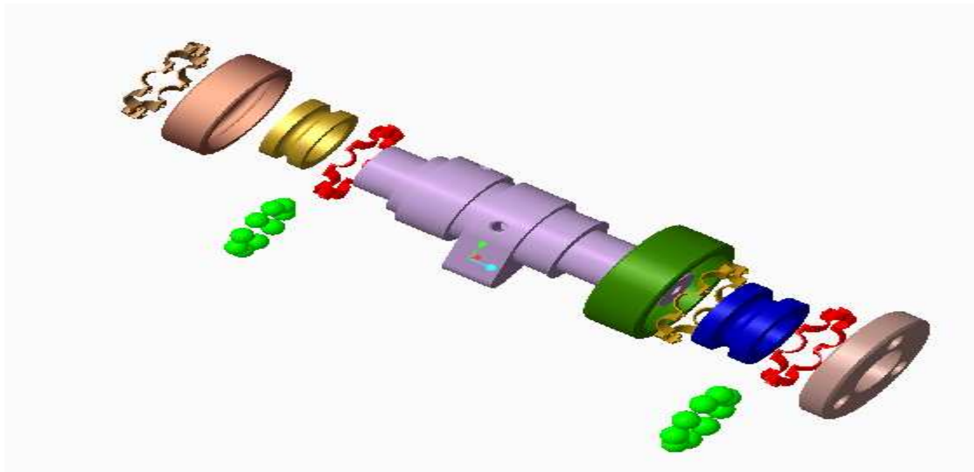
It is the world’s leading CAD/CAM /CAE software, gives a broad range of integrated solutions to cover all aspects of product design and manufacturing.*PRO/E* provides easy to use solution tailored to the needs of small medium sized enterprises as well as large industrial corporations in all industries, consumer goods, fabrications and assembly. Electrical and electronics goods, automotive, aerospace, shipbuilding and plant design. It is user friendly.Solid and surface modeling can be done easily.

The main modules are:

- Sketcher
- Part Design

- Assembly
- Drafting
- Sheet metal

An Exploded view of total CAM shaft



FINITE ELEMENT METHOD / ANALYSIS

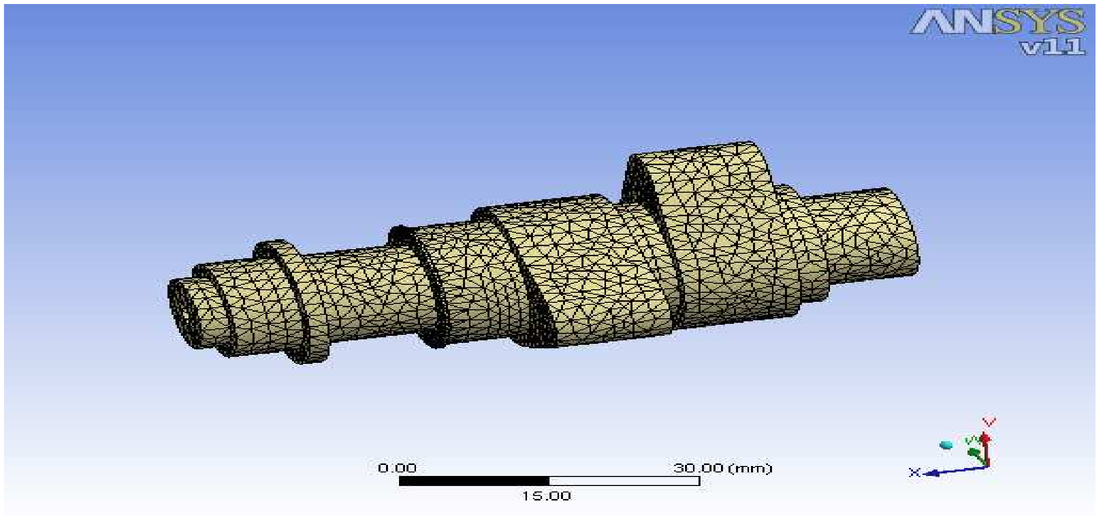
The basic idea in the Finite Element is to find the solution of complicated problem with relatively easy way.In the Finite Element Method the solution region is considered as built up many small, interconnected sub regions called finite elements.It has been successfully applied to solve several type of engineering problems like heat conduction, fluid dynamics, seepage flow and electric and magnetic fields.The final goal of FEA is to find the large deformations and maximum stress occurring in the structure.

PROCEDURE FOR ANSYS

Static analysis is used to determine the displacements stresses, stains and forces in structures or components due to loads that do not induce significant inertia and damping effects.The kinds of loading that can be applied in a static analysis include externally applied forces and pressures, steady state inertial forces such as gravity or rotational velocity imposed (non-zero)displacements, temperatures (for thermal strain). A static analysis can be either linear or nonlinear. In our present work we consider linear static analysis.

MESH GENERATION

In the finite element analysis the basic concept is to analyze the structure, which is an assemblage of discrete pieces called elements, which are connected, together at a finite number of points called Nodes. Loading boundary conditions are then applied to these elements and nodes. A network of these elements is known as mesh.Generally, automatic mesh generating capabilities of preprocessor are used rather than defining the nodes individually.

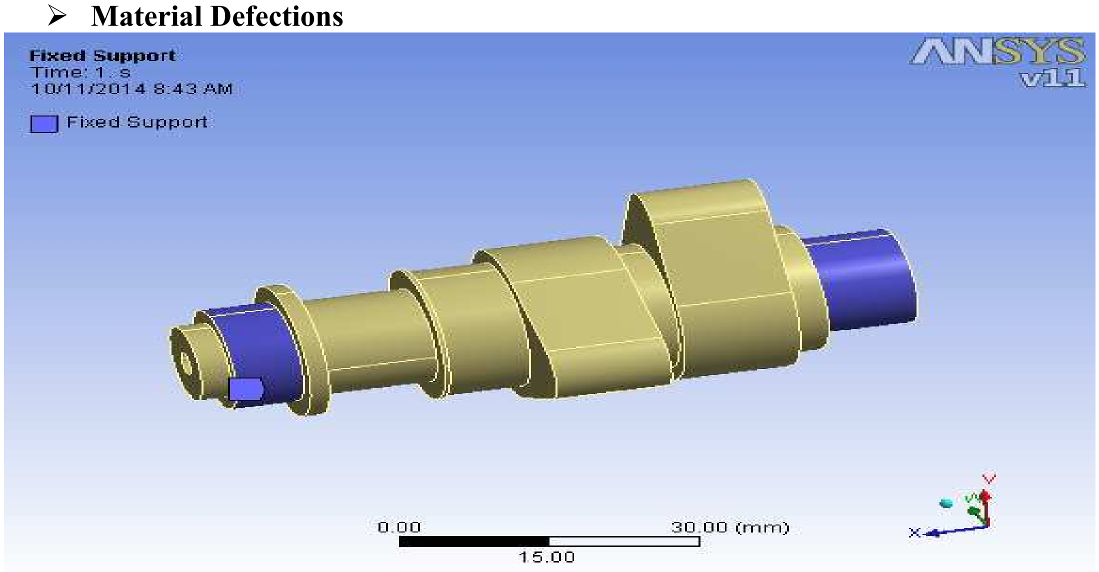


Mesh Generation of the Modal

BOUNDARY CONDITIONS AND LOADING

After completion of the finite element model it has to constrain and load has to be applied to the model. User can define constraints and loads in various ways. All constraints and loads are assigned set ID. This helps the user to keep track of load cases.

- **Modal display**
- **Material Defections**



Boundary Conditions and Loading

SOLUTION

The solution phase deals with the solution of the problem according to the problem definitions. All the tedious work of formulating and assembling of matrices are done by the computer and finally displacements are stress values are given as output.

THERMAL ANALYSIS

A thermal analysis calculates the temperature distribution and related thermal quantities in brake disc. Typical thermal quantities are:

- The temperature distribution
- The amount of heat lost or gained
- Thermal fluxes

Types of Thermal Analysis

- Steady state thermal analysis.
- Transient thermal analysis

STRUCTURAL ANALYSIS

Structural analysis is the most common application of the finite element analysis. The term structural implies civil engineering structure such as bridge and building, but also naval, aeronautical and mechanical structure such as ship hulls, aircraft bodies and machine housing as well as mechanical components such as piston, machine parts and tools.

RESULTS AND DISCUSSION

From Static structural analysis the values obtained for the materials Chilled cast iron, Steel alloyare Tabulated below.

FOR CHILLED CAST IRON

Total deformation(mm)		Von-mises stress(mpa)	
Max	Min	Max	Min
0.010143	0	157.5	0.12107

Static structural analysis result for Chilled cast iron

FOR STEEL ALLOY

Total deformation(mm)		Von-misesstress(mpa)	
Max	Min	Max	Min
0.0056878	0	157.19	0.36128

Static structural analysis result for Steel alloy

CONCLUSION

Results obtained from Static structural analysis we can say that the material Steel alloy is also applicable for manufacturing the Camshaft. As the Total deformation and Von-mises stress values of camshaft is less compared with Chilled cast iron.

This Result is applicable for the further analysis as well as for the manufacturing processes can be decided from results. Another application of this analysis is material selection related to camshaft which becomes easier for the manufacturer

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