Dynamic And Fatigue Analysis of Camshaft

Pramod D Pawar[1], Dr.S P Palekar[2]
[1, 2] Dept of Mechanical Engineering
[1, 2] Sanjivani College of Engineering,Kopargoan

Abstract- *Fabrication of piston using Al-Si-Mg is also easier than using Aluminium. 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.*

I. INTRODUCTION

A cam is a mechanism that makes a cam follower move with a reciprocating motion. Camshaft is one of the key parts or components in the engines of automobile and other vehicles. The performance is to control the open and close intervals of the inlet and exhaust poppet valves by its cams. Due to the cyclic impact loading on the contacting surfaces of the cam and the follower, it often gives rise to premature wear of cam profile and affects a routine run of the valve gear such as the rotational speed, valve displacement and the torque.There are two main categories of cams:

[1] cams moving with a rotary motion.
[2] cams moving with a linear motion.

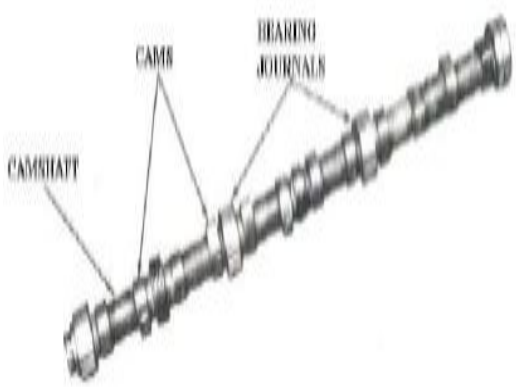

Figure 1:- Cam and Camshaft

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.

While going through published research it has been observed that analysis of camshaft is not dealt by researchers, as very few research are available. Therefore, in present study is made to carry out analysis. [1]

Study of the brittle material (Cast iron) was not conducted for the camshaft by using maximum & minimum principal stress theory. [2] Static case was not studied by taking into consideration the angular velocity due to rotation for camkshaft. [3] Vibration analysis to calculate natural frequency was not performed before to check the resonance condition.

Analysis of camshaft is carried out in order to sustain cyclic and vibratory loading. By performing dynamic analysis ,natural frequency will be calculated and observed for resonance condition by using FEA software. Static analysis will be also performed to find out static strength of camshaft. Along with this, fatigue analysis will be carried out to determine the strain and stress life. Above analysis is carried out for forged steel and nodular cast iron material. Comparison of the results will be done between the two materials for weight & cost optimization opportunities. Comparison of the results will be done between the two materials for weight & cost optimization opportunities.

In the present study the camshaft of Two wheeler (Bajaj Discover) vehicle is considered, the CAD model for the same will be prepared in CATIA software. For optimization purpose materials considered in this study are nodular Cast iron and forged steel for camshaft. Dynamic Analysis i.e. Vibration Analysis will be carried out for calculating the natural frequency of camshaft shaft by using FEA software ANSYS-16.0.Static Analysis will be carried out to calculate the strength of the camshaft by using FEA software.Fatigue analysis will be carried out to determine the strain and stress life of camshaft by FEA software.

Comparison of results between the two materials will be carried out for weight & cost reduction opportunities.

Validation of results will be carried out by comparing the FEA results with those obtained by analytical method. Camshafts rotate at high speeds causing vibrations in the system. Camshafts are also subjected to varying contact fatigue loads due to the contact of the plunger on the cam. Due to these fluctuations, vibration and fatigue failures occur on the shaft. Hence modal and fatigue analysis need to be carried out on the camshafts to ensure safety and to determine the life of the member.The camshaft will modeled in CATIA software and exported as STEP format for further analysis. The ANSYS software will be then used, to obtain the natural frequency, mode shapes and the fatigue alternative stresses of the camshaft member. Validation of the finite element modal and fatigue analysis results will be carried out by comparing them to the analytical method.

The methodology used for doing the analysis is as follows:

[1] To develop a 3D model of camshaft using modelling software like CATIA.
[2] The 3D model is converted into stp and imported into ANSYS to perform Modal, Static And fatigue analysis.
[3] Above analysis will be carried out for both forged steel and CI material.
[4] Deflection and stresses will be plotted in the ANSYS for the camshaft.
[5] Developing the mathematical model for carrying out the analytical study.
[6] Comparison of the result obtained from analytical and FEA approaches for the validation purpose.
[7] From the result obtained, optimal material will be suggested for camshaft.

II. LITERATURESURVEY

Jaiganesh, et al. [1] studied the manufacturing of PMMA Cam Shaft by rapid prototyping. Rapid prototyping is a technique used to quickly fabricate an assembly, components or parts using three-dimensional Computer Aided Design and Computer Aided Manufacturing (CAD-CAM). It is an additive layer manufacturing technology.

Wang, et al. [2] have studied Prediction of fatigue failure in a camshaft using the crack modelling method. Camshafts made of grey cast iron and used in Rover vehicles were tested under cyclic bending and torsion and modelled using FE.

Mallikarjuna, et al. [3] have design & Manufacture low cost Camshaft used In Two Wheeler. The camshaft and its associated parts control the opening and closing of the two valves. The associated parts are push rods, rocker arms, valve springs and tappets. This shaft also provides the drive to the ignition system. The camshaft is driven by the Camshaft through timing gears.

Michalski et al. [4] have did experimental study of diesel engine cam and follower wear with particular reference to the properties of the materials. The main objective of this paper is to study and experimentally quantify the cam and follower wear mechanisms of a diesel direct valve-gear.

Soejimaa, et al. [5] studied on friction and wear characteristics of cam and follower: influences of soot contamination in engine oil. In order to clarify the friction and wear mechanism of the contact between cam and follower in the valve train incorporated in an EGR system, an experimental investigation was performed with a cam-follower test rig.

Shobha [6] did analysis of Cam Shaft in Automobiles Using Different Materials. 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.

Mortazavian, et al. [7] in their study, a finite element analysis method is developed for simulating a camshaft cap punching bench test. Stiffness results of simulated camshaft cap component are correlated with test data and used to validate the model accuracy in terms of material and boundary conditions.

Vivekanandan, et al. [9] explored Modelling, Design and Finite Element Analysis of Cam Shaft. In FEM, behaviour of cam shaft is obtained by analysing the collective behaviour of the elements to make the cam shaft robust at all possible load cases.

Mahesh, et al [10] did computational Geometric Modeling and Finite Element Structural Analysis of Automobile Camshaft. This Cam is a Mechanical Linkage used especially in transforming rotary motion into linear motion. Its main function is to control the valve timing in I.C Engines.

Saraswat, et al. [11] did analysis on camshaft by using nodular cast iron as the material of the component. CAE software are used for geometric modelling of the camshaft

assembly and ANSYS for stress, strain and deformation analysis.

Kumar, et al [12] studied the vibration analysis of the various camshaftsthat are used in times and to find a material that have the minimum natural frequency and no effects on the efficiency of the engine.

Bongale and Kapilan [13] analyzed two lobes of cams from cam assembly for structural safety for static conditions and for rotor dynamic conditions. The results are obtained for major structural safety parameters of stress and deflection. The results show complete safety of the problem.

Mali, et al. [14] made an attempt to change the flat face of follower to a curved face follower, so that the required point contact can be achieved. As line contact between existing cam and follower mechanism results in high frictional losses which results in low mechanical efficiency. It is observed that the frequency of vibration in the existing and modified cam and follower mechanism remains almost same.

Liu, et al. [15] studied method of improving joining strength by using cams with noncircular hole was presented. Through numerical simulation and experiment, plastic deformation law of hydro-joining process was studied.

Patil , et al.[16] modeled camshaft in CATIA software and exported in STEP format for FEA analysis The ANSYS software was then employed, to obtain the natural frequency, mode shapes and the fatigue alternative stresses of the camshaft member.

The outcomes of the literature review are

- Camshaft plays a vital role in engine.
- Analysis of the camshaft assembly on ANSYS can help in better understanding of the results.

The life of camshaft depends on the material of camshaft.
The cam is forged as one piece with the camshaft.

III. METHODOLOGY

The diameter of camshaft

D1 = 0.16*cylinder bore+12.7
D1 = 0.16* 57+12.7 = 21.82mm

The base circle diameter is about 4mm greater than camshaft diameter

Base circle diameter = 21.82+3 = 24.82mm = 25mm
Width of camshaft w1 = 0.09*cylinder bore+6
W1 = 0.09*57+6 = 11.13mm
OA = minimum radius of camshaft +(1/2diameter of roller)
= 12.5+(1/241) = 33mm
Camshaft Load Calculations**:**

The maximum RPM of bike is 8500rpm and Camshaft and hence this speed is considered to calculate force coming on cam as below.

At 8500RPM:
Frequency: η=Engine speed/60
η =8500/60
η = 141.66
$\omega = 2\pi\eta$
$\omega = 2\pi*141.66 = 889.67$
$F=m\omega^2r$
r=0.01091m, radius of cam
Mass of Steel Cam: 0.37387 Kg
Mass of CI cam: 0.34351 Kg

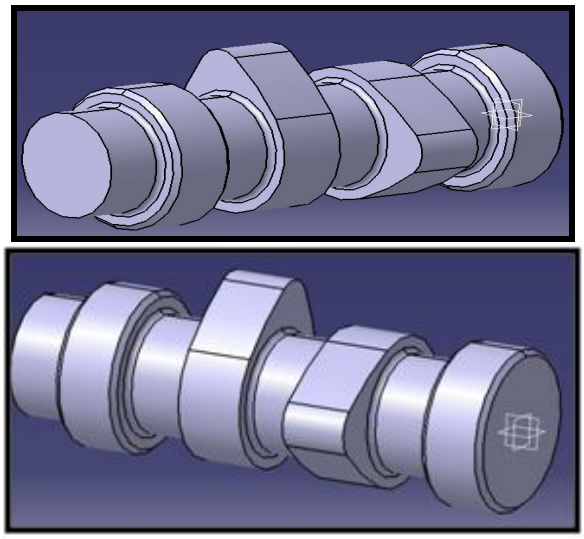

Table 1:- Properties of materials

Material Property	Unit	Forged Steel	Cast Iron
Modulus of Elasticity	GPa	221	178
Poisson's Ratio	-	0.3	0.27
Mass Density	kg/m3	7833	7197

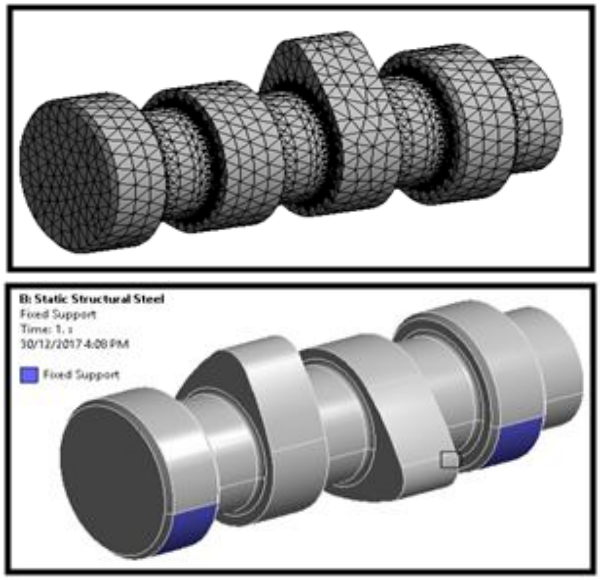

Figure 2:- Boundary Condition

IV. RESULTS

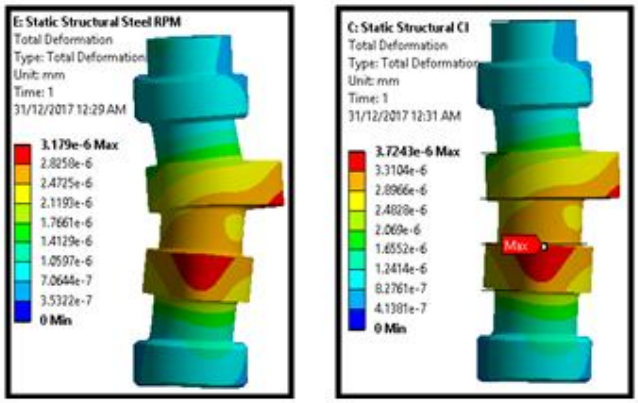

Figure3:-Total Deformation for Rotational Loading

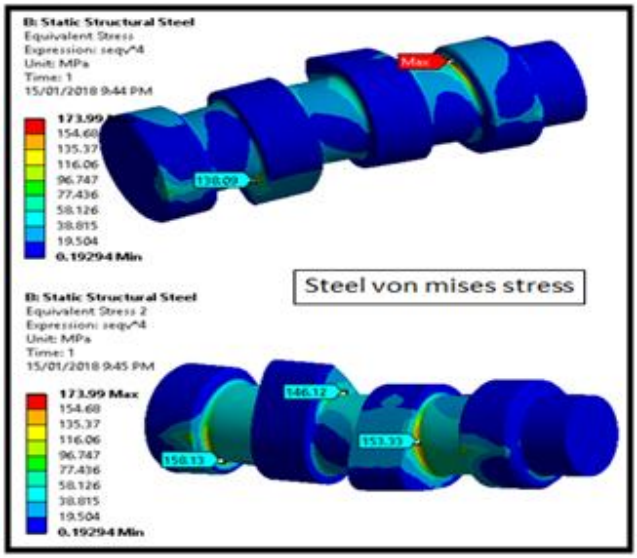

Figure 4:- Von Mises Stress

FEA approach where utilised in order to m carry out static, modal and fatigue analysis of camshaft of forged steel and cast iron material. In order to avoid resonance condition, the natural frequency of both the materials of camshaft is calculated. Effect of the rotational velocity on camshaft stress is also observed and it found to be negligible.

REFERENCES

[1] V. Jaiganesh, A. A. Christopher , E. Mugilan,"Manufacturing of PMMA Cam Shaft by Rapid Prototyping", Procedia Engineering, 2014, (97) 2127 – 2135.

[2] G. Wang, D. Taylor, B. Bouquin, J. Devlukia, A. Ciepalowicz,"Prediction of fatigue failure in a camshaft using the crack modelling method", Engineering Failure Analysis 2000,(7) 189-197.

[3] V. Mallikarjuna,N. G Jashuva,. B.Nagaraju, R.Reddy,"Design Manufacturing and Cost Estimation of Camshaft Used In Two Wheeler", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) , , , 2014, (Volume 11) Issue 1, 53-67.

[4] J. Michalski, J. Marszalek, K. Kubiak,"An experimental study of diesel engine cam and follower wear with particular reference to the properties of the materials", Wear 2000,(240)168–179.

[5] M. Soejimaa, Y. Ejimaa, K. Uemorib, M. Kawasaki, "Studies on friction and wear characteristics of cam and follower: influences of soot contamination in engine oil",JSAE Review 2001,(23), 113–119.

[6] M. Shobha,"Analysis of Cam Shaft in Automobiles Using Different Materials", IJESC,2016, (Volume 6) Issue No.10 ,2893-2896.

[7] S.Mortazavian, J. Moraveji, R. Adimi, and X.Chen,A Finite Element Method for Camshaft Cap Durability Analysis, SAE Technical Paper , (2017)

[8] V.Swamulu, N. Siva Nagaraju, T. Srinivas,"Design and analysis of cam shaft for multi cylinder engine", IRJET , 2015, (Volume: 02) Issue: 06, 229-232