Experimental & FEA Analysis of Camshaft for Two Wheeler

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Abstract-*Camshafts are crucial components in combustion engines. Their purpose is to control the opening and closing of intake and exhaust valves, which affects various aspects of an engine's performance. The valves control the intake of the air-fuel mixture in the combustion chamber and the exhaust of combustion gases. The synchronization of this task with the engine's cycle is essential for the system to work as desired and timing parameters such as valve duration affect the engine's power and efficiency. 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. In this study, experimental analysis of camshaft of two wheeler vehicle to finding equivalent (von mises) stresses and shear stress and also numerical finite element technique was applied on the camshaft model for validation of experimental results. The camshaft was modeled in ansys workbench and then further analysis through ANSYS software. To obtain the natural frequency and the fatigue alternative stresses of the camshaft member. Various theories for fatigue life such as Goodman theory were employed to verify the finite element fatigue analysis results as well as experimental analysis.*

Keywords-component; formatting; style; styling; insert (key words)

I. INTRODUCTION

Camshaft is one component of the internal combustion engine that engineers are always concerned about how to predict and extend the service life. Variables like lift profile and material of the cam, valve trains configuration and manufacturing process are responsible for the fatigue performance of the camshaft. High values of stress in the peak of the cam are the main responsible of cam damage. Cams are commonly used in opening and closing of valves in internal combustion engines. Both the inlet and outlet valves are regulated using cam and follower. The study of cam and follower mechanism becomes important for desired and required performance of the engines.

A. Working of Camshaft:

The key parts of any camshaft are the lobes. As the camshaft spins, the lobes open and close the in take 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. As the piston starts moving downward in the intake stroke(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(BDC) at the end of the stroke, and would close as the piston completes the exhaust stroke. 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 start 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.

II. LITERATURE REVIEW

A.S.Dhavale et. al. has carried out on the fracture analysis on camshaft. He was found that the two-mass SDOF model for a cam follower system determined that the dynamic model for the cam-follower must consist of at least two masses. One of the masses allowed an approximation of the contact force between cam and follower while the other mass was used to predict dynamic behavior. They also found main reason of the fracture is determined as a casting defect, and also found about failure was related to a material production problem.

R. V. Wanjari et. al. has analysis on failure analysis of camshaft. They worked on the high load and high speed on cam shaft and also analyses have carried out on the failure of these components. They give the suggestion for cam shaft for prevent premature wear and failure of the camshaft, have to need for consider all the factors which may causes failure of camshaft and design it.

S.G.Thorat et. al. has numerically analysis on cam shaft. They worked on to design cam shaft analytically, its modeling and analysis under FEM. They created by the basic needs of an engine with the available background data such as power to be transmitted, forces acting over the camshaft by means of valve train while running at maximum speed. They found that on his modal analysis of existing camshaft is carried out. As per analytical solution deflection of camshaft was 5.985*10-4 mm. from analysis result max deflection is 0.48*10-3mm. Maximum bending stress in camshaft is 12.656MPa from analytical solution and from 11.094MPa. They compared analytical and analysis results it was clear that designing of camshaft is correct and safe.

B. Chandra Sekhar et. al. has carried out on cam shaft and its associated parts for multi cylinder engine. They were worked on theoretical calculations carry out to design the cam profile (using displacement drawing and cam profile drawing). The values of natural frequency should match with traditional camshaft. After model analysis dynamic frequency analysis was done to determine the displacements due to external vibrations. According to the results obtained from the analysis aluminum 360 (special grade for casting automotive parts) is the best choice for camshaft manufacturing.

Suhas K.S. et. al. has carried out on the fatigue analysis of cam shaft through FEA. They worked on a 6 station 2 lobe cam was to be analyzed for wear conditions for the different load conditions; reduce the wear and improve the fatigue life of the cam shaft. They found that the following

- Camshaft was analyzed for modal frequency. The first natural frequency value is around 815 Hz.
- Fatigue SN curve data is applied to the Ansys Fatigue module and stresses are captured for all the six load cases. The stresses are varying between 330 N/mm2 to 427 N/mm2 with contact loads and rotational loads.
- The fatigue analysis was carried out with two intermediate supports which show improvement in the problem. The fatigue stress is reduced to 78.6Mpa which is less then allowable stress of 86.2 showing safety of the problem.

Karri Anil et. al. has analysis structural on cam shaft. They worked on the cam stress, strain and total deformation values with different materials are as Cast Iron material, Aluminum Alloy and Billet steel material. They found that after analysis on different materials of cam shaft like Cast Iron, Billet Steel and Aluminum Alloy of Cam shaft total deformation observed in billet steel was comparatively less when compared between cast iron and Aluminum Alloy.

III. PROBLEM DEFINITION

Camshafts are also subjected to varying contact fatigue loadsdue 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. In this study, a numerical finite element technique was applied on the camshaft model to carry out the above mentioned analysis. The camshaft was modeled in ANSYS for further analysis in ANSYS software was then employed, to obtain the natural frequency, mode shapes and the fatigue alternative stresses of the camshaft member.

IV. DESIGN CONSIDERATION

A. For 150cc 4 Stroke IC engine

D = Diameter of bore = 57mm
L = stoke = 58.6mm
a = Area of piston
V = Velocity of piston
d_P = Diameter of part
a_P = Area of part
d_V = Diameter of valve
$\alpha = 30^0$
h = $\frac{d_P}{4\cos\alpha}$ = Maximum lift of the valve

Design of Camshaft

The cam is forged as one piece with the camshaft.
The diameter of camshaft:

$$D^1 = 0.16\, X\, cylinder\ bore + 12.7$$

The base circle diameter is about 4mm greater than camshaft diameter
Base circle diameter = D^1+ 3
Width of camshaft W^1 = 0.09 x cylinder bore+6
OA = minimum radius of camshaft + (1/2 diameter of roller)

Design of Key

D^1 = 21.82 mm
Width of key w = 0.25 x D^1
Thickness of key t = 0.66w
Length of key l = D+1.5D
Gas pressure = 15.454 N/mm^2
Compression ratio = 10:1
So cylinder pressure and suction pressure is 10 times less than the gas pressure
$P_c = P_s$

Table -01 Material Properties (Alloy Structural Steel case hardened)

S.NO.	Mechanical Properties	Values
1	Young's Modulus	206 GPa
2	Density	7800 Kg/m³
3	Poisson' Ration	0.3
4	Yield Strength	588 MPa
5	Tensile Strength	785 MPa

V. EXPERIMENTAL ANALYSIS

Fatigue and frequency testing of composite material camshaft was performed in ruconser india mumbai to find out fatigue life of camshaft. Following is setup of frequency testing machine shown fig. and also prepared fixture which is used for holding camshaft, which used in fatigue as well as frequency testing machine. Fatigue and frequency testing having conducted.

Fig. 3 Frequency testing machine of camshaft

The following results are observed by experimental analysis:
Table:-

S.No.	Content	Experimental Results
1	Alternating Stress	5.68 MPa
2	Equivalent Stress	11.43 MPa
3	Shear Stress	2.22 MPa
4	Factor of safety	11.7 Min. 15.6 Max.

VI. NUMERICAL ANALYSIS

With the help of ANSYS analysis, calculated the Von- Misses stress and natural frequency of camshaft. This is shown in bellow.

Design of Camshaft

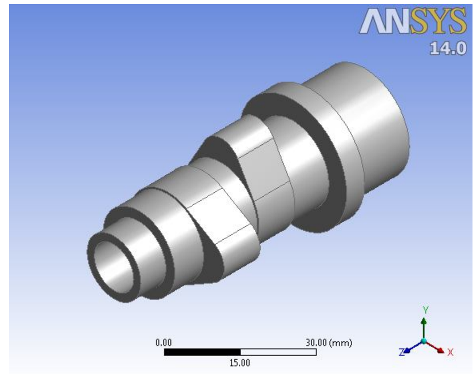

Fig:-5 Design of Camshaft

Mesh of Camshaft

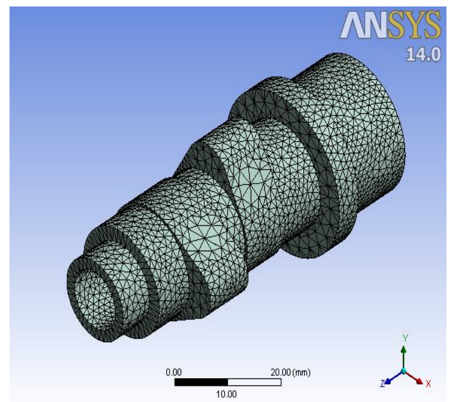

Fig:-6 Mesh of Camshaft

Equvalent alternating stress Results of Camshaft

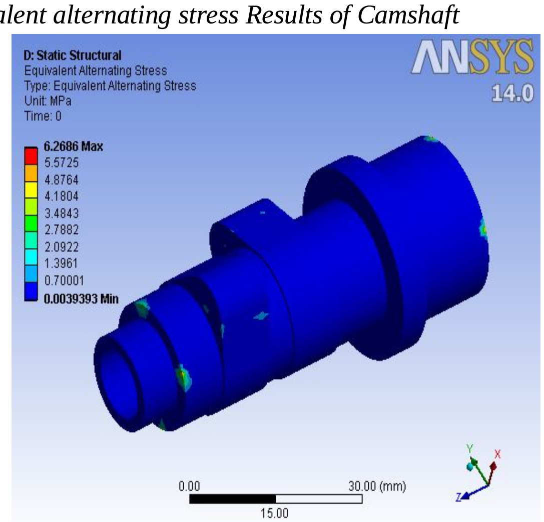

Fig:-7 Equivalent alternating stress of Camshaft

Natural Frequency at different condition results of Camshaft

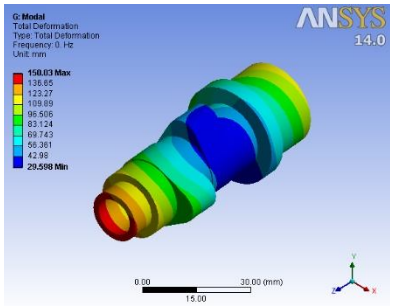

Fig:-8 Frequency of Camshaft

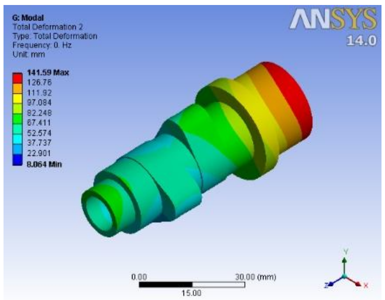

Fig:- 9 Frequency of Camshaft

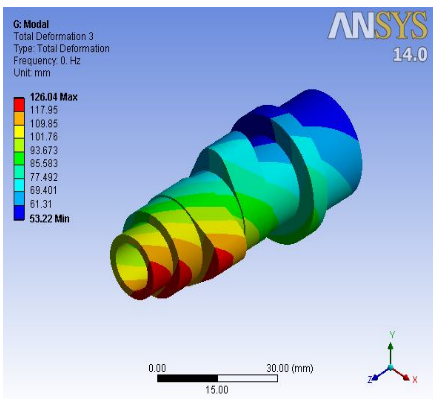

Fig:- 10 Frequency of Camshaft

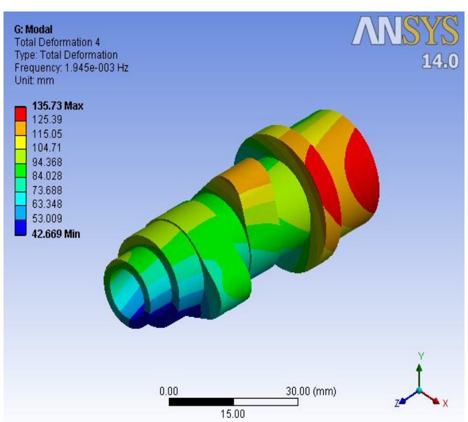

Fig:- 11 Frequency of Camshaft

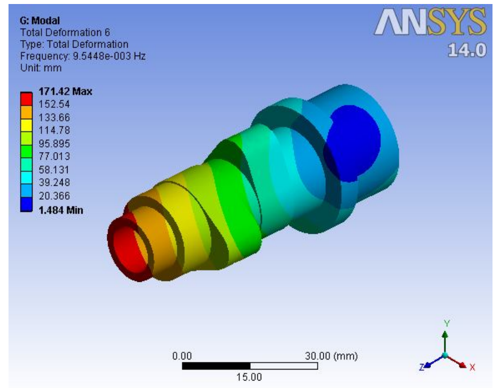

Fig:- 12 Frequency of Camshaft

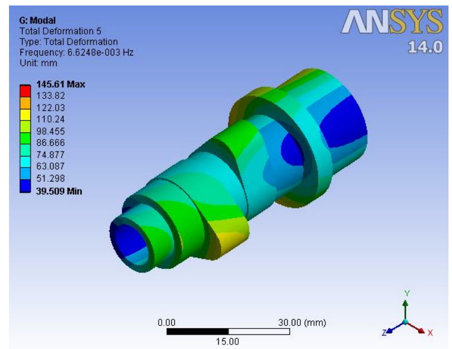

Fig:- 13 Frequency of Camshaft

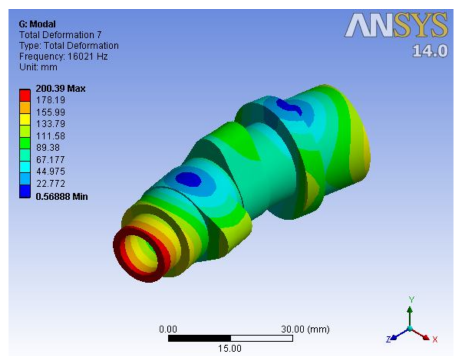

Fig:- 14 Frequency of Camshaft

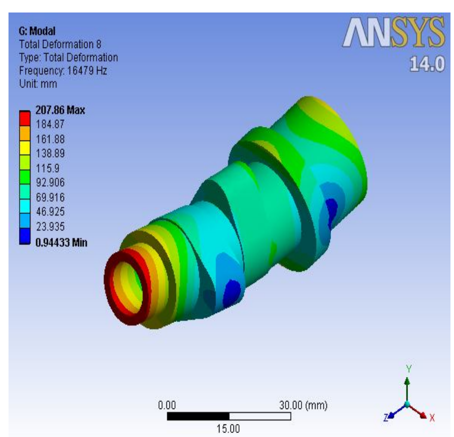

Fig:- 15 Frequency of Camshaft

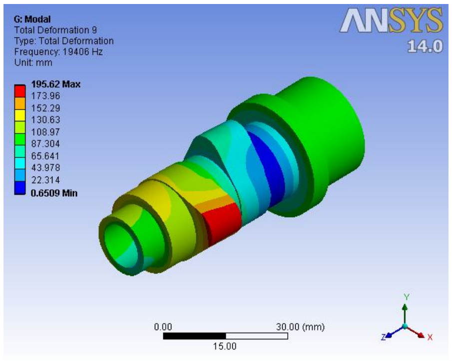

Fig: - 16 Frequency of Camshaft

VII. CONCLUSION

Based on the subject study and the analysis carried out, the conclusions drawn can be summarized as follows:

- It is believed that the high frequency vibrations are resulting due to variable resisting torque induced in the camshaft at 4000 rpm engine speed.
- Determination of natural frequency is important for the understanding of the resonance phenomenon which occurs when the vibration comes in context with the natural frequency. Which is fairly away from the natural frequency of the camshaft i.e. 207.868 Hz; hence the system is safe from resonance.
- The alternating stress calculated using ANSYS module is 6.2686 MPa, and the Goodman criterion

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