International Journal of Science and Modern Engineering (IJISME)
ISSN: 2319-6386, Volume-1 Issue-6, May 2013

Design and Analysis of Camshaft by Changing Parameters which Causes Failure

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Abstract— Camshaft can be defined as a machine element having the curve outlined or a curved grooved, gives the predetermined specified motion to another element called the follower. In automotive field, Camshaft and its follower take importance roles to run the engine. Nowadays the car maker have developed the vary schemes of cam profile to match with the engine performance. Since the system deals with high load and high speed and many analyses have been carried out on the failure of the components. The analysis is done either by experimental or finite element analysis. The result from the finite element analysis is an approximate of the component failure. In the mean time, the software development is improving in this few decades. This project aim determines the stress concentration on the cam and followers during normal operation. More over, this project used the camshaft used in Tata safari dicor 2.2L engine in type. Pro-E wildfire 5.0 and Ansys software are used for determination of stress concentration on the components.. In the analysis, the typical values for coefficient of friction, materials, and spring rate are used. The result from finite element analysis showed that the maximum stress concentration occurred at camshaft that leads to the failure of the component. Value for maximum stress is over the allowable stress or rocker arm material. Other components are approximately safe where the maximum stress is not over the allowable stress for components.

Index Terms-Cams and followers; engine speed; failure of camshaft; materials; valves

I. INTRODUCTION

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. On the other hand, simultaneously the most serious, under cyclic bending and torsion, fatigue fracture of camshaft initiating at stress concentration easily occurs. Therefore it demands the camshaft has not only excellent wear resistance but also adequate anti-impact toughness.[1]

Manuscript received May 01, 2012. (Fill up the Details)
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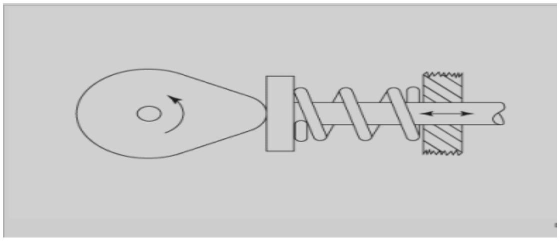

Fig.1: Working of Cam

II. OBJECTIVE

i) Analysis of camshaft by changing parameters due to which failure occur.
ii) Alternatively apply the parameters on camshaft.
iii) Analysis of results and select the best result.

III. PARAMETERS WHICH CHANGE

From the literature review, it is concluded that, there are various factors which causes failure of camshaft. Some factors of these are material properties, load/ force on the camshaft, engine speed and engine temperature. In this project, we are changing these four parameters. The alternates of the above parameters are to be selected first. The maximum load on the camshaft is calculated, it is 5000 N and other two ranges of loads below the maximum limit is taken (it is 3500 N and 2000 N). Load on the camshaft can also be decided from the engine speed. For 3500 N, engine speed is near about 1630 RPM and for 2000 N it is 1250 RPM.

Another parameter is material. Generally cast iron or steel are used for the manufacture of camshaft. But the heat flux rate of this material is very low and it may causes deformation of camshaft. For this aluminium alloy is selected for project. There are four material, aluminium alloy, gray cast iron, forged steel and structural steel. The maximum temperature of any 2200 cc engine is near about 600^0 C. So it is taken as maximum temperature and other two temperatures are 430^0C and 250^0C.[3]

IV. DESIGN PROCEDURE OF SHAFT

Camshaft is subjected to bending stresses, so the design procedure of shaft subjected to bending is applied.[2]
We know that,

$$\frac{M}{I} = \frac{\sigma_b}{y} \quad \text{.................................. (1)}$$

Where, M = Bending moment,
I = M I of cross sectional area of the shaft about axis of rotation,

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σ_b= bending stress,
y = distance from NA to outer most fibre
M I of solid shaft,

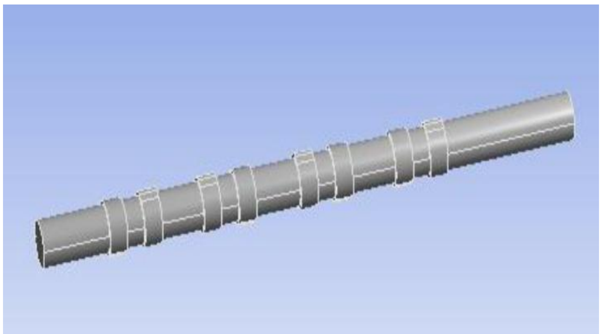
$$I = \frac{\pi}{64} d^4$$

$$y = \frac{d}{2}$$

Equation (1) becomes,

$$\frac{M}{\frac{\pi}{64} d^4} = \frac{\sigma_b}{\frac{d}{2}}$$

$$M = \frac{\pi}{32} \times \sigma_b \times d^3$$



V.LOAD CALCULATION

From the actual road test it is calculated that, the maximum load on the camshaft is 5000 N.
It is calculated by following available data,
Actuating length/ height of the valve, h = 0.05 m
Loading spring stiffness, $k_s = 1.0 \times 10^5$ N/m
Peak loading force, $F = h \times k_s$
$F = 0.05 \times 1.0 \times 10^5$
$\boldsymbol{F = 5000\ N}$

VI. RELATION BETWEEN ENGINE SPEED AND CAMSHAFT LOAD

Generally camshaft is manufactured by gray cast iron. Mass of the camshaft made up of gray cast iron is 5.9234 kg. The maximum load on the camshaft is during the engine speed of 1000 RPM to 2200RPM, because this is the initial stage of vehicle to move and acceleration is high.[6]

AT 1250 RPM:

$$\text{Frequency, } \eta = \frac{engine\ speed}{60}$$

$$\eta = \frac{1250}{60} = 20.83 \text{ Hz}$$

$$\omega = 2\pi \times \eta$$

$$\omega = 2\pi \times 20.83 = 130.87\ rad/s$$

$$F = m\omega^2 r$$

$$F = 5.9234 \times 130.87^2 \times 0.02$$

$$\boldsymbol{F = 2028.99\ N}$$

Approximately it is taken as 2000 N.

AT 1650 RPM:

$$\text{Frequency, } \eta = \frac{engine\ speed}{60}$$

$$\eta = \frac{1650}{60} = 27.5 \text{ Hz}$$

$$\omega = 2\pi \times \eta$$

$$\omega = 2\pi \times 27.5 = 172.78\ rad/s$$

$$F = m\omega^2 r$$

$$F = 5.9234 \times 172.78^2 \times 0.02$$

$$\boldsymbol{F = 3536.61\ N}$$

Approximately it is taken as 3500 N.

AT 1950 RPM:

$$\text{Frequency, } \eta = \frac{engine\ speed}{60}$$

$$\eta = \frac{1950}{60} = 32.5 \text{ Hz}$$

$$\omega = 2\pi \times \eta$$

$$\omega = 2\pi \times 32.5 = 204.20\ rad/s$$

$$F = m\omega^2 r$$

$$F = 5.9234 \times 204.20^2 \times 0.02$$

$$\boldsymbol{F = 4939.83\ N}$$

Approximately it is taken as 5000 N.

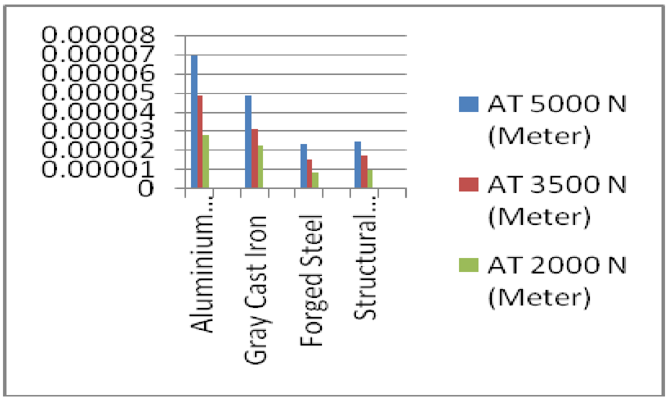
VII. RESULTS

Following results are obtained by applying all the parameters on the CAD model in ANSYS software.

Total deformation:

Load	AT 5000 N	AT 3500 N	AT 2000 N
Unit	(Meter)	(Meter)	(Meter)
Al. Alloy	0.0000695	0.0000486	0.0000277
Gray C. I	0.0000488	0.0000314	0.0000224
Forged Steel	0.0000233	0.0000156	0.0000893
Structural Steel	0.0000245	0.0000172	0.0000987

Graphical representation:

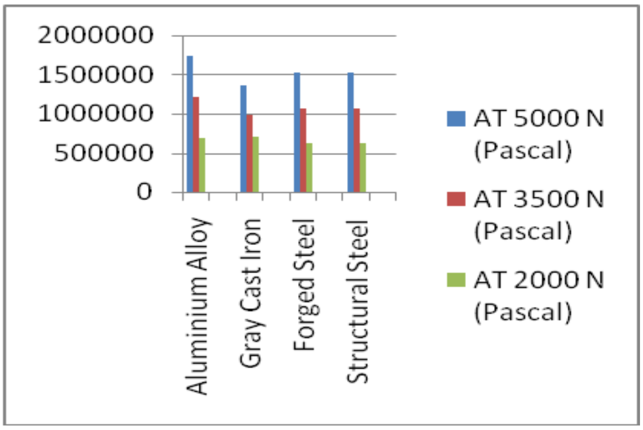


Maximum shear stress:

Load	AT 5000 N	AT 3500 N	AT 2000 N
Unit	(Pascal)	(Pascal)	(Pascal)
Aluminium Alloy	1730000	1210000	693000
Gray Cast Iron	1360000	985000	703000
Forged Steel	1530000	1070000	615000

Structural Steel	1520000	1070000	615000

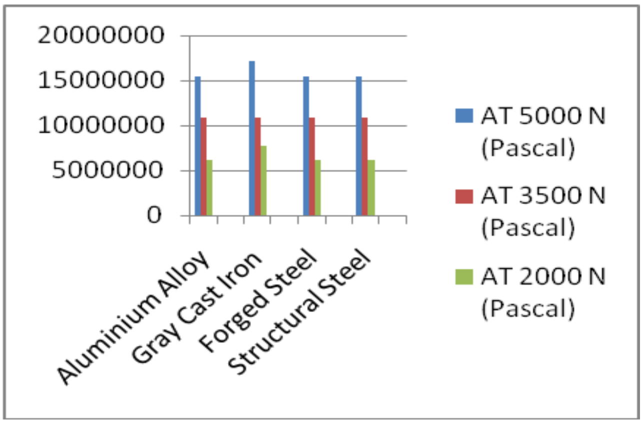
Graphical Representation:



Maximum equivalent stress:

Load	AT 5000 N	AT 3500 N	AT 2000 N
Unit	(Pascal)	(Pascal)	(Pascal)
Aluminium Alloy	15400000	10800000	6180000
Gray Cast Iron	17200000	10900000	7780000
Forged Steel	15500000	10800000	6210000
Structural Steel	15500000	10800000	6210000

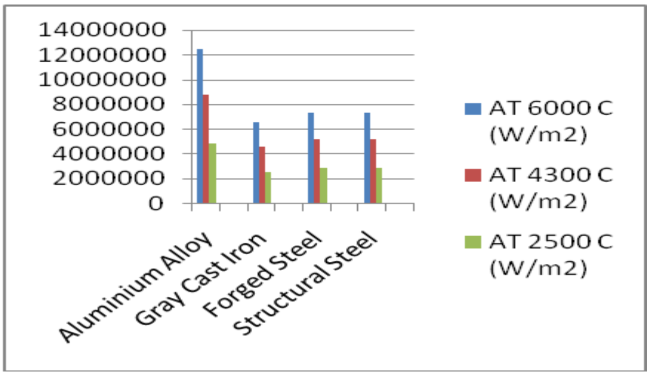
Graphical Representation:



Maximum Heat Flux:

Temp.	AT 600^0 C	AT 430^0 C	AT 250^0 C
Unit	(W/m^2)	(W/m^2)	(W/m^2)
Aluminium Alloy	12500000	8770000	4850000
Gray Cast Iron	6590000	4650000	2590000
Forged Steel	7380000	5210000	2910000
Structural Steel	7380000	5210000	2910000

Graphical representation:



VIII. CONCLUSION

From the above results obtained and graphical representation of the results, it is concluded that, maximum heat flux rate in the aluminium alloy as compare to other materials and it is good when we think about only heat flux rate. But the values of shear stress and total deformation is also very high in aluminium alloy and it is not good, these values should be low.

Shear stress is the main factor in the design consideration of camshaft. From the above four materials, the values of shear stress in gray cast iron is minimum. And the value of total deformation is low in forged steel.

The maximum values of shear stress and total deformation is obtained at maximum load i.e. 3500N to 5000N. This load is obtained at initial/ starting stage of the vehicle (1650 to 1950 RPM). So it is recommended that, the vehicle should cross this range of engine speed as early as possible and the gray cast iron is the best material for manufacturing of camshaft.

ACKNOWLEDGMENT

I would like to expresses my gratitude to the many people who have assisted me during the course of this research. Special thanks must go to my guide Prof. T. C. PARSHIWANIKAR for their continued support, guidance and friendship.

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