FRACTURE, FATIGUE GROWTH RATE AND VIBRATION ANALYSIS OF CAMSHAFT

Dr.K.VASANTHA KUMAR Associate professor and head, Department of Mechanical Engineering, JNTUHUCEJ, Telangana

Y.AKHIL KUMAR*, AKULADEEPCHANDER MTECH, Department of Mechanical Engineering, JNTUHUCEJ, Telangana **Email: akhilsunny060@gmail.com**

ABSTRACT

In automobile Two valves are played important role in opening and closing by the camshaft, which drives the power from the crank shaft with the help of gears and it companion components like push rods rocker arms, value springs and tappet are some of the related value timing. These values are represent by one of the numerous oblong lobes that protrudes from a cylinder rod that runs entire length of the cylinder blank. These cam lobe rotates, which press or some other intermediate mechanism to force the value to open and ignition system also driven by this camshaft. In this work, a camshaft for a multi-cylinder engine is designed, and the camshaft's 3D model is produced using the modelling programme CREO and Imported into ANSYS. After completing the element parameters, meshing, and restrictions, the loads are applied to the camshaft for three different materials, starting with 1.SS 316. 2. C55 Mn15. 3. Alloy steel with Ni, Cr, and Mo. 4. EN24T 5. Malleable cast iron to calculate the displacement and equivalent stress of the cam shaft.

1. INTRODUCTION

a shaft with one or more cams attached to it, such as the camshaft used to regulate the valves of an internal combustion engine. The engine's "brain" is referred to as the cam shaft.

The camshaft is perhaps the most complicated part of an internal combustion engine, and very few people are genuinely aware of how they operate. The camshaft's job is to regulate valve timing, making sure that the engine's fuel and air intake and exhaust valves open and close at the appropriate times. The camshaft's eccentric bumps' sizes, shapes, and locations ensure that the engine runs smoothly. Despite its intricacy, camshaft terminology as shown in figure1 is simple to understand when it is digested in small chunks.

Since Nikolaus Otto created the first successful four-stroke engine in 1876, camshafts have been a part of internal combustion engines. Over 100 million cars are currently on the road, and every single one of them uses a camshaft to provide the power required to move. Throughout history, the location of the camshaft within the engine has altered a great deal. The pushrod and the overhead camshaft are currently the most prevalent design types. A pushrod engine with the camshaft below and to the side of the combustion chamber is depicted this configuration, the camshaft rotates rocker arms, which rotate pushrods, which rotate lifters, which open the appropriate valve.

1.1 CAM TERMINOLOGY

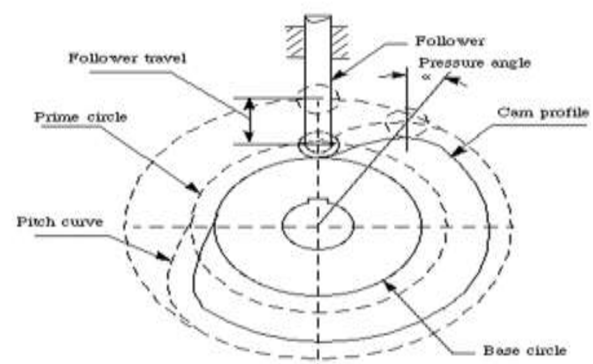

Figure1 cam terminology

1.2 CAMSHAFT'S FAILURES

Dry Camshaft Wear: The weight losses of the samples were used to calculate the dry camshaft wear as a function of the load and test time. During the wear, a level sensor recorded the variation in camshaft profile. Throughout the experiments, a computer screen displayed a constant display of the profile variation. A shift in the cam surface's wear processes along the contact surface was discovered. Just near the cam tip did the maximum wear value come about.

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When the payload's motion cannot be consistently repeated because of wear to the cam at the contact surface between the cam and the cam-follower, the cam is said to have failed.

Cam and cam-followers can fail in a number of ways. The main modes of failure are

Each failure mode has a 'failure mechanism'. There are desirable material properties to prevent each failure mode.

2.LITERATURE REVIEW

Ansari et al in 2017 [1] carried out a finite element structural analysis of a car's camshaft. They used ANSYS for stress, strain, and deformation analysis, as well as Pro-E and CAE tools for geometric modelling of the camshaft assembly. According to the findings, which were based on the deformation and stress produced, aluminium metal matrix composites are a good material for camshaft assembly.

Bongale and Kapilan et al in 2016 [2] conducted a finite element analysis of the camshaft assembly in both static and dynamic modes. They modelled the geometry in the Solid Edge programme before using Hyper mesh to mesh the camshaft assembly. They built an assembly with a two-lobe camshaft and used BS-EN-10025 material for their analysis. Two scenarios—one involving self-weight and the other involving external stress—were analysed.

Perez et al in 2015 [3] completed the task analysis and ergonomics evaluation of the camshaft production operation in a business in Mexico's central area. The researcher conducted an ergonomics analysis while plant employees worked on the CNC machine. They did the site and employee visual inspection and video recording.

MATERIALS	SS316	Ni Cr Mo alloy steel	C55 Mn15	Malleable cast iron	EN 24T
DENSITY Kg/m3	8000	8200	7800	7450	7850
MODULUS OF ELASTICITY (MPa)	193000	210000	215000	165000	225630
POSSION RATIO	0.28	0.3	0.3	0.27	0.29
YIELD STRENGTH (MPa)	290	687	490	230	680
MAX TENSILE STRENGTH (MPa)	580	932	850	620	950

Kumar et al in 2015 [4] employed finite element analysis to look at the vibration of the camshaft. Over the duration of their work, they concentrated their research on analysing the vibrations that various camshafts created. Additionally, materials with less natural frequency and little effect on engine performance were sought after. Numerous materials are taken into account by them, such as chilled cast iron, billet steel, EN24, and EN8D. They considered the loads originating from the engine cylinder, spring pressure, gas pressure, and valve-trains in order to calculate the overall deformation created in the camshaft.

Chanagond and Raut et al in 2015 [5] By maximising its surface contact area, the roller cam finite element analysis was carried out. They focused their research on minimising the friction that develops between the cam and roller. In order to reduce the amount of friction between the cam and roller, some modifications have been made to the cam roller assembly to convert the line contact into a point contact in order to reduce the amount of friction generated in the assembly. In general, there is a line contact between the cam and roller that increases friction and decreases the efficiency of the engine.

Ramadhas et al in 2015 [6**]** The dynamic study of the cam and follower was performed using finite element analysis. Using the FEA programme ANSYS. they examined the cylindrical cam and follower arrangement under low-speed conditions. During a packing assembly, the cam and follower assembly was examined both statically and dynamically. They investigate the vibration and impact forces that are present during the process using modal analysis.

3.OBJECTIVES

The main objective is to Model and Analysis of camshaft for 6cylinder IC engine.

1. The camshaft for a six-cylinder IC engine is modelled in the modelling programme CRE0 using existing dimensional specifications.
2. By altering angular velocity, force, and torques with respect to time, dynamic analysis is performed. Analysis of total deformation, strain, and stress distribution for various camshaft materials.
3. A camshaft is subjected to a mode analysis to examine the natural frequency with regard to time.

Dynamic and modal analysis is done on 6cylinder camshaft in simulation software ANSYS

Further comparing the simulation results with theoretical values. To find the best suited material for 6cylinder camshaft.

3.1 MATERIALS USED FOR CAMSHAFT

Table 1 showing properties of material

Camshaft material is the most important detail in stopping premature wear of performance camshafts.

Due to the material's through-hardening properties, it was primarily employed between 1930 and 1945 and is still used today for induction-hardened camshafts used with roller cam followers. It works best when driven against a cooled cam follower and is used by British Leyland in the A Series and B Series engines. which steel is ideal for

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camshafts. It acquires a surface hardness and polish similar to cold iron after being nitrided.
In this present work replacing the above materials with
1.SS 316.
2. C55 Mn15.
3.Ni Cr V Mo alloy steel.
4. EN24T
5.Malleablecast iron
Table: material properties data

3.2 ENGINE SPECIFICATIONS

In this paper used the tata cummins engine for the design and analysis of camshaft.in this engine 5880cc,power output 160 kw,compression ratio 17.5:1,crank shaft speed 3200rpm and torque 597Nm.

These are the specifications of the engine used in this project.

Table 2 showing the dimensional data of camshaft

DIMENSIONAL DATA	
specifications	Units in mm
Length of camshaft	745
Diameter of camshaft	47.5
Diameter of bearing	87.5
Length of bearing l1	30
Diameter of roller d	8
Diameter of cam d	63.5
Thickness of Cam lobe	20
Lift of cam lobe L	11

According to the the table2 dimensional data used for designing of camshaft in this project. These dimensions taken from the practical working condition of the IC engine.

4. MOELING AND ANALYSIS OF CAMSHAFT

The modelling of camshaft as shown in the figure 2 design in Creo parametric CAD software. These are designed according the above calculation.

Figure 2 showing cam shaft

The ANSYS Workbench environment is an intuitive up-front finite element analysis tool that is used in conjunction with CAD systems and/or Design Modeler. ANSYS Workbench is a software environment for performing structural, thermal, and electromagnetic analyses. The class focuses on geometry creation and optimization, attaching existing geometry, setting up the finite element model, solving, and reviewing results. The class will describe how to use the code as well as basic finite element simulation concepts and results interpretation.

4.1 MESHING

According to the figure 3 showing the meshing in camshaft model in the ansys software.these meshing used for obtaining the finite result in the ansys.

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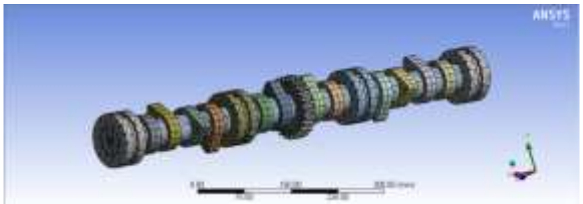

Figure 3 showing meshing in ANSYS

4.2 BOUNDARY CONDITION

According to the figure 4 showing the boundary conditions of the camshaft are displacement, cylindrical support and pressure. These colours are indicate the location of the boundary condition.

Figure 4 showing boundary and load conditions

4.3 EQUIVALENT (VON MISES) STRESS

According to the figure5 showing the von mises stress in the camshaft model in the ansys software.in these maximum equivalent (von mises) stress is 16.585Mpa and minimum equivalent (von mises) stress is 0.0078Mpa

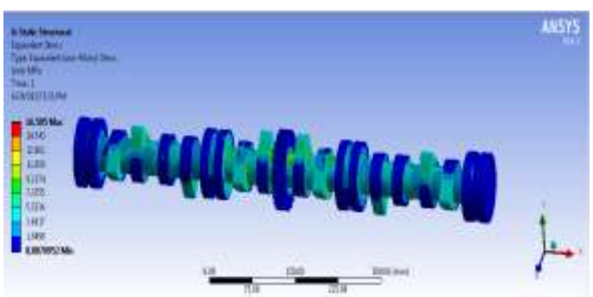

Figure 5 showing von mises stress

VON MISES STRAIN

According to the figure 6 showing the von mises strain in the camshaft model in the ansys software.in these maximum equivalent (von mises) strain is 8.36e-5 and minimum equivalent (von mises) strain is 1.3389e-7.

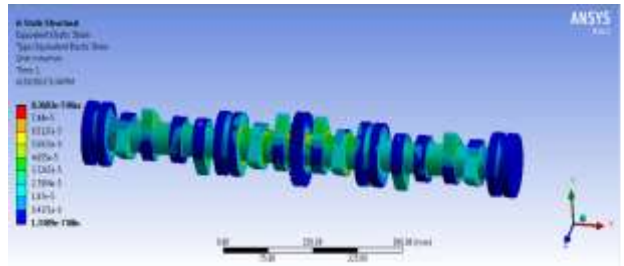

Figure 6 showing von mises strain

TOTAL DEFORMATION

According to the figure7 showing the maximum deformation in the camshaft model in the ansys software.in this maximum deformation 0.01mm and minimum deformation 0 mm.

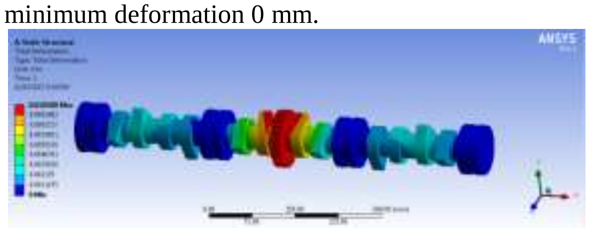

Figure 7 showing total deformation

5. FATUIGE ANALYSIS OF CAM SHAFT

Fatigue analysis is the structural evaluation of a system's susceptibility to failure under cyclical pressures. Software for analysing fatigue behaviour under cyclic loads is widely available. Cycled loading on a material causes the progressive and localised structural degradation known as fatigue. A crack that propagates under high-stress concentrations that cycle often could eventually cause leaks. The name of this failure mechanism is fatigue.

5.1.1 Fatigue Analysis Methods

Any of the two techniques indicated below used to do a fatigue analysis.

- Fatigue analysis using the Stress-Life (S-N) or S-N technique
- The Local Strain or Strain-Life (e-N) fatigue analysis technique

In the piping business, the S-N method of fatigue analysis is quite well-liked. The S-N curve is used as input by the Caesar II programme, which then compares the piping

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stresses with it to produce a safe time limit before failure as a result of fatigue study.

LIFE

According to the figure 8 life of a camshaft in the ansys software.in this maximum life of the camshaft 1e9 and minimum life of camshaft 1.4e7.

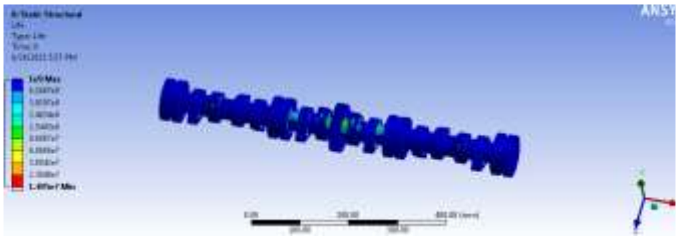

Figure 8 showing life of camshaft

DAMAGE

According to the figure 9 damage of a camshaft in the Ansys software. Damage is 66.892.

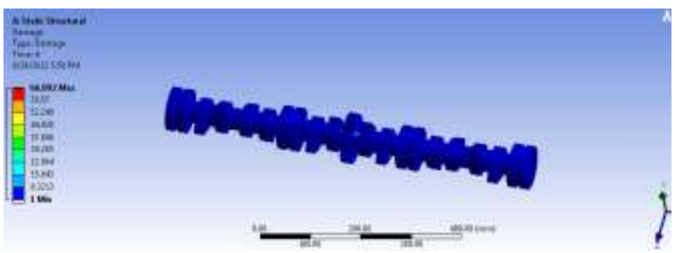

Figure 9 showing damage of camshaft

SAFTEY FACTOR

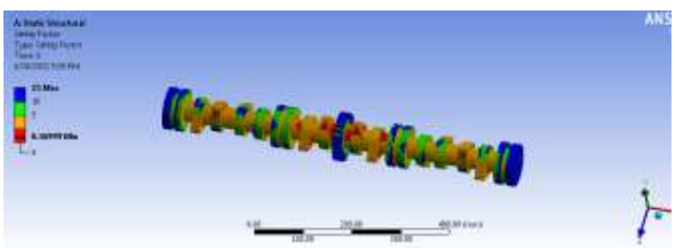

Figure 10 showing safety factor

MODAL ANALYSIS

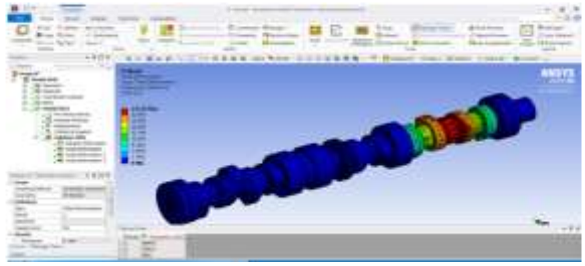

Figure 11 deformation and natural frequency for EN24T

5.1.2 DYNAMIC ANALYSIS

VON MISES STRESS

According to the figure 12 showing the von mises stress in the camshaft model in the ansys software.in these maximum equivalent (von mises) stress is 17.66 Mpa and minimum equivalent (von mises) stress is 0.006Mpa.

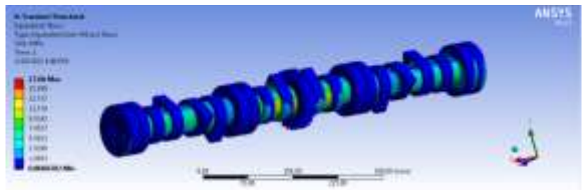

Figure 12 showing von mises stress

VON MISES STRAIN

According to the figure 13 showing the von mises strain in the camshaft model in the ansys software.in this maximum equivalent (von mises) strain is 9.21e-5mm and minimum equivalent (von mises) strain is 1.1e-7mm.

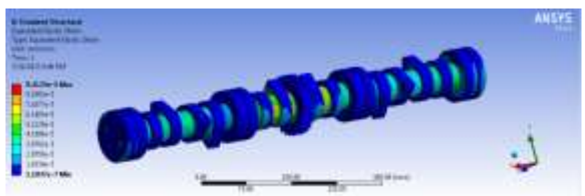

Figure 13 von mises strain

TOTAL DEFORMATION

According to the figure14 showing the maximum deformation in the camshaft model in the ANSYS software.in this maximum deformation 0.07mm and minimum deformation 0 mm.

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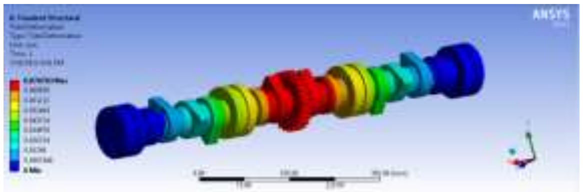

Figure 14 total deformation

7. RESULTS AND DISCUSSIONS

Material	Deformation (mm)	Stress (N/mm^2)	Strain
Ss316	0.078103	17.66	9.21e-5
C55Mn15	0.1459	18.461	0.00016901
Nickel chromium molybdenum alloy steel	0.14278	18.321	0.0001669
Malleable cast iron	0.13736	17.539	0.0016056
EN24T	0.01058	16.585	8.3683e-5

Table: stress, strain and deformation at 1.54MPa pressure

Following simulations that simply take into account pressure, various stress, strain, and deformation values are generated for the aforementioned materials. when comparing simulation results against one another. Less levels of stress, strain, and deformation are found for EN24T material.

Modal analysis

Material	Mode shapes	Frequency (Hz)
Ss316	1	3584.1
	2	3591.8
	3	5732.5
C55Mn15	1	3840.6
	2	3848.9
	3	6081
Nickel chromium vanadium molybdenum alloy steel	1	3702
	2	3709.9
	3	5861.5
Malleable cast-iron	1	3430.2
	2	3437.5
EN24T	1	3694.8
	2	3705.7
	3	6851

After consideration of cylindrical support and displacement during the modal analysis. For the materials mentioned above, natural frequency is produced at three distinct mode values. while contrasting the results of the simulation. More natural frequency is obtained for EN24T material.

From the results of the dynamic, fatigue, and modal analyses, we may infer that EN24T material is the best, thus this material is further compared to values that have been theoretically determined.

Fatigue analysis results

Material	Life	Damage	Safety factor
Ss316	8.44e+06	118.01	0.311
C55Mn15	9.25e+06	107.89	0.32102
Nickel chromium molybdenum alloy steel	1.018e+07	98.209	0.33035
Malleable cast iron	1.261e+07	79.277	0.35209
EN24T	1.495e+07	66.892	0.36999

CONCLUSION

In this thesis, dynamic, fatigue, and modal analyses for a modelled 6-cylinder IC engine camshaft are performed in ANSYS for various materials. Based on the results of this work, the following conclusions can be drawn: By comparing the results of dynamic analysis for various

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materials, EN24T material has the lowest stress value, and by comparing the results of modal analysis for various materials, EN24T material has the highest natural frequency.

Finally, figures from EN24T material simulation simulation stress and factor of safety are compared to values determined theoretically. The stress value obtained by simulation is lower than the theoretically calculated value, while the safety factor is higher than the theoretical value.

Therefore, it follows that the EN24T material is also the ideal choice for the camshaft of a six-cylinder IC engine from the foregoing arguments.

REFERENCES

[1] Anwar M. and Z. Ansari Finite Element Structural Analysis of an Automobile Camshaft, International Journal for Research in Applied Science & Engineering Technology, Vol. 5, Number 2, pages 464–468.
[2] Finite Element Analysis for Static and Rotor Dynamic Camshaft Analysis by Bongale and Kapilan, International Journal for Ignited Minds, Vol. 3, Number 6, pages 102–109
[3] J. N. S. Perez and J. L. H. Arellano Task Analysis and Ergonomic Evaluation in Camshaft Production Operations, Procedia Manufacturing, Vol. 3, pp. 4244-4251.
[4] Goyal A., Barmola A., Kushwaha N., and Kumar D and Singha S. (2015), "Vibration Analysis of The Camshaft Using Finite Element Method," 10–11 April 2015, National Conference on Knowledge, Innovation in Technology and Engineering, pp. 251-254.
[5] Finite Element Analysis of Roller Cam by Optimisation of Surface Contact Area, Chanagond A. G. and Raut L. B., International Journal of Advanced Engineering Research and Studies, Vol. 4, Number 2, pages 5–6.
[6] 2015, "Dynamic Analysis of a Cylindrical Cam and Follower Using Finite Element Analysis," International Journal on Recent Technologies in Mechanical and Electrical Engineering, Vol. 2, Issue 4, pp. 46–53. Ramadhas R., Boopathi S. V., and Dinesh K. R.
[7] Contact Fatigue Analysis Using Finite Element Analysis for 6 Station 2 Lobe Cam Shaft, Indian Journal of Applied Research, Vol. 4, Issue 7, pp. 185-187, Suhas K. S. and Haneef M., 2014.
[8] Manufacturing of PMMA Cam Shaft by Rapid Prototyping by Jaiganesh V., Christopher A. A., and Mugilan E., Procedia Engineering, Vol. 97, pp. 2127–2135, 2014.
[9] Vibration Analysis of The Camshaft Using Finite Element Method, National Conference on Knowledge, Innovation in Technology and Engineering, 10-11 April 2015, pp. 251-254. Kumar D., Goyal A., Barmola A., Kushwaha N., and Singha S.
[10] Design and Analysis of Camshaft, 11th IRF International Conference Proceedings, 15 June 2014, Pune, India. Thorat S. G., Dubey N., Shinde A., Fulpagare P., and Suryavanshi M.

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