Design and Evaluation of Camshaft Used in Multi Cylinder Engine

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Abstract: The camshaft is driven by the crankshaft through timing gears cams are made as integral parts of the camshaft and are designed in such a way to open and close the valves at the correct timing and to keep them open for the necessary duration. A common example is the camshaft of an automobile, which takes the rotary motion of the engine and translates it into the reciprocating motion necessary to operate the intake and exhaust valves of the cylinders. In this work, a camshaft is designed for multi cylinder engine and 3D-model of the camshaft is created using modeling software CATIA. The modeled in CATIA is imported in to ANSYS. After completing the element properties, meshing and constraints the loads are applied on camshaft for three different materials namely SS 316, C55 Mn15, NiCrVMo alloy steel, and EN24T 5. Malleable cast iron to determine the displacement, equivalent stress of the cam shaft.

Keywords: camshaft, CATIA, Ansys, SS316, C55 Mn15, alloy steel and EN24T 5.

I. INTRODUCTION

A projection on a rotating part in machinery, designed to make sliding contact with another part while rotating and to impart reciprocal or variable motion to it. Cams are used to convert rotary motion into reciprocating motion. A shaft with one or more cams attached to it, e.g., working of valves in an internal combustion engine is controlled by camshaft. Cam shaft is called the “brain” of the engine. The camshaft is arguably the most complex component in an internal combustion engine and very few people know how they actually work. The function of the camshaft is to control the valve timing, ensuring that the valves open and close at the proper time to allow fuel and air to enter and exit the engine. The size, shape, and placement of all the eccentric bumps on the camshaft make the engine operate properly. Despite the complexity, camshaft terminology can be easily understood when absorbed in small pieces. This description will explain the basic principles of camshafts and the effects they have on overall engine performance.

1.1 Materials used in camshaft

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

There are various materials that camshafts are manufactured from:

Cast Iron

Hardenable iron:

This is Grade 17 cast iron with an addition of 1% chrome to create 5 to 7% free carbide. After casting, the material is flame/or induction hardened, to give a Rockwell hardness of 52 to 56 on the C Scale. It is not the most suitable material for performance camshafts in overhead cam (OHC) engines. Spherical Graphite Cast Iron Known as Sg Iron: A material giving similar characteristics to hard enable. Its failing as a camshaft material is hardness in its cast form, which tends to scuff bearings in adverse conditions. The material will heat treat to 52 to 58 Rockwell. This material was used by Fiat in the1980’s

Chilled Chrome Cast-iron:

Chilled iron is Grade 17 cast iron with 1% chrome. When the camshaft is cast in the foundry, machined steel moulds the shape of the cam lobe is incorporated in the mould. When the iron is poured, it hardens off very quickly (known as chilling), causing the cam lobe material to form a matrix of carbide (this material will cut glass) on the cam lobe. This material is exceedingly scuff-resistant and is the only material for producing quantity OHC performance camshafts.

Nickel-Chromium-Molybdenum-Vanadium Alloy Steel: Chromium, molybdenum and cobalt-based alloy with outstanding strength and corrosion resistance, MP35N is ideal for applications in the aerospace, marine, chemical, and medical fields.

1.2 Applications of Cam Shaft

Cams are widely used in automation of machinery, gear cutting machines, screw machines, printing press, textile industries, automobile engine valves, tool changers of machine centers, conveyors, pallet changers, sliding fork in warehouses etc.

Cams are also used in I.C engines to operate the inlet valves and exhaust valves. The cam shaft rotates by using prime movers. It causes the rotation of cam. This rotation produces translator motion of tappet against the spring. This translator motion is used to open or close the valve.

II. LITERATURE REVIEW

Prof. H.D.Desai Prof. V.K.Patel, et, al "Computer Aided Kinematic and Dynamic Analysis of Cam and Follower", the analysis of anything other than a simple configuration can be quite complex. The analysis will depend upon the type of follower and the detailed geometry. Because of these difficulties with the analysis, it was common for accelerations to be determined graphically.

KhinMaung Chin, et al " Design and Kinematics Analysis of Cam-Follower System" & Dr. David J Grieve, "Forces in the Valve Train of an Internal Combustion Engine", they will make some simplifying assumptions that a knife edge follower is being used. This will not be very accurate, but will give some idea of values.

A. Rivola, M. Troncossi, G. Dalpiaz and A. Carlini, et al "Elastodynamic analysis of the desmodromic valve train of a racing motorbike engine by means of a combined lumped/finite element model" if a rocker has a ratio of 1.5:1, it should open the valve 1.5 times the amount of the cam lift. Almost all factory type rockers fall short of their claims. Chevy claims a 1.5:1 rocker ratio on small-blocks, I found that most are 1.44:1 and under. In a healthy street motor .020" less valve lift could mean a 10 to 15 hp power loss. So, make sure that the rockers that you choose are from a reputable company. I've had good luck with Crane Cams, Iskenderian, and Competition Cams.

Yuan L. Lai, Jui P. Hung, and Jian H. Chen, et al “Roller Guide Design and Manufacturing for Spatial Cylindrical Cams", he assumes that the cam is opening and closing the valve for 120o of its rotation. Hence the complete valve cycle is completed in 1/3 camshaft revolution, or 0.01 sec.

III. Problem Description

Camshafts are rotating components with critical loads. Hence the determination of exact load values becomes the challenging one compared with other rotating members. This project provides the guidelines to solve such situation.

- The objective is to design cam shaft analytically and analyze the stress distribution on the cam shaft for static, dynamic at different materials.
- Analyze the frequency on the camshaft for modal analysis.
- Estimate the life of the cam shaft for fatigue analysis.

IV. CAD and CATIA

Throughout the history of our industrial society, many inventions have been patented and whole new technologies have evolved. Perhaps the single development that has impacted manufacturing more quickly and significantly than any previous technology is the digital computer.

CATIA (an acronym of computer-aided three-dimensional interactive application) is a multi-platform software suite for computer-aided design (CAD), computer-aided manufacturing (CAM), computer-aided engineering (CAE), PLM and 3D, developed by the French company Dassault Systems. CATIA started as an in-house development in 1977 by French aircraft manufacturer AVIONS MARCEL DASSAULT, at that time customer of the CADAM software to develop Dassault's Mirage fighter jet. It was later adopted by the aerospace, automotive, shipbuilding, and other industries.

CAMSHAFT DIMENSIONS:

Width of Cam = 19 mm

Camshaft diameter = 28.75 mm

Journal diameter = 51 mm

Height of Cam = 41.3 mm

Base circle diameter = 33.65 mm

Total lift of cam = 7.65 mm

3D MODEL OF CAMSHAFT

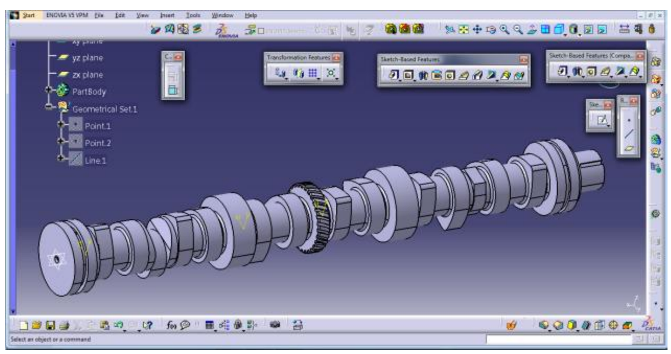

Fig.1. 3D Model of Camshaft

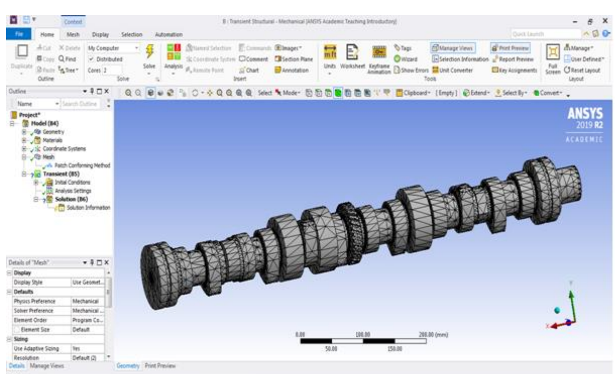

Fig. 2. Meshed model.

V. FINITE ELEMENT METHOD

Finite Element Method (FEM) is also called as Finite Element Analysis (FEA). Finite Element Method is a basic analysis technique for resolving and substituting complicated problems by simpler ones, obtaining approximate solutions Finite element method being a flexible tool is used in various industries to solve several practical engineering problems. In finite element method it is feasible to generate the relative results. ANSYS is an Engineering Simulation Software (computer aided Engineering). Its tools cover Thermal, Static, Dynamic, and Fatigue finite element analysis along with other tools all designed to help with the development of the product. The company was founded in 1970 by Dr. John A. Swanson as Swanson Analysis Systems, Inc. SASI. Its primary purpose was to develop and market finite element analysis software for structural physics that could simulate static (stationary), dynamic (moving) and heat transfer (thermal) problems

ANALYSIS OF CAMSHAFT

Deformation

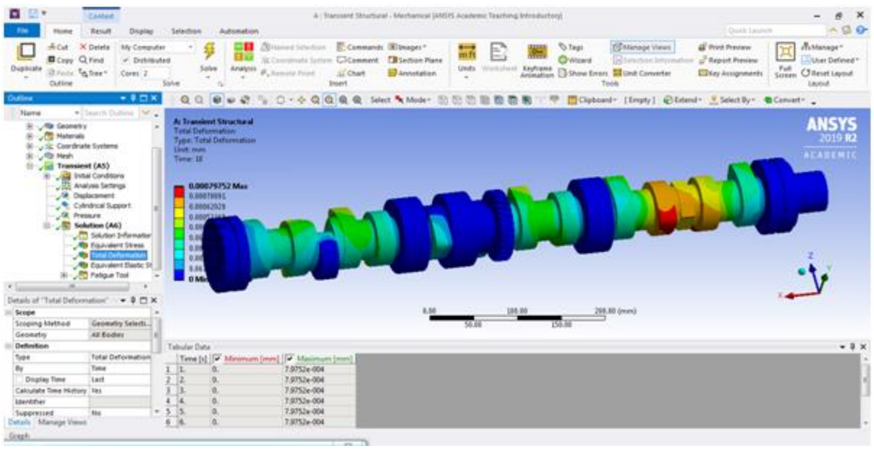

Fig. 3. Deformation of the camshaft.

According to the result Fig. 3. the maximum deformation at middle of the cam shaft its indicated red color and minimum deformation at both ends of the cam shaft its indicated blue color.

Stress

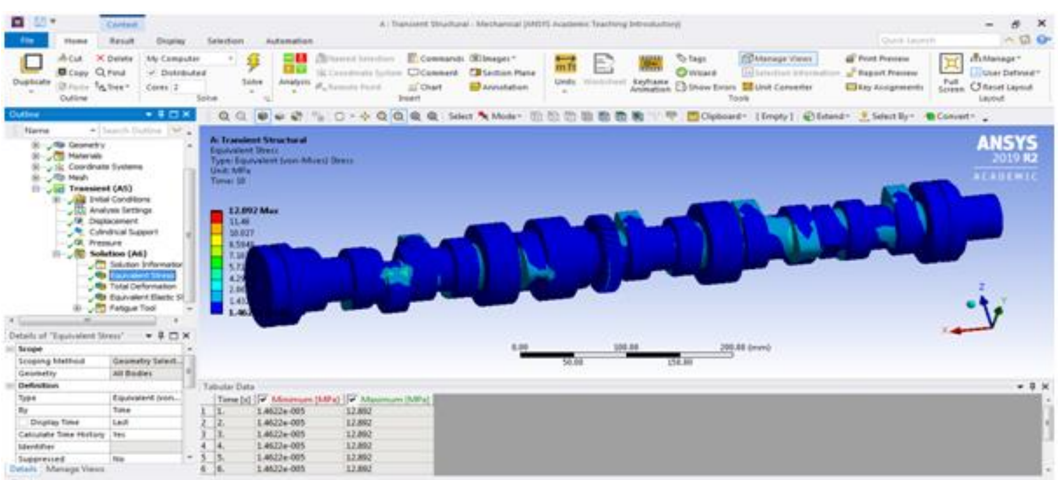

Fig. 4. Stress of the camshaft.

According to the result Fig.4., the minimum stress at middle of the cam shaft its indicated red color and maximum stress at both ends of the cam shaft its indicated blue color.

Strain

According to the result Fig. 5, the minimum strain at middle of the cam shaft its indicated red color and maximum strain at both ends of the cam shaft its indicated blue color.

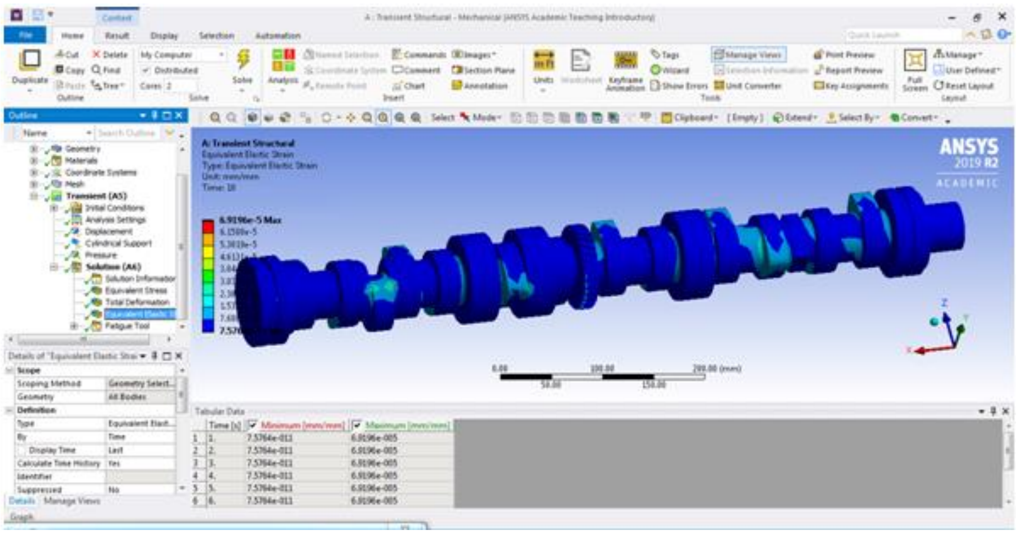

Fig. 5. Strain of the camshaft

Modal Analysis of Camshaft

Mode 1

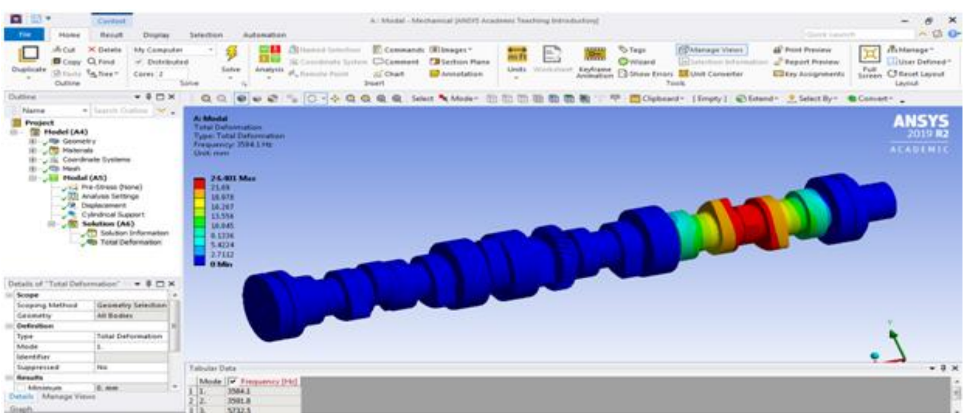

Fig. 6: Mode 1 of the camshaft

According to the result Fig.6, the maximum deformation at middle of the cam shaft its indicated red color and minimum deformation at both ends of the cam shaft its indicated blue color.

After simulations are done with only pressure consideration different stress, strain & deformation values are generated for above materials. When comparing simulation values with each other. For EN24T material less stress, strain and deformation values are obtained.

VI. RESULTS

Material	Deformation (mm)	Stress (N/mm^2)	Strain
SS316	0.00079752	12.892	6.9196e-5max
C55Mn15	0.00070687	12.653	6.1212e-5max
NiCrVMo alloy steel	0.0007237	12.753	6.267e-5max
Malleable cast iron	0.00093625	12.933	8.1289e-5max
EN24T	0.0007014	12.541	6.566e-5max

VI. CONCLUSION

Based on the experimental analysis, this work made following conclusions:

- By observing dynamic analysis results table among different material, the minimum stress value is obtained for EN24T material.
- By observing modal analysis result table among different material, the maximum natural frequency is obtained for EN24T material.
- Finally, EN24T material simulation stress and factor of safety values are compared with theoretically calculated values. simulation stress value is less than theoretically calculated value and factor of safety of simulation value is more than theoretical value.
- So, from above statements it can be conclude that he EN24Tmateral is also a best suited material for 6cylinder IC engine camshaft.

REFERENCES

[1] Ansari Z., Anwar M. and Ahmed M. Y., 2017, Finite Element Structural Analysis of Automobile Camshaft, International Journal for Research in Applied Science & Engineering Technology, Vol. 5, Issue 2, pp. 464-468.

[2] Bongale V. and Kapilan N., 2016, Static and Rotor Dynamic Analysis of Camshaft using Finite Element Analysis, International Journal for Ignited Minds, Vol. 3, Issue 6, pp. 102-109.

[3] Perez J. N. S., Arellano J. L. H. and Garcia M.C. N., 2015, Task Analysis and Ergonomic Evaluation in Camshaft Production Operations, Procedia Manufacturing, Vol. 3, pp. 4244-4251.

[4] Kumar D., Goyal A., Barmola A., Kushwaha N. and Singha S., 2015, 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.

[5] Chanagond A. G. And Raut L. B., 2015, Finite Element Analysis of Roller Cam by Optimisation of Surface Contact area, International Journal of Advanced Engineering Research and Studies, Vol. 4, Issue 2, pp. 5-6.

[6] Ramadhas R., Boopathi S. V. and Dinesh K. R., 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.

[7] Thorat S. G., Dubey N., Shinde A., Fulpagare P. and Suryavanshi M., 2014, Design and Analysis of Camshaft, Proceedings of 11th IRF International Conference, 15 June 2014, Pune, India. International Journal of Engineering

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[8] Suhas K. S. and Haneef M., 2014, 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.

[9] Jaiganesh V., Christopher A. A. and Mugilan E, 2014, Manufacturing of PMMA Cam Shaft by Rapid Prototyping, Procedia Engineering, Vol. 97, pp. 2127 – 2135.

[10] Wanjari R. V. and Parshiwanikar T. C., 2013, Failure of Camshaft, International Journal of Innovative Technology and Exploring Engineering, Vol. 2, Issue 6, pp. 248-250.

[11] Dhavale A. S. and Muttagi V. R., 2012, Study of Modeling and Fracture Analysis of Camshaft: A Review, International Journal of Engineering Research and Applications, Vol. 2, Issue 6, pp. 835-842.

[12] H. D. Desai and V. K. Patel, ―Computer Aided Kinematic and Dynamic Analysis of Cam and Follower,‖ Proceed-ings of the World Congress on Engineering, Vol. 2, 30 June-2 July 2010, London, pp.117-127