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Design & Static Analysis of Cam Shaft in Automobile Engines

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ABSTRACT

This research employs SolidWorks for comprehensive camshaft design and ANSYS Static Structural for finite element analysis. Focused on internal combustion engine performance, it covers kinematics, dynamic loads, and material selection. SolidWorks is utilized for detailed modeling, and ANSYS analyzes stress distribution, fatigue life, and structural integrity. Key parameters include cam profile optimization, load distribution, and material behavior, with a goal of enhancing performance and mechanical robustness. The study contributes insights for the automotive industry, advocating for the transition to advanced materials for improved reliability and efficiency in engine components, guided by virtual prototyping and adherence to engineering standards.

Keywords: Camshaft design, SolidWorks, ANSYS Static Structural, Finite Element Analysis (FEA), Mechanical engineering, Automotive industry.

1. INTRODUCTION

A cam is a rotating or sliding piece in a mechanical linkage used especially in transforming rotary motion into linear motion or vice versa. It is often a part of a rotating wheel (e.g. an eccentric wheel) or shaft (e.g. a cylinder with an irregular shape) that strikes a lever at one or more points on its circular path. The cam can be a simple tooth, as it is used to deliver pulses of power to a steam hammer, for example, an eccentric disc or other shape that produces a smooth reciprocating (back and forth) motion in the follower, which is a lever contacting the cam. The cam can be seen as a device that translates from circular to reciprocating (or sometimes oscillating) motion. A cam is a mechanical device used to transmit motion to a follower by direct contact.

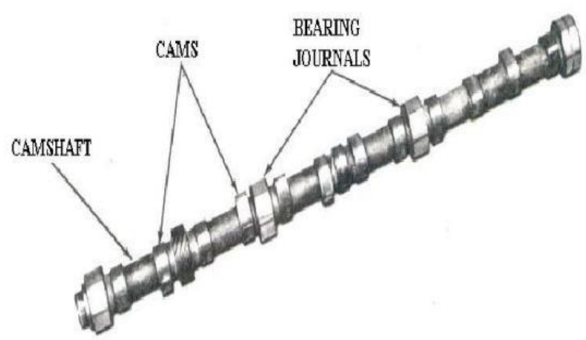


Fig.No.1.1 Cam and Cam Shaft.

The camshaft is driven by the engine's crankshaft through a series of gears called idler gears and timing gears. The gears allow the rotation of the camshaft to correspond or be in time with, the rotation of the crankshaft and thereby allows the valve opening, valve closing, and injection of fuel to be timed to occur at precise intervals in the piston's travel. To increase the flexibility in timing the valve opening, valve closing, and injection of fuel, and to increase power or to reduce cost, an engine may have one or more camshafts. Typically, in a medium to large V-type engine, each bank will have one or more camshafts per head. In the larger engines, the intake valves, exhaust valves, and fuel injectors may share a common camshaft or have independent camshafts.

Depending on the type and make of the engine, the location of the camshaft or shafts varies. The camshaft(s) in an in-line engine is usually found either in the head of the engine or in the top of the block running down one side of the cylinder bank. When the piston travels below the level of the ports, the ports are "opened" and fresh air or exhaust gases can enter or leave, depending on the type of port. The ports are then "closed" when the piston travels back above the level of the ports. Valves are mechanically opened and closed to admit or exhaust the gases as needed. The valves are in the head casting of the engine. The point at which the valve seats against the head is called the valve seat. Most medium-sized diesel engines have either intake valves or exhaust valves or both intake and exhaust valves.

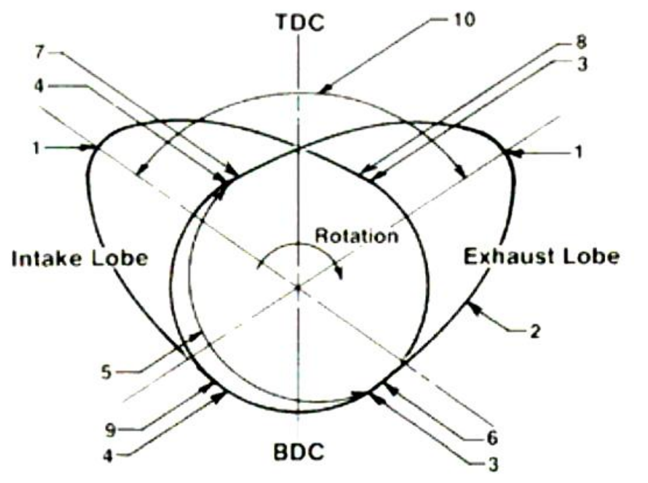


Fig.no.1.2 Rotation of Cam Shaft

Cam is a mechanical member for transmitting a desired motion to a follower by direct contact. The driver is called cam, and the driver is called follower. Cam mechanism is a case of a higher pair with line contact. Camshaft is the Brain of the engine must include cam lobes, bearing journals, and a thrust face to prevent fore and after motion of the camshaft. In addition, camshaft can include a gear to drive the distributor and an eccentric to drive a fuel pump. Camshaft is controlling the valve train operation. Camshaft is along with the crankshaft it determines firing order. Camshaft is along with the suction and exhaust systems it determines the useful rpm range of the engine. Camshaft is used in the engine for transfer's motion to inlet & exhaust valve. If transfer of motion is not proper, then strokes will not work in proper way. Also, it affects the performance of the engine. To make work of camshaft in precise way. It is required to design a good mechanism linkage; the dynamic behavior of the components must be considered; this includes the gross kinematic motion and self-induced vibration motion. Dynamic models were created to obtain insight into dynamic behavior of the system prior to manufacturing. These models were mathematical tools used to simulate and predict the behavior of physical systems. They contain systems properties which are masses, stiffness constants, and damping coefficients. The automotive sector has reached a very high production capacity in the last decades. Depending on this increasing capacity, stable growth is anticipated in the world economy. The economic value of the work capacity in the automotive sector is very large and this shows that the automotive sector is the 6theconomic sector worldwide. The sector has an interrelationship with more than 300 different fields.

So, if there is any malfunction in the main or side industries, the whole functions of the produced cars are affected. On the other hand, failure analysis is a special field of study for materials and mechanical engineers. On one side, the materials engineer is intended to develop his/her observational and reasoning skills for the understanding of interrelationship between observable features and properties or performance. On the other side, the mechanical engineer studies the possible failure locations and types and amount of the existent stress levels. Many studies have been carried out on the automotive failure analysis is that the mostly failed parts are from engine and its components among the automotive failures. This is followed by the driving train failures. Among the studies on engine component failures, the prediction of fatigue failure in a camshaft using the crack-modeling method.

Fig.No.1.3 Camshaft

1.1 Background

Cam mechanisms are used for various tasks in a wide range of machines. Some examples are pumps, linear actuators and mechanical automation devices. But the most common and thoroughly studied use for cams is valve actuating in internal combustion engines. A cam mechanism's purpose in an internal combustion engine 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. The cams are disposed along a stiff shaft which rotates at half the speed of the crankshaft in a four-stroke engine and the same speed in a two-stroke engine. This shaft is driven by the crankshaft by either a gear or a chain mechanism and is situated in the engine's structure using a series of bearings. It can also contain an eccentric for fuel pumping and a gear mechanism for distributor driving and oil pumping.

The challenge of designing a camshaft needs the designer to solve many problems. The shape of the cam must be chosen, the kinematics of the valve motion, the forces and moments that the cam transmits to the shaft must be calculated. The shaft suffers certain deformations and stresses due to the suffered loads, which should comply with specified ranges or a given security factor, and its bearings admit a certain amount of load and shaft curvature. All this is performed side by side with design decisions on the mechanisms structural and dimensional properties, which makes of this task a highly iterative process.

1.2 Purpose

The purpose of this project is to develop an interactive software tool that assists the user in the solution of the main encountered problems in the previously defined design task. The program should simplify the task by incorporating algorithms with the capacity to process a flexible amount of input data and send results back for the user to analyze them without the need of doing extensive calculations or preparing mathematical and FEM models. Another objective is to make the program as intuitive and helpful as possible, for a person new to the software to be able to use it without previous instruction. A person with low knowledge on the topic should be able to understand what each variable means, what the program does and how the given results affect the design. It should therefore have an informative and instructively oriented interface. Lastly, the program's code should be divided into clearly explained parts for it to be easily modified or improved. A side objective of the project is to provide a base for anyone who wishes to either improve the program or use parts of it to use it in new software, mainly if it is for educational purposes. The program's source is therefore intended to be available to anyone that wishes to retrieve it.

2. LITERATURE REVIEW

The significance of the literature review is to assess the Research conducted in the past in a particular domain. The review of the theory is conducted to bring clarity in the understanding of the existing body of knowledge. The theories, concepts, definitions were studied to have a better understanding of the knowledge in the domain selected. The literature review also gave insights into various theoretical concepts, current trends and practical issues in the field of marketing. It also assisted in understanding current trends in marketing. The review of the research papers, thesis was reviewed to find out the research gaps in the existing body of knowledge, the gaps in terms of the Study group selected, Geographical area, the commodity selected etc. The literature is reviewed to understand the Instruments used for data collection the statistical tools used for interpretation of data and to prove the hypothesis. The research papers over a period of more than 20 years were reviewed to identify the research gaps to identify a theme to conduct research in the gaps identified and contribute to the existing body of knowledge.

The researcher reviewed about 30 different reference books on various topics related to Marketing, Brand Management, Segmentation, and Market Research. The number of papers reviewed from research journals and professional journals came to 30 to approximately 80. A large volume of literature is published in the form of surveys and white papers which provided important insights into the domain of Marketing. Several websites were also studied. This chapter presents a summary of relevant knowledge about cam mechanisms, camshafts, their characteristics and different components.

2.1 Use of Cams in Internal Combustion Engines

The camshaft's function in an engine is to operate the valve train. The lobes on the camshaft push open the valves against the force of the valve springs. Cam shape is the major factor in the operating characteristics of the engine; it has more control over the engine's performance characteristics than any other component **(Ellinger and Halderman, 1991).** There are essentially two kinds of engines depending on the valve train architecture: pushrod and overhead cam engines. Pushrod engines are more compact. In these engines the camshaft is in the block, and it actuates the valves through a pushrod connected to the follower that transmits the cam push all the way to the cylinder head. Overhead cam engines, on the other side, have fewer moving parts in the valve train, which makes it more rigid and allows higher speeds. There can be a single camshaft operating both intake and exhaust valves and one camshaft for the intake and another one for the exhaust. These are called single and double overhead camshafts, respectively **(Ellinger and Halderman, 1991).**

2.2 CAMSHAFT AND VALVE TRAIN COMPONENTS

Depending on the type of engine and its architecture different components can be found in the valve train and the camshaft. A camshaft includes a drive, bearing journals, cam lobes and possibly an accessory drive and/or an eccentric cam lobe for fuel pump operation. The valve train can contain different kinds of followers, and depending on the engine architecture, pushrods and/or rocker arms. **Ellinger and Halderman (1991)** provide an extensive description of these components. Their main characteristics will be summarized next. The camshaft is driven by the crankshaft through either gears, sprockets and chains, or sprockets and timing belts. The gears or sprockets must be keyed to the shaft so they can only be installed in one position. The camshaft can then be placed in the correct relative position to the crankshaft through aligning of marks on the gear teeth or chain links. This is necessary for the valve opening and closing timing to be correct. Internal combustion engines use plain bearings for their inexpensiveness and high load carrying capacity. On pushrod engines, camshaft bearing journals must have a bigger radius than the lobes so that the shaft can be installed in the engine block through the bearings. Overhead camshafts usually use cap bearings. Bearing journals are in this case small in comparison with the cam lobes.

Followers transform the cam lobe rotary motion into longitudinal motion by following the lobe's outer surface in a certain direction. They usually have a relatively flat surface that slides on the cam. Other follower designs include a circular roller to follow the cam contour, which reduces the valve train friction. Some overhead cams operate directly on a rocker arm, which has a curved surface. This is also called a finger follower. In pushrod engines, rocker arms reverse the upward movement of the pushrod to produce a downward motion on the tip of the valve. Rocker arms are designed to reduce the follower lift while maintaining the valve lift. The side of the arm that actuates the valve is longer than the one actuated by the pushrod. The ratio between these lengths is approximately equal to the ratio between the valve and the follower lift.

2.3 CAM TIMING SPECIFICATIONS

The cam lobe shape determines the valve motion, which as stated before has major control over the engine's performance. It therefore needs to be designed taking timing specifications into consideration and controlling its influence on the mechanism's dynamics.

The opening and closing motion of the valve can be defined using different types of functions, which affect the velocity and accelerations of the valve train, and therefore the loads suffered in the mechanism. The function that describes the followers, and therefore the valve's motion is called pitch curve, and three common pitch curve functions are parabolic, harmonic and cycloidal **(Spotts, Shoup and Hornberger, 2004).** Cam timing specifications are defined in terms of the angle of the crankshaft in relation to top dead center (TDC) or bottom dead center (BDC). The intake valves should open a certain time before the piston reaches TDC, to assure that the valve is open when the intake stroke starts. It also closes after BDC since the air fuel mixture inertia still draws mixture in even though the piston starts to rise. The exhaust valve opens slightly before BDC and after TDC because of the same reasons. Thus, there is a certain time in the crankshaft rotation in which both valves are open, called "valve overlap" **(Ellinger and Halderman, 1991).** In the diagram shown in Fig.no.2.1 the valve intake opening time is represented by the blue line and the exhaust by the red one.

Fig.no.2.2 shows a representation of the valve lift as a function of the crankshaft rotation angle. The pitch curve function is in this case cycloidal. Note the valve overlap and the valves opening and closing before and after dead centers. springs, retainers, rotators and locks. The purpose of the complete system is to open and close the intake port and exhaust port which lead to the combustion chamber. The main function of the camshaft is to open and close the engine valves as and when required. The design of the camshaft is such that the valves are open and closed at the precise time and at the controlled rate with reference to the position of the piston. There are two lobes per cylinder in the camshaft. One lobe is to drive the intake valve and the other is to drive the exhaust valve. It is thus imperative that the V4 engine has a camshaft with 8 lobes. The valve train part which is in the direct contact with the cam is known as follower or the lifter.

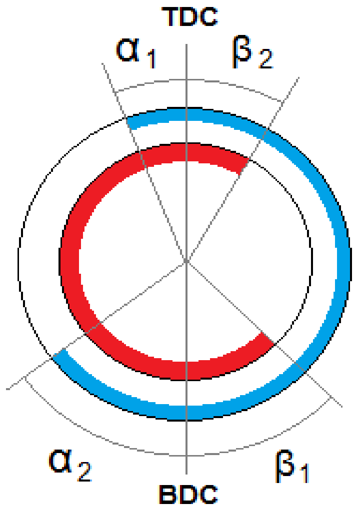


Fig.no.2.1 Cam timing diagram

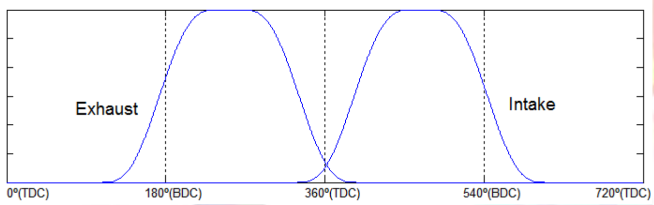


Fig2.2 Example of cam timing representation

3. OVERVIEW OF COMPONENT

An important concern of the various engineers in the IC engine field is to predict and extend the service life of the camshaft. There are various variables on which the stress performance of the camshaft depends. They are cam material, the lift profile, valve train configuration and the various manufacturing processes. Many efforts in the manufacturing industry are undergoing in which the effect of grinding on the service lifetime of the camshaft is studied. The lobes of the Cam Shaft are ground to produce the required surface finish and lift profile. It is found by the manufacturers that the quality as well as the service life of the cam shaft is dependent on the way the camshaft is ground (Abusive, moderate or gentle) There are millions of parts involved in the mass production grinding of the camshafts. The output rates are limited by the detrimental effect of the thermal damage to the cam shafts. Thus, it is imperative to have a link between the grinding process and the engineering design to have high rates of production of the camshafts as well as have an efficient design.

4. INTRODUCTION OF SOLIDWORKS

4.1 INTRODUCTION

SolidWorks is a solid modeling computer-aided design (CAD) and computer-aidedengineering(CAE) computer program that runs on Microsoft Windows. SolidWorks is published by Dassault systems. More than 3,246,750 product designers and engineers worldwide, representing 240,010 organizations, use SOLIDWORKSto b r i n g their designs to life–from the coolest gadgets to innovations that deliver a bettertomorrow. Dassault Systems SOLIDWORKS Corp. offers complete 3D software tools that let you create, simulate, publish, and manage your data. SOLIDWORKS products are easy to learn and use and work together to help you design products better, faster, and more cost-effectively. The SOLIDWORKSfocus on ease-of-use allowsmore engineers, designers and other technology professionals thanever before to take advantage of 3D in bringing their designs tolife.

- It is headquartered at Waltham, Massachusetts, USA.
- The latest version of Solidworkswas released on 19thSeptember 2016 as SolidWorks 2017.

SolidWorks partners with third party developers toadd functionality in niche market applications likefinite element analysis, circuit layout, tolerance checking, etc. SolidWorks has also licensed its 3D modelingcapabilities to other CAD software vendors, notablyANVIL.

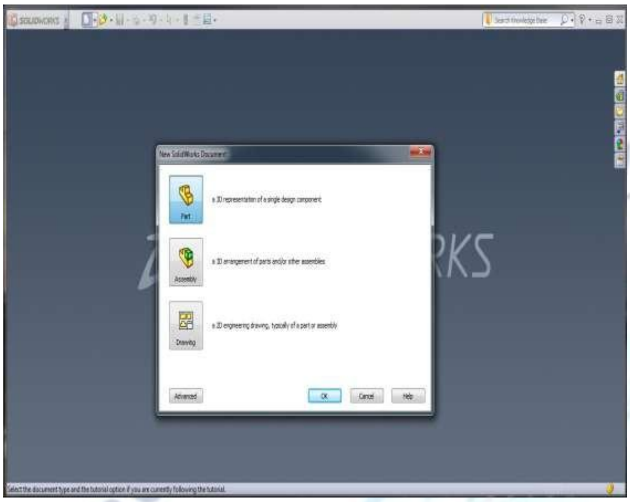
4.2 HISTORY

SolidWorks Corporation was founded in December 1993 by Massachusetts Institute ofTechnology graduate Jon Hirschtick.Hirschtickused $1 million he had made while a member of the MIT Blackjack Team to set up the company. Initially based in Waltham,Massachusetts,United States, Hirschtickrecruited a team of engineers with the goal of building 3D CAD software that was easy-to-use, affordable, and available on the Windows desktop. Operating later fromConcord, Massachusetts, SolidWorks released its first product SolidWorks 95, in November 1995. In 1997 Dassault, best known forits CATIA CAD software, acquired SolidWorks for $310 million in stock.[5]Jon Hirschtickstayed on board for the next 14 years in various roles. Under his leadership, SolidWorks grew to a $100 million revenuecompany.

SolidWorks currently markets several versions of the SolidWorks CADsoftware in addition to e-Drawings, a collaboration tool, and DraftSight, a 2D CAD product.

SolidWorks was headed by John McEleney from 2001 to July 2007 and JeffRay from2007 to January 2011. The current CEO is Gian Paolo Bassi from Jan 2015. Gian Paolo Bassi replaces Bertrand Sicot, who ispromoted Vice PresidentSales ofDassault systems' Value Solutions saleschannel.

4.3 THE SOLIDWORKSMODEL

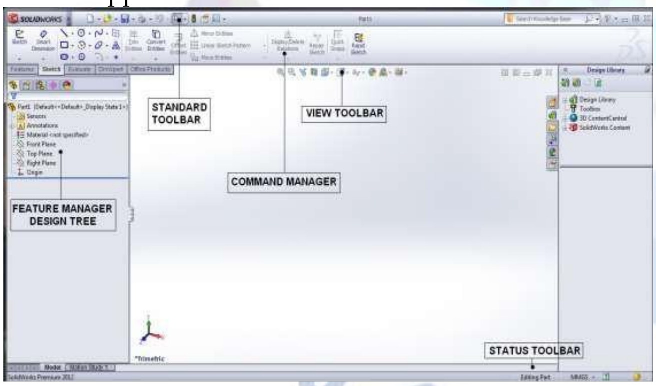


The SolidWorks model is made up of:

- **Parts** -2D design (Sketch), 3D design (Features) , Part design consider in the part designsection.
- **Assemblies** - Assembling of two or more than two parts consideredin thissection.
- **Drawings**- Designing with standards is consideredin the drawingsection.

4.4 SOLIDWORKS USERINTERFACE

The interfaceis nativeWindowsinterface, and such behaves in the same manner as other Windowsapplications.



4.4.1 Menus:

1. It provides access to all commands that SolidWorksoffers.
2. When a menu item has a right pointing arrow, it means thereisasub-menu associated with thechoice,
3. When a menu item is followed by a series of dots, it means that option opens a dialog box with additional choices orinformation

4.4.2 Toolbarsmenus:

1. Provide shortcut senabling to quickly access the most frequently used commands.
2. They are organized according to function and can be customized, removed and rearranged according to yourpreferences.

4.5 DESIGN OF CAM SHAFT

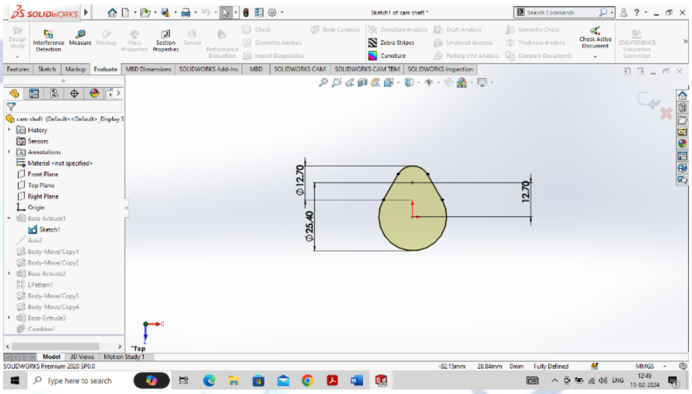


Fig.4.1 2D Sketch

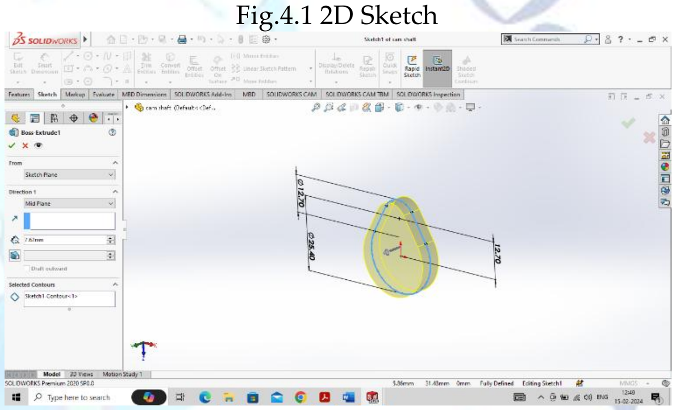


Fig.4.2 extrude boss 1

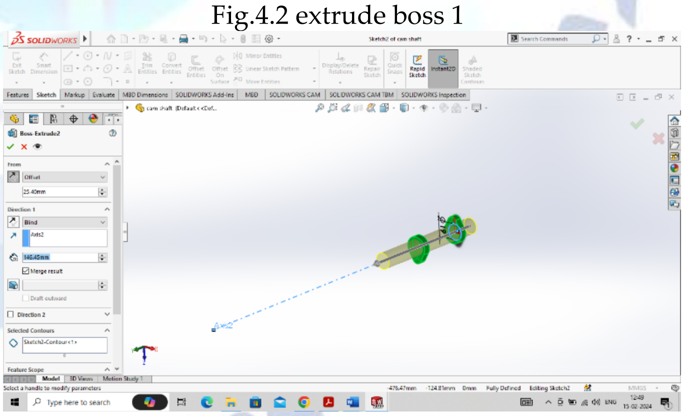


Fig.4.3 extrude boss 2

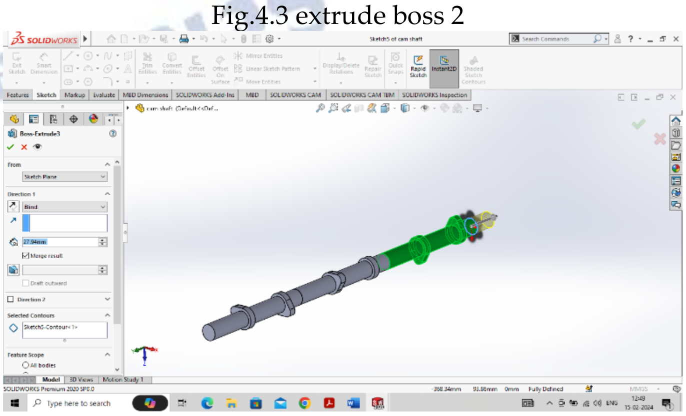


Fig.4.4 extrude boss 3

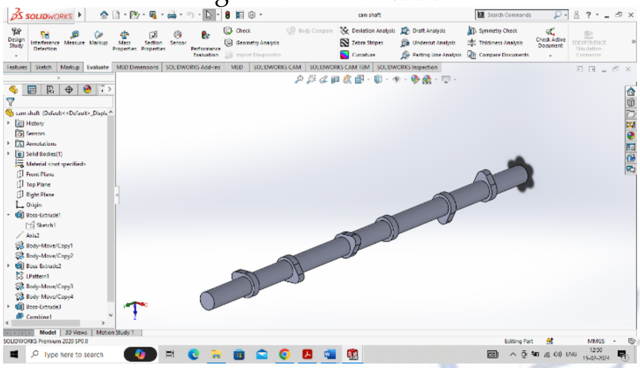


Fig.4.5 Design of cam shaft

5. ANALYSIS

5.1 Introduction to finite element analysis

The essential idea in fem is that the body or structure may be separated into littler components of limited measurements called "Finite Elements". The first body or the structure is then considered as a gathering of these components associated at a limited number of joints called "nodes" or "nodal points." Basic capacities are approximated the relocations over each limited component. Such accepted capacities are called "shape capacities". This will speak to the uprooting within the component as far as the remit Element technique is a scientific apparatus for illuminating common and fractional at the hubs of the components. The Final differential comparison because it is a numerical instrument, it can take care of the unpredictable issue that can be spoken to in differential mathematical statement from. The use of FEM is boundless as respects the arrangement of commonsense configuration issues. FEM has good efficiency to solve problems and cost critical problems as the cost for computing power is high. The finite element method can be utilized to solve problems in the following areas:

- Structural analysis
- Thermal analysis
- Vibrations and dynamics
- Buckling analysis
- Acoustics
- Fluid flow simulations
- Crash simulations.
- Mould flow simulations

Now a days, even the simplest of products rely on the finite element method for design evaluation. This is on account of contemporary configuration issues normally can't be understood as precisely and inexpensively utilizing some other system that is at present accessible. Physical testing was the standard in the years passed by, however now it is just excessively costly and tedious too. The limited component technique depends on building an entangled article with basic squares or driving a confounded item into little and sensible pieces. Use of this basic thought can be discovered all over the place in ordinary life and buildings. The philosophy of FEA can be explained with a small example such as measuring the area of a circle.

Area of one triangle: $S_i=1/2*R^2*\sin\theta_I$.

Area of the circle: $S_N=1/2*R^2*N*\sin(2\Pi/N) \rightarrow \Pi R^2$ as $N\rightarrow\infty$.

Where N= total number of triangles (elements)

To calculate the area of circle without using conventional formula, one of the approaches could be dividing the area into number of equal segments. The area of each triangle multiplied by the number of such segments gives the total area of the circle.

5.2 A BRIEF HISTORY OF THE FEM:

WHO?

The reference credited is to Courant (Mathematician), Turner (aircraft industry), Clough (California University), Martin (aircraft industry), Argyris (German university), etc. However, it was probably established by several pioneers independently.

WHEN?

- Initial idea in mathematical terms was put in 1940s.
- Application to simple engineering problems in 1950s.
- Implementation in large computers in 1960s.
- Development of pre and post processors in 1980s.
- Analysis of large structural problems in 1990s.

WHERE?

Implementation and application were mainly in aircraft industry and automobile sectors (large and fast computers were available only in these industries).

WHAT?

Field problems in the form matrix of organizing large numbers of algebraic equations are used and matrix equations are solved. Differential equations are changed into an algebraic form. Blocks with different geometry are hooked together for creating complex geometry of the engineering problem.

WHY?

The advantage of doing FEM analysis is that it is simple to change the geometry, material and loads recomputed stresses for modified product rather than build and test. The method can be used to solve almost any problem that can be formulated as a field problem. The entire complex problem can be cast as a larger algebraic equation by assembling the element matrices within the computer and solved.

5.3 MESHING:

MESHING: Before lattice the model and even before building the model, it is essential to consider whether a free work or a mapped cross section is proper for the examination. A free work has no limitations as far as component shapes and has no predefined example connected to it. Contrast with a free work, a mapped cross section is confined if the component shape it contains and the pattern of mesh. Mapped area mesh contains either quadrilateral or just triangular components, while a mapped volume cross section contains just hexahedron components. If we need this kind of lattice, we must form geometry as arrangement of genuinely normal volumes and/or regions that can acknowledge a mapped network.

5.4 STRUCTURAL STATIC ANALYSIS:

The load effects can be calculated on a structure by ignoring the damping and inertia effects, such as those caused by time varying loads can be calculated by structural static analysis. Steady equivalent loads like steady inertia loads and time varying loads are included in Static analysis. Static analysis is utilized to decide the removals, burdens, strains and powers in structures or segments brought about by burdens that don't instigate noteworthy dormancy and damping impacts. Enduring stacking and reaction conditions are accepted, i.e. the stress and the structure's reactions are expected to differ gradually as for time. The kinds of load can be applied in static analysis include:

- Force and pressure application on body.
- Steady state inertial forces.
- Displacement.
- Thermal behavior.

5.5 ANSYS WORKBENCH

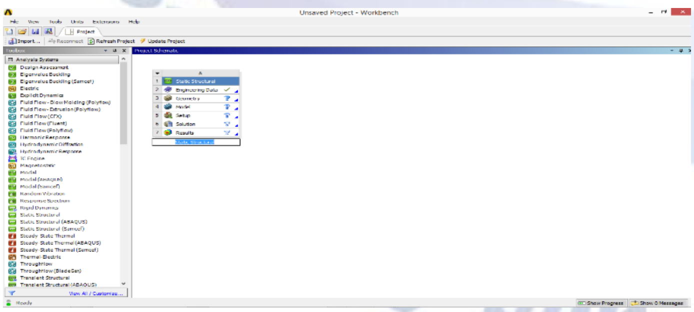


Fig.no.5.1 steady state thermal analysis

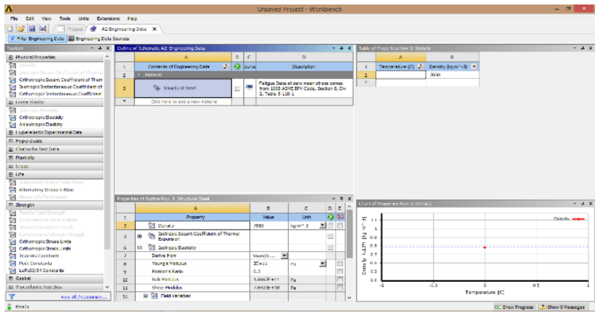


Fig.no.5.2 engineering materials

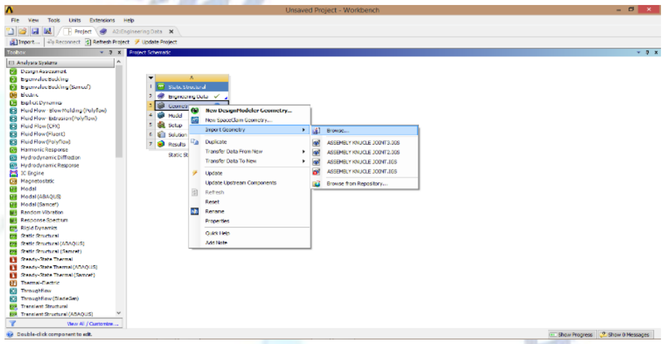


Fig.no.5.3 Import the Geometry from Catia

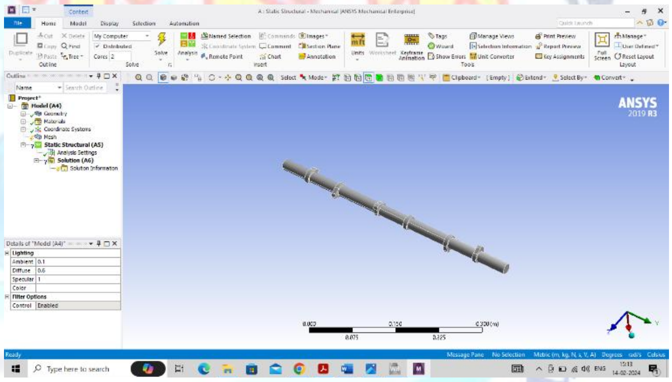


Fig.no.5.4 imported camshaft

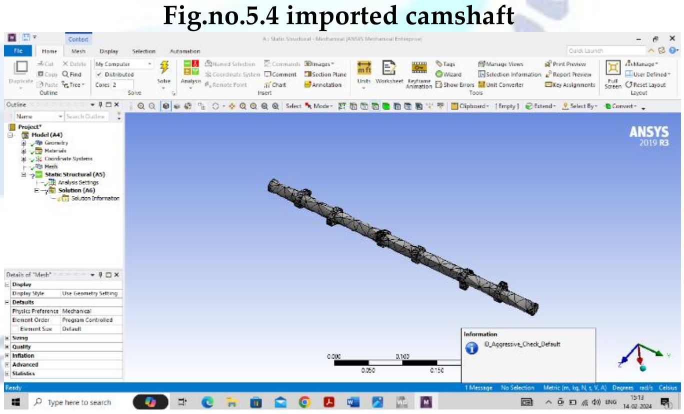


Fig.no.5.5 meshing of cam shaft

5.4.1 Structural steel

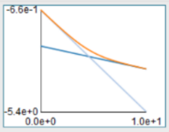
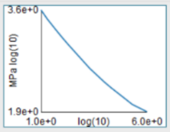
Structural Steel	
Fatigue Data at zero mean stress comes from 1998 ASME BPV Code, Section 8, Div 2, Table 5-110.1	
Density	7.85e-06 kg/mm³
Structural	
Isotropic Elasticity	
Derive from	Young's Modulus and Poisson's Ratio
Young's Modulus	2e+05 MPa
Poisson's Ratio	0.3
Bulk Modulus	1.6667e+05 MPa
Shear Modulus	76923 MPa
Isotropic Secant Coefficient of Thermal Expansion	1.2e-05 1/°C
Compressive Ultimate Strength	0 MPa
Compressive Yield Strength	250 MPa
Strain-Life Parameters	
S-N Curve	
Tensile Ultimate Strength	460 MPa
Tensile Yield Strength	250 MPa
Thermal	
Isotropic Thermal Conductivity	0.0605 W/mm·°C
Specific Heat Constant Pressure	4.34e+05 mJ/kg·°C
Electric	
Isotropic Resistivity	0.00017 ohm·mm
Magnetic	
Isotropic Relative Permeability	10000

Table 5.1 material properties of structural steel

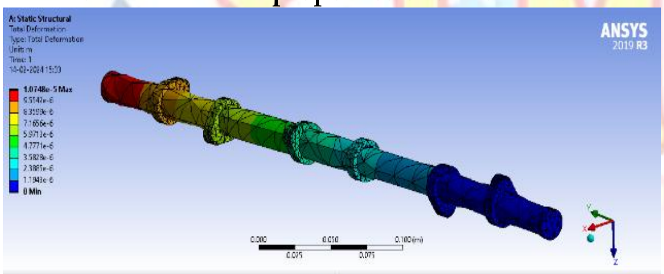


Fig.no.5.7 Total deformation

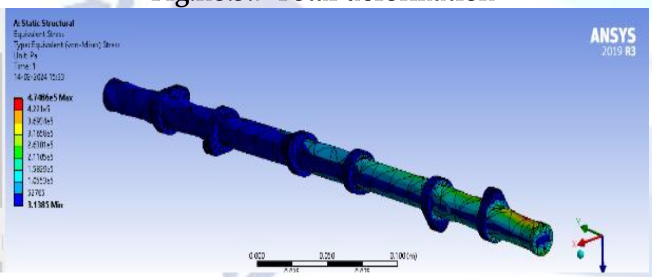


Fig.n.5.8 Equivalent stress

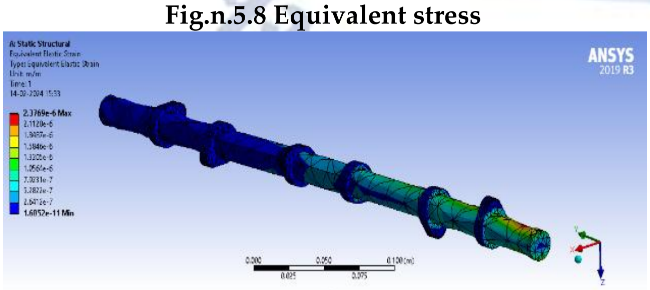


Fig.no.5.9 Equivalent elastic strain

5.4.2 Aluminium Alloy

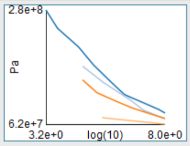
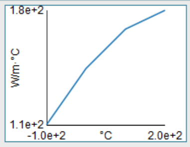
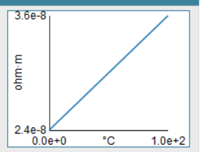
Aluminum Alloy	
Density	2770 kg/m³
Structural	
Isotropic Elasticity	
Derive from	Young's Modulus and Poisson's Ratio
Young's Modulus	7.1e+10 Pa
Poisson's Ratio	0.33
Bulk Modulus	6.9608e+10 Pa
Shear Modulus	2.6692e+10 Pa
Isotropic Secant Coefficient of Thermal Expansion	2.3e-05 1/°C
Compressive Ultimate Strength	0 Pa
Compressive Yield Strength	2.8e+08 Pa
S-N Curve	
Tensile Ultimate Strength	3.1e+08 Pa
Tensile Yield Strength	2.8e+08 Pa
Thermal	
Isotropic Thermal Conductivity	
Specific Heat Constant Pressure	875 J/kg·°C
Electric	
Isotropic Resistivity	
Magnetic	
Isotropic Relative Permeability	1

Table 5.2 material properties of Aluminium alloy

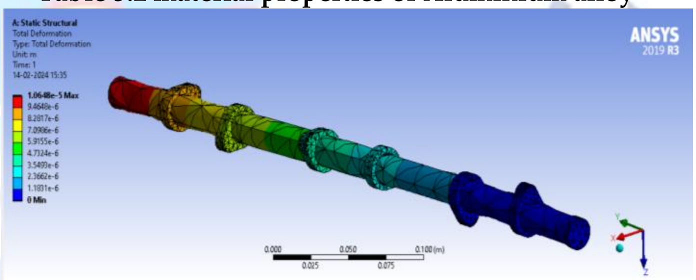


Fig.no.5.10 Total deformation

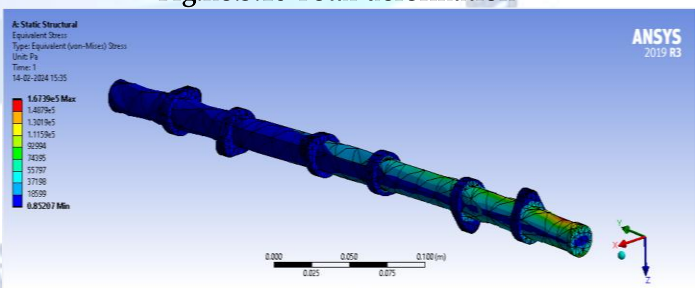


Fig.no.5.11 Equivalent stress

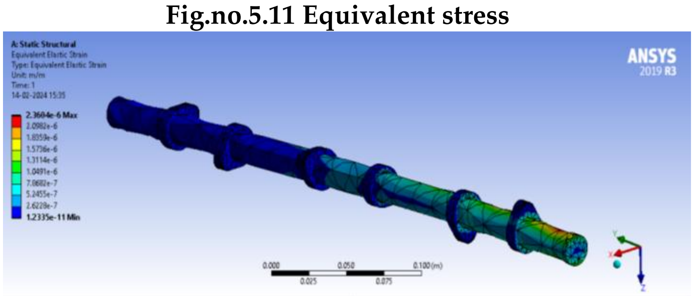


Fig.no.5.12 Equivalent elastic strain

5.4.3 Gray Cast Iron

Gray Cast Iron

Density	7.2e-06 kg/mm³
Structural	
Isotropic Elasticity	
Derive from	Young's Modulus and Poisson's Ratio
Young's Modulus	1.1e+05 MPa
Poisson's Ratio	0.28
Bulk Modulus	83333 MPa
Shear Modulus	42969 MPa
Isotropic Secant Coefficient of Thermal Expansion	1.1e-05 1/°C
Compressive Ultimate Strength	820 MPa
Compressive Yield Strength	0 MPa
Tensile Ultimate Strength	240 MPa
Tensile Yield Strength	0 MPa
Thermal	
Isotropic Thermal Conductivity	0.052 W/mm·°C
Specific Heat Constant Pressure	4.47e+05 mJ/kg·°C
Electric	
Isotropic Resistivity	9.6e-05 ohm·mm

Table 5.3 material Properties of Gray Cast Iron

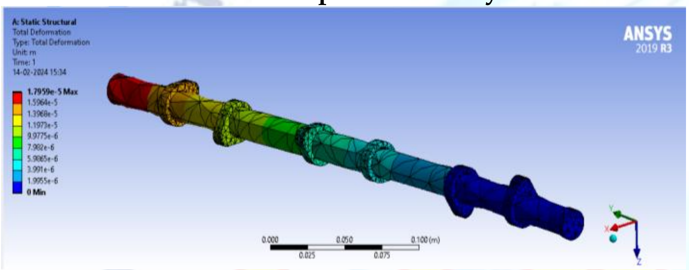


Fig.no.5.12 Total deformation

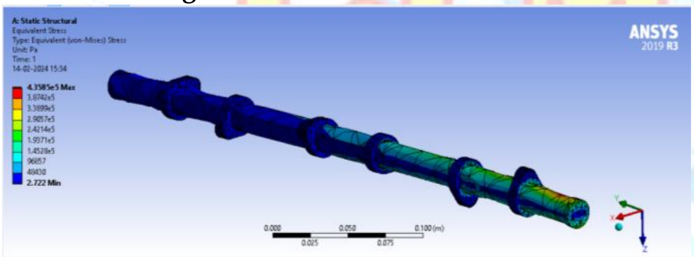


Fig.no.5.13 Equivalent stress

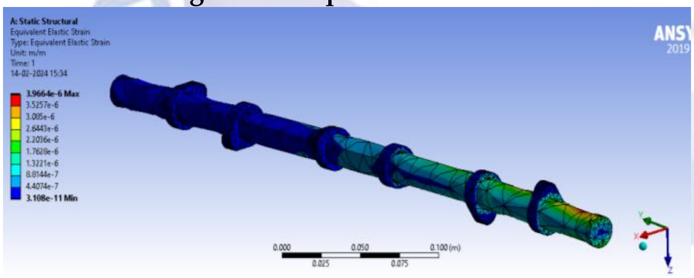


Fig.no.5.14 Equivalent elastic strain

5.5 VERIFICATION

Since the cam kinematic and dynamic problems are relatively simple, errors in the calculations can be easily identified by trying different designs and analyzing the provided results. Testing was therefore considered enough for the verification of the program's performance in cam calculations. Shaft calculations were more complicated to program. Important errors could also be identified by testing.

For example, beam diagrams should be coherent in themselves and between them, and this is verified by observing and analyzing them. But the large number of variables, constants, equations and input data used in these calculations make the program more susceptible to calculation errors, and even if the resulting diagrams seem coherent, the generated numerical results could be wrong. The shaft calculations were therefore further analyzed for verification.

An example camshaft was designed using the program, and a certain camshaft angular position was chosen to analyze the resulting stresses in that specific load case. The forces and torques in the cam lobes and drive for the chosen case were retrieved from the program.

6. RESULT AND DISCUSSION

- On performing structural analysis and modal analysis of camshaft using both the materials, the following results were obtained.
- From structural analysis, the displacement and stress values of camshaft using cast iron, steel and titanium are as follows:

	Deformation (m)	Stress (Pa)	Strain
Gray Cast Iron	1.7959e-005	3.9664e-006	4.3585e+005
Steel	2.4046e-003	8.4374	4.3892e-005
Aluminum	4.7728e-003	8.7795	9.3577e-005

- From the above table, camshaft displaces less in steel when compared to cast iron.

7. CONCLUSION

In this project Design and Model Analysis of camshaft is done by using SOLIDWORKS and ANSYS software. By using ANSYS the model analysis is done to find out the structural analysis of Cam. The deformation and stress are calculated. The design of the cam is done by using SOLIDWORKS software. The design is done by using cam profile at inlet and outlet (exhaust). The Cam have knife edge follower. The structural analysis is used to find the stress and displacement values in Cam. In this project the preferred material for Cam is selected at its working environment. The material selection is done by considering stress, deformation of the materials. The material selection for Cam is done by using ANSYS software. In this the three materials are compared. The stress and deformation are calculated at inlet and outlet of Cam. Finally, the steel is preferred.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] Machine Design by R.S. KHURMI&J.K. GUPTA.

[2] Theory of machines by sadhu singh.

[3] Theory of Machines by R.S. KHURMI.

[4] Model Analysis By Brian J. Schwarz & Mark H. Richardson Vibrant Technology, Inc. Jamestown, California 95327

[5] Potter, R. and Richardson, M.H. "Identification of the Modal Properties of an Elastic Structure from Measured Transfer Function Data" 20th International Instrumentation Symposium, Albuquerque, New Mexico, May 1974.

[6] Vold, H. and Rocklin, G.T., "The Numerical Implementation of a Multi-Input Estimation Method for Mini-Computers", 1st International Modal Analysis Conference, Orlando, FL, September 1982.

[7] Ferment, D. and Richardson, M. H. "Global Frequency & Damping from Frequency Response Measurements", 4th International Modal Analysis Conference, Los Angeles, CA, February 1986

[8] http://wapedia/en/hydraulic_lifters

[9] http://wapedia/en/sliding_friction

[10] http://wapedia/en/surface_hardening

[11] http://auto.howstuffworks.com/camshaft.html.