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Design and Analysis of Multi Cylinder Camshaft Used In Railways

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ABSTRACT

The camshaft is driven by using the crankshaft via timing gears cams are made as vital additives of the camshaft and are designed in the kind of manner to open and close to the valves at the proper timing and to maintain them open for the vital length. A commonplace example is the camshaft of an automobile, which takes the rotary motion of the engine and interprets it in to the reciprocating movement essential to carry out the consumption and exhaust valves of the cylinders.

In these paintings, a camshaft is designed for 6 cylinder engine and 3-D-model of the camshaft is created the use of modeling software program CATIA. The modeled in CATIA is imported in to ANSYS. After completing the element residences, meshing and constraints the loads are achieved on camshaft for three certainly one of a kind substances specifically EN351 AISI8620, EN99 and EN40Bto decide the displacement, equivalent strain of the cam shaft.

In this thesis, static, modal, fatigue and dynamic analysis done in ANSYS.

1. INTRODUCTION TO CAM SHAFT

1.1 CAMSHAFT

CAM: 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

CAMSHAFT: 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 engine1 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.

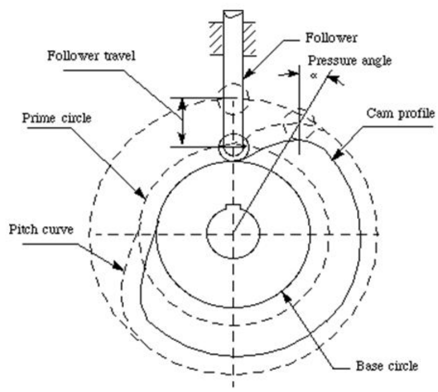

Fig:1 cam shaft

1.2.1 Base Circle: The smallest circle centered on the cam rotation axis, and tangent to the cam surface. The size of the base circle is dictated by spatial restrictions of the application.

1.2.2 Trace point: A theoretical point on the follower, corresponding to the point of a fictitious knife-edge follower. It is used to generate the pitch curve. In the case of a roller follower, the trace point is at the center of the roller.

1.2.3 Home Position: The orientation of the cam

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that corresponds to 0□ on a displacement curve.

1.2.4 Reference Circle (or prime circle): A circle centered at the cam axis whose radius is equal to the distance to the trace point. It is the smallest circle from the cam center through the pitch curve

1.2.5 Pressure Angle: The angle between the direction of motion of the follower and the direction of the cam contact force is called pressure angle. Pressure angle should not exceed 30□.

1.2.6 Pitch curve: The path generated by the trace point at the follower is rotated about a stationary cam.

1.2.7 **Working curve**: The working surface of a cam in contact with the follower. For the knife-edge follower of the plate cam, the pitch curve and the working curves coincide. In a close or grooved cam there is an inner profile and an outer working curve.

1.5 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:-

1.5.1 CAST IRONS

HARDENABLEIRON:

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.

SPHEROIDAL GRAPHITE CAST IRON KNOWN AS SG IRON: A material giving similar characteristics to hardenable. 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 RockwellC. This material was used by Fiat in the1980's

CHILLED CHROME CASTIRON:

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 are 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.

1.5.2 STEEL CAMSHAFTS

CARBON STEEL – EN8 (BS970 080M40) /EN99(BS970 070M55):

Used mainly in the 1930 to 1945 period and is currently used for induction hardened camshafts in conjunction with roller cam followers, due to the through-hardening characteristics of the material.

ALLOYED STEELS – EN351 AISI 8620 andEN34:

Used by British Leyland in the A Series and B Series engine and best when run against a chilled cam follower.

NITRIDING STEEL –EN40B:

The best steel for camshafts. When nitrided it gives a surface hardness and finish similar to chilled iron.We used this when replacing chilled iron camshafts in competition engines. This material is used on several of the current F1 engines.

1.6 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 wearhouses etc.

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

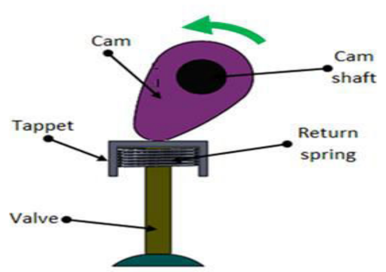

Figure 1.6 Cam in I.C engine

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1.6.1 Cams in automatic lathes

The cam shaft is driven by a motor. The cutting tool mounted on the transverse slide travels to desired depth and at desired feed rate by a set of plate cams mounted on the cam shaft. The bar feeding through headstock at desired feed rate is carried out by a set of plate cams mounted on the camshaft.

1.6.2 Automatic copying machine

The cam profile can be transferred onto the work piece by using a roller follower as shown in Figure 4.3.12 . The follower can be mounted with a cutting tool. As the cam traverses, the roller follows the cam profile. The required feature can be copied onto the workpiece by the movement of follower over the cam profile.

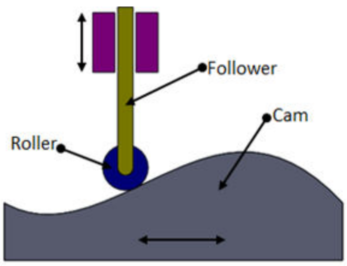

fig : 1.7 Automatic copying of cam profile

1.7 ADVANTAGES OF CAMSHAFT

- Very efficient, produce items quicker.
- less chance for product to malfunction (less chance for error)
- Can create more complicated products- unique shapes--> all uniform and clean
- more cost efficient over time
- Labour costs are lover

1.8 DISADVANTAGES OF CAMSHAFT

- Initial cost of purchasing CAM is high
- Expensive and lengthy training on how to use CAM machinery
- May lead to rise in unemployment (less workers needed)

1.9 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.

Material properties

Material	Density (g/cc)	Young's modulus (MPa)	Poisson's ratio
EN99	7.87	190000	0.265
EN351 AISI8620	2.8	80000	0.33
Nickel chromium vanadium molybdenum alloy steel	8.2	210000	0.29

LITERATURE REVIEW

[1] 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.

[2] 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.

[3] 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

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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.

[4] 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

1 INTRODUCTION TO CAD

CAD (Computer Aided Design) is the use of computer software to design and document a product's design process.

Engineering drawing entails the use of graphical symbols such as points, lines, curves, planes and shapes. Essentially, it gives detailed description about any component in a graphical form.

3.1.1 Background

Engineering drawings have been in use for more than 2000 years. However, the use of orthographic projections was formally introduced by the French mathematician Gaspard Monge in the eighteenth century.

Since visual objects transcend languages, engineering drawings have evolved and become popular over the years. While earlier engineering drawings were handmade, studies have shown that engineering designs are quite complicated. A solution to many engineering problems requires a combination of organization, analysis, problem solving principles and a graphical representation of the problem. Objects in engineering are represented by a technical drawing (also called as drafting) that represents designs and specifications of the physical object and data relationships.

INTRODUCTION TO CATIA

CATIA is an acronym for Computer **A**ided **T**hree-dimensional **I**nteractive **A**pplication. It is one of the leading 3D software used by organizations in multiple industries ranging from aerospace, automobile to consumer products.

CATIA is a multi platform 3D software suite developed by Dassault Systèmes, encompassing CAD, CAM as well as CAE. Dassault is a French engineering giant active in the field of aviation, 3D design, 3D digital mock-ups, and product lifecycle management (PLM) software. CATIA is a solid modelling tool that unites the 3D parametric features with 2D tools and also addresses every design-to-manufacturing process. In addition to creating solid models and assemblies, CATIA also provides generating orthographic, section, auxiliary, isometric or detailed 2D drawing views. It is also possible to generate model dimensions and create reference dimensions in the drawing views. The bi-directionally associative property of CATIA ensures that the modifications made in the model are reflected in the drawing views and vice-versa.

These are only four of the many workbenches that CATIA offers. A few of the other modules include Machining, Equipment & System, Infrastructure and Ergonomics Design & Analysis. And of course, there are many other CATIA workbenches, each important in its own way.

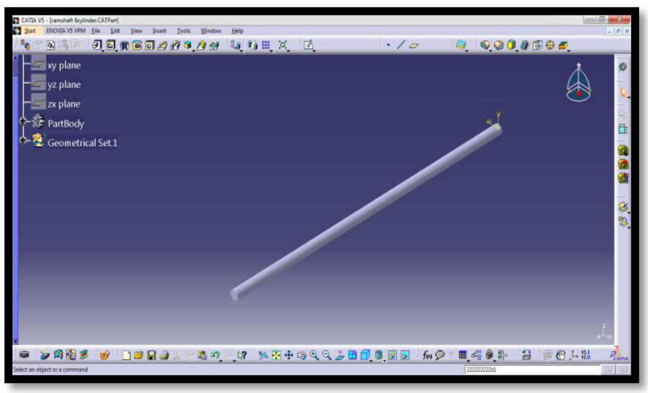
Bore = 103 mm
Stroke = 120 mm
Compression ratio = 17:1
Inlet valve opens = 100 TDC
Inlet valve closes = 460 BDC
Exhaust valve opens = 460 BDC
Exhaust valve closes = 100 TDC
Firing order = 1-2

B. 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

3-D MODEL OF CAM SHAFT

Shaft



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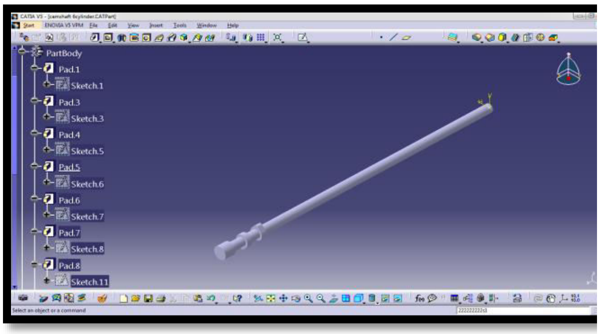
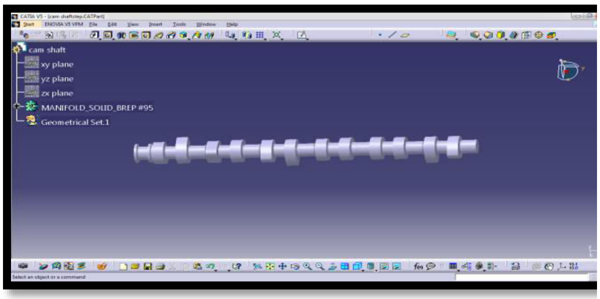
Cam





4.1 INTRODUCTION TO FEA

Finite detail assessment is a way of solving, normally approximately, fine issues in engineering and technology. It is used specially for troubles for which no real solution, expressible in a few mathematical shape, is to be had. As such, it's miles a numerical instead of an analytical method. Methods of this type are wanted due to the fact analytical techniques can't deal with the real, complex issues which might be met with in engineering. For instance, engineering strength of substances or the mathematical idea of elasticity can be used to calculate analytically the stresses and traces in a dishonest beam, however neither can be very a success in locating out what's taking area in part of a car suspension gadget inside the course of cornering.

1 STATIC ANALYSIS

The strength of components is a key requirement in understanding a product's performance, lifecycle and possible failure modes. Mechanical loading, thermal stress, bolt tension, pressure conditions and rotational acceleration are just some of the factors that will dictate strength requirements for materials and designs. ANSYS Mechanical ensures your product's viability and safety by predicting the strength required for the loads your design will experience in service.

4.2.2. FATIGUE ANALYSIS

There are two general categories of fatigue analysis:

Fatigue based on crack formation.

Fatigue based on crack growth. The choice of analysis type is based on the given application.λ

When in the design phase, or for components requiring only a few cycles of life, crack formation may be sufficient.

For highly engineered parts, for components that are manufactured in bulk such as automotive parts, or for in-service life prediction, crack growth may be required.

4.2.3. MODAL ANALYSIS

Modal analysis is a process of extracting modal parameters (natural frequencies, damping loss factors and modal constants) from measured vibration data. Since the measured data can be in the form of either frequency response functions or of impulse responses, there are frequency domain modal analysis and time domain modal analysis.
The fundamental of modal analysis using measured frequency response function data is about curving fitting the data using a predefined mathematical model of the measured structure. This model assumes the number of DoFs of the structure, its damping type and possibly the number of vibration modes within the measured frequency range.

STATIC ANALYSIS OF CAMSHAFT

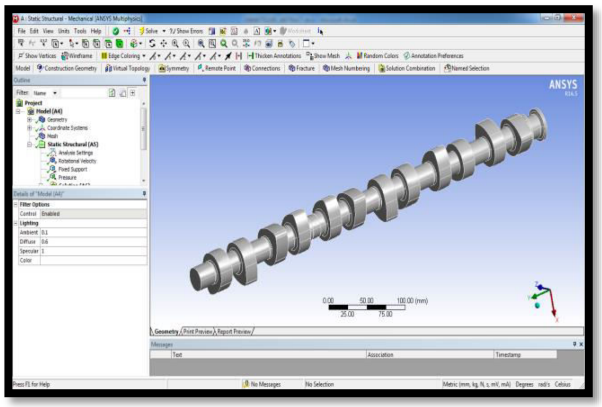


Fig 4.3.1 Imported model

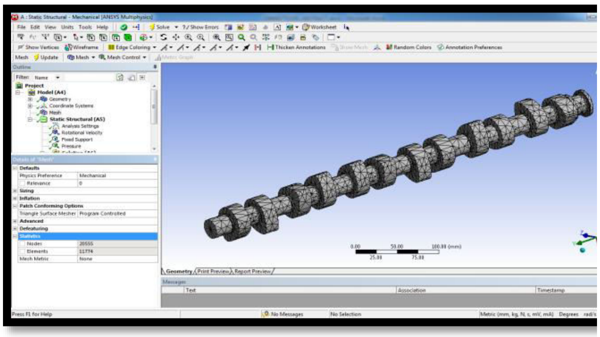


Fig 4.3.2 Meshed model

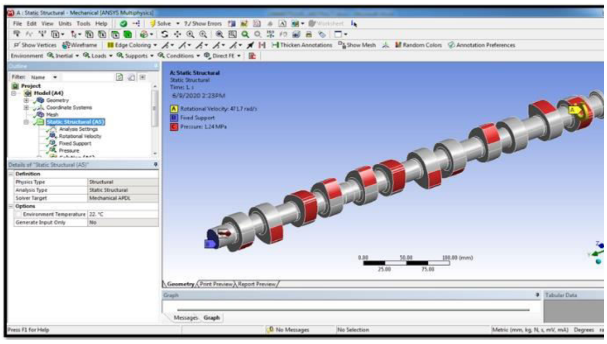


Fig 4.3.3 Load conditions

MATERIAL- EN40B

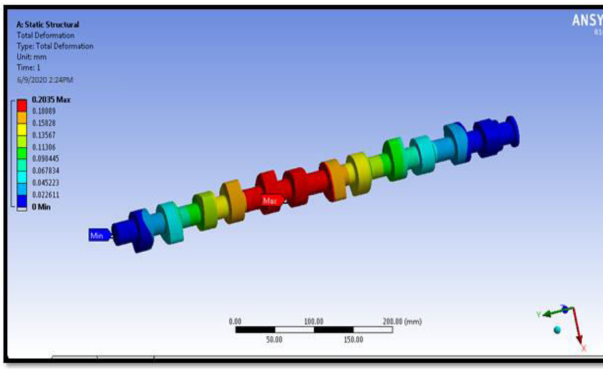


Fig 4.3.10 Deformation

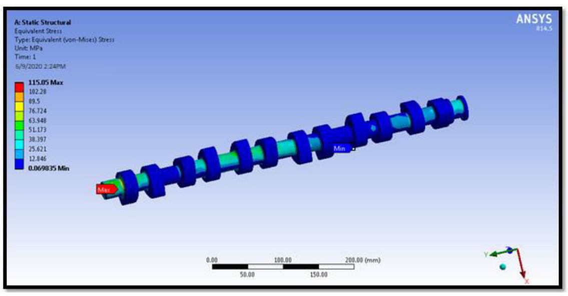


Fig 4.3.11 Stress

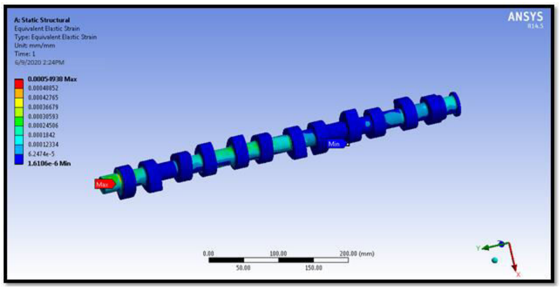


Fig 4.3.12 Strain

MATERIAL- EN40B

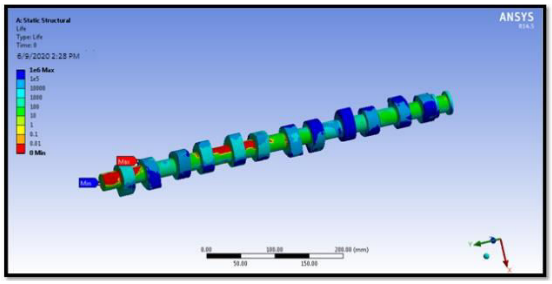


Fig 4.4.7 Life

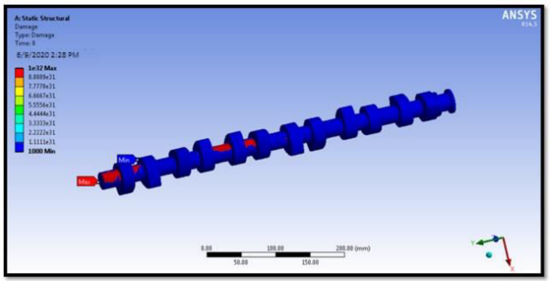


Fig 4.4.8 Damage

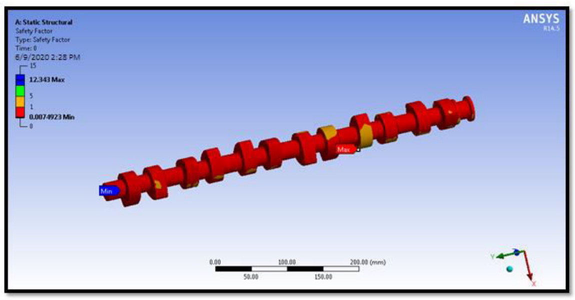


Fig 4.4.9 Safety factor

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MATERIAL- EN40B

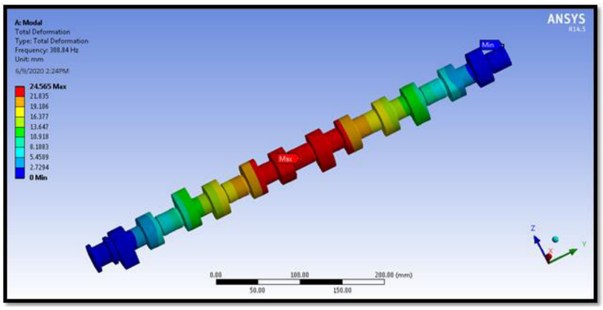

Fig 4.5.7 mode shape-1

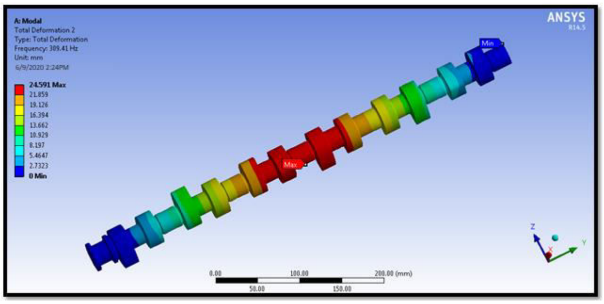

Fig 4.5.8 mode shape-2

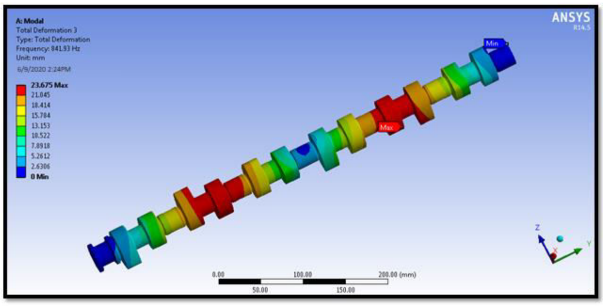

Fig 4.5.9 mode shape-3

4.6 DYNAMIC ANALYSIS OF CAM SHAFT

MATERIAL- EN40B

At 10 sec (15KN)

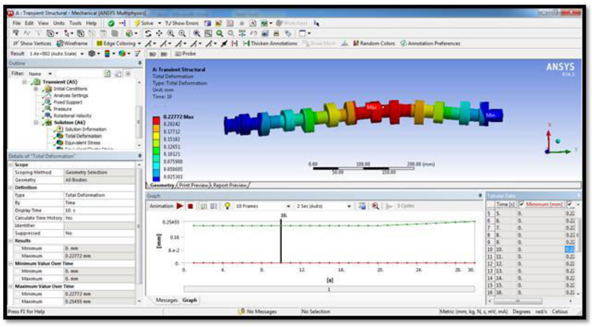

Fig 4.6.19 Deformation

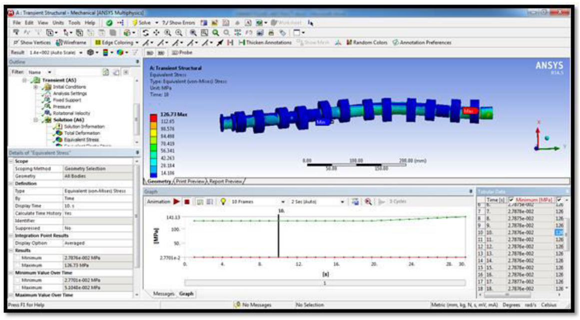

Fig 4.6.20 Stress

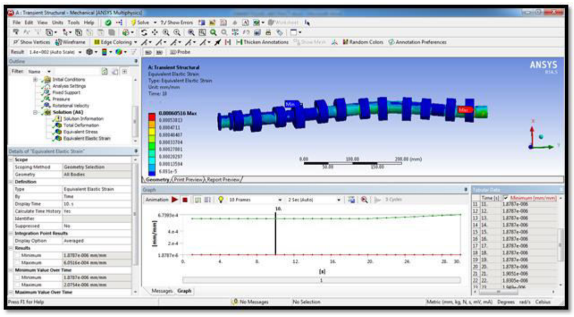

Fig 4.6.21 Strain

Table: 1 Static analysis results table

Material	Deformation (mm)	Stress (MPa)	Strain
EN99	0.22848	116.51	0.00061485
EN351 AISI8620	0.60938	132.75	0.0016642
EN40B	0.2035	115.05	0.00054938

Table: 2 Fatigue analysis results table

Material	Life	Damage	Safety factor
EN99	$1 \times e^{6}$	$1 \times e^{32}$	0.0073983
EN351 AISI8620	$1 \times e^{6}$	$1 \times e^{32}$	0.0064936
EN40B	$1 \times e^{6}$	$1 \times e^{32}$	0.0074923

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Table:3 Modal analysis results table

Material	Mode shapes	Deformation (mm)	Frequency (H
EN99	1	25.067	298.87
	2	25.093	299.4
	3	24.121	815.0
EN351 AISI8620	1	42.061	328.17
	2	42.109	328.82
	3	40.645	894.14
EN40B	1	24.565	308.84
	2	24.591	309.41
	3	23.675	841.93

CONCLUSION

In this thesis, a camshaft is designed for 6 cylinder engine and 3-D-model of the camshaft is created the use of modeling software program CATIA. The modeled in CATIA is imported in to ANSYS. After completing the element residences, meshing and constraints the loads are achieved on camshaft for three certainly one of a kind substances specifically EN351 AISI8620, EN99 and EN40Bto decided the displacement, equivalent strain of the cam shaft.

- By observing the static analysis results the maximum deformation at EN351 AISI8620 material and minimum stress has EN40B.
- By observing the fatigue analysis, the safety factor value maximum has EN40B.
- By observing the modal analysis results the maximum frequency has EN40B.
- By observing the dynamic analysis, the stress value minimum stress value has Nickel Chromium vanadium molybdenum alloy Steel.

So, it can be concluded the EN40B material is the better material for 6-cylinder cam shaft.

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