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DESIGN AND STRUCTURAL ANALYSIS OF CAM SHAFT

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ABSTRACT

The cam shaft and its associated parts control the opening and closing of the two valves. The associated parts are push rods, rocker arms, valve springs and tappets. It consists of a cylindrical rod running over the length of the cylinder bank with a number of oblong lobes protruding from it, one for each valve. 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 in to 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 solid works. The model created in solid works is imported in to ANSYS. After completing the element properties, meshing and constraints the loads are applied on camshaft for three different materials namely aluminum alloy, forged steel and cast iron. For that condition the results have been taken has displacement values and von miss's stresses for the static state of the camshaft. After taking the results of static analysis, the model analysis and harmonic analysis are done one by one. Finally, comparing the three different materials the best suitable material is selected for the construction of camshaft.

Keywords: Camshaft, model analysis, 3D-model and harmonic analysis

1. INTRODUCTION

Cam is a mechanical member for transmitting a desired motion to a follower by direct contact. The driver is called cam and driven 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 transfers motion to inlet & exhaust valve. If transfer of motion is not proper, then the stokes will not work in proper way. Also, it effects on performance of engine. To make work of camshaft in precise way. It is required in order 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, its 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 6th economic 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 influenced. On the other hand, the 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 on the possible failure locationsandtypes 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 drive train failures. Among the studies on the engine component failures, the prediction of fatigue failure in a camshaft using the crack-modeling method.

2.LITERATURE REVIEW

Marla Srikanth, D Venkata Subbarao [2] Fracture, Fatigue Growth Rate and Vibration Analysis of Cam Shafts Used in Railways. The cam shaft and its combined capacity guide the beginning and finish of the two valves. The associated parts are thrust rods, rocker arms, valve springs and tappets. It consists in of a cylindroid's oppression continuous over the number of extend lobes extend from it, one for each gate. A camshaft is a shaft to which a cam is undisturbed or which a cam shapes a component part. The vibration in the camshaft reduces the effectiveness of the engine and augments the rubbing between the rocker arms and the camshaft. This study is centered towards the oscillation analysis of the variegated camshafts that are used in times and to find a material that have the minimum native crowd and no effects on the ability of the electrical engine. The goal of the project is to design cam shaft analytically, its modeling and Analysis under FEA. In FEA we are using fracture, fatigue and vibration analyses through finding the behavior of cam shaft. Fracture analysis through finding the strain intensity factor, Fatigue analysis through finding the safety factor, life and damage of cam shaft and finally Vibration analysis through finding the frequency of the body. Behavior of cam pit is obtained by take apart the collective conduct of the elements to mate the cam well strong at all possible govern act.

Steven McClintock, Jason Walking Shaw, Charles McCartan, Geoff McCullough, Geoff Cunningham [3] Camshaft Design for an Inlet-Restricted FSAE Engine**.** Restricting the flow rate of air to the intake manifold is a convenient and popular method used by several motor sport disciplines to regulate engine performance. This principle is applied in the Formula SAE and Formula Student competitions, the rules of which stipulate that all the air entering the engine must pass through a 20mm diameter orifice. The restriction acts as a partially closed throttle which generates a vacuum in the inlet plenum. During the valve overlap period of the cycle, which may be as much as 100 degrees crank angle in the motorcycle engines used by most FSAE competitors, this vacuum causes reverse flow of exhaust gas into the intake runners. This, in turn, reduces the amount of fresh air entering the cylinder during the subsequent intake stroke and therefore reduces the torque produced. This effect is particularly noticeable at medium engine speeds when the time available for reverse flow is greater than at the peak torque speed. The objective of the study described in this paper was to mitigate the reverse flow effect by reducing the duration of the valve overlap period. A thermodynamic model of the Yamaha YZF R6 engine was developed for this purpose and validated using cycle-averaged and crank angle-resolved test data. The resulting model was then used to find the optimum values of lift, duration and timing for both the intake and exhaust valves. The camshafts required to give these valve lift profiles were designed using valve train analysis software. This process included a consideration of the dynamic forces encountered by the valve train and ensured that the resulting stresses remained within safe limits. The new camshafts increased the torque output by up to 30% at medium engine speeds, without reducing the high-speed torque, and therefore significantly improved the vehicle drivability.

Mallikarjuna, N. Jashuva, G. Nagaraju,B. Rama BhupalReddy[4]. DesignManufacturing and Cost Estimation of Camshaft Used inTwo-Wheeler**.** The camshaft and its associated parts control the opening and closing of the two valves. The associated parts are push rods, rocker arms, valve springs and tappets. This shaft also provides the drive to the ignition system. 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 the valves at the correct timing and to keep them open for the necessary duration. In this project, a camshaft is designed for a two-wheeler engine by using theoretical calculations. Cam profile is designed by using the calculations. A 3D model of the Camshaft is created using modeling software solid works. For manufacturing cam shaft following manufacturing method are used by Machining, Casting and Forging. From above processes we selected casting processes because it's used for bulk production. For the manufacture of Camshaft Core and Cavity is to be extracted from the model using manufacturing module in Pro/Engineer. Total Mold base is to be designed for the camshaft which is ready to go for production. CNC Program is to be generated for both core and cavity using roughing and finishing processes. This is also done in manufacturing module in Pro/Engineer. Total cost required for the manufacturing of die is estimated. From this project we will learn a manufacturing method for camshaft. solid works is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design.

Balasubramaniam.A1, Jerwinprabu.A 2, Mahendrababu.G.R[5] Design Optimization of Cam Shaft Angle Monitoring System For Industrial Improvements.Camshaft is used in the engine for transfers' motion to inlet & exhaust valve. If transfer of motion is not proper, then the strokes of the engine will not be done in proper way. It also effects on performance of engine. This research deals with the optimization of drive camshaft using the substitution of composite material over the conventional steel material for drive shaft has increasing the advantages of design due to its high specific stiffness and strength. Drive shaft is the main component of drive system of an automobile electronics. Use of conventional steel for manufacturing of drive shaft has many disadvantages such as low specific stiffness and strength. Conventional drive shaft is made up into two parts to increase its fundamental natural bending frequency. As its simplest a camshaft inspection system can consist of a Roll scan, camshaft sensor, sensor arm and manually rotatable stand for the camshaft. The camshaft, which controls when the inlet and exhaust valves open and close, plays a significant role in this process. To Measure the angle of cam shaft with 0.5mm precision level and also control quality.

Praveen Kavuri, Dara Ashok [6] Fracture, Fatigue Growth Rate and Vibration Analysis of Camshaft in Railways.The cam shaft is the device regulates the opening and closing of the two valves. The connected parts are push rods, rocker arms, valve springs and tappets. It had number of lobes protruding over a cylindrical shaft, one for each valve. The cam lobes force the valves to open by or on some intermediate mechanism as they rotate. Also, this same rotation of the shaft offers the drive to the ignition system. Camshafts are made from steel and sit below the cylinders and pistons in the engine block. At present, camshafts are being manufactured in railways by rolled steel bars and machined by turning and excessive removal of material. We are replaced with replacement of steel alloy 6061, forged steel & cast iron. For checking, 3D-model of the camshaft is created using modeling software CREO parametric software and analysis done in ANSYS with different materials replacement of steel alloy, forged steel & cast iron. In this paper, the static analysis and Modal analysis done to conclude the deformation, stresses, strains and the deformation with respect to frequencies at different mode shapes and fatigue analysis is to estimate the life of the component.

3. METHODOLOGY

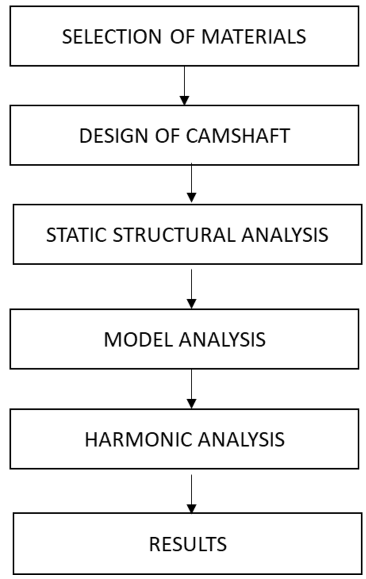


FIG:1 METHODOLOGY

4. INTRODUCTION OF SOFTWARE

4.1 CAD/CAM/CAE

The Modern universe of design, improvement, fabricating so on, in which we have ventured can't be envisioned without obstruction of computer. The use of computer is with the end goal that; they have turned into an essential piece of these fields. On the planet advertise now the opposition in cost factor as well as quality, consistency. accessibility, pressing, stocking, conveyance and so on. So are the necessities driving ventures to embrace present day method instead of neighborhood compelling the businesses to adjust better strategies like CAD/CAM/CAE, and so on. The Possible fundamental approach to ventures is to have brilliant products at low expenses is by utilizing the computer Aided Engineering (CAE), Computer Aided Design (CAD) And Computer Aided Manufacturing (CAM) set up. Facilitate many devices is being introduced to streamline and serve the necessity CATIA, PRO-E, UG are some among numerous.

This infiltration of method concern has pushed the makers to

Increase productivity
Shortening the lead-time
Minimizing the prototyping expenses
Improving Quality
Designing better products

4.2 SOLIDWORKS

SolidWorks is one of the products of SolidWorks Corporation, which is powered by Dassault System 3D experience platform. SolidWorks mechanical design automation software is a feature-based, parametric solid modeling design tool that lets designers quickly sketch out ideas, experiment with features and dimensions, and produce models and detailed drawings. It takes advantage of the easy to learn Windows graphical user interface in which designers can use simple drag and drop (DD), copy paste functionality same as in the Windows. Many of the icons such as print, open, cut and save are also part of the SolidWorks application which is familiar with Windows functions. When designing a model using SolidWorks, you can visualize it in three dimensions, the way the model exists once it is manufactured. SolidWorks is structured in three basic types: part mode, assembly mode and drawing mode. Part mode is the basic building block in this software. For example, you must have to create a part before you create assembly. Assembly mode contains parts or other assemblies, called sub-assemblies. These three modes are discussed below one by one.

5. MODELING OF CAMSHAFT

5.1 DESIGN OF CAMSHAFT

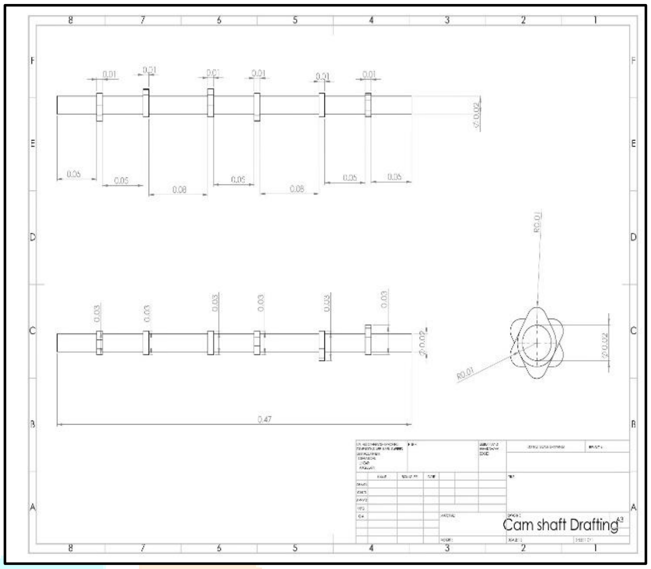


FIG :2 DESIGN OF CAMSHAFT

5.2 MODEL OF CAMSHAFT USING SOLIDWORKS

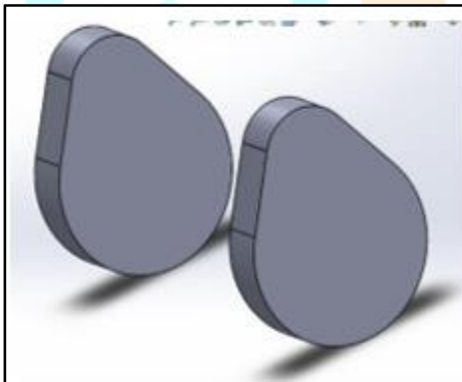


FIG :3 MODEL OF CAM

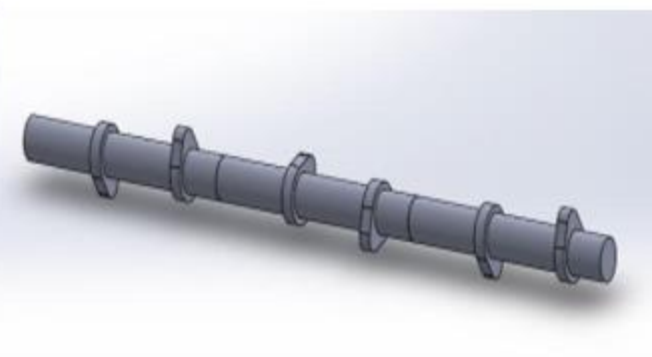


FIG :4 MODEL OF CAMSHAFT

6. ANALYSIS OF CAMSHAFT

6.1 STATIC STRUCTURAL ANALYSIS OF CAMSHAFT

A static structural analysis determines the displacement, stresses, strain and forces in structures or components caused by loads that do not induce significant and damping effects.

ANALYSING

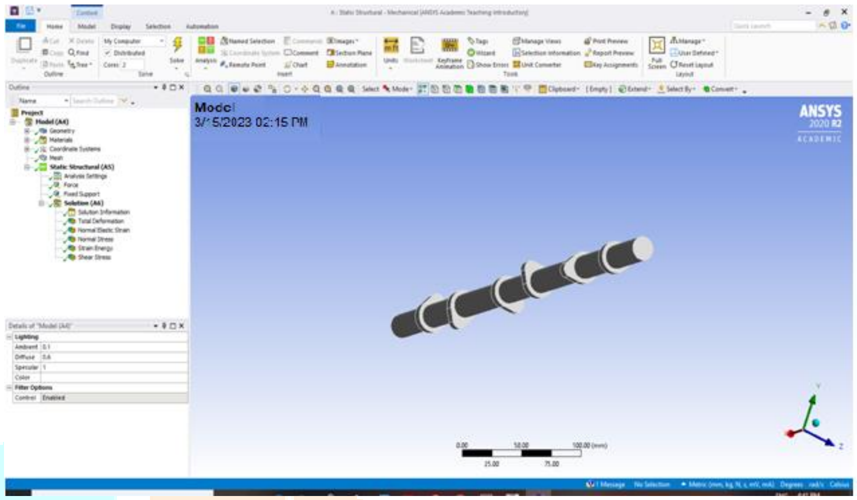


FIG :5 STATIC STRUCTURAL GEOMETRY

Select mesh on left side part tree right click generate mesh

FIG :6 STATIC STRUCTURAL OF MESH GENERATION

RESULTS---FORGED STEEL

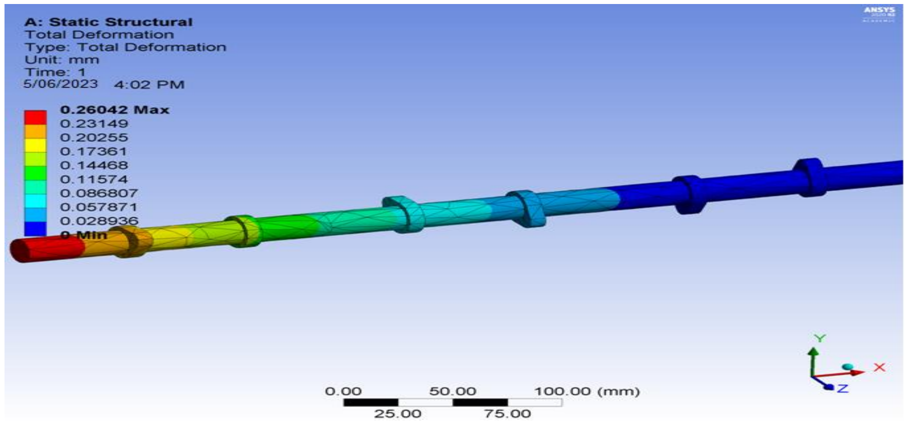


FIG :7 DEFORMATION FORGED STEEL

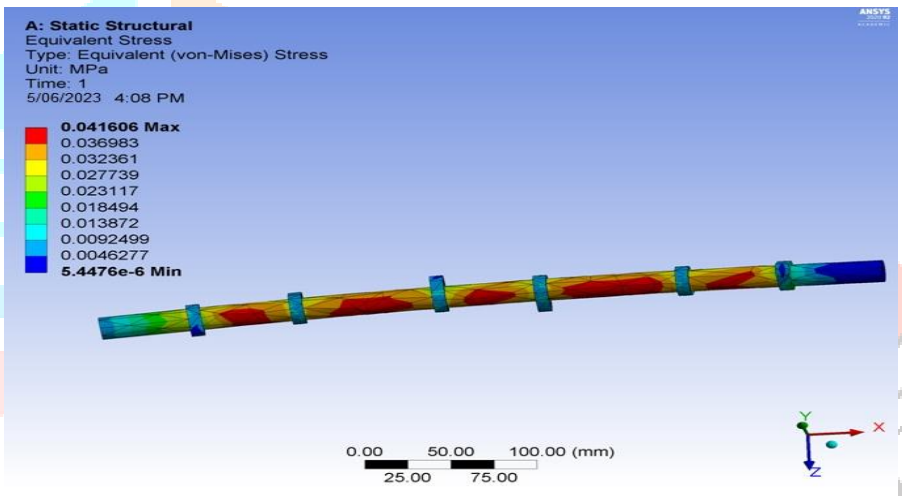


FIG:8 EQUIVALENT STRESS FORGED STEEL

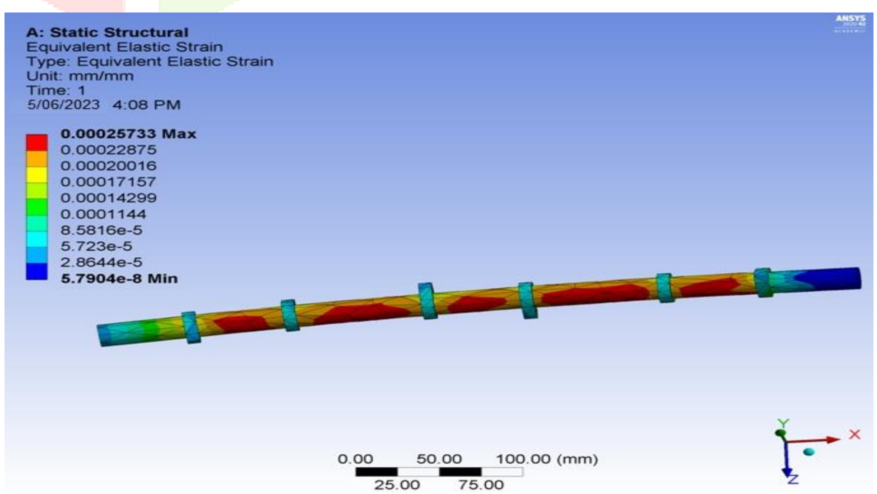


FIG:9 EQUIVALENT STRAIN FORGED STEEL

RESULTS---AL ALLOY:

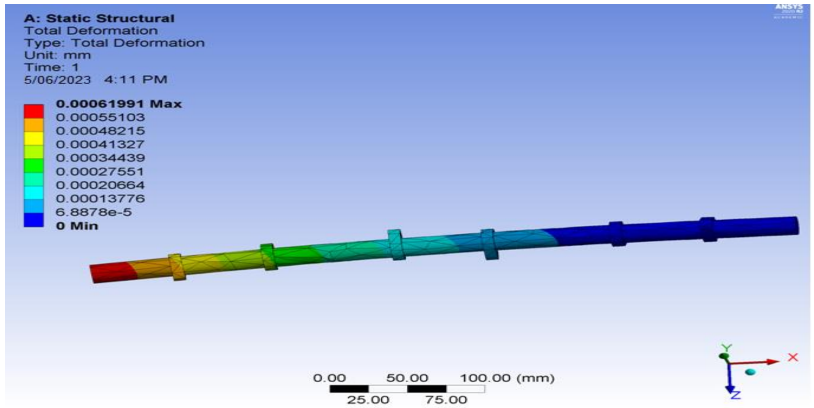


FIG:10 DEFORMATION AL ALLOY

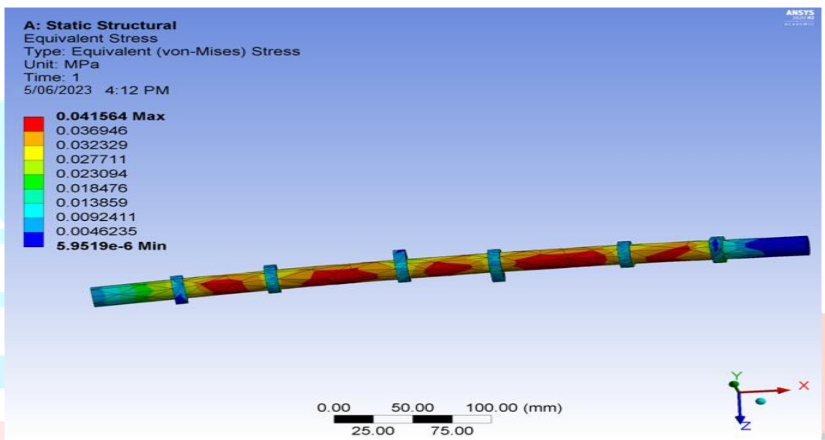


FIG:11 EQUIVALENT STRESS AL ALLOY

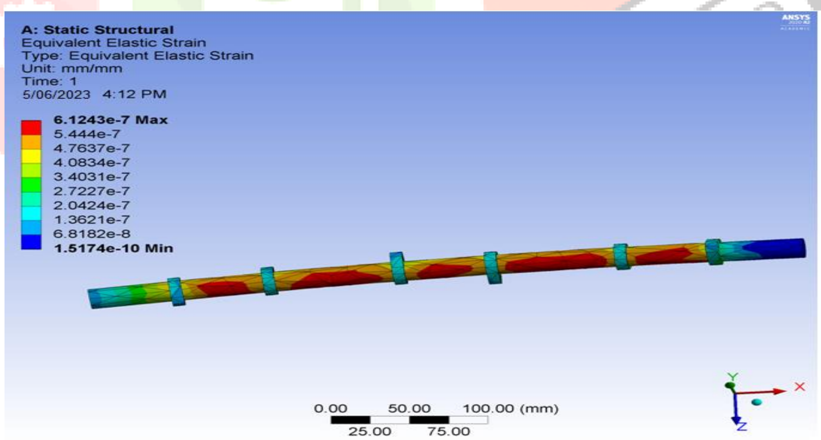


FIG :12 EQUIVALENT STRAIN AL ALLOY

RESULTS---CAST IRON

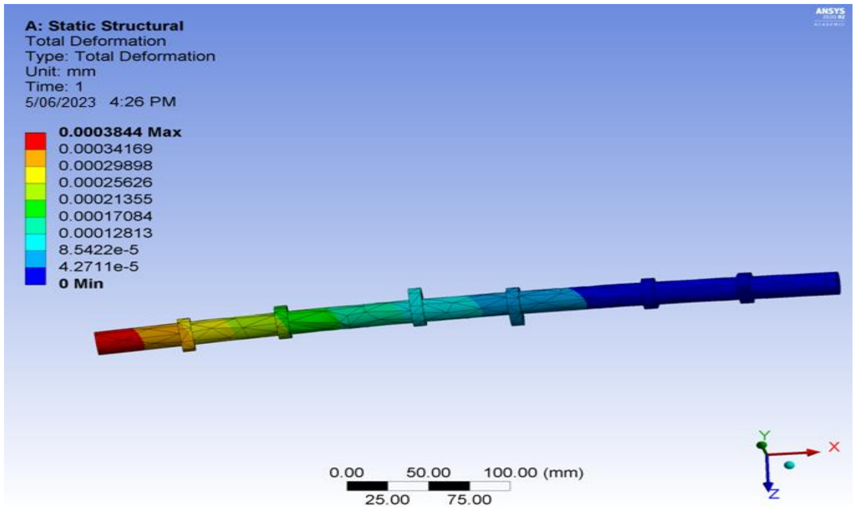


FIG:13 DEFORMATION CAST IRON

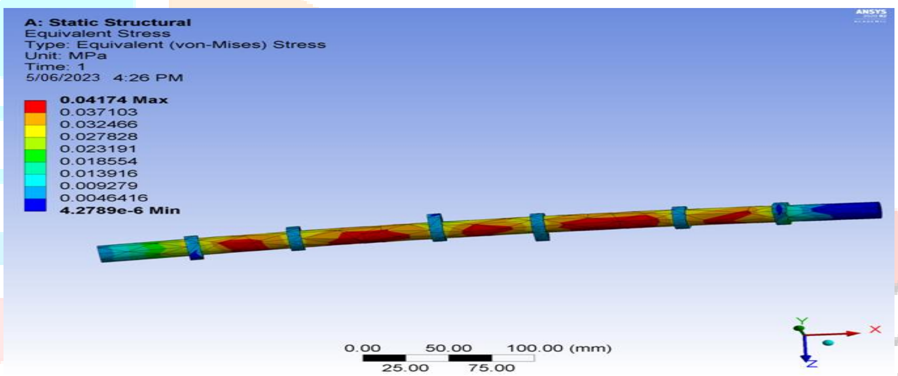


FIG:14 EQUIVALENT STRESS CAST IRON

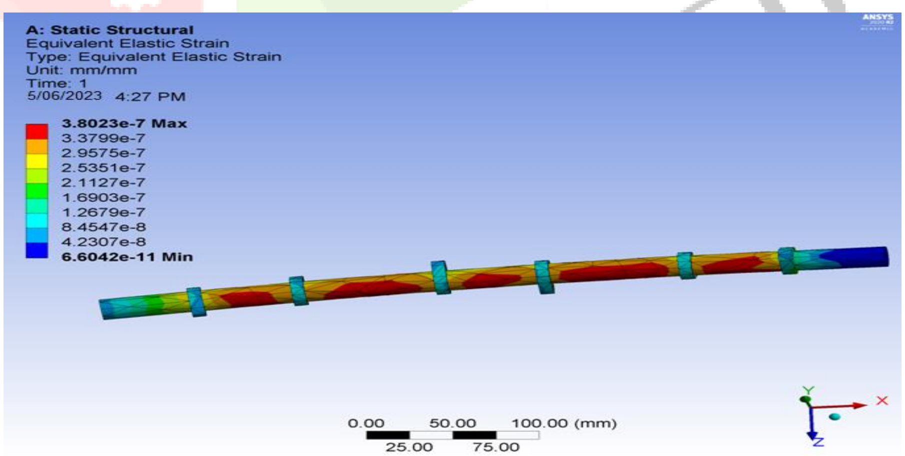


FIG:15 EQUIVALENT STRAIN CAST IRON

6.2 MODEL ANALYSIS

A model analysis is ordinarily used to decide the vibration attributes (characteristic frequencies and mode shapes) of a structure or a machine part while it is being designed. It can likewise fill in as a beginning stage for another, more itemized, dynamic analysis, for example, a harmonic reaction or full transient dynamic analysis. Model examinations, while being a standout amongst the most fundamental dynamic analysis writes accessible in

ANSYS, can likewise be more computationally tedious than a run of the mill static analysis. A lessened solver, using naturally or physically chose ace degrees of opportunity is utilized to definitely diminish the issue size and arrangement time.

RESULTS----FORGED STEEL

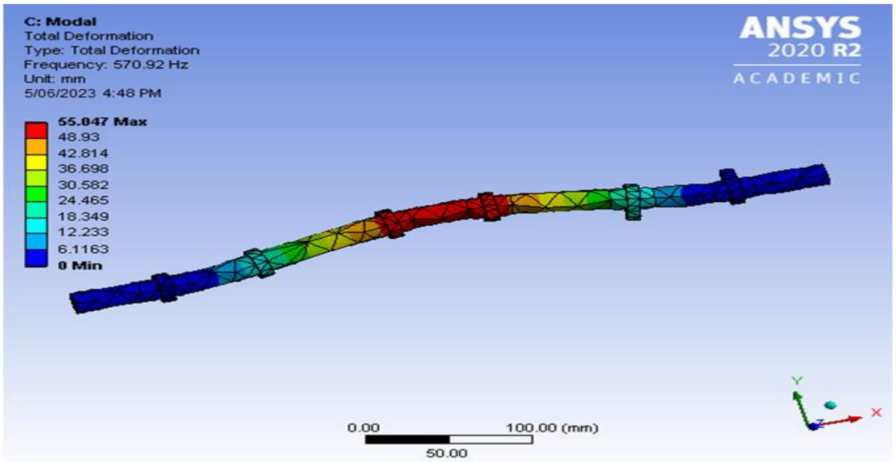


FIG:16 MODE 1-FORGED STEEL

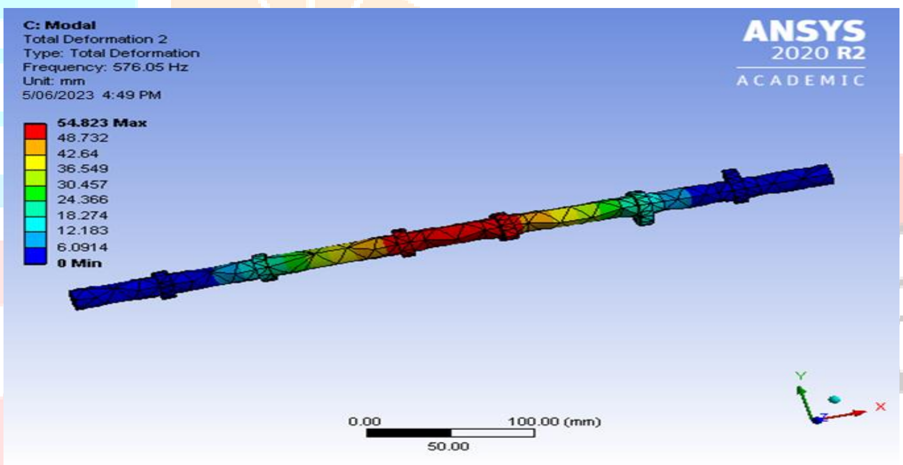


FIG :17 MODE 2-FORGED STEEL

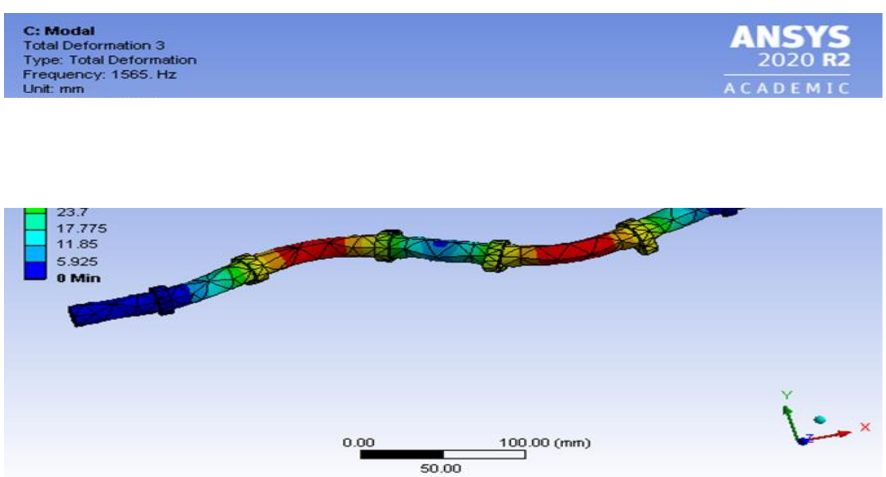


FIG:18 MODE 3-FORGED STEEL

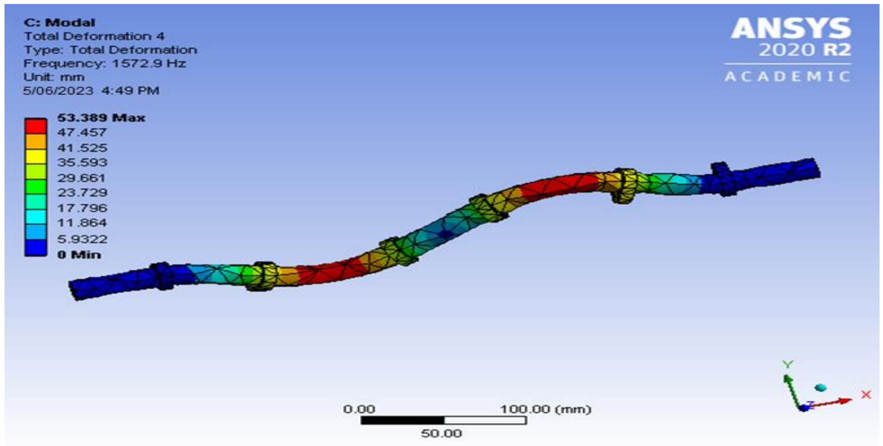
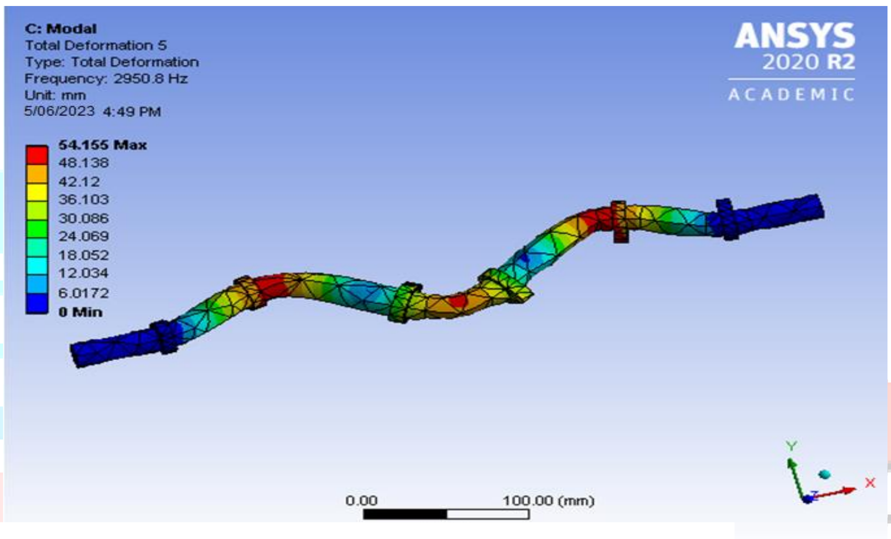


FIG:19 MODE 4-FORGED STEEL



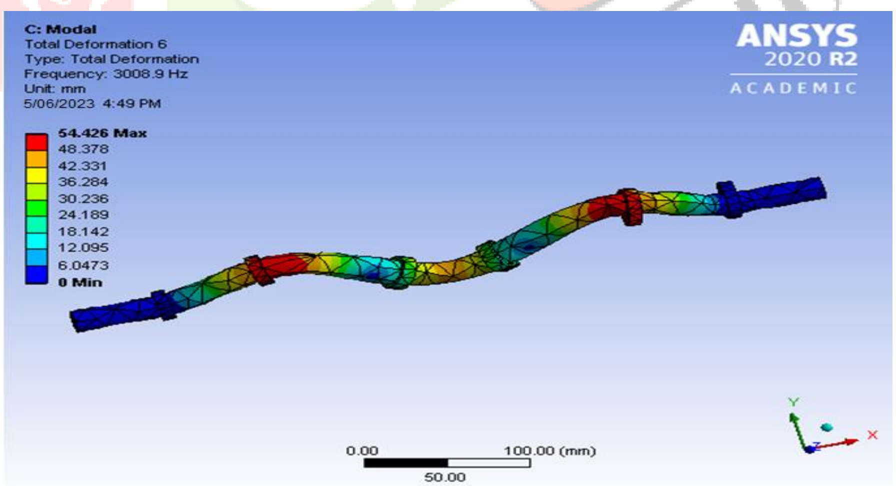


FIG:21 MODE 6-FORGED STEEL

RESULTS----AL ALLOY

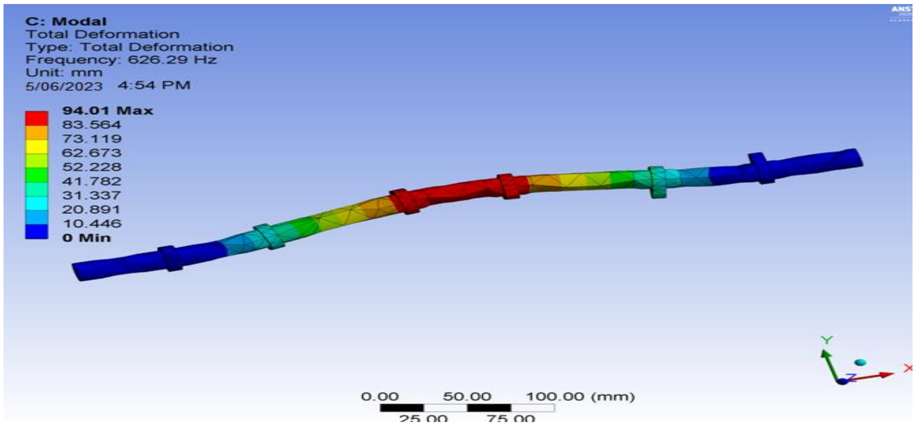


FIG:22 MODE 1-AL ALLOY

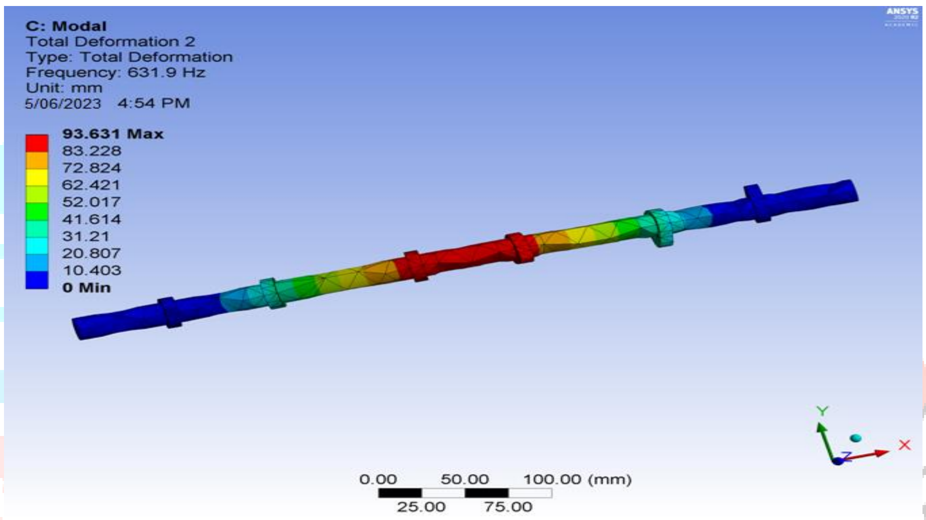


FIG:23 MODE 2-AL ALLOY

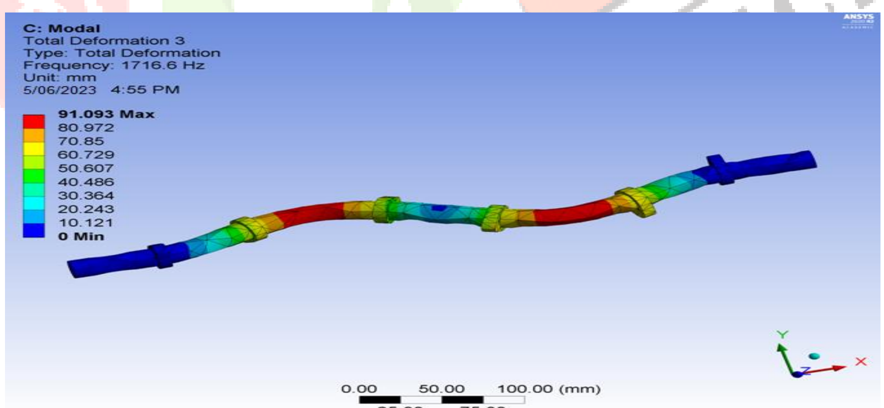


FIG:24 MODE 3-AL ALLOY

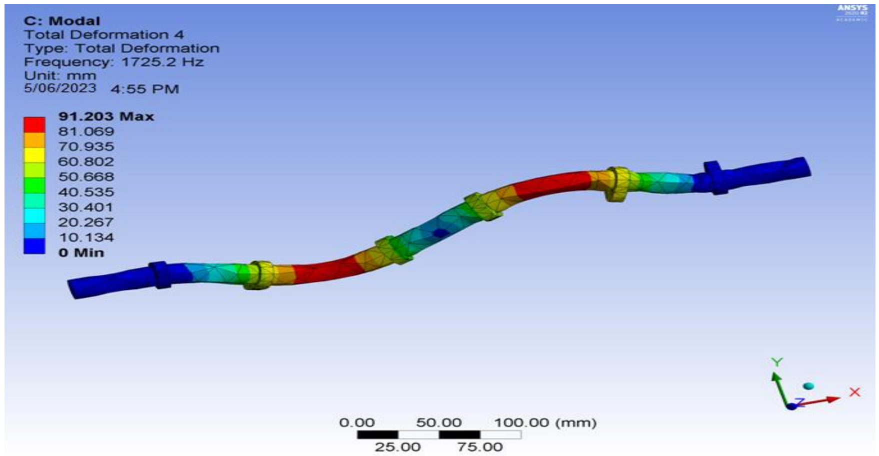


FIG:25 MODE 4-AL ALLOY

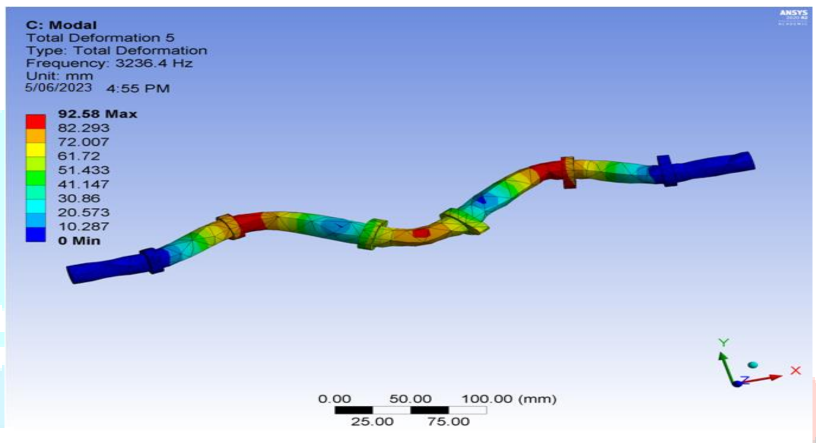


FIG :26 MODE 5-AL ALLOY

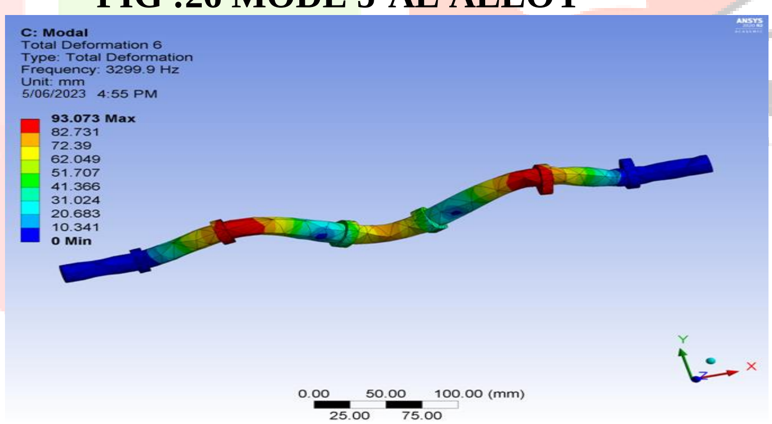


FIG:27 MODE 6-AL ALLOY

RESULTS----CAST IRON

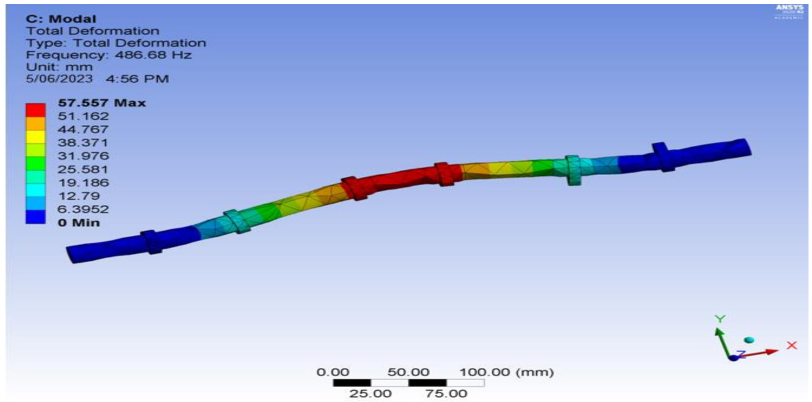


FIG:28 MODE 1-CAST IRON

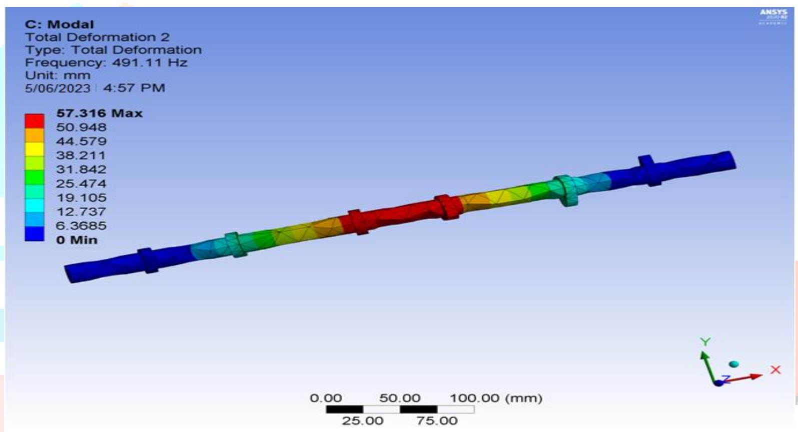


FIG :29 MODE 2-CAST IRON

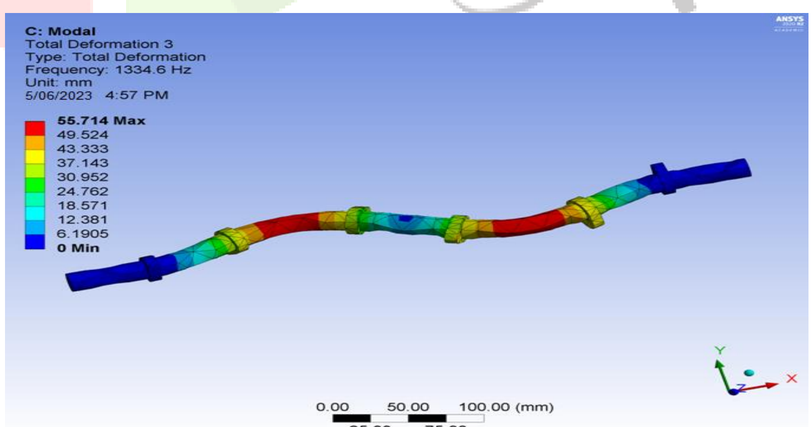


FIG :30 MODE 3-CAST IRON

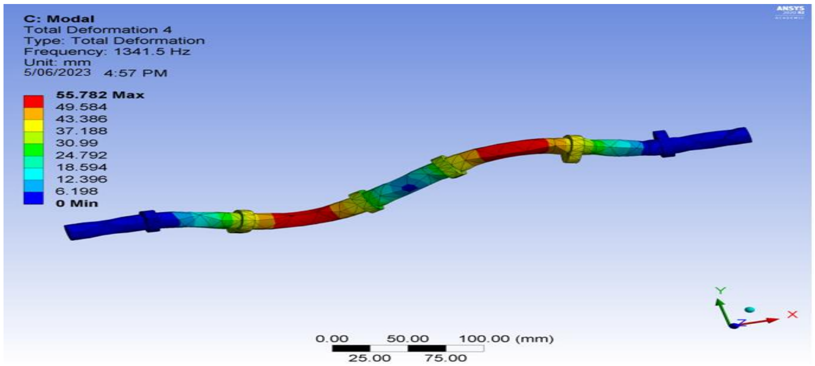


FIG:31 MODE 4-CAST IRON

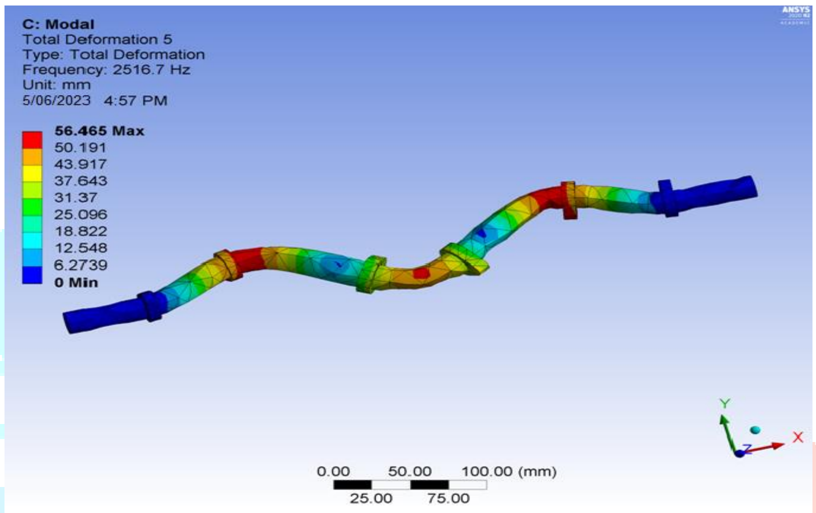


FIG:32 MODE 5-CAST IRON

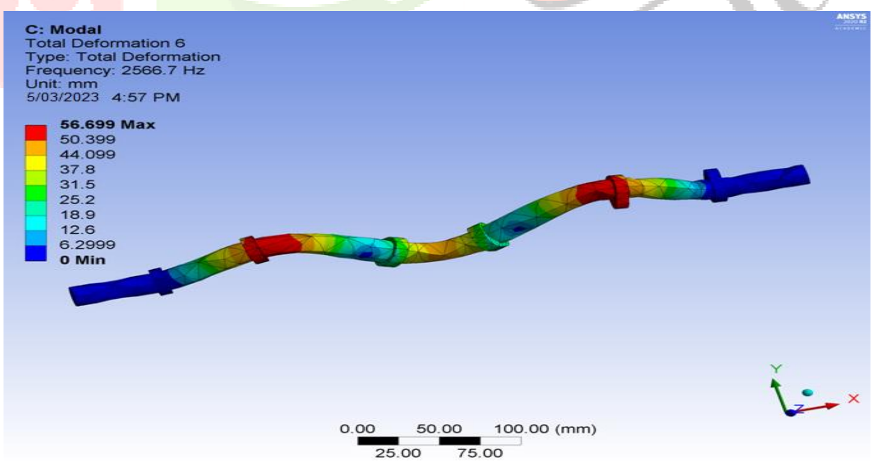


FIG :33 MODE 6-CAST IRON

6.3 HARMONIC ANALYSIS:

Utilized widely by organizations who produce pivoting hardware, ANSYS Harmonic analysis is utilized to foresee the maintained dynamic conduct of structures to reliable cyclic stacking. A harmonic analysis can be utilized to check regardless of whether a machine design will effectively conquer reverberation, weakness, and other hurtful impacts of forced vibrations.

HARMONIC ANALYSIS OF FORGED STEEL

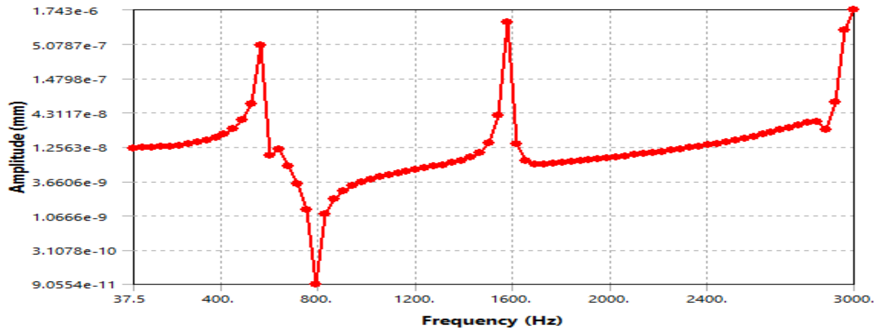


FIG:34 FREQUENCY GRAPH OF FORGED STEEL

HARMONIC ANALYSIS OF AL ALLOY

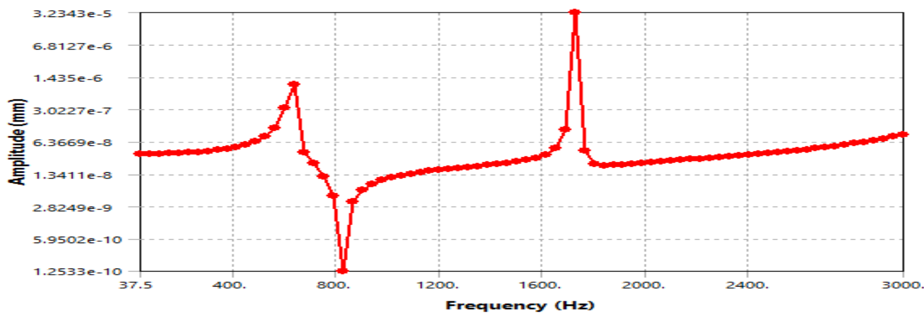


FIG:35 FREQUENCY GRAPH OF AL ALLOY

HARMONIC ANALYSIS OF CAST IRON:

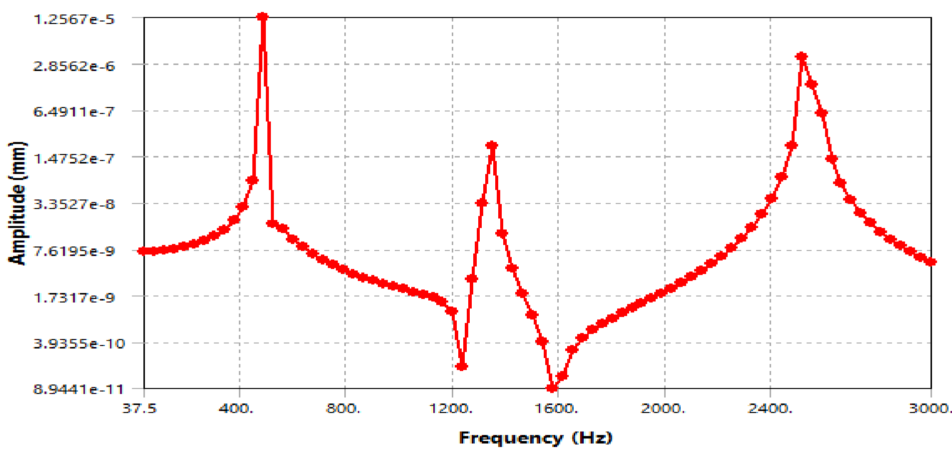


FIG :36 FREQUENCY GRAPH OF CAST IRON

7. RESULTS AND DISCUSSION

STRUCTURAL ANALYSIS

In static analysis the following is the displacement levels and stress levels attained for 3 materials.

Material	Deformation (mm)	Stress (MPa)	Strain
Forged steel	0.26042	0.041606	0.00025733
Al alloy	0.00061991	0.041564	6.1243e-7
Cast iron	0.0003844	0.04174	3.8023e-7

FIG: 37 RESULT OF STRUCTURAL ANALYSIS

MODAL ANALYSIS

Modal analysis is done to determine the natural frequencies under applied loads and five modes were drawn and noted frequencies and displacements for 3 materials.

Modes	Forged steel	Al alloy	Cast iron
Mode 1	55.047	94.01	57.557
Mode 2	54.823	93.631	57.316
Mode 3	63.326	91.093	55.714
Mode 4	63.155	91.203	55.782
Mode 5	64.389	92.58	56.465
Mode 6	64.426	93.073	56.699

HARMONIC ANALYSIS

In Harmonic analysis the loading is carried at a frequency ranging from 0 to 3000Hz and then the graphs were drawn for displacement and frequency. The following are the displacement levels attained for 3 materials.

Frequency (HZ)	Amplitude of Forged steel(mm)	Amplitude of Al alloy(mm)	Amplitude of Cast iron(mm)
400	1.9943e-008	4.9578e-008	2.9334e-008
1600	1.4088e-008	3.4627e-008	1.3055e-010
3000	1.743e-006	8.9789e-008	5.0886e-009

Fig: 39 RESULT OF HARMONIC ANALYSIS

8.CONCLUSION

Theoretical calculations carry out to design the cam profile (using displacement drawing and cam profile drawing). Analysis was carried out to evaluate the design using traditional materials cast iron and forged steel. Material optimization was carried out to replace the traditional material with new composite alloys. Static analysis is carried out to find the displacement and stress due to loads and then modal analysis is carried out to determine the frequency values due to its geometric shape and material property (natural frequency's). The values of natural frequency should match with traditional camshaft. After model analysis dynamic frequency analysis was done to determine the displacements due to external vibrations. According to the results obtained from the analysis al alloy is the best choice for camshaft manufacturing.

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