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Design evaluation of cam shaft used in multi cylinder engine

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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 cam lobes force the valves open by pressing on the valve, or on some intermediate mechanism as they rotate. 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 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 pro/Engineer. The model created in pro/E is imported in to ANSYS. After completing the element properties, meshing and constraints the loads are applied on camshaft for three different materials namely aluminium alloy 360, forged steel and cast iron. For that condition the results have been taken has displacement values and von misses 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: Design; Evaluation; Cam Shaft; Multi Cylinder Engine.

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.

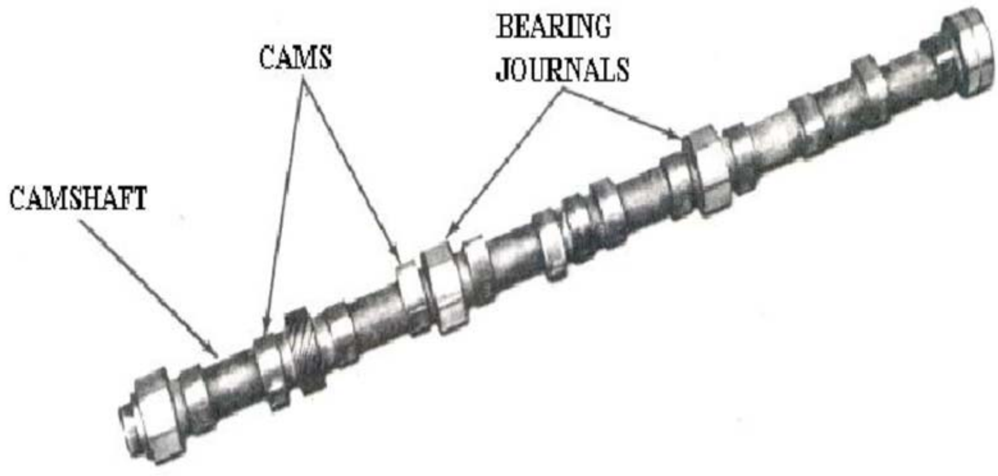
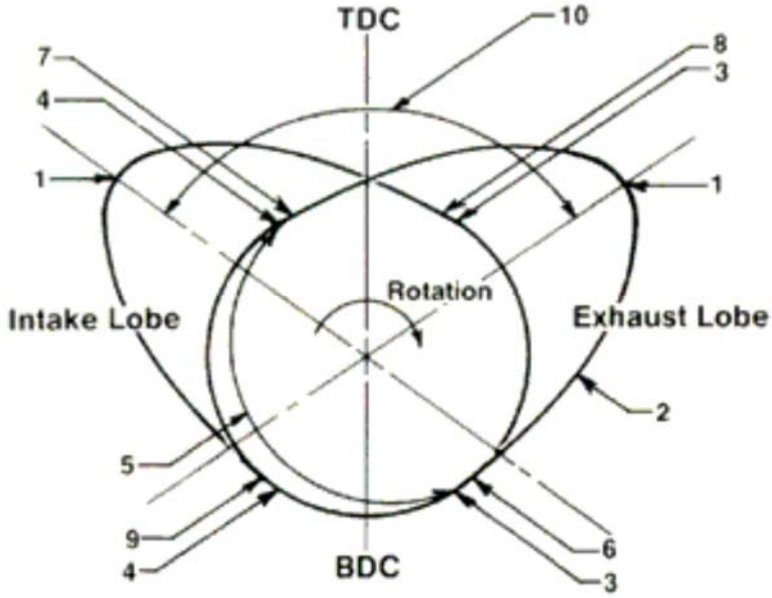


Fig 1: Cam and Camshaft



1. Max lift or nose 2. Flank Opening clearance ramp 3. Closing clearance ramp 4. Base circle 5. Exhaust opening timing figure 6. Exhaust closing timing figure 7. Intake opening timing figure 8. Intake closing timing figure 9. Intake to exhaust lobe separation

Fig 2: CAM Specifications

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 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 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. Modeling of Camshaft in Part Design Module

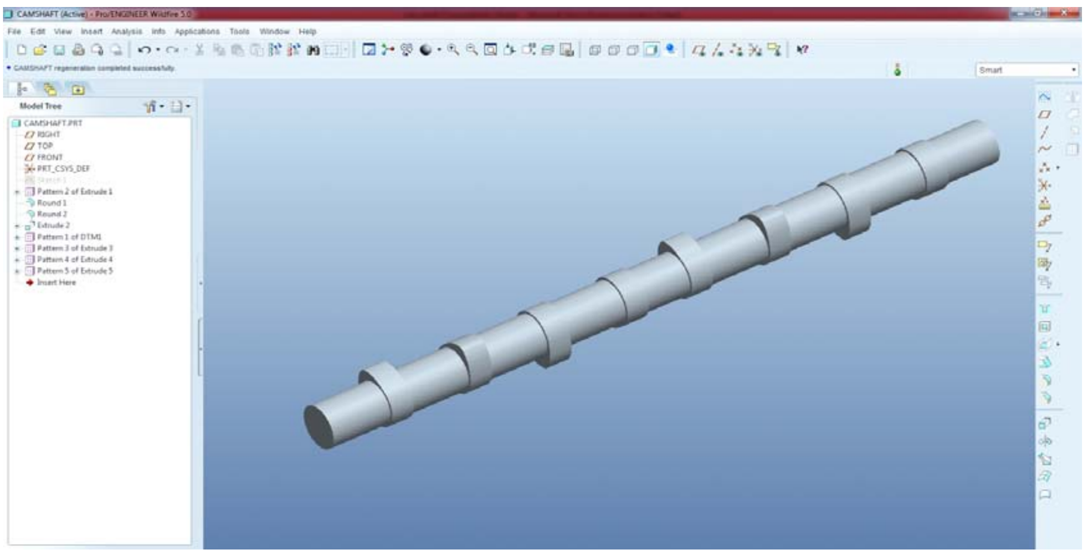


Fig 3: Pro/_Engineer modal of cam 3.0 Structural Analysis using Aluminum Alloy A360

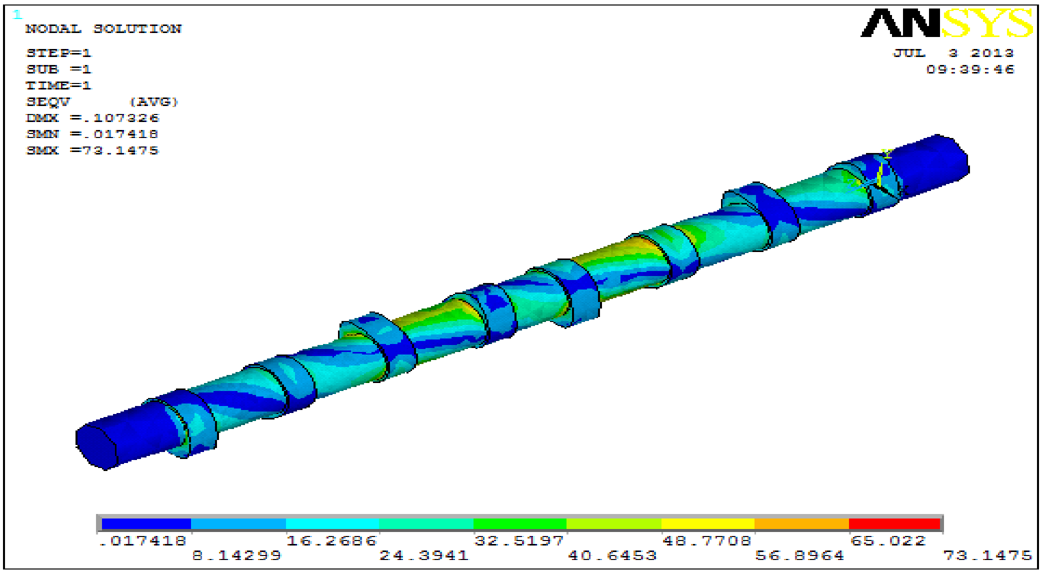


Fig 4: Von Mises stresses

3.1 Structural Analysis using forged steel

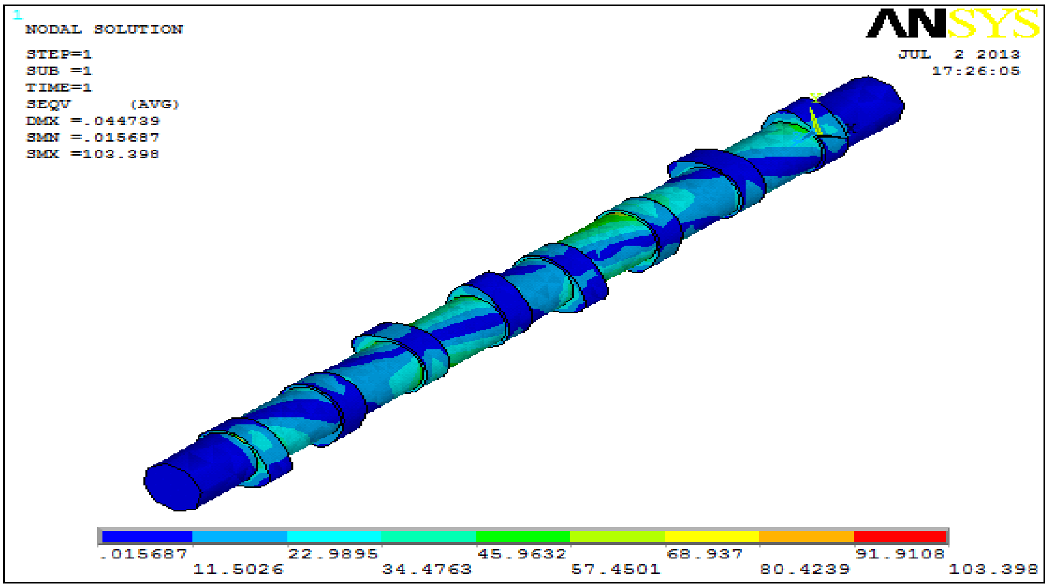


Fig 5: Von Mises stress

3.2 Structural Analysis using cast iron

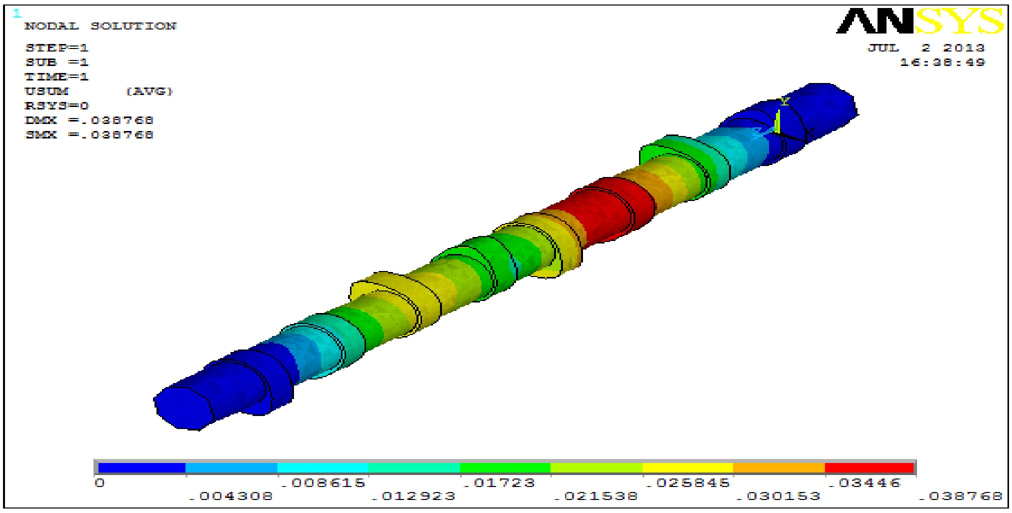


Fig 6: von mises stress

Aluminum Alloy A360

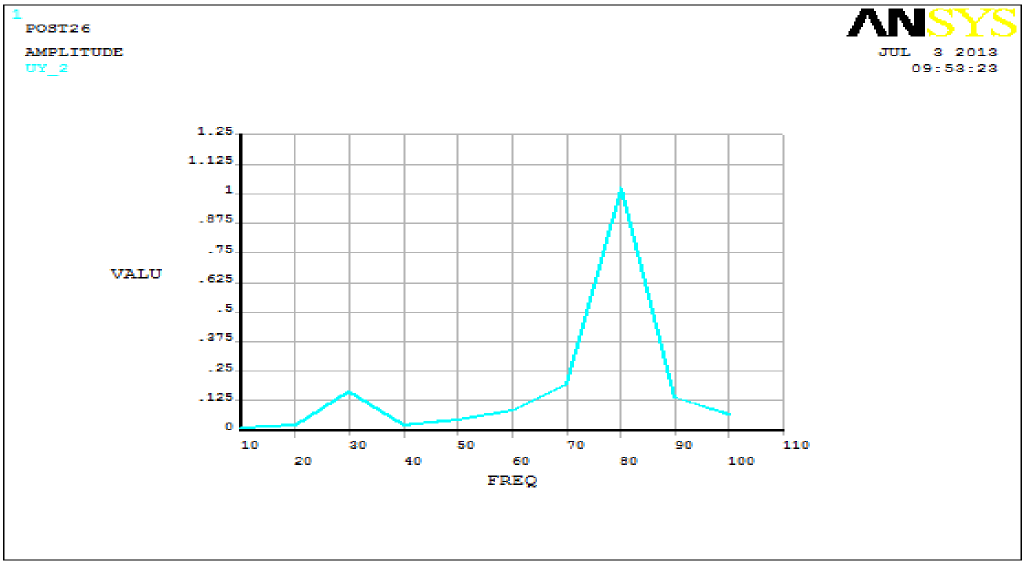


Fig 7: The above image is showing displacement value between two cams

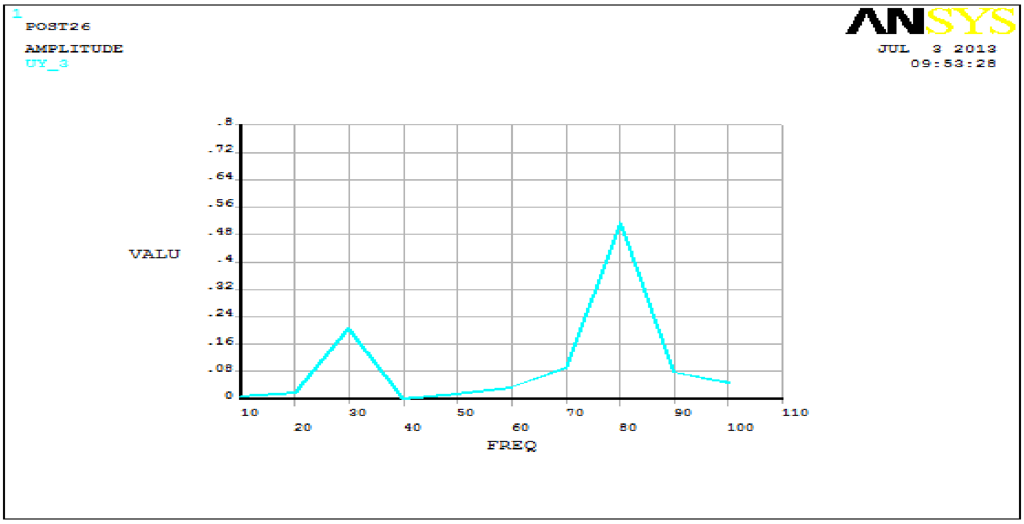


Fig 8: The above image is showing displacement value at bottom of cam

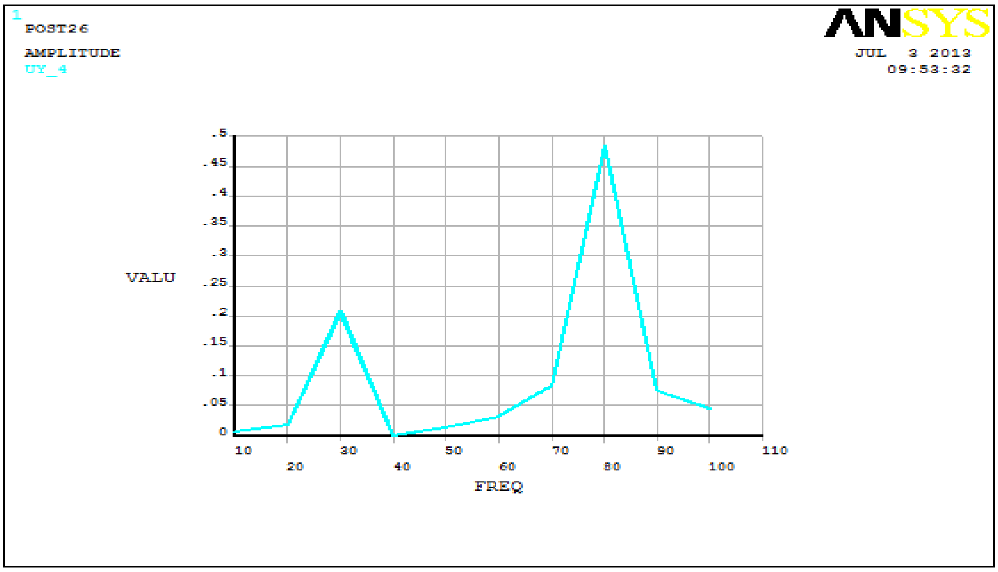


Fig 9: The above image is showing displacement value at top of cam Forgedsteel

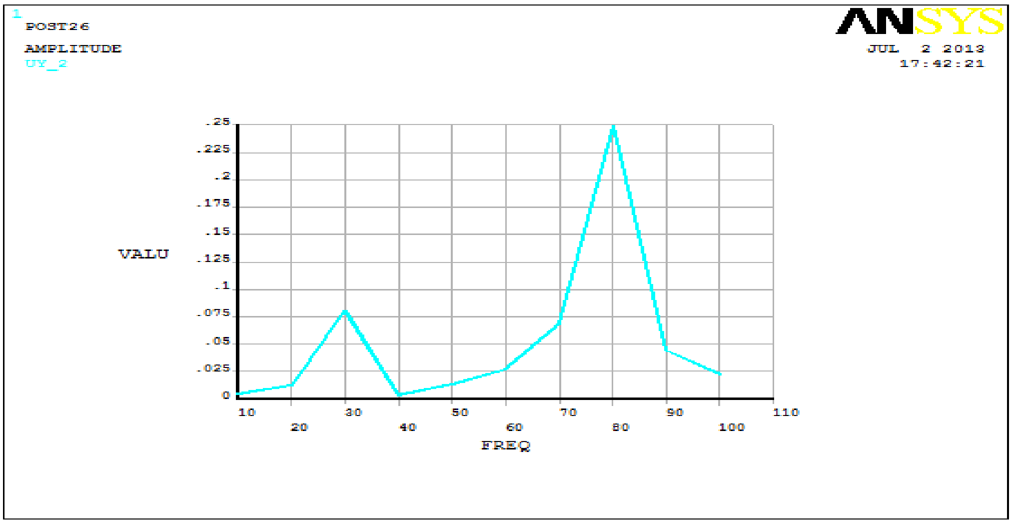


Fig 10: The above image is showing displacement value between two cams

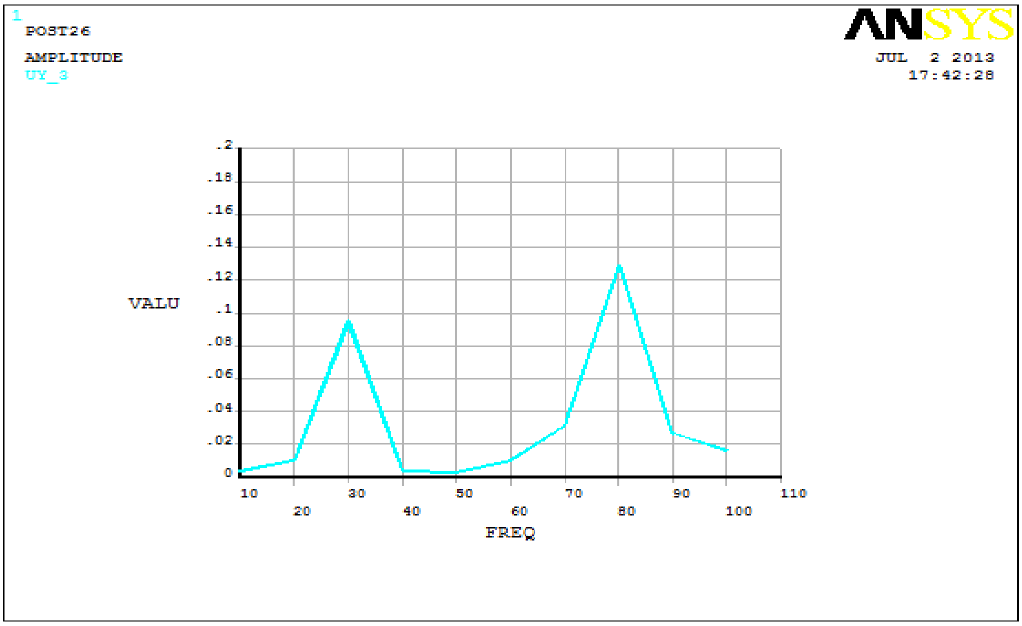


Fig 11: The above image is showing displacement value at bottom of cam

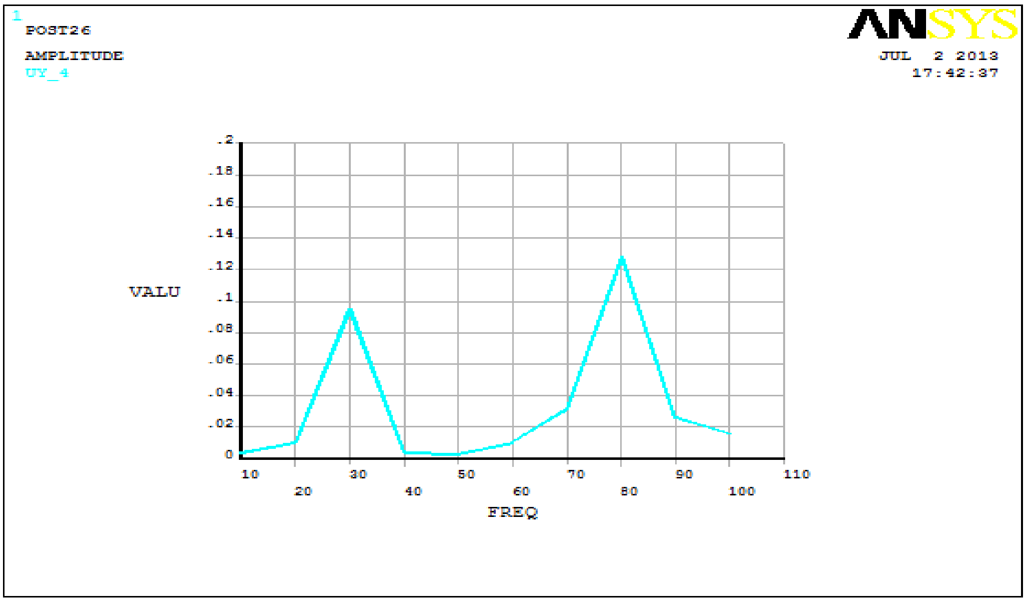


Fig 12: Displacement value at top of cam

4. Results and Discussion

Table 1: In static analysis the following are the displacement levels and stress levals attained for 3 materials

Material	Stress In N/mm^2	Displacement In mm
Aluminum Alloy 360	73.1475	0.107326
Forged steel	103.398	0.44739
Cast iron	102.939	0.38768

Table 2: 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	Aluminum Alloy 360	Forged steel	Cast iron
Mode1	29.1927	31.0061	28.9509
Mode2	29.3719	31.4549	29.1224
Mode3	77.9079	82.7244	77.3148
Mode4	78.3563	83.9152	77.7416
Mode5	129.954	138.713	130.980

Table 3: In Harmonic analysis the loading is carried at a frequency ranging from 0 to 100Hz and then the graphs were drawn for displacement and frequency. The following are the displacement levels attained for 3 materials

	Aluminum Alloy 360	Forged steel	Cast iron
Harmonic 10%	1.1	0.25	0.16
Harmonic 25%	0.52	0.13	0.1
Harmonic 50%	0.46	0.125	0.1

5. Conclusion

Theoretical calculations carry out to design the cam profile (using displacement drawing and cam profile drawing). Analysis was carry out to evaluate the design using traditional materials cast iron and forged steel. Material optimization was carry 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 aluminum 360 (special grade for casting automotive parts) is the best choice for camshaft manufacturing.

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