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Design and Analysis of Rocker Arm

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Abstract: **A rocker arm is an oscillating lever that conveys radial movement from the cam lobe into linear movement at the poppet valve to open it. One end is raised and lowered by a rotating lobe of the camshaft while the other end acts on the valve stem. When the camshaft lobe raises the outside of the arm, the inside presses down on the valve stem, opening the valve. When the outside of the arm is permitted to return due to the camshafts rotation, the inside rises, allowing the valve spring to close the valve. This project mainly dealt with modelling of rocker arm and the analysis over that. The modelling of the component was done by using the advanced modelling software CATIA V5. The analysis was done by using one of the most important numerical methods is FEA and the software used is ANSYS 14.0. Importing operation requires a special file format called IGES (initial graphic exchange specification). The geometry model analysis is done and evaluated the all mode shapes with natural frequencies and results are tabulated for the different materials at different load conditions. In this project rocker arm is modelled with the help of CATIA V5 software, and also saved in the form of .stl (stereo lithography).**

Keywords: **Rocker arm, cam shaft, spring valve, FEA, CATIA, ANSYS 14.0.**

I. INTRODUCTION

As a rocker arm is acted on by a camshaft lobe, it pushes open either an intake or exhaust valve. This allows fuel and air to be drawn into the combustion chamber during the intake stroke or exhaust gases to be expelled during the exhaust stroke. Rocker arms were first invented in the 19th century and have changed little in function since then. Improvements have been made, however, in both efficiencies of operation and construction materials

Background of Rocker Arm

A. *Working of Rocker Arm*

The rocker arm is an oscillating lever that conveys radial movement from the cam lobe into linear movement at the poppet valve to open it. One end is raised and lowered by a rotating lobe of the camshaft (either directly or via a tappet (lifter) and pushrod) while the other end acts on the valve stem. When the camshaft lobe raises the outside of the arm, the inside presses down on the valve stem, opening the valve. When the outside of the arm is permitted to return due to the camshafts rotation, the inside rises, allowing the valve spring to close the valve. The drive cam is driven by the camshaft. This pushes the rocker arm up and down about the turn-on pin or rocker shaft. Friction may be reduced at the point of contact with the valve stem by a roller cam follower. A similar arrangement transfers the motion via another roller cam follower to a second rocker arm. This rotates about the rocker shaft, and transfers the motion via a tappet to the poppet valve. In this case this opens the intake valve to the cylinder.

A rocker arm is simply a mechanically advantaged lever that translates camshaft data into valve actuation. The mechanical advantage is defined by a rocker's ratio. The standard small-block Chevy (SBC) uses a 1.5:1 ratio rocker arm. In other words, the rocker-arm tip (output) moves 1.5 times the displacement of its pushrod socket (input), or camshaft-lobe lift. The 1.5:1-ratio rocker arm translates 0.350 inches of camshaft-lobe lift into 0.525 inch of valve lift (0.350 inch x 1.5 = 0.525 inch). By increasing the rocker-arm ratio, it's possible to increase valve lift without ever touching the camshaft. A 1.6:1-ratio rocker arm translates the same 0.350 inch of camshaft-lobe lift into 0.560 inch of valve lift (0.350 inch x 1.6 = 0.560 inch). This is a lift increase of about 6.7 percent. Valve lift can typically be increased as much as 10 percent by increasing rocker ratio. Since rocker arms are used to control both the intake and exhaust valves, swapping

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high-ratio rocker arms onto an engine increases both the intake-air command and the exhaust-scavenging potential. Generally speaking, a bump in rocker-arm ratio results in a noticeable performance gain. The almighty General knows this; GM swapped in a set of high-ratio 1.6 (up from the LT1's 1.5) rockers on the LT4 and later specified the LS7 ratio at a healthy 1.8 (up from the LS2's 1.7).

B. *Types of Rocker Arms*

Rocker arms are of various types, there design and specifications are different for different types of vehicles (bikes, cars trucks, etc). Even for same type of vehicle category rocker arms differs in some way. Types of rocker arm also depend upon which type of Internal-combustion engine is used in a vehicle (i.e. Push Rod Engines, Over Head Cam Engines, etc).

These are the types of rocker arms, Stamped Steel Rocker Arm, Roller Tipped Rocker Arm, Full Roller Rocker Arm, Shaft Rocker Arms, Centre Pivot Rocker Arms and End Pivot (Finger Follower) Rocker Arms. The Stamped Steel Rocker Arm is probably the most common style of production Rocker Arm. They are the easiest and cheapest to manufacture because they are stamped from one piece of metal. They use a turn-on pivot that holds the rocker in position with a nut that has a rounded bottom. This is a very simple way of holding the rocker in place while allowing it to pivot up and down. The Roller Tipped Rocker Arm is just as it sounds. They are similar to the Stamped Steel Rocker and add a roller on the tip of the valve end of the rocker arm. This allows for less friction, for somewhat more power, and reduced wear on the valve tip. The Roller Tipped Rocker Arm still uses the turn-on pivot nut and stud for simplicity. They can also be cast or machined steel or aluminium. The Full Roller Rocker Arm is not a stamped steel rocker. They are either machined steel or aluminium. They replace the turn-on pivot with bearings. They still use the stud from the turn-on pivot but they don't use the nut. They have a very short shaft with bearings on each end (inside the rocker) and the shaft is bolted securely in place and the bearings allow the rocker to pivot. The Shaft Rocker Arms build off of the Full Roller Rocker Arms. They have a shaft that goes through the rocker arms. Sometimes the shaft only goes through 2 rocker arms and sometimes the shaft will go through all of the rocker arms depending on how the head was manufactured. The reason for using a shaft is for rigidity. Putting a shaft through the rocker arms is much more rigid than just using a stud from the head. The more rigid the valve train, the less the valve train deflection and the less chance for uncontrolled valve train motion at higher RPM. The Centre Pivot Rocker Arm looks like a traditional rocker arm but there is a big difference. Instead of the pushrod pushing up on the lifter, the Cam Shaft is moved into the head and the Cam Shaft pushes directly up on the lifter to force the valve down. In this case the pivot point is in the centre of the rocker arm and the Cam Shaft is on one end of the rocker arm instead of the pushrod. The End Pivot or Finger Follower puts the pivot point at the end of the Rocker Arm. In order for the Cam Shaft to push down on the Rocker Arm is must be located in the middle of the rocker arm.

II. MODELLING OF ROCKER ARM

Modelling of the Rocker arm is done in CATIA V5 3D modelling workspace. By using commands in CATIA like, sketch, pad and shell the following line diagram is created.

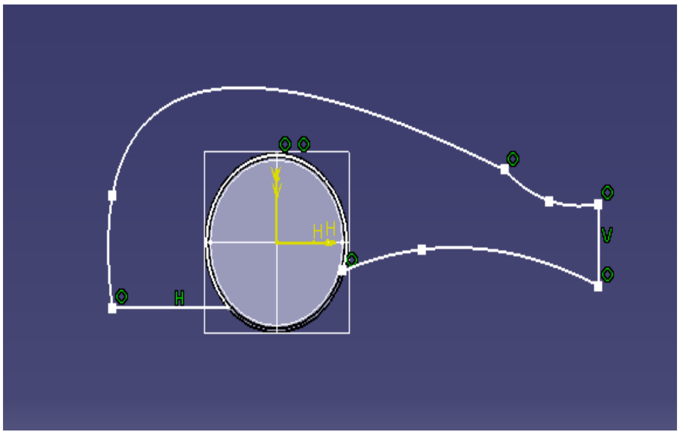

Fig. 1

This line diagram is made over the solid shaft and by using pad command solid part is obtained to the required length.

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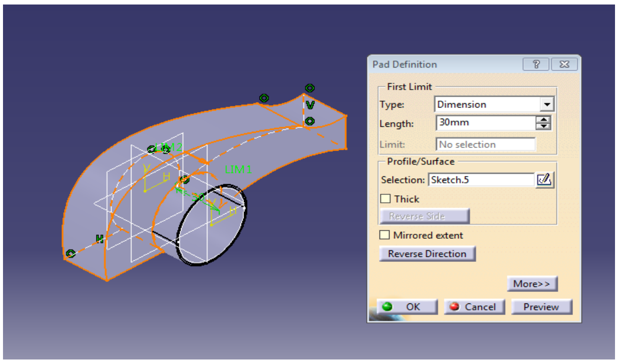

Fig. 2

The end part of the main body is made with the help of commands like sketch, pad. The sketching is on a defined plane as line diagram and it is solid extruded with the help of pad command. With the help of fillet and pad command in CATIA, the final Rocker arm is made.

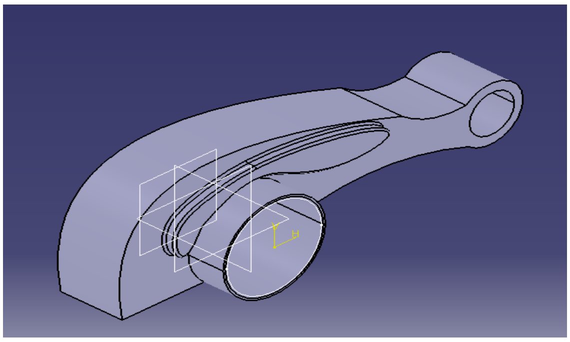

Fig. 3

III. ANALYSIS

We use Modal Analysis to determine the vibration characteristics (Natural frequencies and mode shapes) of a structure of a machine component while it is being designed. It also can be a starting point for another, more detailed, Dynamic Analysis, such as a transient dynamic, a harmonic response analysis, or a spectrum analysis. Uses for Modal Analysis: The Natural frequencies and mode shapes are important parameters in the design of a structure for Dynamic loading conditions. They are also required if you want to do a spectrum analysis or a mode superposition harmonic or transient analysis.

Open Ansys Workbench through Start All programs – Ansys – Workbench. Right Click on the mesh – Insert -Sizing, Select Units from Units Menu as Metric (mm, kg, N, S etc.), Put the cursor on body sizing – select all objects by using body and box selection method, select all by dragging a window –apply – Ok and keep the cursor on body sizing and enter element sizing 10mm in bottom details window. Right Click on the mesh – Generate Mesh. The mesh will be generated as shown below.

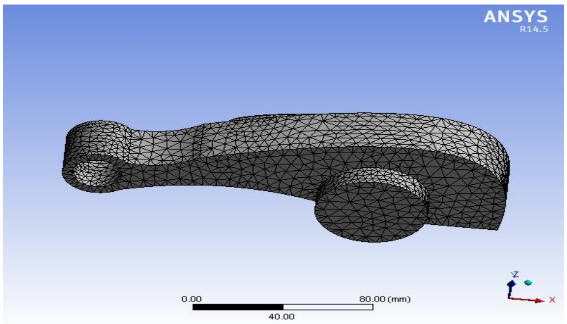

Fig. 4

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To add the material properties select all parts in the geometry – select required material in the bottom details window. Fixed Support: Right Click on analysis settings – insert – fixed support – select the bottom of spring - Apply as shown below.

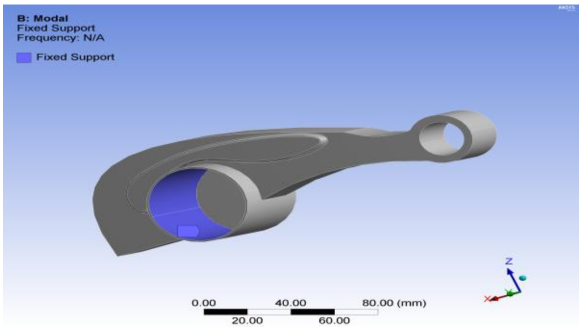
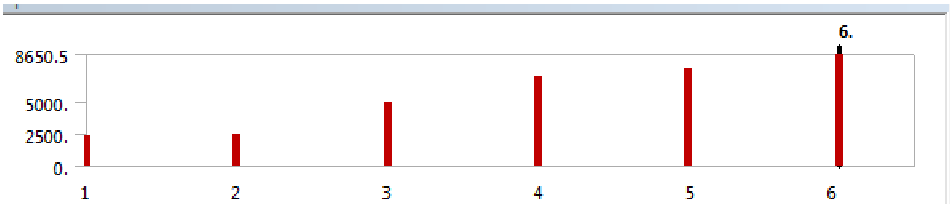


Fig. 5

Right Click on the solution – Solve. Right click on the graph window – select all – Right click again Create Mode Shape Results – Right Click on solution – Evaluate all results



	Mode	Frequency [Hz]
1	1.	2381.8
2	2.	2524.
3	3.	4968.7
4	4.	6892.2
5	5.	7482.9
6	6.	8650.5

The first mode of deformation obtained in first mode is 115.33mm at 2381.8Hz natural frequency.

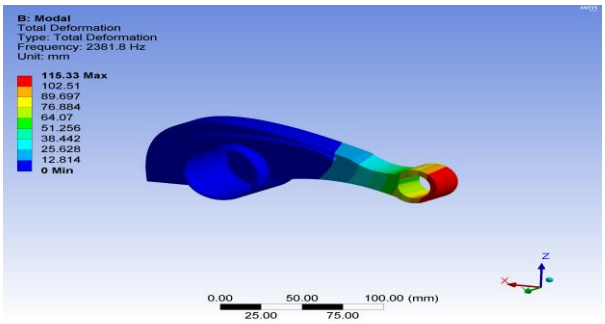


Fig. 6

The 2nd mode of deformation obtained in second mode is 105.11mm at 2524 Hz natural frequency.

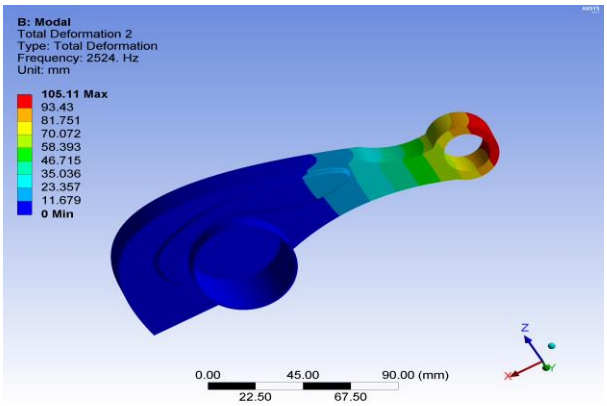


Fig. 7

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The 3rd mode of deformation obtained in third mode is 615.05mm at 4968.7 Hz natural frequency

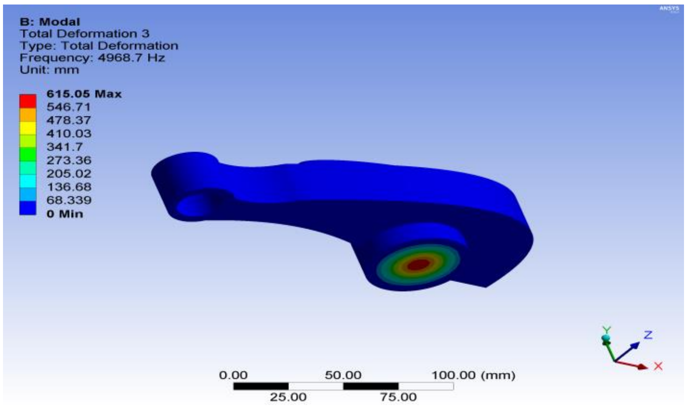

Fig. 8

The 4th deformation obtained in fourth mode is 98.367mm at 6892.2Hz natural frequency

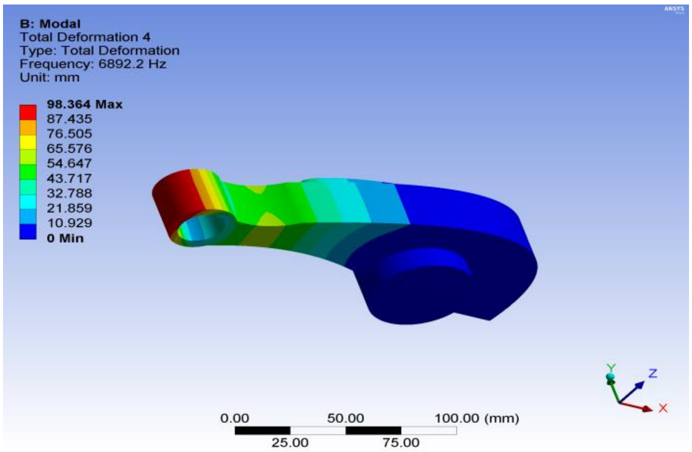

Fig. 9

The 5th mode of deformation obtained in fifth mode is 143.71mm at 7482.9Hz natural frequency

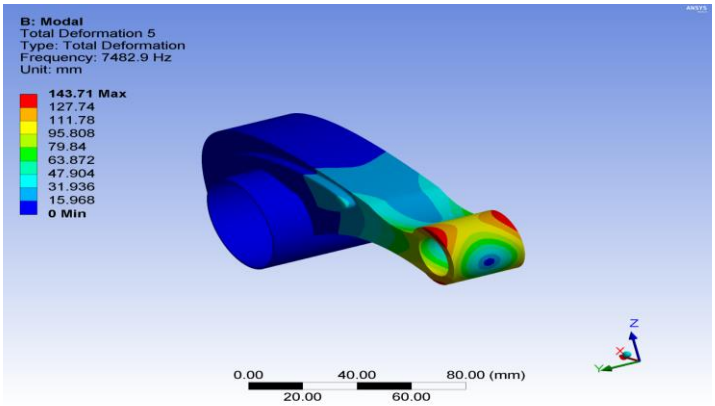

Fig. 10

IV. CONCLUSION

Rocker arm is an important component of engine, failure of rocker arm makes engine useless also requires costly procurement and replacement. An extensive research in the past clearly indicates that the problem has not yet been overcome completely and designers are facing lot of problems specially, stress concentration and effect of loading and other factors. The finite element method is the most popular approach and found commonly used for analysing fracture

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mechanics problems. Lightweight rocker arms are a plus for high rpm applications, but strength is also essential to prevent failure. In recent years, Aftermarket steel roller tip rockers have become a popular upgrade for the most demanding racing applications. Some of these steel rockers are nearly as light as aluminium rockers. But their main advantage is that steel has better fatigue strength and stiffness than aluminium. So we can say that steel is the better material in terms of strength and aluminium is good for making low cost rocker arms.

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