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DESIGN AND FABRICATION OF ROCKER ARM

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Abstract

The application of finite element method using ANSYS soft ware is a useful and important tool as the experimental study and analysis of components have always been an expensive and complex issue. The present work deals with three dimensional solid modeling, design & analysis of rocker arm of an I.C Engine.

The main objective of this project is to design & perform structural analysis of the rocker arm by using ANSYS software. The geometric model of the rocker arm is developed by using CAD software CATIA V5 R18.

The Rocker arm is subjected to high mechanical stresses and deformation due to various forces acting on it. In order to reduce the inertia forces on the rocker arm, an I-section of rocker arm is used and finite element analysis is performed using ANSYS soft ware. The rocker arm is designed and the forces on the same are calculated. Structural analysis is carried out using different materials in order to arrive at optimized design of rocker arm.

I. INTRODUCTION

The application of finite element method using ANSYS soft ware is a useful and important tool as the experimental study and analysis of components have always been an expensive and complex issue. The present work deals with three dimensional solid modeling, design & analysis of rocker arm of an I.C Engine.

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II. LITERATURE SURVEY

In the old days, rocker arms were all pretty much what we term a "shoe" design; meaning the contact pad with the valve had a large radius scruff surface that depressed upon the valve tip as the rocker moved through its rotation. The term of course comes from the appearance to a shoe's sole, but also to the mechanical motion much like a foot and boot would do, as it pushes off. This pushing off motion, as many will already know, has the effect of the rocker arm stretching itself as it moves through the depressing (lift) cycle. It is actually lengthening itself as it moves across the valve tip, and you see this by the wide foot print (we call a "witness mark") atop the valve tip. The use of rocker arms goes back to many things predating engines, but the principles were never required to be so specific on axis point heights and their consequences, as it is for helicopter bell cranks, and racing engines! There was no rocket science to designing these parts a hundred years ago, which ended up on our prehistoric cars and early airplanes. Engineers simply made designs that tried to minimize the degree of how much scuffing was imposed on the valve tip; got it close, and moved on to more important questions.

Throughout the history of the rocker arm, its function has been studied and improved upon. These improvements have resulted in rocker arms that are both more efficient and more resistant to wear. Some designs can actually use two rocker arms per valve, while others utilize a "rundle" roller bearing to depress the valve. These variations in design can result in rocker arms that look physically different from each other, though every rocker arm still performs the same basic function

Since energy is required to move a rocker arm and depress a valve, their weight can be an important consideration. If a rocker arm is excessively heavy, it may require too much energy to move. This may prevent the engine from achieving the desired speed of rotation. The strength of the material can also be a consideration, as weak material may stress or wear too quickly. Many automotive applications make use of stamped steel for these reasons, as this material can provide a balance between weight and durability. Some applications, particularly diesel engines, may make use of heavier duty materials. Engines such as these can operate at higher torques and lower rotational speeds, allowing such materials as cast iron or forged carbon steel to be used.

III. FUNCTION 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.

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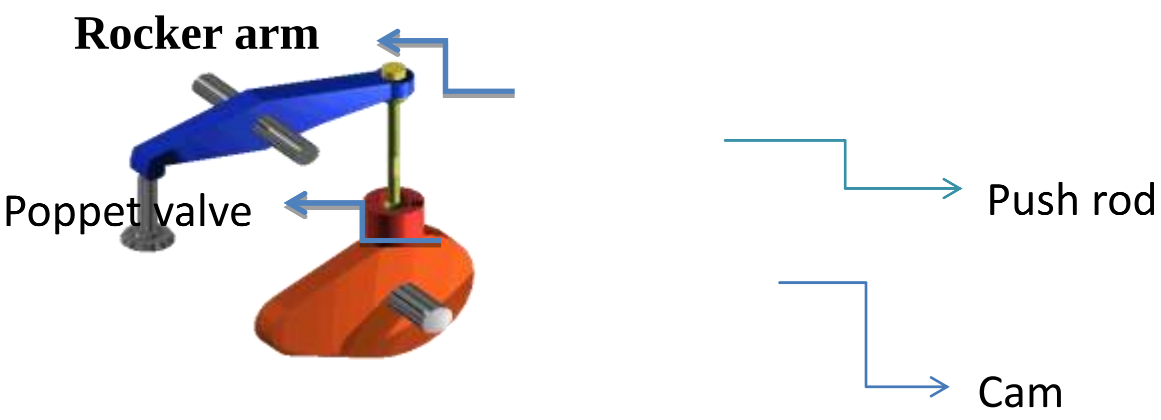


The rocker arm is an oscillating lever that conveys radial movement from the cam lobe into linear movement at the poppet valve to open it.
one end is raised and lowered by a rotating lobe of a camshaft (via a tappet and pushrod) while the other end acts on the valve stem.
When the camshaft lobe raises 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 camshafts rotation, the inside raises, 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 pin or rocker shaft, the roller is used in order to reduce the friction at the point of contact with the valve stem.

IV. TYPES OF ROCKER ARM

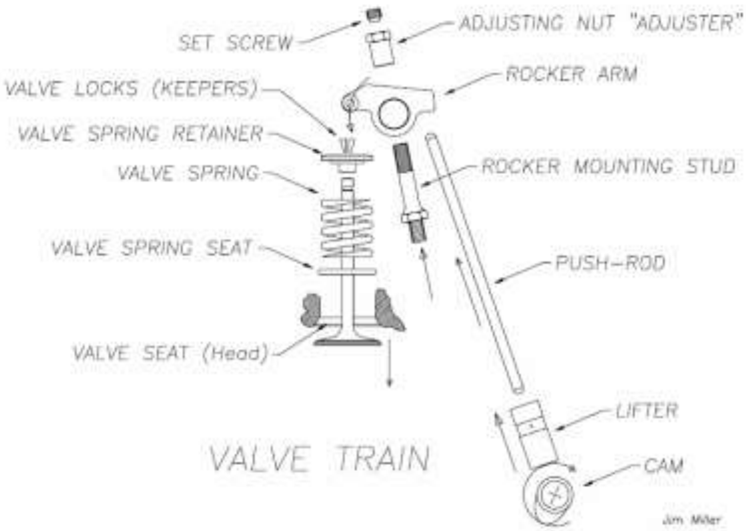
- Stamped Steel Rocker Arm
- Shaft Rocker Arm
- Centre Pivot Rocker Arm
- End Pivot (Finger Follower) Rocker Arm
- Roller Rocker Arm
- Roller Tipped Rocker Arm

Roller Rocker Arm :
A roller rocker is a rocker assembly that uses bearings instead of metal sliding on metal.
A cam/rocker assembly uses a normal cam, but the roller-tip-rocker has a wheel on the end of it like that of a measuring wheel, which rolls by the use of needle roller bearings. Others will add roller bearings for the main pivot also. Although roller rockers are used in both pushrod and overhead cam engines, roller rockers for pushrod and overhead cam engines are considerably different in design. For pushrod engines, roller rockers employ a roller where the rocker contacts the valve stem. On the other hand, roller rockers for overhead cam engines employ a roller where the rocker contacts the cam. This greatly reduces frictional losses and wear compared to slipper followers (where the cam simply slides on a surface on the rocker arm). The difference between a

roller rocker and a standard rocker with slipper followers on an overhead cam engine is analogous to the difference between roller lifters and flat tappet lifters on a pushrod engine.
The amount of power required to spin a cam is surprisingly high, and it gets harder if stiffer valve springs are used, which are necessary to prevent valve float with aggressive cam profiles at high rpm.

V. DESIGN OF ROCKER ARM

It may be made of cast iron, cast steel, or malleable iron. In order to reduce inertia of the rocker arm, an *I*-section is used for the high speed engines and it may be rectangular section for low speed engines. In four stroke engines, the rocker arms for the exhaust valve are the most heavily loaded. Though the force required to operate the inlet valve is relatively small, yet it is usual practice to make the rocker arm for the inlet valve of the same dimensions as that for exhaust valve. A typical rocker arm for operating the exhaust valve is shown in Fig. 32.24. The lever ratio a / b is generally decided by considering the space available for rocker arm. For moderate and low speed engines, a / b is equal to one. For high speed engines, the ratio a / b is taken as 1/ 1.3. The various forces acting on the rocker arm of exhaust valve are the gas load, spring force and force due to valve acceleration.



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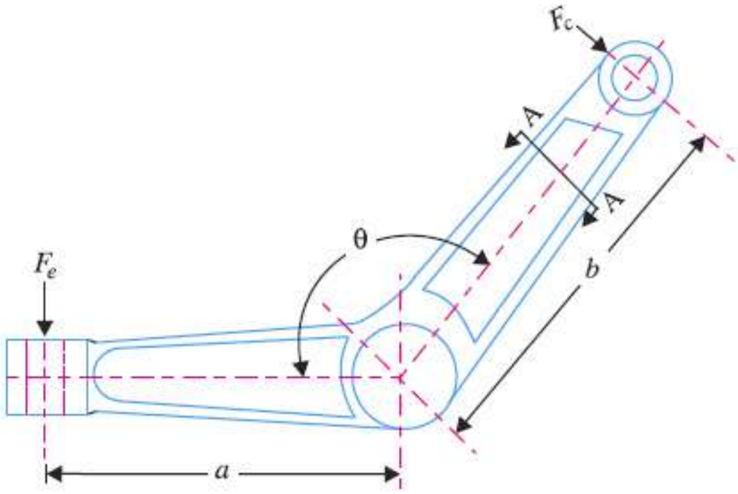


Section at A-A

Design Methodology:

Let m_v = Mass of the valve,
d_v = Diameter of the valve head,
h = Lift of the valve,
a = Acceleration of the valve,
p_c= Cylinder pressure or back pressure when the exhaust valve opens, and
p_s= Maximum suction pressure.

We know that gas load,

P = Area of valve × Cylinder pressure when the exhaust valve opens

$= \frac{\pi}{4}(d_v)^2 p_c$

Spring force,

F_s= Area of valve × Maximum suction pressure

$= \frac{\pi}{4}(d_v)^2 p_s$

and force due to valve acceleration,

F_{va}= Mass of valve × Acceleration of valve

$= m_v \times a$

∴ Maximum load on the rocker arm for exhaust valve,

$F_e = P + F_s + F_{va}$

It may be noted that maximum load on the rocker arm for inlet valve is

$F_i = F_s + F_{va}$

Since the maximum load on the rocker arm for exhaust valve is more than that of inlet valve, therefore, the rocker arm must be designed on the basis of maximum load on the rocker arm for exhaust valve.

Design of the cross-section (I-section) of the rocker arm

The thickness of the web is calculated from the equation

$F \times l = \sigma \times Z$

F=Force due to exhaust gases, N

l= effective length of a rocker arm, *mm*

σ = allowable stress, N/mm^2

Z= section modulus

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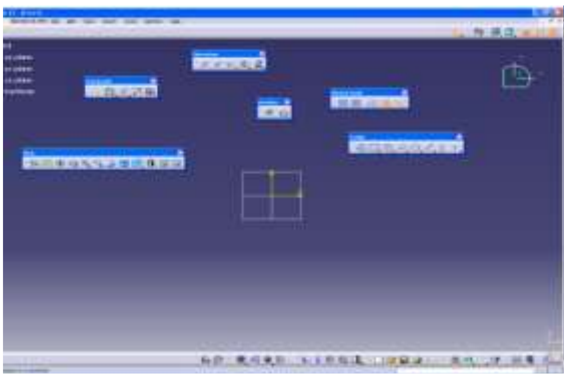
The thickness of the web is(t) = *8mm.*
Width of flange= 2.5t= 2.5 × 8=*20mm*
Depth of web = 4 *t*= *4* × 8 = *32 mm*
and depth of the section = 6*t* = 6×8= *48 mm*
Introduction to CATIA :
CATIA V5 R18 (Computer Aided Three Dimensional Interactive Application), is one of the world's leading CAD/CAM/ CAE packages. Being a solid modeling tool it not only unites the 3D parametric features with 2D tools, but also addresses design-through-manufacturing process. The Bi-directionally associative nature of this software ensures that the modifications made in the model are reflected in the drawing views and vice versa.

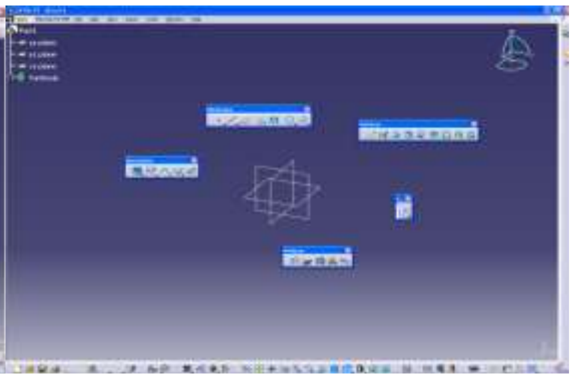
CATIA serves the basic design tasks by providing different modules. A module is defined as a specified as a specified environment consisting of a set of tools, which allows the user to perform specific design tasks in particular area.

VI. WORKBENCHES USED IN CATIA

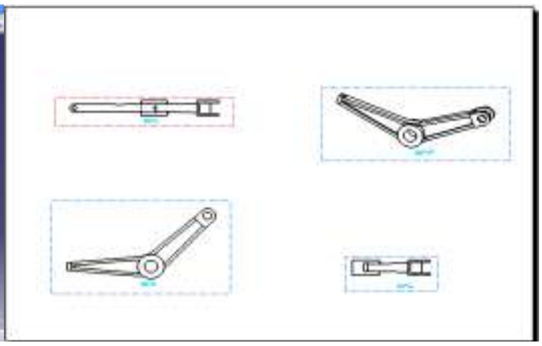
- **Part Design workbench -** It is a parametric & feature based environment where we draw solid models
- **Wireframe and Surface Design -** It is also a parametric & feature based environment, in this we can draw wireframe and surface models
- **Assembly Design workbench -** This workbench is used to assemble the components using assembly constraints in the workbench

TOOLS USED TO DRAW A DESIGN IN CATIA
Profile tool bar
Sketch tools
Operation
Workbench
Constraints tool bar





1. PART DESIGN WORK BENCH **2. WIREFRAME AND SURFACE DESIGN**



3. ASSEMBLY DESIGN WORKBENCH **4. VIEWS OF ROCKER ARM**

1. ASSEMBLED VIEW **2. EXPLODED VIEW**

VII. RESULTS OF ROCKER ARM USING ANSYS:

Rocker arm is checked for its strength & optimization on Aluminium & Spheroidal Cast Iron. The material properties & analysis results are compared below:

MATERIAL PROPERTIES:

Mtrl. properties	Aluminium alloy 6061	Spheroidal Cast Iron
Young's modulus	75 GPa	170 GPa
Poisson's ratio	0.33	0.27
Density	2.7 gm/cm^3	7.1gm/cm^3

RESULTS:

Parameters	Aluminium alloy 6061	Spheroidal Cast Iron
Maximum stress	4730.71	3074.36
Deformation	0.420E-04	0.132E-0.4

VIII. 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 analyzing fracture 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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