International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 12 | Dec 2018 www.irjet.net p-ISSN: 2395-0072

Theoretical Analysis of Rocker Arm

V. R. Magdum[1], S. H. Sawant[2]

[1]*PG Student, Department of Mechanical Engineering, Dr. J. J. Magdum College of Engineering, Jaysingpur, India*
[2]*Professor, Department of Mechanical Engineering, Dr. J. J. Magdum College of Engineering*

---***---

Abstract - *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. There has been lot of work carried out related to design and analysis of rocker arm, but it is not possible to include all work here. Only most relevant work is mentioned here. The research started from developing theories related to design and analysis of rocker arm and is now moving towards optimizing various parameters according to applications.*

Key Words: Design and Analysis, Rocker Arm, Stresses, Strain, HDPE, S-glass fiber, Deformation.

1. INTRODUCTION

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 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 head. The finite element method offers virtually unlimited problem generality by permitting the use of elements of various regular shapes. It is a method of dividing the part in to smaller elements and analyzing by the way of calculating stiffness.

2. DESIGN DEVELOPMENT

2.1 Selection of material-

Several factors considered in selecting a suitable material are weight, cost, availability, reliability and manufacturability. On a cursory look upon the rocker arm made in the past the most obvious materials were steel and its alloys, aluminum and its alloys. Also carbon composite also used. On further, detailed study for the mechanical properties of materials so we shortlisted materials for our study as shown in table below.

Table-1: Material properties

Material	Youngs Modulus (GPa)	Poissons Ratio	Density
EN8	200	0.3	7850
S-Glass Fibre(S-2)	88.9	0.23	2500
HDPE (ASTM, D-638)	1.2	0.43	941
Composite	2.23	0.38	7097

2.2 Design specification-

Rocker arm is an important part of the valve train in fuel injection system providing not only the means of actuating the valves through a fulcrum utilizing the lifter and the push rod but also provide a means of multiplying the lift ratio. Cam shaft design has advanced in leaps and bounds over last three decades but overhead valve engines with centrally located camshafts still use lifters and push rod and rocker arms as a means of opening and closing the intake and exhaust valves in fuel injection pumps. The maximum force exerted by the valve rod on the tappet will be determine the bending moment for the design of the cross-section of the rocker arm.

This force consist of the following 3 factors-

1. The gas pressure on valve when it opens
2. The inertia force when the valve moves up
3. The inertial spring force to hold the valve on its seat suction pressure inside the cylinder during the suction stroke.

So, by considering above factor we design rocker arm which has less sharp edges for less stress concentration, lightweight & accurate dimensions.

3. MODELLING OF ROCKER ARM

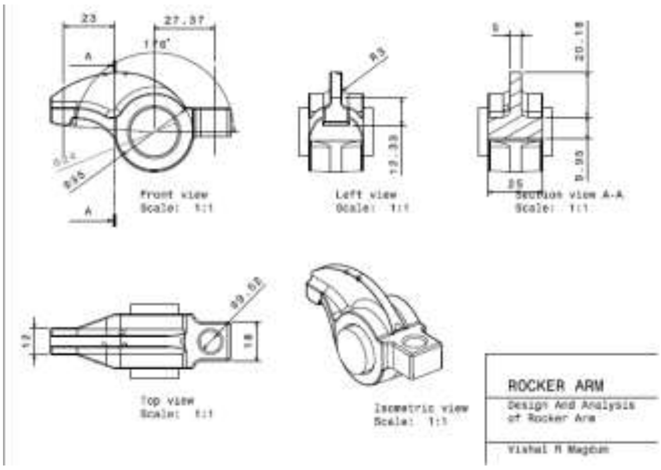

Fig-1: Rocker arm model

The rocker arm we used is of Royal Enfield's lombardini engine. The type, power & other engine specification are given in table below,

Table-2: Engine specification

Type	Air cooled, diesel engine
No. of Cylinder	1
Bore / Stroke	97mm × 100mm
Max. Engine Output	5.07 kW at 3000 rpm
Max. Torque	15 Nm at 2500 rpm

Valve diameter = dv = 40 mm

Lift of valve = h = 13 mm

Cylinder pressure = Pc = 0.6 N/mm^2

Max. suction pressure = Ps = 0.02 N/mm^2

Diameter of fulcrum pin = d1 = 24 mm

Boss diameter = D1 = 35 mm

Speed of engine = N = 3000 rpm

Angle of action of cam = $\Phi = 110^{o}$

Angle between two arms = $\Theta = 176^{o}$

Volume of rocker arm =V = 3.71×10^{-5} m^3

Distance between shaft centre to pin centre = L = 27.37 mm

Width of rocker arm = b = 25 mm

Distance from neutral axis = d = 6.57 mm

Vertical distance from neutral axis = y = 6.5 mm

Density of material = ρ in kg/ m^3

Mass of material = m in kg

Weight of rocker arm= W in N

Acceleration due to gravity = g = 9.81 m/ s^2

So we have to find different stress acted on rocker arm. For that we use material "EN 8" steel which has density= ρ = 7850 kg/ m^3

Mass of rocker arm,

$m = V \times \rho = 3.71 \times 10^{-5} \times 7850 = 0.292$ kg

Weight of rocker arm,

$W = V \times \rho \times g$

$= 3.71 \times 10^{-5} \times 7850 \times 9.81$

$W = 2.861$ N ...(1)

Calculating forces,

Gas load on valve,

$P1 = \pi/4 \times (dv)^2 \times Pc$

$= \pi/4 \times (40)^2 \times 0.6$

$P1 = 753.98$ N ...(2)

Total load on valve,

$P = P1 + W$

$= 753.98 + 2.86$

$P = 756.83$ N ... (3)

Initial spring forces (considering weight of valve),

$Fs = \pi/4 \times (dv)^2 \times Ps - W$

$= [\pi/4 \times (40)^2 \times 0.02] - 2.861$

$F_s = 22.27$ N ...(4)

Speed of camshaft,

$S = N/2 = 3000/2 = 1500$ rpm

Angle turned by camshaft per second,

$A = S/60 = (1500/60) \times 360 = 9000$ degree/ sec

Time for valve to open & close,

$t = \Phi / A = 110 / 9000 = 0.012$ sec

Max. Acceleration of valve,

$a = (2\pi/t)^2 \times (h/2)$

$= (2\pi/0.012)^2 \times (0.013/2)$

$a = 1782.01\ m/s^2$ ...(5)

force due to valve acceleration,

$F_a = (m \times a) + W$

$= (0.292 \times 1782.01) + 2.861$

$F_a = 523.20$ N ...(6)

Max. load on Rocker arm for exhaust valve is,

$F_e = P + F_s + F_a$

$= 756.83 + 22.27 + 523.20$

$F_e = 1302.3$ N ...(7)

Two arms of rocker arm is equal, so forces on them are also equal i.e. Fe = Fc

Calculating stresses,

Bending stress near critical limit is,

$\sigma_b = \{[(F_e)] \times [L - (D1/2)] \times [y]\} / [(b \times d^3) / (12)]$

$= \{[(1302.3)] \times [27.37 - (35/2)] \times [6.5]\} / [(25 \times 6.57^3) / (12)]$

$\sigma_b = 141.412\ N/mm^2$ ...(8)

Shear stress at critical limit is,

$\tau = \sqrt{[(\sigma_b / 2)^2 + (F_e / b\times d)^2]}$

$= \sqrt{[(141.41 / 2)^2 + (1302.3 / 25\times 6.57)^2]}$

$\tau = 71.14\ N/mm^2$ ...(9)

Von-misses stress is,

Forces acted only in X direction so $\sigma_b = \sigma_x$ & $\sigma_y = 0$.

$\sigma_1 , \sigma_2 = \sqrt{\{(\sigma_x + \sigma_b)/ 2\}} \pm \{[(\sigma_b - \sigma_b)/2]^2 + [\tau]^2\}$

$= \sqrt{\{(141.41 + 0)/ 2\}} \pm \{[(141.41 - 0)/2]^2 + [71.14]^2\}$

$\sigma_1 = 170.50\ N/mm^2$

$\sigma_2 = -29.55\ N/mm^2$

Von-misses stress is given by,

$\sigma_v = \sqrt{\{[\sigma_1]^2 - [(\sigma_1) \times (\sigma_2)] + [\sigma_2]^2 + [(3) \times (\tau)^2]\}}$

$= \sqrt{\{[170.50]^2 - [(170.50) \times (-29.55)] + [-29.55]^2 + [(3) \times (71.14)^2]\}}$

$\sigma_v = 195.69\ N/mm^2$ ...(10)

Max. Deformation,

We consider section A-A to find maximum deformation of rocker arm.

For section A-A

Horizontal distance from neutral axis,

B1 = 9.956 mm & B2 =20.18 mm

Vertical distance from neutral axis,

H1 = 25mm & H2 = 5 mm

Length = l = 23 mm

Young's modulus for EN8 = $E = 200\times 10^3\ N/mm^2$

Inertia of section A-A,

$I = [(B1\times H1^3) + (B2\times H2^3)] / 12$

$= [(9.956\times 25^3) + (20.18\times 5^3)] / 12$

$I = 12658.12\ mm^4$

Max. Deformation is,

$\delta_{max} = [(F_e) \times (l)^3] / [(3)\times(E) \times (I)]$

$= [(1302.3) \times (23)^3] / [(3) \times (200 \times 10^3) \times (12658.12)]$

$\delta max = 0.0286$ mm ...(11)

From equation (8), (9), (10) & (11) we calculated following values of rocker arm of material EN8,

Bending stress near critical limit = $\sigma b = 141.412$ N/mm^2

Shear stress at critical limit = $\tau = 71.14$ N/mm^2

Von-misses stress = $\sigma v = 195.69$ N/mm^2

Max. Deformation = $\delta max = 0.0286$ mm

Similarly, we were calculated all above values for different materials which is shown in table below,

Table-3: Analytical results of all materials

Material	EN8	S-Glass Fibre(S-2)	HDPE (ASTM, D-638)	Composite
Density- ρ (kg/m^3)	7850	2500	2500	7097
Youngs Modulus-E (GPa)	200	88.9	1.2	2.23
Bending stress -σb (N/mm^2)	141.41	102.41	9.33	135.66
Shear stress- τ (N/mm^2)	71.14	51.53	45.67	68.25
Von-misses stress- σv (N/mm^2)	195.69	162.52	143.22	186.49
Max. Deformation- δmax (mm)	0.0286	0.0340	0.2763	0.1796

Following graph shows comparison between stresses i.e. shear stress & von-misses stress developed in all materials calculated by Analytical Method.

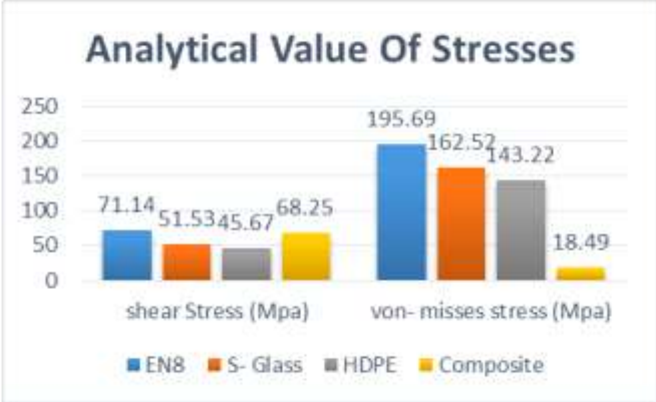

Chart-1: Comparing stresses value (analytical method)

4. CONCLUSION

In this paper theoretical study of design & analysis of rocker arm is carried out. In this study we found that stresses developed in rocker arm of material EN8 is high & material HDPE is low.

REFERENCES

1. Tawanda Mushiri and Charles Mbohwa (2015), “Finite Element Analysis of a Car Rocker Arm” International Conference on Operations Excellence and Service Engineering Orlando, Florida, USA, September 10-11-2015.

2. Jafar Sharief and K. Durga Sushmitha (2015), “Analysis of Rocker Arm”, International Journal of Computational Engineering Research (IJCER), Volume, 05, Issue, 11.

3. G.A. Nassef, Elkhatib and Mostafa Yakout (2016), “Analysis of a Failed Rocker Arm Shaft of a Passenger Car Engine”- Case Studies in Engineering Failure Analysis 5–6 (2016) 10–14.

4. Syed Mujahid Husain and Siraj Sheikh (2013), “Design of Rocker Arm”, International Journal of Mechanical Engineering, ISSN 2278 – 0149,Vol. 2, No. 3, July 2013.

5. Antaryami Mishra (2014), “Stress Analysis of Glass/HDPE Composite Rocker Arm by Finite Element Method”- International Journal of Engineering Science and Innovative Technology (IJESIT), Volume 3, Issue 3, May 2014.

6. Chung, C.-S. & Kim, H.-K (2010), “Safety Evaluation of Rocker Arm of A diesel Engine”, Journal of Materials & Design, 31(2), pp. 940-945, 2010.