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# Design and Analysis of Rocker Arm by Finite Element Method using ANSYS

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***Abstract*— The rocker arm is a fundamental component for valve actuating mechanism of an Internal Combustion engine. Over the years, several tests and analysis, considering factors such as weight, cost, stresses etc., has been carried out for optimization of rocker arms. The failure of rocker arm is an important concern. This paper deals with modelling and analysis of stresses developed in a rocker arm. The required model was designed using the Solidworks 2013 and finite element analysis was carried out using ANSYS 16.0 software.**

***Index Terms*—ANSYS, Finite Element Analysis (FEA), Rocker arm, Solidworks.**

## I. INTRODUCTION

The rocker arm, a component of an Internal Combustion engine, is a reciprocating two arm lever. One end of the arm is actuated by rotating lobe of camshaft while the other acts on the valve stem. The basic function of a rocker arm is opening and closing of the inlet and exhaust valve with respect to motion of cam and follower [1]. 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 [2].

Fig. 1. Rocker Arm Assembly [9]

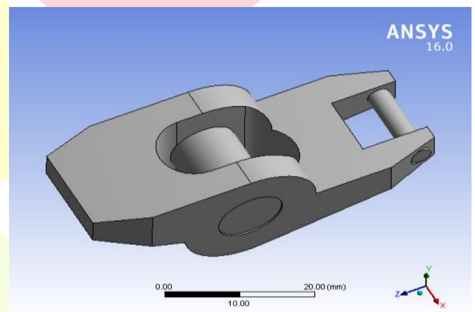


Fig. 2. CAD model of Rocker arm

It also provides a mean of multiplying the lift ratio. As a lever, its actual function is to change the direction of force and not effort multiplication. It conveys radial movement from the cam lobe into linear movement at the poppet valve to open it [3]. Different vehicles require different designs and specifications or rocker arms. The type of internal combustion engine also determines the types of rocker arms. The mechanical advantage of rocker arm is termed as 'Rocker ratio'. Rocker arms are used to control both the intake and exhaust valves, swapping 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 [4].In moderate and low speed engine, 1:1 ratio is used while for high speed engines it is around 1:1.3

The rocker arm for exhaust valve is heavily loaded and requires more force for operation compared to inlet valve. But in practice, for ease of manufacturing, rocker arms for both inlet and exhaust are identical [5].

The various forces act on the arms during the operation. These forces can be mainly categorized into:

1. Gas pressure on valve, which comes into play when valve opens

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2. Inertia force, which opposed the upward movement of the valve

3. Inertial Spring force, which hold the valve on its seat against the suction.

The Failure of rocker arm is an important concern as it is an important component of IC engine. Several failure analysis has been made till now. Stresses and vibrations during the engine operation results in deflection of rocker arms. It was observed that initiation and growth of the cracks was facilitated by a microstructure of low fatigue strength and multiple-origin fatigue was dominant failure mode [1].

Lee, Cho & Joo observed that the failure of the rocker arm shaft was caused by the bending load and unstable boundary condition [6].

## II. OBJECTIVE

The objective is to design Rocker arms of HMCF UD and Carbon Steel EN6 using Solidworks 2013 and carry out the finite element analysis (FEA) on the prepared model using ANSYS 16. Thus, we obtained the values of various stresses and deformation. This result was then compared with the result from analysis with existing Structural Steel rocker arm.

## III. MATERIAL AND PROPERTIES

The general material used for rocker arms are Steel, Aluminum, Forged steel, Stainless steel, alloys and composites. Husain and Sheikh led to a conclusion that steel is better than aluminum in terms of strength while aluminum is better for low costing arms [4]. Sharief & Sushmitha analyzed a composite rocker arm of high density polyethylene (HDPE) reinforced with short S-glass fibers of 10% volume fraction [7].

HMCF UD and Carbon Steel EN 6 have been used for analysis. Carbon Steel EN 6 carbon steel is a medium strength steel. It is generally provided in square and flat round bar as key steel [8].Composite like High Modulus Carbon Fibre Unidirectional (HMCF UD) are not common in practice but they are extremely lightweight with considerably good strength.

TABLE I: MATERIAL PROPERTIES

| Material | Carbon Steel EN 6 | HMCF UD | Structural Steel |
|---|---|---|---|
| Density (g/cm$^3$) | 7.85 | 1.6 | 7.85 |
| Young's Modulus (GPa) | 200 | 175 | 200 |
| Ultimate Tensile Strength (MPa) | 585 | 1000 | 460 |
| Poisson's Ratio | .285 | 0.3 | 0.3 |

## IV. DESIGN AND CALCULATIONS

### *A. Nomenclature:*

$m_v$ = mass of valve
w = weight of associated parts with valve
$d_v$ = diameter of valve
h = lift of valve
a = Acceleration of the valve
$P_c$ = Cylinder pressure
$P_s$ = Maximum suction pressure
$d_f$ = fulcrum pin diameter
$d_b$ = diameter of boss
l = Length of arm
$\theta$ = angle subtended by arms with respect to each other
$P_g$ = Gas load on the valve
$P_t$ = Total load on the valve
$F_i$ = Initial Spring Force
$F_a$ = Force due to acceleration of valve
$P_e$ = Maximum load on the rocker arm for exhaust valve
t = Valve closing/ opening time
N = Rpm of the engine
$N_c$ = Speed of camshaft
$R_f$ = Reaction at fulcrum pin

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TABLE II: ENGINE SPECIFICATION

| | |
|---|---|
| Type | Turbo charged, Common rail injection Diesel Engine |
| No. Of Cylinders | 6- V configuration |
| Bore/Stroke | 84mm x 90mm |
| Capacity | 2,933 cc |
| Max. Engine Output | 182 Kw @ 4200 rpm |
| Max. Torque | 600 N-m @ |

$m_v = 0.09\ kg$
$d_v = 40\ mm$
$h = 13\ mm$
$r = \frac{h}{2} = 6.5\ mm$
$P_c = 0.4\ N/mm^2$
$P_s = 0.02\ N/mm^2$
$d_f = 8\ mm$
$d_b = 18\ mm$
$\theta = 110°$

*B. Force Calculation*

1. Gas load on the valve:

$$P_g = \frac{\pi}{4} \times d_v^2 \times P_c$$
$$= 502.4$$
$$w = m \times g$$
$$= 0.09 \times 9.8$$
$$= 0.882\ N$$
$$P_t = P_g + w = 503.282\ N$$

2. Spring Force

$$F_i = \left(\frac{\pi}{4} \times d_v^2 \times P_s\right) - w$$
$$= 24.238\ N$$

3. Force due to acceleration of valve

$$N_c = {}^{N}\!/_{2} = 2100\ rpm$$

4.Angle turned by camshaft per second,

$$\theta_c = \frac{2100}{60} \times 30 = 12600\ deg/sec$$

$$t = \frac{\theta}{\theta_c}$$
$$= \frac{110}{12600}$$
$$= .009\ sec$$
$$a = \omega^2 \times r$$
$$= \left(\frac{2\pi}{t}\right)^2 \times r$$
$$= 3168.02\ m/s^2$$
$$F_a = ma + w$$
$$= 286\ N$$

5. Reaction at fulcrum pin

$$P_e = P_t + F_i + F_a$$
$$= 503{,}282 + 24.238 + 286$$
$$= 813.52$$

Length of both the arms are equal,

$$\Rightarrow P_c = P_e = 813.52$$
$$R_f = \sqrt{F_e^2 + F_i^2 - 2 \times F_e \times F_i \times cos\theta}$$
$$= 1625.43\ N$$

## V. METHODOLOGY

*A. Modelling in Solid works*

The dimensions for the parts were determined analytically which were later used in modelling. The base of rocker body was an extruded entity. The extruded cut profiles were applied on the top. The model was saved in IGES format and imported to ANSYS workbench.

*B. Meshing*

Figure shows the meshed model of rocker arm for analysis process. For analysis, model was messed using triangular surface mesher. The number of Nodes used in this meshing is 31120 and elements are 17949. The model is mashed and analyzed to get the correct value. The high number of elements for chosen for better and authentic results.

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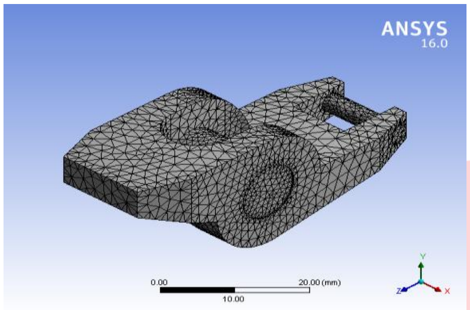


Fig. 3. Meshed Model

## VI. ANALYSIS AND RESULTS

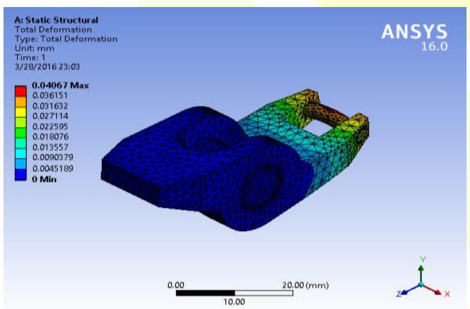


Fig. 4. Total deformation for structural steel rocker arm

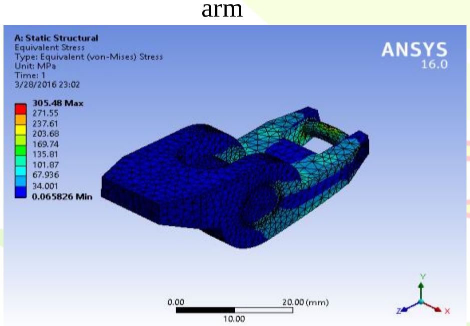


Fig. 5. Equivalent (Von- Misses) Stress for Structural steel rocker arm

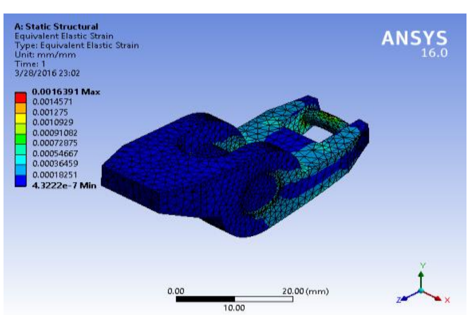


Fig. 6. Equivalent (Von- Misses) Strain for Structural steel rocker arm

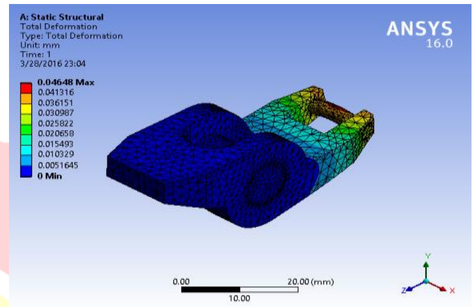


Fig. 7. Total deformation for HMCF UD rocker arm

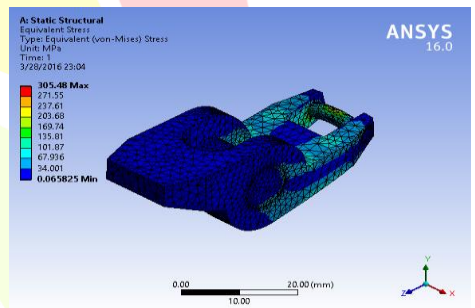


Fig. 8. Equivalent (Von- Misses) Stress for HMCF UD rocker arm

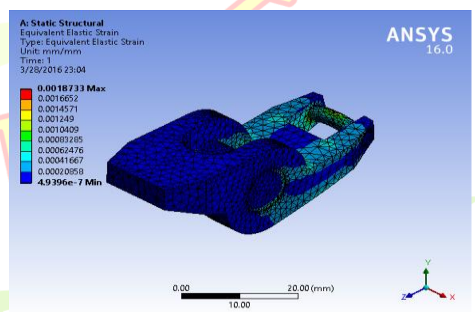


Fig. 9. Equivalent (Von- Misses) Strain for HMCF UD rocker arm

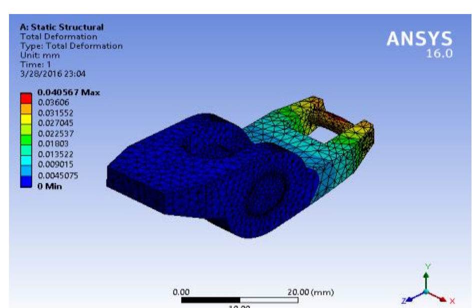

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Fig. 10. Total deformation for Carbon Steel EN 6 rocker arm

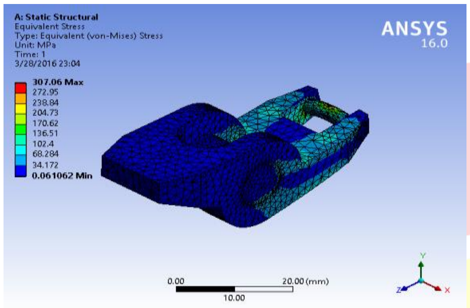


**Fig. 11. Equivalent (Von- Misses) Stress for Carbon Steel EN 6 rocker arm**

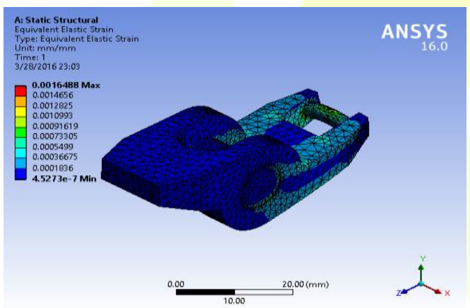


Fig. 12. Equivalent (Von- Misses) Strain for Carbon Steel EN 6 rocker arm

**TABLE III: RESULTS**

| Material | | Structural Steel | HMCF UD | Carbon Steel EN 6 |
|---|---|---|---|---|
| Total Deformation (mm) | Max | 0.0406 | 0.04648 | 0.040567 |
| | Min | 0 | 0 | 0 |
| Equivalent Stress (MPA) | Max | 305.48 | 305.48 | 307.06 |
| | Min | 0.0658 | 0.0658 | 0.061 |
| Equivalent Elastic Strain (mm/mm) | Max | 0.00169 | 0.00187 | 0.00164 |
| | Min | 4.322E-07 | 4.9396E-07 | 4.527E-07 |

## VII. CONCLUSION

The Von-Misses stress values for Structural Steel, HMCF UD and Carbon Steel Carbon Steel EN 6 rocker arms are 305.48 MPa, 305.48 MPa and 307.06MPa. The total deformation for structural steel rocker arm is 0.04067 mm while the same for HMCF UD and Carbon Steel EN 6 rocker arm is 0.04648 mm and 0.040567 mm.

From the above results, it can be observed that a light weight and considerably high strength HMCF UD can be used as rocker arm. The composite rocker arm is able to withstand the load equivalent to that a structural rocker arm can. As for Carbon Steel EN 6, it is observed that for a lower deformation, it showed almost same value of stress, leading to the conclusion that it can be used for rocker arm. Hence, it can be concluded that both HMCF UD and Carbon Steel EN 6 can be used as material for rocker arm.

## VIII. REFERENCES

[1] Z. W. Yu, X. L. Xu, "Failure analysis of diesel engine rocker arms", *Engineering Failure Analysis*, Volume 13, Issue 4, June 2006, Pages 598-605.

[2] S. M. Husain, and Prof. S. Sheikh, "Design and analysis of rocker arm", International Journal of Mechanical Engineering and Robotics Research

[3] Chin-Sung Chung, Ho-Kyung Kim "Safety evaluation of the rocker arm of a diesel engine", *Materials & Design*, Volume 31, Issue 2, February 2010, Pages 940-945

[4] S. M. Husain, and Prof. S. Sheikh, "Rocker arm: - A review", *International Journal of Innovative Research in Science, Engineering and Technology*, Vol. 2, Issue 4, April 2013

[5] V B Bhandari, *Design of Machine Elements*, ch 25, pp 906-909

[6] D. W. Lee, S. S. Cho, and W. S. Joo,"An estimation of failure stress condition in rocker arm shaft through FEA and microscopic fractography", *Journal of Mechanical Science and Technology* 22 (2008) 2056~2061

[7] J. Sharief, K. D. Sushmitha, "Design and analysis of a Rocker Arm", *International Journal of Computational Engineering Research (IJCER)*, Volume 05, Issue 11, November 2015

[8] Extract from: http://www.engineerUGStudent.co.uk/steel_selection.html

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[9] Extract from: https://www.google.co.in/search?q=rocker+arm+assembly&espv=2&biw=1366&bih=667&source=lnms&tbm=isch&sa=X&ved=0ahUKEwiurNWJgOTLAhVYBo4KHbdnBbsQ_AUIBigB#tbm=isch&q=rocker+arm+&imgdii=jFdMyJ32A7Ff2M%3A%3BjFdMyJ32A7Ff2M%3A%3BD1t4UiReY3UxIM%3A&imgrc=jFdMyJ32A7Ff2M%3A