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# A review: Rocker Arm

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## ABSTRACT

***Rocker arm is part of the valve actuating mechanism. It is responsible for the opening and closing the intake and exhaust valves. Rocker arms are typically in between the pushrod and intake and exhaust valves. They allow the push rods to push up on the rocker arm and push down on the valves. Over the years of rocker arm have been optimized in its designed and material for better performance durability, toughness, high dimensional stability, wear resistance, strength, as well as economic factors, are the reasons for optimization of the rocker arm. This paper review types of rocker arm based on published sources in order to understand the rocker arm for its problem identification and further optimization. This paper present what is rocker arm? Where it is used, history related to the rocker arm, reason of the failure of rocker arm are also discussed in this paper.***

***Keywords***— *Rocker arm, Valve actuating mechanism, HMCFUD material*

## 1. INTRODUCTION

The rocker arm is an important part of the valve train mechanism in the fuel injection system of IC engines to satisfy functional requirements opening of inlet and exhaust valves. It acted on by a camshaft lobe. It actuates the valve through a fulcrum using the lifter and the push rod it also provides a means of multiplying the lift ratio. It pushes open either an intake and exhaust valve. This allows fuel and air to be drawn into the combustion chamber during the intake stroke and exhaust gases to be expelled during the exhaust stroke.

### 1.1 Working

The rocker arm is an important part of the valve train in the fuel injection system. It provides actuating the valves through a fulcrum utilizing the lifter and the push rod, it also provides a means of multiplying the lift ratio [2]. In an overhead valve engine camshaft located at the center to use lifters, push rods and rocker arm. It means opening and closing the intake valve and exhaust valve in fuel injections pumps. Advancement in rocker arm for reduces noise, higher strength and weight [5], [7] [19].

It is an oscillating lever which conveys radial movement from the cab lobe into linear movement at the poppet valve to open it. Here, one end is raised and lowered by a rotating lobe of the camshaft. The other end acts on the valve stem. At that time camshaft lobe raises the outside of the ram and inside presses down valve stem, opening the valve. When the outside arm is returned due to camshaft rotation, the inside rises, allow closing a valve spring valve. [8], [10]

Due to camshaft drive, the cam is driven. It pushes a rocker arm up and down about-turn on a pin. The roller arm follower reduces friction at the point of contact. This similar arrangement transfers the motion via another roller cam follower to the second rocker arm. It rotates about the rocker shaft and transfers the motion via poppet valve. The following figure shows rocker arm in valve stem at one end and valve train mechanism with cam at another end. [22]

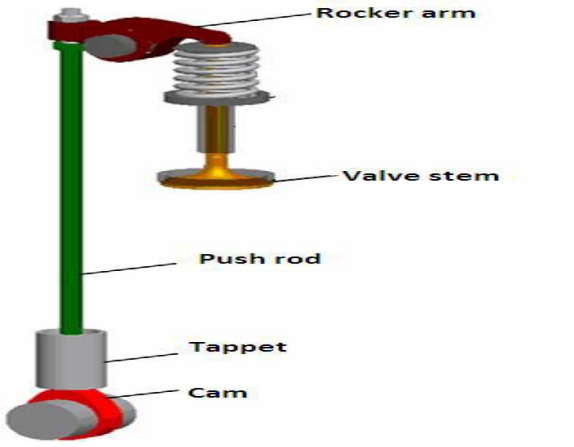


**Fig. 1: Rocker arm**

### 1.2 Types of the rocker arm

Different types of rocker arms are to be used in different types of vehicles as like buses, cars, trucks, bikes, etc. types of rocker arm depend on which type of internal combustion engine is used in a vehicle i.e. push rod engines, overhead cam engines, etc.[10],[12],[21],[22]

(a) Stamped steel rocker arm- it is the most common type of rocker arm it stamped from one piece of metal so its manufacturing is simplest, easiest and cheapest. They use a turn on a pivot and hold the rocker arm in position with a nut which is the rounded bottom.

(b) Roller tipped rocker arm- it's similar to the stamped steel rocker arm. In this rocker arm only added roller so that reduces

 

wear. It uses in turn on pivot nut and stud for simplicity. Manufacturing materials are cast or machined steel or aluminum.

(c) Full roller rocker arm-manufacturing materials are used either steel or aluminum. Here only replace turn on a pivot with bearings and uses stud from the turn-on pivot but don't use the nut.

(d) Shaft rocker arm- it is built off from the full roller rocker arm. They have a shaft that goes through the rocker arms and sometimes shafts only goes through 2 rocker arms and sometimes the shaft will go through all of the rocker arms depending on how the head manufactured.

(e) Centre pivot rocker arm- it looks like a traditional rocker arm but both have many differences. Pivot points are the centre of the rocker arm and the cam shaft is on one end of the rocker arm.

(f) End pivot rocker arm-it is also known as finger-follower rocker arm puts the pivot point at the end of the rocker arm. It must be located in the middle of the rocker arm.

### 1.3 Failure of rocker arm

Failure is a measure issued because it's an important component of push rod IC engines. Usually, fracture occurred at the interface between the engine block and rocker arm shaft also fracture occurred at the interface between the hole and neck of the rocker arm. [2], [9], [12], [22]. Various other factors are as follow:

(a) The fracture occurred at the hole of the rocker arm as a name of this fracture it occurred at the rocker arm (as shown in figure 2) the spheronization of dementia to pearlie make material hard and due to that decrease to result in lower fatigue strength and failed rocker arms. Initiation and growth of cracks are seeing by the microstructure of low fatigue strength

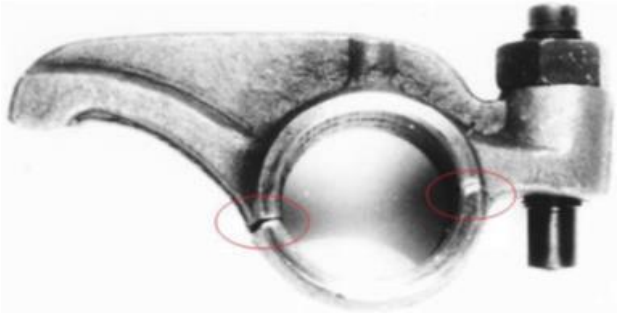

**Fig. 2: Rocker arm**

(b) The fracture occurred at the neck of the rocker arm: The elongation and ultimate tensile strength of the rocker arm were 2.5 % and 164 MPa respectively. The normal die-cast Al-alloys value is slightly more than UTS value. In the stress measurement test, the compressive stress exhibits the maximum value at the idling state and decreases as increasing the engine speed. The maximum experimental stress at the neck was 21 MPa at the engine idle speed.

(c) Failure of the rocker arm shaft is caused by the bending load-orthogonal array indicated that the minimum and maximum stresses were 161 MPa and 711 MPa respectively. Therefore stress range Dd was 550 MPa. The stress range obtained from the relationship between the range of the stress intensity factor and striation spacing was 592.42 MPa. It fails boundary condition this result indicates failure of the rocker arm shaft is caused by the bending load.

(d) Wears of rocker arm pads: the superior wear resistance of silicon nitride pads for LPG taxi engines and it was found that excessive calcium and phosphorous adsorption on contact surfaces lubricated with diesel engine grade oil contained primary type zinc dialkyl dithiophosphate and huge amounts of detergent of calcium. It caused the excessive of micro-pits observed on the cam noses.

(e) Fatigue failure of rocker arm shaft- number of cycles to be fracture is expected to be less than 129650 cycles if the rocker arm shaft is operated under failure boundary condition. The maximum stress measured in fatigue under most failure boundary condition of rocker arm shaft between each loading condition is 221.2 MPa, hence it has finite fatigue life.

(f) Carbon builds up at the end of valve stem- here valve guide wear occurs on the inside diameter of the guide valve in a straight line with the center line of the rocker arm.

(g) Failure due to friction- here continuous reaction with push rod and valve stem cause friction due to touching of each other this result in cheap formation.

## 2. LITERATURE REVIEW

The most popular materials used for manufacturing rocker arms are steel, aluminum, high-density polyethylene alloy (HDPE) (sai Krishna, Jitendra)[15], other materials are MNC materials (AlSiC) (Shridhar ,nihari)[1], chromium-molybdenum steel, grey cast iron, high strength steel, structural steel (Ambare,Zope) [2], carbon steel, HMCF UD (Bacha, Swaminathan, Deshpande)[3], Aluminum composite, Al 6061 (Chaitanya and Sreenivasan)[4], Al (ALDC8), E Glass/ epoxy composite material (Rahul Kirthi)[5], Aluminum (6061-T6) (Vishnu and Praveen Kumar)[6] aluminum alloy 7075 (P.Prasad) [7] also uses aluminum alloy, cast iron, titanium alloy (kullayappa, Krishna)[12] S. glass fibre, composite (Antaryami Mishra)[16] carbon steel EN-6 (Karki, Jha)[18]

**Shridhar, Miss T.E.Niharika,** [1] published a paper on "modeling and analysis of four-wheeler rocker arm", this paper shows the stress analysis of rocker arm and the hand crank by using finite element analysis software ANSYS. Here taking comparison of maximum shear stress total deformation and equivalent stress value for steel, aluminum alloy, metal matrix composite AlSiC are compared the paper shows the density of MMC (AlSic) is less than existing material so it decreases the weight of the 4 wheeler rocker arm and also increases the efficiency of the material.

**A.D. Ambare, Dr. S.B.Zope, Prof A.R.Patil,** [2] published a paper on "design analysis and optimization of the pivot of rocker arm", used automobile which traveled 135240 km and dominant fractured occurred at the neck of the rocker arm. This rocker arm made of cast aluminum ALDC8. First, evaluate fatigue endurance of rocker arm and finite element modeling analysis. Here the structural analysis of the rocker arm which is done to find the strength of the model. Taking 2 points loading we did analysis by applying loads on point which is on the model by varying five different materials. The result shows stress and deformation is the main criteria it shows structural steel has better fatigue strength and stiffness hence paper suggest structural steel has better material for a rocker arm.

**Sachin Bacha, P. Swaminathan, D. Deshpande**, [3] published a paper on "Design and static structural analysis of rocker arm in I.C.Engine", the paper shows design and calculation of rocker arm using analytical calculation.

**Dr. Goteti Chaitanya and Reddy Sreenivasan**, [4] published a paper on "Design optimization of I.C.Engine rocker arm using Taguchi based design of experiments", paper write about the fracture of rocker arm also in these paper structural steel, AL 6061 is used. Using Taguchi method maximum fatigue life is for rocker made with structural steel and arm ratio 1:1. AL 6061 with arm ratio 1:1.3 which shows total deformation is minimum.

 

Vonmises stresses are minimum for Al composites with arm ratio 1:1.3.

**Rahul Kirti,** [5] published a paper on "Finite element analysis of rocker arm of a diesel engine using radios linear", Here paper introduced finite element analysis and also procedure of FEA. By using three different materials and find its weights and maximum stresses von mises stresses are almost same of 3 different material but the weight of E Glass/Epoxy composite material is lowest so rocker arm is also lighter weight so researcher used E Glass/Epoxy composite.

**P.Prasad,** [7] published a paper on "Design SND analysis of 2 rocker arm", this paper gives an introduction of CAD/CAE also using a design he calculates deformations, stresses, and strains of carbon steel, aluminum alloy 7075, HMCFUD. From that fatigue analysis, the safety factor more for carbon steel so the researcher recommended carbon steel for a rocker arm.

**Syed Mujahid Husain, Prof.Siraj Sheikh,** [8] presented the paper on," Design and analysis of rocker arm" reviewed the specification and calculating forces acting on rocker arm also analysis of various stresses

**A.D. Ambare, Dr. S.B.Zope,** [9] published a paper on "a review of design analysis and optimization of the pivot of rocker arm", researcher design a rocker arm using an analytical method

**V. Bhagya sagar, Ms goroginam Santhi,** [10] published a paper on "Design and analysis of rocker arm" here researcher introduced and working of rocker arm also they write about form and function. Design of rocker arm and calculating forces acting on rocker arm finally they can say that HMCFUD polymer material producing less stress and high strength value. The weight of HMCFUD material is very low but strength is high.

**V.R. Magdhum, S.H. Sawant**, [11] published a paper on "an overview of design and analysis of rocker arm", the researcher gives an important role in stress analysis in rocker arm, also development theories related to fatigue failure of the rocker arm and find out different parameters according to the application of them.

**D. Raja Kullayappa, M. Naga Ramya Krishna, M. Ashok Chakravarthy, R. Rama Chandra,** [12] published a paper on "analysis and optimization of rocker arm", the researcher gives an introduction and working of rocker arm also they introduced fracture of rocker arm and manufacturing method of the rocker arm. Here use three different materials which are an aluminum alloy, titanium alloy, and cast iron. Here they design a rocker arm and apply forces, equivalent stresses, and maximum shear stresses and from that, they recommended aluminum alloy.

**Mohd Moseli Muhammad, Mahdi Chelsa, Mohd Subhi bin Din Yati,** [13] presented a paper on, "Failure and analysis of a diesel engine rocker arm" here in ships and boats which failed in service. The fractured occurred at the threaded part of the rocker arm. A detailed metallurgical investigation was conducted to identify the mode of failure and the point at which the crack occurred.

**Hendrikrisma, T.Kunz and C.Greene,** [14] presented a paper on, "Design and development of a 2 step rocker arm" designed and developed a two-step rocker arm for type II valve trains. Which improve engine efficiency, emissions and are relatively low cost. Here for testing a rocker arm uses a combination of theoretical and experimental methods.

**Sai Krishna, Jithendra,** [15] presented the paper on "Modelling and analysis of I. C. Engine rocker arm" focused on the used a high-density polyethylene alloy (HDPE) as compared to steel aluminum alloy and it concludes that HDPE has low strength and stiffness. These paper show that steel and aluminum alloy is better for design.

**Antaryami Mishra,** [16] presented a paper on" Stress Analysis of Glass/HDPE Composite Rocker Arm by Finite Element Method" he made an attempt to find out various stresses under extreme load condition for a polymer matrix composite rocker arm. He focused on light weight and reasonably high strength composite of Glass/HDPE can be used as a rocker arm. Even loading conditions the composite rocker arm of the fuel injection pump has been considered for analysis owing to its light weight, higher strength, and good frictional characteristics.

**Anush Karki, Anupam Raj Jha, Rakesh Jaiswal, Saurav Rajgadia, Ankit Basnet, Debayan Das, Pawan Jaiswal, Rabindra Nath Barman,** [18] presented the paper on **"**Design and Analysis of Rocker Arm by Finite Element Method using ANSYS" who used high strength HMCF UD and carbon steel EN as a rocker arm. Here rocker arm designed in CAD model and then meshing on it.

**A. Nagaraja, G.Suresh Babu,** [19] presented the paper on "Design and Optimization of Four Wheeler Rocker Arm for Neck and Hole" focused on the finite element method with four wheeler rocker arm using theoretical formulas. it is designed for fulcrum pin, design for valve spring, design for tappet, design for the forked end and rocker arm cross-section. From experience steel is the better material in terms of strength and aluminum is good for making low-cost rocker arms, HDPE is compared to steel and aluminum alloy low strength and stiffness.

**Jafar Sharief, K.Durga Sushmitha,** [20] presented the paper on "Design and Analysis of Rocker Arm" where the modeling of the rocker arm is done by using pro-e and the analysis is performed by Ansys this project consists of structural analysis of rocker arm which is done to find the strength of the model. To find strength used 4 different materials which are alloy steel-1, alloy steel-2, composite material, and steel.

**Tawanda Mushiri, Charles Mbohwa,** [21] presented the paper on "Finite element analysis of a car rocker arm" focused on used 'High-Density Polyethylene Composite' HDPE material in rocker arm for analysis and it is compared with steel rocker arm. And from the experiment, it is proved that HDPE is suitable for rotor arm as compared to steel.

**Syed M.H., Prof Siraj Sheikh,** [22] published a paper on "Rocker arm- A Review", this paper describes a type of rocker arm, failure of the rocker arm, also material uses in a rocker arm. This review paper concluded that steel is a better material than aluminum. On the basis of strength.

## 3. CONCLUSIONS

Rocker arm is an important component of the engine. Failure of the rocker arm is a major problem which makes a rocker arm useless also requires costly procurement and replacement. From past research papers, failure of rocker arm has not yet been overcome completely. Finite element method is the most popular approach and commonly used for analyzing fracture. Steel, aluminum, high-density polyethylene alloy, MMC, AlSiC,

 

Aluminum alloy, cast iron, E glass/epoxy composite material, HMCFUD polymer are used to design rocker arm. From which metal matrix composites decrease the weight of rocker arm and efficiency of the rocker arm increases. E Glass/epoxy composite material also decreases the weight of the material. Also, HMCFUD material increases produce less stress and high strength value and decrease weight up to 25% and the increasing total strength of the object. HDPE material has low strength and stiffness than steel and aluminum. From the above composite materials, hmcfud material produces less stress and high strength value and decreases weight up to 25% also increases total strength so hmcfud material recommended for a rocker arm.

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