Design, Analysis & Optimization of Pivot of Rocker Arm

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Abstract— Rocker arms are part of the valve-actuating mechanism. Over the years rocker arms have been optimized in its design and material for better performance. Durability, toughness, high dimension stability, wear resistance, strength and cost of materials as well as economic factors are the reasons for optimization of rocker arm. Various types of rocker arm used in vehicles and different materials used for making rocker arm are studied in this paper. Failure of rocker arm is a measure concern as it is one of the important components of push rod IC engines. Present work finds the various stresses under extreme load condition. For this we are modeling the arm using design software and the stressed regions are found out using Ansys software. Rocker arm is the important component of engine assembly in this paper we consider rocker arm and through the literature finite element analysis(FEA)in ANSYS is done for five different material viz. Aluminum alloy, chromium molybdenum, grey cast iron, HSS, structural steel. The result of ANSYS shows that structural steel is the best material for rocker arm. The result of software is validated experimentally by tensile test on UTM, brinell test on hardness tester and microstructural analysis.

Key words: Pivot of Rocker Arm, Rocker Arm

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 be The traveling distance of the automobile used in this study was 135,240 km. A dominant fracture occurred at the neck of the rocker arm. The rocker arm was made of cast aluminium ALDC8. It was fabricated by die casting method and its surface was anodized. In this study, the fatigue endurance of a rocker arm is evaluated by experimentation and a Finite Element Modelling (FEM) analysis. To measure the stress, stresses on the neck, which are the most critical, were measured using an attached strain gage with change of rpm of the engine. A series of fatigue tests were conducted on miniature samples extracted from new rocker arms. Fatigue performance was evaluated using the results from the stress measurement and FEM analysis, and the possible causes of failure were assessed.en made, however, in both efficiencies of operation and construction materials.

II. Working of Rocker Arm

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. Advancement in materials used in construction of rocker arm for reducing the noise, weight and higher strength for efficient operation is going on throughout the globe since long. The usual materials used for such purpose are Steel, Aluminium, and Forged steel to Stainless steel, alloys and composites. The success to investigate the possibility creating a light weight rocker arm that could provide a friction reducing fulcrum using needle bearings and a roller tip for reduced friction between the rocker and the valve stem but still be less expensive than steel lies in the development of composite rocker arms. Lighter mass at the valve is also allowed for increased speed while strength of the material caters to durability. The rocker arm usually operates at 40-500 C and the maximum pressure is exerted by the gas. Therefore in this investigation it has been thought proper to analyse a composite rocker arm of high density polyethylene (HDPE) reinforced with short S-glass fibres of 10% volume fraction. Finite element analysis may be carried out to determine the stresses and make a comparison between steel and composite to predict the failure modes.

Fig. 1: Pivot of Rocker ARM

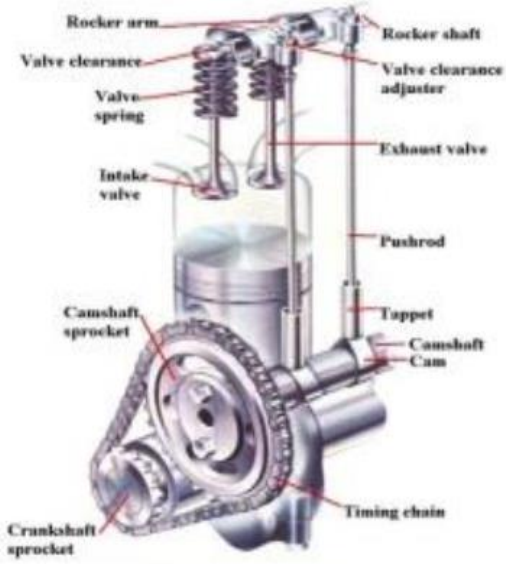

Fig. 2: Valve Train Assembly

III. FAILURE OF ROCKER ARM

Failure of rocker arm is a measure concern as it is one of the important components of push rod IC engines. Failure usual occurs at due to fracture at the hole or neck of the rocker arm. Various other factors are also mentioned below.

A. The Fracture Occurred at the hole of the Rocker Arm

The fracture occurred at the hole of the rocker arm. Multiple origin fatigue is the dominant failure mechanism. The spheroidisation of cementite in pearlite makes the hardness of the material of the failed rocker arms decrease to result in lower fatigue strength. Initiation and growth of the cracks was facilitated by a microstructure of low fatigue strength. The fracture of rocker arm at the hole is shown in fig.

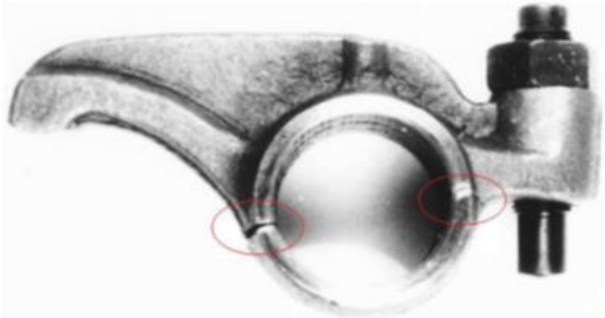

Fig. 3: Fracture of Rocker Arm at the Hole

B. The Fracture Occurred at the neck of the Rocker Arm

The ultimate tensile strength (UTS) and elongation of the rocker arm material were 164.0 MPa and 2.5%, respectively. This UTS value is slightly lower than that of normal die-cast Al alloys. In the stress measurement test, the compressive stress exhibits the maximum value at the idling state and decreases as the engine speed increases. The maximum experimental stress at the neck was _21.0 MPa at the engine idle speed. Hence, this rocker arm is deemed to be safe in terms of fatigue fracture, taking into consideration the fatigue endurance limit of 58.8 MPa. The safety factors of this component are 2.6 and 3.8 based on the fatigue endurance limit and the modified fatigue endurance limit, respectively, suggesting that this S.F is appropriate. However, gas porosities introduced during the die-casting process provide sites of weakness at which premature fatigue crack initiation and finally fatigue fracture of this rocker arm can occur. Therefore, it is necessary to control the melt quality during the diecasting process in order to secure the safety of this type of rocker arm due to stresses acting on it.

Fig. 4: Failure of a rocker arm at neck

C. Failure of the rocker arm shaft is caused by the bending load

FEA results for the failure boundary condition obtained from orthogonal array indicated that the maximum and minimum stresses were 711 MPa and 161 MPa, respectively. The stress range $\Delta\sigma$ was 550 MPa. The stress range $\Delta\sigma$ obtained from the relationship between striation spacing and the range of the stress intensity factor was 592.42 MPa. The failure boundary condition estimated by using an orthogonal array and ANOVA was very useful because the relative error between the stress ranges obtained from striation and the stress ranges from FEA fell within 7%. Thus this result indicates Failure of the rocker arm shaft is caused by the bending load .

D. Wear of Rocker Arm Pads

The superior wear resistance of silicon nitride pads for LPG taxi engines and it was found, that excessive calcium and phosphorus adsorptions on contact surfaces lubricated with diesel engine grade oil contained primary type zinc dialkyl dithio phosphate and large amounts of calcium detergent. The excessive adsorption of some additives caused the micro-pits observed on the cam noses following every test conducted with that grade of oil. It is thought that the pits were formed by acid corrosion following chemical reactions

E. Fatigue Failure of Rocker Arm Shaft

Fatigue crack in rocker arm shaft for passenger car was initiated at through hole and subsequently propagated along its sidewall. If rocker arm shaft is operated under actual failure boundary condition, number of cycles to fracture is expected to be less than 129,650 cycles. The maximum stress measured in failure region under the most dangerous failure boundary condition of rocker arm shaft between each loading condition is 221.2 MPa, which exceeds fatigue limit of 206 MPa and hence rocker arm shaft with this boundary condition has finite fatigue life.

F. Carbon Builds Up at the end of Valve Stem

Due to carbon build up at the end of valve stem. Valve guide wear occurs on the inside diameter of the valve guide in a straight line with the centre line of the rocker arm.

G. Failure due to friction

The continuous interaction with the valve stem and push rod cause friction as they are touching each other this result in cheap formation.

IV. METHODOLOGY

1) Identify the most suitable material for Pivot from class of materials.
2) To determine the dimensions for Pivot analytically.
3) Efficient CAD modelling of Pivot.
4) Evaluate the design data with the help of software analysis.
5) Experimental analysis of the Pivot Rocker arm and obtaining the results.
6) Compare the results obtained from Analytical method, software analysis and experimental analysis.

V. FINITE ELEMENT ANALYSIS

A. CAD Model

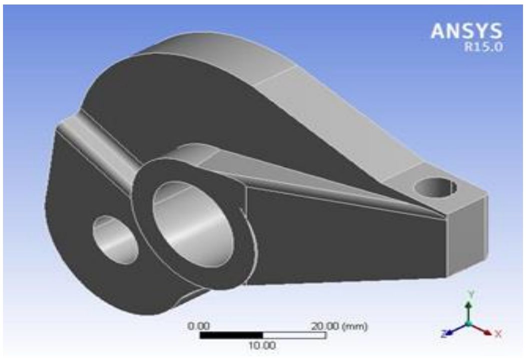

Fig. 5: CAD Model

B. Finite Element Analysis by ANSYS of 5 Different Material Static Structural Diagram of Rocker Arm

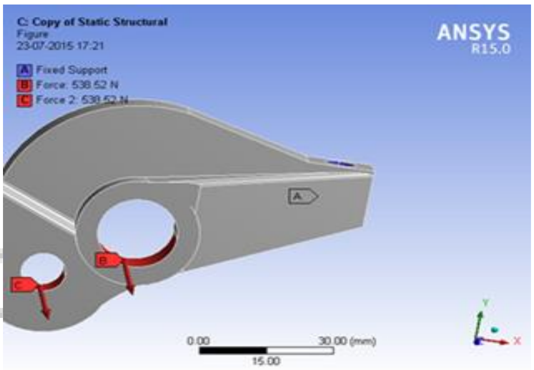

Fig. 6: Finite element analysis by ANSYS of 5 different material Static structural diagram of rocker arm

1) *Aluminum Alloy*

a) Total Deformation

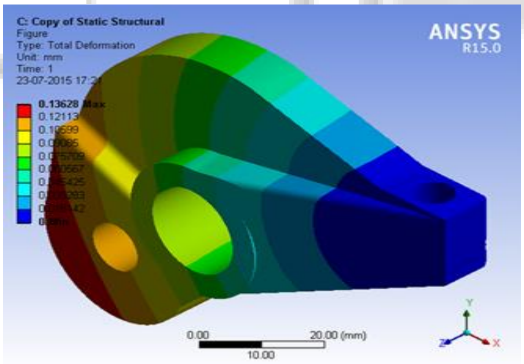

Fig. 7: Total Deformation

b) Equivalent von-mises stress

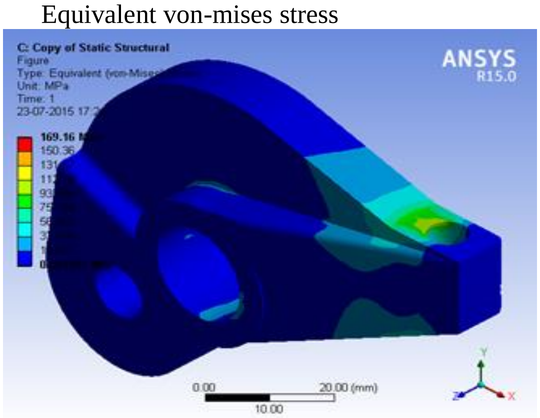

Fig. 8: Equivalent von-mises stress

2) *Chromium Molybdenum Steel*

a) Total Deformation

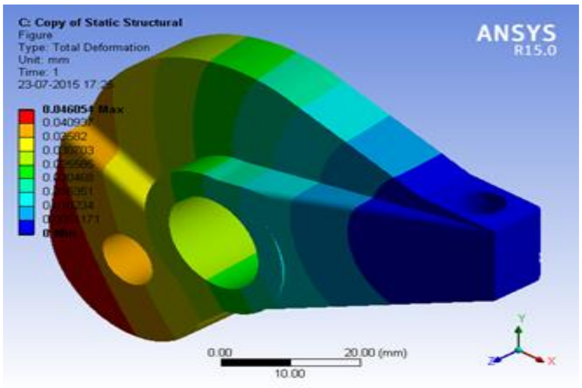

Fig. 9: Total Deformation

b) Equivalent von-mises stress

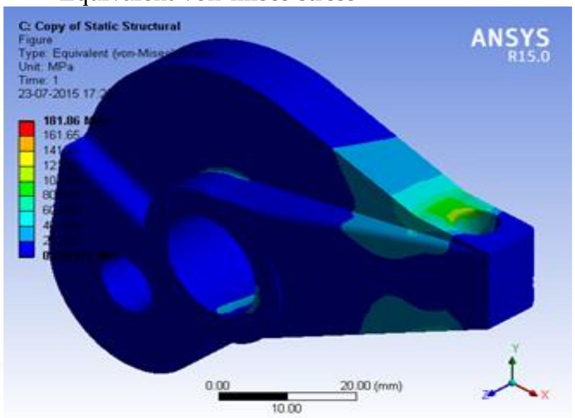

Fig. 10: Equivalent von-mises stress

3) *Gray Cast Iron*

a) Total deformation

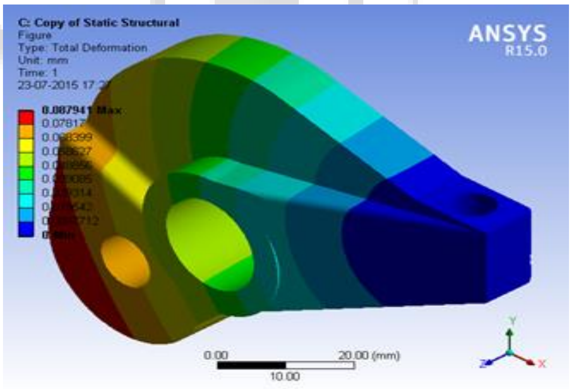

Fig. 11: Total Deformation

b) Equivalent von-mises stress

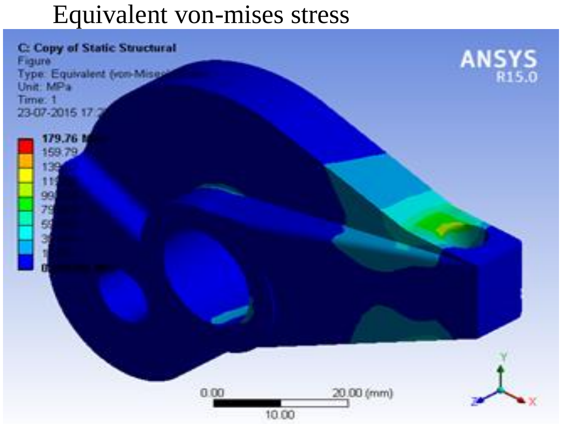

Fig. 12: Equivalent von-mises stress

4) *High Strength Steel*

a) Total deformation

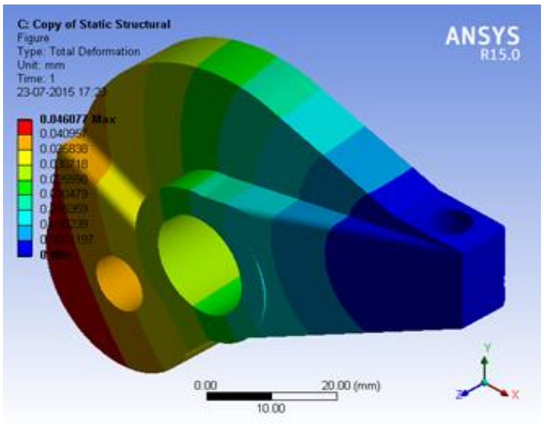

Fig. 13: Total Deformation

b) Equivalent von-mises stress

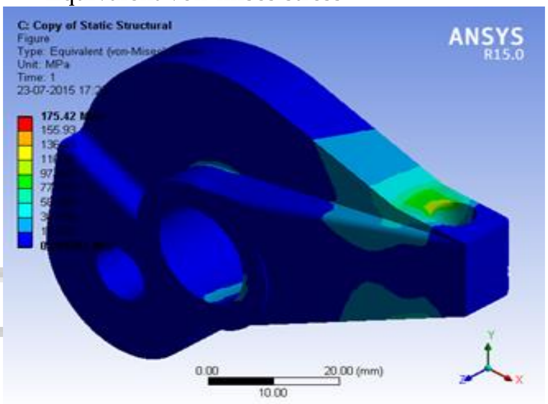

Fig. 14: Equivalent von-mises stress

5) *Structural Steel*

a) Total deformation

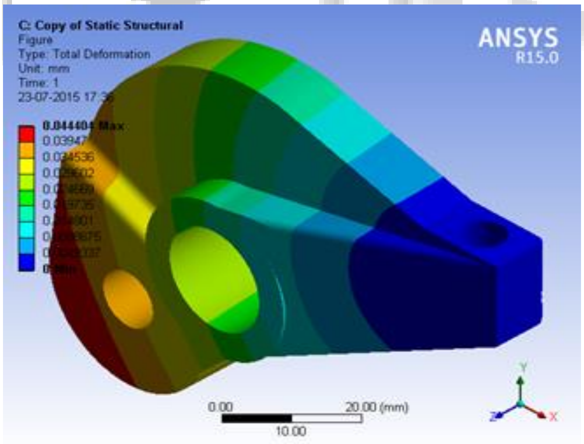

Fig. 15: Total Deformation

b) Equivalent von-mises stress

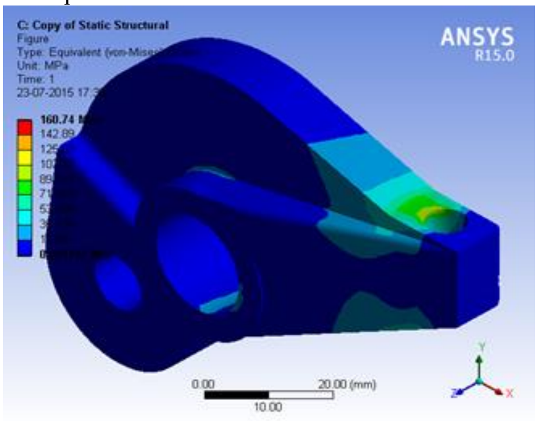

Fig. 16: Equivalent von-mises stress

VI. RESULT AND DISCUSSION

A. *Finite Element Analysis Result*

Type of material	Maximum Von-Mises stress(mpa)	Minimum Von-Mises stress(mpa)	Total Deformation (mm)
Aluminum Alloy	169.16	2.431×10^{-2}	0.1362
chromium molybdenum steel	181.86	1.9171×10^{-2}	0.04605
Grey cast-iron	179.76	1.8786×10^{-2}	0.0879
High strength steel	175.42	1.9703×10^{-2}	0.0460
Structural steel	160.74	2.1727×10^{-2}	0.0440

Table 1: FEA Result

B. *Experimental Result*

Tensile test is cerried out on universal testing machine and elongation shown in table

Material Type	Elongation at yield	Elongation at break
Aluminum alloy	6.72 mm	18.42 mm
chromium molybdenum steel	6.61 mm	20.34 mm
Gray Cast Iron	6.77 mm	18.89 mm
high strength steel	5.54 mm	25.50 mm
Structural Steel	5.30 mm	17.26 mm

Table 2: Experimental Result of UTM

A. *Comparison of FEA & Tensile test result*

Type of material	Finite Element Analysis		Tensile test on UTM	
	Total Deformation (mm)	Equivalent von-mises stress (mpa)	Elongation at yield (mm)	Elongation at break (mm)
Aluminum Alloy	0.1362	169.16	6.72	18.42
chromium molybdenum steel	0.04605	181.86	6.61	20.34
Grey cast-iron	0.0879	179.76	6.77	18.89
High strength steel	0.0460	175.42	5.54	25.50
Structural steel	0.0440	160.74	5.30	17.26

Table 3: Comparison of FEA & Tensile Test Result

VII. Conclusion

The modeling of the rocker arm is done by using pro-e and the analysis is performed by ANSYS. The project consists of structural analysis of rocker arm which is done to find the strength of the model. To find the strength of the model in structural analysis we are taken 5 different materials like Aluminum Alloy, chromium molybdenum steel, Grey cast-iron, High strength steel Structural steel and taken 2 load points on model. We did analysis on the model by applying loads on point of two holes on rocker arm by varying different 5 materials. By the results we observed that the stress and deformation is the main criteria. The literature shows structural steel has better fatigue strength and stiffness. The of FEA and experimental testing on UTM result shows less deformation and less stress of structural steel. Hence structural steel is the better material for rocker arm among all available material.

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