



Finite Element-Based Structural Evaluation Of Rocker Arms With Multimaterial Approach

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Abstract: Rocker arms play a vital role in the valve actuation mechanism of an engine. They are designed to pivot on a shaft or pin fixed to a bracket, which is mounted on the top of the cylinder head. The camshaft actuates one end of the rocker arm, which, in turn, interacts with the valve stem at the other end. In configurations where the camshaft is located below the cylinder head, pushrods are used to transfer motion to the rocker arms. Valve springs ensure that the lifters, equipped with rollers, follow the cam profiles accurately, maintaining proper alignment. The aim of this project is to design rocker arms using CATIA software and perform static structural analysis in ANSYS. By analyzing rocker arms made from different materials—Carbon Steel, Nimonic 80A, and Inconel 718—the study seeks to identify the most suitable material. This determination is based on comparative results for von Mises stress, strain, deformation, and shear stress.

Keywords- ANSYS, Rocker arms, CATIA, Optimization, Stress.

I. Introduction:

The rocker arm plays a crucial role in the valve train of a fuel injection system. It not only facilitates valve actuation through a fulcrum involving the lifter and push rod but also contributes to increasing the valve lift ratio. Despite significant advancements in camshaft design over the past few decades, overhead valve (OHV) engines with centrally located camshafts still rely on lifters, push rods, and rocker arms to control the intake and exhaust valves in fuel injection pumps.

Globally, ongoing research and development efforts aim to enhance rocker arm materials to reduce noise, minimize weight, and improve strength for more efficient engine performance. Common materials used include steel, aluminum, forged steel, stainless steel, alloys, and composites. The development of composite rocker arms has opened new avenues for designing lightweight components. These composite

designs enable the use of needle bearings and roller tips, reducing friction between the rocker arm and valve stem while offering a cost-effective alternative to traditional steel components.



Figure No 1.1: Rocker Arm

A rocker arm is an oscillating lever that transforms the rotational motion generated by a cam lobe into the linear motion needed to open a poppet valve. One end of the rocker arm engages with the valve stem, while the other end is actuated by the camshaft, either directly or through an intermediate tappet (lifter) and pushrod. As the camshaft rotates, it lifts the outer end of the rocker arm, which in turn pushes down on the valve stem, allowing the valve to open. When the cam lobe rotates away, the rocker arm returns to its initial position, enabling the valve spring to close the valve. This coordinated motion, directed by the cam and follower, controls the opening and closing of both intake and exhaust valves.

Rocker arms are commonly manufactured from materials like malleable iron, cast iron, or cast steel. To reduce inertia, rocker arms in high-speed engines often feature an I-shaped cross-section, whereas rectangular cross-sections are more typical in low-speed engines. In four-stroke engines, the rocker arm associated with the exhaust valve usually endures greater mechanical stress. Despite the intake valve requiring less force to operate, it is standard practice to design both intake and exhaust rocker arms with similar dimensions for uniformity and durability.

II. LITERATURE SURVEY

Wei, Jicheng, etc. Lower rocker arm is a crucial section of vertical roller mills, and its lightweight design reduces bulk and production costs. ANSYS Workbench was used to calculate the maximum stress and deformation of the lower rocker arm under operating load. The best design was based on strong components. First, the lower rocker arm body was confirmed to be lightweight. Second, the mass of the lower rocker arm was taken as the optimization target, the stress and displacement generated by the lower rocker arm's load were taken as the constraint conditions, the structural size of the lower rocker arm's internal cavity was taken as the optimization design parameter, and the mathematical model of the optimization design was established. ANSYS Workbench's response surface optimization module and multi-objective genetic

algorithm were used to optimise the lower rocker arm's interior cavity. Optimal findings indicate that the lower rocker mass was decreased by 346.3 kg, or 5.29 percent, while strength and deformation were practically maintained. By improving the design, material is conserved and costs are lowered, providing a reference for the lower rocker arm's design and light weight. Rocker arm study using ANSYSV11software. ANSYS Workbench was used to find the CAD model's Equivalent Stress and Maximum Shear Stress. ANSYS Workbench results are compared to hand-calculated results. ANSYS Workbench was used to analyse the lower rocker arm. Highest equivalent stress occurred at the transition between the casting at the front end of the lower rocker arm and the web welding, and maximum displacement occurred at the lower rocker arm's pull ring. Design-specified maximum equivalent stress and displacement are met. The lower rocker arm's stress distribution was small, which suggests there is room for lightweight design. The mathematical model of the optimization design was created using the smallest mass of the lower rocker arm as the goal, the structural size of the internal cavity as the input variable, and the maximum equivalent stress and maximum displacement as the constraint conditions (Formula (10)). The interior cavity of the lower rocker arm was improved using the workbench's response surface optimization module and multi-objective genetic algorithm. The first set of ideal parameter combinations was chosen for optimization and static analysis (Table 3). The improved lower rocker arm's mass was decreased from 6552.5 kg to 6206.2 kg to fulfil strength and deformation criteria, meeting the 5.29 percent optimization objective. The lower rocker arm's structural optimization approach may be used to optimise other complicated mechanical devices. [1]

Iruthayaraj R, Palani S said that in the car industry, design and cost are significant competitions. Our everyday lives depend on cars. The car's engine is significant. Engine assembly and disassembly are laborious. It's time-consuming. If the engine has a valve leak, valve bend, or anomalous combustion, the entire engine must be disassembled and reworked. The engine has too many pieces to disassemble quickly. "Rocker arm replica" reduces time consumption. By utilising this, the cylinder head is removed without serious harm. Compared to the current way, time would be saved. Our idea aims to shorten the time needed to disassemble and reassemble engines without damaging them. The proposed methodology reduces cylinder head disassembly time compared to the existing method. By reducing cylinder head disassembly time, production may be boosted. Also prevent cylinder head damage. Replicating the rocker arm shaft can remove the cylinder head without removing key pieces like the intake and exhaust manifolds, EGR, etc. Also In this research, the rocker arm shaft was created and manufactured. After receiving the product, the time consumption was calculated using this approach. Using this rocker arm replica, remove the cylinder head for redesigning. Improve production by lowering engine repair time. [2]

Lori Coon, Mohammad Esteghamatian, et al. address CAD in an industrial environment. Once a finite-element model of a system or pa(is constructed and verified, it may be utilised for various materials. Time-saving for producers. Further, spring elements can mimic non-linear elastomeric components. By employing this method, engineers may save time building FEA models of complex geometries and minimise execution time. The bolts transmit a regular load to the cover and torque at three holes when tightened.

Torque has no influence on cover deflection. Concentrated loads were applied to the holes' perimeters to simulate typical loads. These loads and the gasket and grommet springs are the analysis's boundary conditions. Mesh without gasket and grommets. An ea5geratec ltrei,Ea:ac s-,ap€ B shows Ei. Fig. 9 shows the von-Mises stress distribution, which helps locate plastic deformation zones. This analysis reveals that the cover's Mises stress is four times lower than the aluminium yield strength. Under the given loading circumstances, the engine cover shouldn't distort plastically. Individual force/deflection curves for the three system components were compared to experimental data (Fig. 10). The experiments accord well. After a certain deflection, predictions and experiments diverge. A more finer mesh with parabolic components may produce better results, but it's CPU-intensive. [3]

Huang, Xu To address the extreme wear of rocker arm wire on crown-mounted compensators, the working principle of the rocker mechanism is examined and wire mechanical characteristics are computed using a Simulink model. Rocker mechanism's multi-objective optimization design concept reduces contact stress amplitude between wire rope and three pulleys. MATLAB programme uses rocker and linkage arm length as design parameters. The contact stress of wire rope dropped by 21.6% when rocker and linkage arm lengths were 3450mm and 5900mm, reducing fatigue failure and wear loss. The rocker mechanism's contact angle and contact stress are analysed and estimated using Simulink. Contact stress changes periodically, according to the results. Pulley 1 has the smallest contact stress amplitude of the three at 7.24MPa. Pulley 2 has the largest amplitude at 25.15MPa, indicating it wears the most. By analysing the influence of the rocker mechanism's structural characteristics on contact stress, the optimization aim is to reduce the contact stress amplitude between the wire rope and three pulleys. The multi-objective optimization design model of a rocker mechanism is built in MATLAB and computed using the fgoalattain function. Optimizing structural characteristics (rocker arm 3450mm and linkage arm 5900m) reduced wire rope contact stress by 21.6%. [4]

Raviulla et al. analysed rocker arm heat by geometry. When filters operate with substantial temperature variations between the fine base and surrounding fluid, the temperature-dependent thermal conductivity of the fine material must be considered to accurately measure its heat generation. This research uses three aluminium alloys (A380, B390, C443) The study considers cap form and size. [5]

Kirti Recommended The rocker arm is crucial to an internal combustion engine's functionality. It controls intake and exhaust valves. Rocker Arms are between the pushrod and intake/exhaust valves. They allow pushrods to raise rocker arms and lower valves. In this work, a 3D solid model of a Rocker Arm is created in CATIA and saved in.igs format. Hyper Mesh performs static analysis on the model. Von-Mises stress and displacement values of aluminium ALDC8 rocker arm are computed and validated. Comparing rocker arm FE studies for two materials. Chromoly steel and E Glass/epoxy are utilised. Also compared is Rocker arm weight. The stress analysis results aid enhance rocker arm component design and save manufacturing time and cost. Weight reduction helps engine design. High-strength, lightweight ALDC8 cast aluminium is used for Rocker arms. Lightweight rocker arms are good for high-rpm applications, but strength is also important. The rocker arm's neck has 19.3MPa of stress. The stress is significantly below

225MPa. Von-Mises stresses are similar for three distinct materials (al ALDC8, Chrome moly steel alloy, E Glass/epoxy composite). Rocker arm neck is most stressed. Increase the neck material to reduce this. For validation of FEA findings, identical model under same loading conditions was compared [1]. For aforesaid loading circumstances, stresses are far below yield stress (225MPa). The research finds 19.3MPa of von Mises stress. Maximum displacement is 0.024mm, which is acceptable. [6]

Rocker arm is a lever used to convey cam or pushrod action to a valve stem, according to V R Magdum and S H Sawant. Increase rocker arm strength and durability is under study. IC rocker arm is stressed. Work reveals rocker arm strains. We model the arm using CATIA and ANSYS to find strained zones. Using diverse materials for rocker arms increases their longevity and strength. This reduces rocker-arm strains. Changing the rocker arm's material affects its stresses. After comparing stress values, we propose rocker arm material. The design of rocker arms has been a popular study issue due to their importance in stress analysis. The researchers developed ideas on rocker arm fatigue failure and then determined application-specific parameters. [7]

EXPERIMENTAL INVESTIGATION

The failure can be traced to the use of inappropriate content. Other materials outside steel should be considered as potential replacements for rocker arms made of steel due to the drawbacks of steel, such as their high cost and heavy weight. Because it is necessary to conduct an in-depth analysis of the material's qualities before putting them into use, advanced materials are frequently utilised.

Objectives of the Project:

- Design of Rocker arm CI engine specifications.
- Obtaining design of Rocker arm using CATIA V5 and then imported into ANSYS 16.2.
- Meshing of design model using ANSYS 16.2.
- Analysis of Rocker arm by using static analysis method.
- Comparing the performance of Four different materials CARBON STEEL, NIMONIC 80A, INCONEL 718.
- Identification of the Suitable material for manufacturing of the Rocker arm under specified conditions.

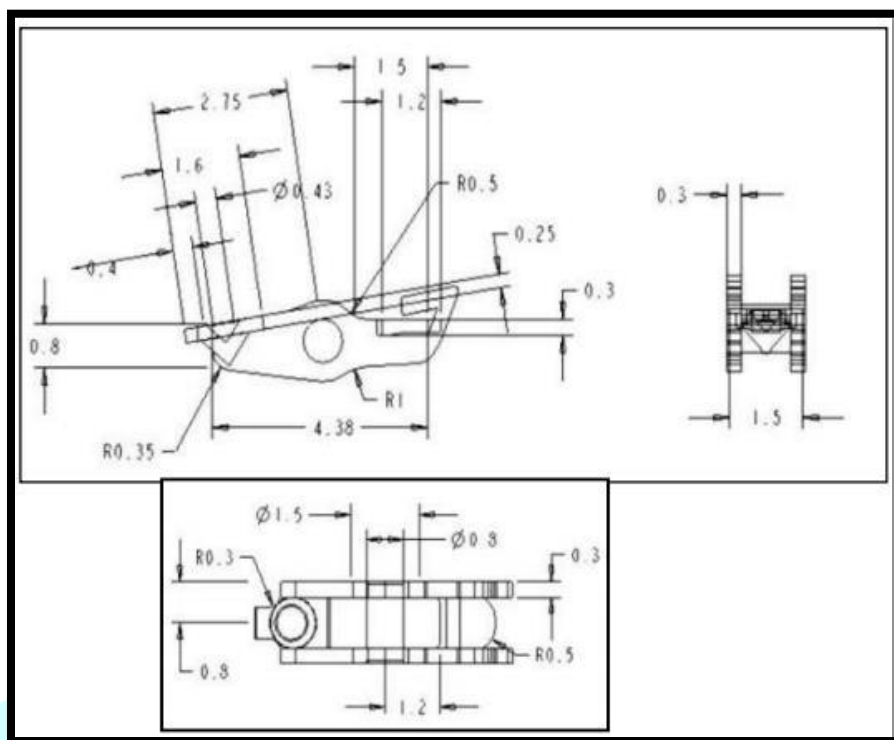


Figure 3.1: Design specifications of a rocker arm

III. EXPERIMENTAL RESULTS

4.1. Static Structural Analysis

After importing the rocker arm model into the ANSYS Workbench, a discretization was performed such that there was an equal amount of nodes and elements. Ansys was used to mesh the rocker arm model into a variety of nodes and elements, all of which were automatically created in accordance with the automation of the ansys work bench tool.

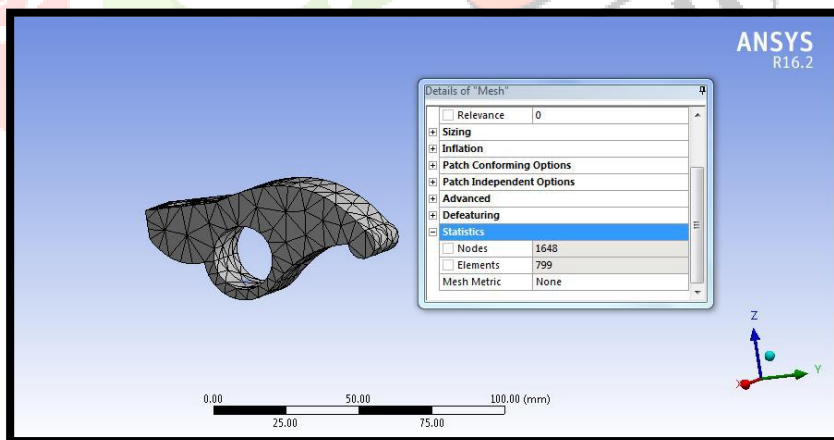


Figure 4.1: Meshing

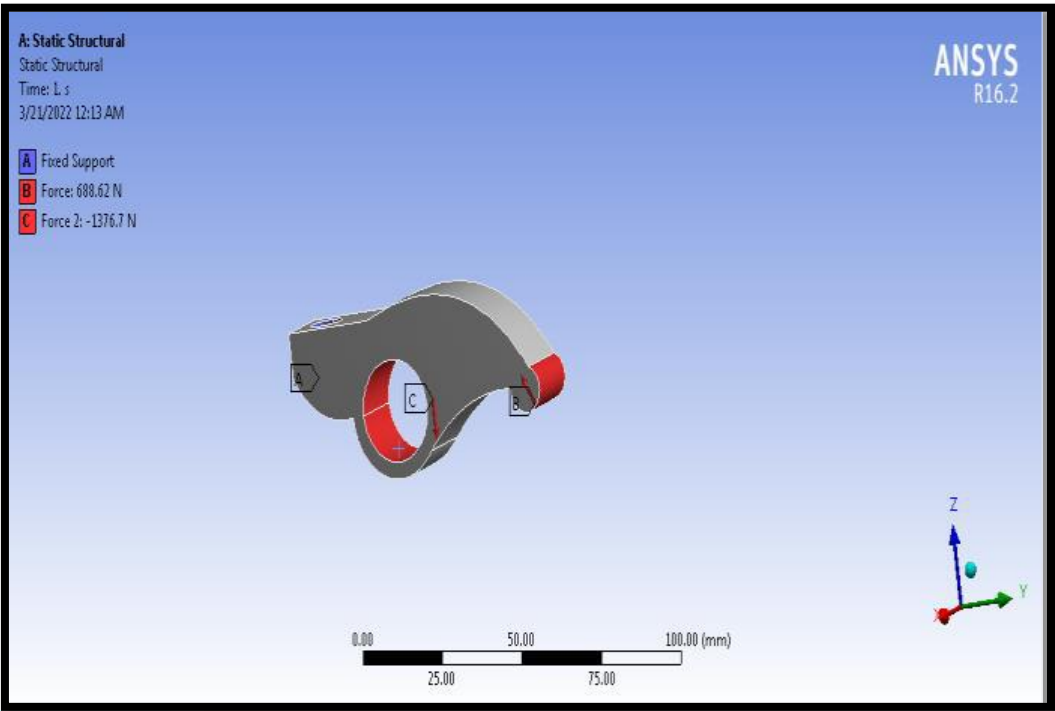


Figure 4.2: Boundary Conditions

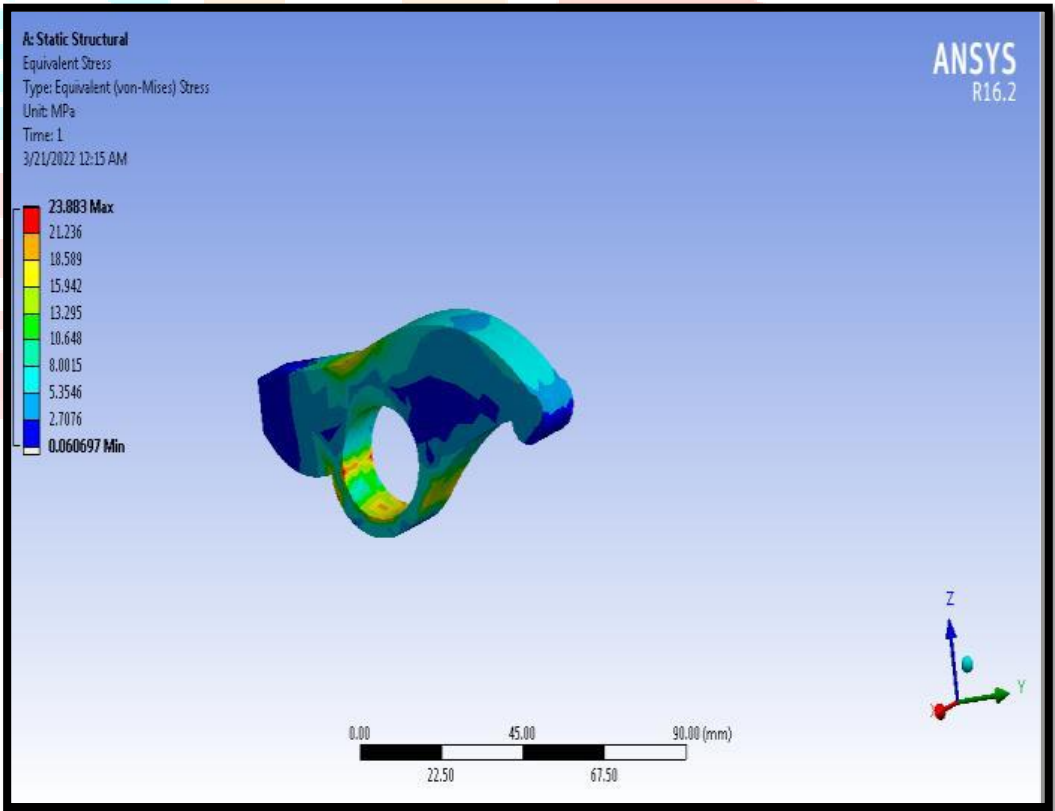


Figure 4.3: Von Misses Stress Distribution on Rocker Arm

IV. CONCLUSION

According to the studies that were mentioned earlier, it was discovered that the rocker arm can withstand the load equivalent to that which is sustained by an Inconel-718 rocker arm, despite being subjected to rigorous loading conditions. Inconel-718 rocker arms are always less affected by the loading conditions that are applied when compared to the other two materials. The rocker could break in the corners that have the most acute angles after being used for an extended length of time, as shown by the maximum stress. The Maximum equivalent stress of 23.883 Mpa is the maximum possible value. In comparison to carbon steel and Nimonic-80A, the figures for total deformation, shear stress, and residual cases of strain are significantly higher for the material known as Inconel-718. Therefore, Inconel-718 is going to be the material that is being considered for the rocker arm. Finally, it was determined that a rocker arm made of Inconel-718 might be constructed in the near future. This would yield superior results compared to those obtained using traditional materials.

V. REFERENCES

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