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Review on Modelling and Analysis of two-wheeler Connecting Rod with Different Materials Using FEA

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ABSTRACT

The automobile engine connecting rod is manufactured at a high-volume rate and treated as a critical component. The connecting rod is the intermediate link between the piston and the crank and is responsible to transmit the push and pull from the piston pin to crank pin, thus converting the reciprocating motion of the piston to rotary motion of the crank. It is desired to design and optimize a connecting rod for a light weight, energy efficient., ecofriendly spark-ignition four-stroke internal combustion engine application by applying FEA, material optimization and topology optimization. Generally connecting rods are manufactured using carbon steel and in recent days aluminium alloys are finding its application in connecting rod.

The objective of the present review paper is to determine the different parameters which are useful to minimize the mass of the connecting rod considering material optimization and topology optimization methods based on previous research papers.

Keywords: Connecting rod, Material Optimization, Topology Optimization, Carbon steel, Aluminum alloy, FEA

1. INTRODUCTION

The connecting rod (conrod) (figure 1) is a component found within the internal combustion engine. Its main function is to act as the link between the piston head and the crankshaft, allowing for the translation of the reciprocal motion of the piston to the rotational motion of the crankshaft and flywheel. As such, the conrod must be designed to withstand the cyclical loading it experiences within the engine, both from the compressive force of the gas rapidly expanding and acting on the piston head, and the tensile forces that are experienced from the inertia of the piston head pulling on the conrod as it completes its rotation.

figure 1: a steel conrod (1)

Topology optimization is the process of adding or removing material from a model based on a series of limitations to ultimately arrive at the best solution to a problem. TOSCA is a software that is integrated with the finite element structural analysis tool Abaqus Explicit that allows for topology optimization to be performed computationally and efficiently. To perform optimization analysis, the following must be specified:

1. Design responses – these are the variables that are to be used in the analysis.
2. Objective function – this is the variable which is to be minimized or maximized.
3. Numerical constraints – these are the limits within which the objective function must be achieved.
4. Geometric constraints – these are any other design limitations that cannot be quantified, e.g., symmetry of results.

For example, if the problem is to minimize mass while not exceeding a maximum stress, the design responses are mass and stress, with the objective function variable being mass (minimize) and the constraints are stress (<= specified value). It is also possible to multiple variables in the objective function which can be weighted based on their relative importance to the problem, and the design space can be specified so that material is not removed from any critical areas.

2. LITERATURE REVIEW

1.O.K. Ajayi, B.O. Malmo, S.D. Paul, A.A. Adel eye, S.A. Babalola (2021)

Titanium alloys have carved out a place in mechanical parts that need to be both strong and light. Exotic automobile parts are now constructed of titanium alloys, which contributes to the exorbitant cost of these vehicles. In contrast to the choice of high-end materials, which is normally based on weight, shape and model optimization have played an essential role in cost reduction. The impact of shape optimization on Ti-6Al-4 V utilized as a connecting rod in a 500-cc engine is examined in this study. Using Autodesk Inventor, a model of the connecting rod was produced, and the various forces and constraints were calculated, then used in ANSYS to simulate the failure. The clearance at the crank end was optimized to accomplish shape optimization. The optimized model resulted in a weight reduction of 11.7 percent, as well as lower deformation and stress distributions. It was determined that optimizing the shape by changing the clearance at the crank end provided the greatest results.

2.G. Shanmugasundara, M. Dharani Dharan, D. Vishwa, A.P. Sanjeev Kumar (2020)

"Connecting rod design, analysis, and topology optimization" The connecting rod design parameters were computed in this study, and the model was created using Creo Parametric and ANSYS for Finite Element Analysis. Autodesk Fusion 360 is used to optimize the topology of the existing connecting rod design, and ANSYS is utilized to analyze the optimized design. When comparing the optimized design to the initial design, the maximum principal stress, equivalent stress, maximum principal strain, and total deformation are less in the optimized design, and there is a weight reduction of about 3.5 percent for the steel material subjected to the force of 39473.16N. Based on the current connecting rod analysis results, the topology optimization was performed on the shank region that joins the small end and big end, and the optimization was performed by including holes in the shank region where the stress is minimal.

3.A. Pandiyan, G. Arun Kumar, and G. Premkumar (2019)

"Design, Analysis, and Topology Optimization of a Connecting Rod for Single Cylinder 4–Stroke Petrol Engine" In this study, the coupled steady-state thermal structural analysis of a connecting rod was performed before and after weight reduction, and the von mises stresses, total deformation, factor of safety, and total heat-flux for the given loading conditions were observed. Following the coupled field analysis, the stress in loading situations was evaluated, and places where surplus material might be reduced were determined. Initially, significant localized stress at the tiny end of the connecting rod can be alleviated by expanding the area in this region by providing fillets. Topology optimization was undertaken to lower the weight of the connecting rod subjected to compressive and tensile loads. The connecting rod's shank section gave the most possibilities for weight reduction. A6061 outperforms LM6 and ADC12 both before and after optimization. The von Mises stress, deformation, total heat flux, and safety factor are nearly identical. According to the FEA, the chosen material of aluminum 6061–T6 toughened alloy reduced the weight of the existing connecting rod by up to 4.1 percent. The optimal connecting rod weight is found to be 130.02 grammes.

4.Aisha Muhammad, Mohammed A. H. Alia Ibrahim Haruna Shannon (2019)

"Optimization of a diesel connecting rod design" In this study, the finite element approach is shown to be an excellent method for modelling and analyzing structures. Weight and structural optimization of a connecting rod coupled using the Finite Element Method and ANSYS is carried out and discussed in this article. The operations were carried out on a connecting rod made of structural steel with a static force of 100N and 500N, respectively. A comparison of the analytical results before and after optimization is performed to determine the best available design. Based on the findings of the investigation, it is possible to infer that ANSYS software may be used by manufacturing organizations to reduce material waste and optimize profitability while preserving product quality and dependability.

5. Sundararajan Ranganathan, Sathish Kumar Kupuna, Karthik Sundararajan, and Ashok varthanan Perumal (2019)

The specimen tested on the Vickers device and the Universal testing machine yields a better result. When the test results of the casted specimen are compared to A356, the material property is raised by 30% for A356-5 percent of SiC-10 percent of fly ash in stir casting and almost 65 percent for A356-5 percent of SiC-10 percent of fly ash in stir cum squeeze casting procedure. The finite element approach is used to perform stress analysis in a variety of circumstances. When the analysis results are compared, the total deformation of the material is found to be a reduction of 24 percent of stress for A356-5 percent of SiC-10 percent of fly ash in stir casting and a reduction of nearly 40 percent of stress for A356-5 percent of SiC-10 percent of fly ash in stir cum squeeze casting process.

6. T. Sathish, S. Dinesh Kumar, S. Karthick (2019)

In general, carbon steel is used to make connecting rods; however, currently, aluminum alloys are the greatest alternative material for making connecting rods. Because it is ideally suited for high-speed engines in motorcycles, aluminum alloys are light and absorb great impact strength. The examination of three different aluminum alloy materials, AA2014, AA6061, and AA7075, was the subject of this investigation. For selected three materials with von miss's stress, FEA analysis was performed using ANSYS software; shear stress and total deformation were produced using ANSYS software. Using modelling packages such as SOLIDWORKS and ANSYS software, the examination of several geometric forms of connecting rod, such as solid type and shell type, was carried out. The study yielded an appropriate result, with the deformation and stiffness of each material clearly visible in the output of the studied data as well as in theoretical calculations.

7. D. Gopinath, Ch. Sushma (2015)

"Design and Optimization of Four-Wheeler Connecting Rod Using Finite Element Analysis" In this research investigates the modelling and analysis of a conrod to determine which material is best suited for making a conrod from steel, aluminum, and titanium, however this paper also investigates the optimum shape for reducing the mass of the conrod. The conrod is subjected to a load of 22kN in compression and 2.2kN in tension, which are then multiplied by a factor of safety (FOS) and applied as static loads. The analysis finds that the stresses are lowest in steel, and topology optimization of a steel conrod can achieve a reduction in mass of 10%.

3.CONCLUSION

According to a recent study, researchers are evaluating the methods used to optimize diverse items with the goal of reducing mass without compromising the object's or product's strength or other requirements. More research is needed into the common ways for obtaining amazing deals. Authors are increasingly focusing on material and topology optimization as a gradient-based study for various functions in form optimization. The Adjoint solver is used to optimize certain sections and confer new ones based on the existing variables selected.

- The static structural analysis and Fatigue analysis of connecting rod using different material is done by many researchers and try to improve life span, reduce weight, improve strength and stiffness of connecting rod.
- Modification of design parameters of cross section helped to increase the fatigue life of connecting rod, reduce the weight of connecting rod and it helped to reduce the stresses.
- Strength and stiffness of connecting rod improved by replacing existing forged steel or steel material with alloy or composites. It also helped to reduce the values of stresses and it is cost effective.

4.FUTURE SCOPE

- After reviewing various selection parameter of connecting rod, it has been seen that there is wide scope of research to explore this research work.
- More and more advance hybrid material can be used to manufacture connecting rod that will not only make it lighter but will also reduce its cost.
- Also manufacturing technologies can be developed that can reduce the time of manufacturing and make it possible to design some critical parts of rod with ease.
- It will also use in commercial automobile and increase life of connecting rod.

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