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Vibration Analysis of Composite Connecting Rod

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***Abstract*— Composite materials are now a day widely used in the engineering field. The general characteristics possessed by the composite materials are found to be the reason for using it in the automotive applications. The connecting rod is a major link inside of combustion engine. It connects the piston] to the crankshaft and is responsible for transferring power from the piston to the crankshaft. It must work on high r.p.m. because of which it has to bear severe stresses which make its design vital for internal combustion engine, so that's why we are using composite material for testing is carbon fibre. In this project, design, analysis of the 2-wheeler connecting rod will be performed. The CATIA V5 R20 software has been used for designing the connecting rod 3D model and then the designed connecting rod model is imported into the ANSYS software in which the design is meshed and analysed by using the Finite Element Method (FEM) and the result is manipulated.**
Modal analysis of existing and composite connecting rod will be performed.

Keywords— **Connecting rod, Composite material, Carbon fibre, vibration, natural frequency, FFT analyser, impact hammer**

I. INTRODUCTION

The connecting rod is the intermediate member between the piston and the Crankshaft. In a reciprocating engine, the connecting rod connects the piston to the crank or crankshaft. Together with they form a simple mechanism that converts reciprocating motion into rotating motion. As a connecting rod is rigid, it may transmit either a push or a pull and sothe rod may rotate the crank through both halves of a revolution. Generally connecting rodsare manufactured using carbon steel and in recent days aluminium alloys are finding its application in manufacturing of connecting rod. The connecting rod primarily undergoes tensile and compressive loading under engine cyclic process. The forces acting on connecting rod are forces due to maximum combustion pressure and force due to inertia ofconnecting rod and reciprocating mass. The connecting rod is very hard and strong but sometimes deforms and breaks due to vibration. The determination the natural frequency of components is essential to prevent the resonance phenomenon. Identify the critical velocity of connecting rod for the resonance frequency range is essential. Vibration is a mechanical phenomenon whereby oscillations occur about an equilibrium point. The oscillations may be periodic, such as the motion of a pendulum—or random, such as the movement of a tire on a gravel road. There are generally two categories for the vibrations the free vibrations and forced vibrations, free vibrations occur when the system is under theaction of oscillating systems and their inherent forces external forces there are controversial. All systems that have mass and elasticity can be whit free vibrations, the vibrations that occur in the absence of external stimulus. Vibrations that occur under controversial foreign forces are called forced vibrations, when the controversial operating system is oscillating with frequency, oscillation can be controversial if the impulse frequency of the system natural frequency is resonance mode occurs and may be dangerous,there are large fluctuations. Natural frequency is the frequency at which a system tends to oscillate in the absence of any driving or damping force. Free vibrations of an elastic body are called natural vibrations and occur at a frequency called the natural frequency. Naturalvibrations are different from forced vibrations which happen at frequency of applied force(forced frequency). If forced frequency is equal to the natural frequency, the amplitude of vibration increases.

AIM:

- To determine the natural frequency of existing and composite connecting rod.
- To explore weight & cost reduction.

PROBLEM STATEMENT:

Material Optimization of the component is to make the less time to produce the product that is stronger, lighter and less cost. The design and weight of the connecting rod influence performance. Hence, it is effect on the manufacture credibility. The tensile and compressive stresses are produced due to pressure, and bending stresses are produced due to centrifugal effect & eccentricity. So, the connecting rods are designed generally of I- section to provide maximum rigidity with minimum weight. Changes in the structural designand also material will be significant increments in weight and performance.

Objectives Of Project:

- The main aim of the project is to determine the natural frequency of existing and composite connecting rods.
- In this Project, the static and modal FEA of the connecting rod has been performed by theuse of the ANSYS software.
- Natural frequency of optimized connecting rod is validated by using FFT analyzer and impact hammer test.
- Comparative analysis between FEA & Experimental results.

Scope of Project:

Further changes in the design of connecting rod can be made like selecting any other sectionother than the I-section. Further analysis is possible by choosing different materials for theconnecting rod. Analysis of weight reduction and cost analysis can be done. Maximum stress concentration at the fillet of crank and piston end can be reduced by adding or removing material from the connecting rod. Chamfering of sharp boundaries of connectingrod also helps in reducing the stress level and increases strength of the connecting rod. Dynamic analysis of connecting rod can be done and other factors of failure can be considered.

II. RELEATED WORK

[1] In their study, H. Hanselmann etal, have investigated the failure modes of gas metalarc welds in single lap-shear specimens of high strength low alloy (HSLA) steel. Notched lap-shear specimens of gas metal arc welds were made. Quasi-static test results showed twofailure locations for the welds. The specimens cut from coupons with shorter weld lengthsfailed near the weld root whereas the specimens cut from coupons with longer weld lengthsfailed near the weld toe. Scanning electron and optical microscope images of the failure surfaces and cross sections showed that the gas metal arc welds failed in a ductile necking/shear failure mode. Micro-hardness tests were conducted to provide anassessment of the mechanical properties of the base metal, the heat affected zone, and the weld metal. In order to understand the failure modes of these welds, finite element modelswere developed with the geometric characteristics of the heat affected zones designed to match the micrographs of the cross sections for the long and short welds. Three- dimensional finite element analyses were conducted with consideration of micro void nucleation and growth. The distributions of the void volume fraction near the welds shownfrom the finite element analyses are consistent with the failure modes observed in the experiments. Further finite element analyses were conducted in order to understand the effects of the geometric characteristics of the heat affected zone. The results showed that the geometric characteristics of the heat affected zone have a negligible effect on the load-displacement results; however, the geometric characteristics of the heat affected zone are key factors for the resulting failure location. Finally, finite element analyses were conducted in order to understand the effects of the weld metal geometry. The results indicate that the weld penetration and the weld toe angle have negligible effects on the load-displacement response, the peak load, and the predicted failure locations. R. Isermann etal.

[2] in their paper analyse the structural integrity of structural tubular towers (i.e., towers of wind turbines and floodlight towers) with lack of penetration defectson their circumferential butt welds. The methodology presented is particularised to the analysis of the lack of penetration defects detected in certain sections of several wind towersafter the construction process. It is also analysed how such defects affect the fitness for service of the towers during their theoretical lifespan (20 years). The methodology (based on the use of Failure Assessment Diagrams, FAD) can easily be extrapolated too the assessment of other types of defects or towers. Its main hypotheses consist of establishingthat the defects behave as internal cracks with certain geometries and also that fracture andfatigue are the key processes affecting the structural integrity of the towers. Then, the resulting allowable crack size, corresponding to the lifespan of the tower, for the different sections analyzed and for the different crack geometries considered is determined. Jochen Schaffnit etal.

[3] have discussed a methodology for understanding the relationships between process parameters and the bead area geometry are presented. The objective of the first part of this study is to find the optimal bead area geometry in the GasMetal Arc Welding (GMAW) process. A radial basis function (RBF) neural network is used for the prediction of the cross-sectional area of the welding bead using a three-level factorial design of experiments for the training of the neural network. Ki-Chang Lee etal.

[4] have thrown light on gas metal arc welding (DE-GMAW) process in which a second electrode, non-consumable, or consumable, is added to bypass part of the wire current. The bypass current reduces the heat input in non- consumable DE-GMAW or increases the deposition rate in consumable DE-GMAW. The fixed correlation of the heat input with the deposition in conventional GMAW and itsvariants is thus changed and becomes controllable. At the University of Kentucky, DE- GMAW has been tested/developed by adding a plasma arc welding torch, a GTAW (gas tungsten arc welding) torch, a pair of GTAW torches, and a GMAW torch. Steels and aluminium alloys are welded, and the system is powered by one or multiple power supplieswith appropriate control methods. The metal transfer has been studied at the University ofKentucky and Shandong University resulting in the desirable spray transfer be obtained with less than 100 A base current for 1.2 mm diameter steel wire. At Lanzhou University of Technology, pulsed DE-GMAW has been successfully developed to join aluminium/magnesium to steel. At the Adaptive Intelligent Systems LLC, DE-GMAW principle has been applied to the submerged arc welding (SAW) and the embedded controlsystems needed for industrial applications have been developed. The DE-SAW resulted in1/3 reduction in heat input for a shipbuilding application and the weld penetration depth was successfully feedback controlled. In addition, the bypass concept is extended to the GTAW resulting in the arcing-wire GTAW which adds a second arc established between the tungsten and filler to the existing gas tungsten arc. The DE-GMAW is extended to double-electrode arc welding (DE-AW) where the main electrode may not necessarily.

III. KEY CONCEPT

- Review of literature shows that many authors have reported the design to find best configuration of the Connecting rod in terms of the geometry and they also study on modification of geometry and strength to withstand sudden change in stress while in operating.
- Analysis is done to check the effect of variable design parameter with some boundarycondition.
- Also, finding the effective design which will reduce the weight of structure withoutcompromising on strength.
- Therefore, it is important to determine the factors like stresses, deformation, force etc.which influences the failure, finding the alternate design. New design must be able to withstand all of the loads it is going to undertake.

IV. METHODOLOGY

Literature Survey:

Using the knowledge from literature review, we can know how the CAD model is to be prepared. The conditions required for applying various constraints and how the loads are applied is briefed about in the technical papers referred.

CAD Model Generation

- Getting input data on dimensions of connecting rod.
- Creating 3D model in CATIA.

Determination of loads:

Determination of different loads and boundary condition acting on the component by studying various ref papers, and different resources available.

Testing and Analysis

- Meshing the CAD model and applying the boundary conditions.
- Solve for the solution of meshed model using ANSYS.

Re-Design, Analysis and Results

- Making changes in CAD model for optimization.
- Carrying different iteration by removing material or changing topology based on ANSYSresults.
- Check the maximum stress ensuring it is well within the safe region.

Fabrication, Experimental validation, and Result

- Fabrication of prototype.
- Suitable experimentation and comparison with present connecting rod. Validation of result by comparing with software results

3D Model of connecting Rod.

Fig 1. 3D CAD Model of Existing Connecting Rod

TABLE 1.
Properties of connecting rod
Properties of structural steel

Properties of Outline Row 3: Structural Steel

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	7850	kg m^-3
4	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
7	Derive from	Young's Modulus and Poisso...	
8	Young's Modulus	2E+11	Pa
9	Poisson's Ratio	0.3	
10	Bulk Modulus	1.6667E+11	Pa
11	Shear Modulus	7.6923E+10	Pa

FEA Analysis

Fig 2. Meshed Model

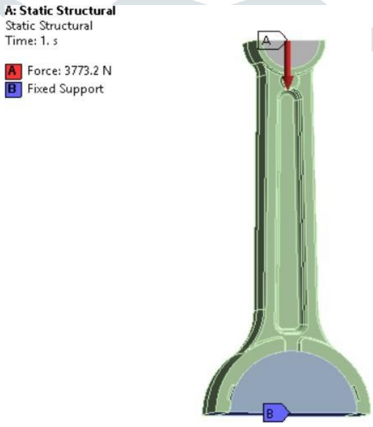

Fig 3. force applied at A & fixed support at B

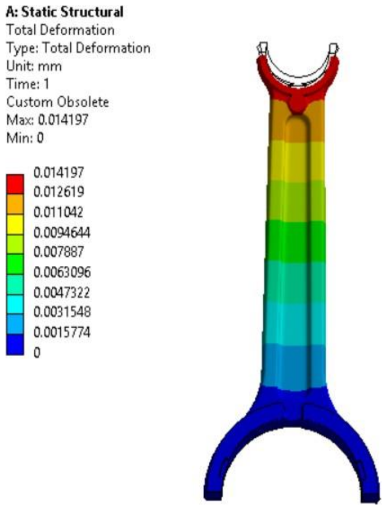

Fig 4. Total deformation

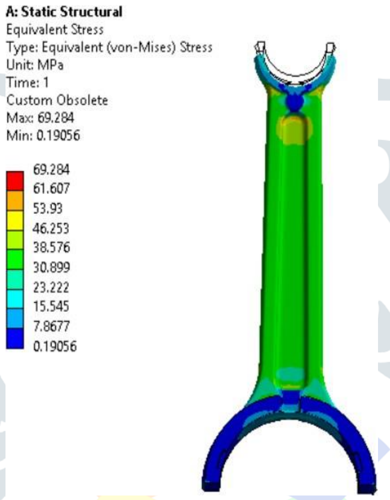

Fig 5. Equivalent (von-Mises) stress

V. RESULT

The comparison, between model analysis result of existing and optimized has been performed and it is summarised in table given below

TABLE 2.

Comparing natural Frequency

Sr. No	Mode	Frequency (Hz)	
		Existing	**Composite**
1	1	1048.2	1122.9
2	2	1734.7	1638.9
3	3	5129.4	4979.1
4	4	6395.4	6762.6
5	5	9325.4	8997.4
6	6	14364	14644

VI. CONCLUSION

- Static and modal analysis results of existing connecting rod proved that the model is more stable and there is scope for optimization.
- The comparison, between modal analysis results of existing and optimized has been performed and it is summarized in table shown above.
- The comparison shows that the frequencies of vibration of the optimized connecting rod in six different modes are almost equal that of existing connecting rod
- This is due to the implementation of topology optimization.
- Hence the comparison shows that the main objective of this project work has been satisfied.
- This modal result will be validated experimentally by performing vibration testing of the optimized connecting rod on the FFT Analyzer.

VII. FURURE WORK

- Experimental setup.
- Validating experimentally by performing vibration testing of the optimized connecting rod on FFT analyser.

VIII. ACKNOLEDGEMENT

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