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Vibration Analysis of Two Wheeler Connecting Rod

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Abstract: ***The connecting rod in a automobile engine connects reciprocating piston to rotating crank shaft, transfers the thrust of piston to crankshaft, and converts the reciprocating motion of piston into rotary motion of the crankshaft. The literature survey suggests that the connecting rod fails during operating under various loading conditions. Maximum stresses are developed at fillet section of big and small ends. Hence it is very much essential to understand the various loads acting on it, and the vibrations produced during transmission of thrust. In our present work we are focused on experimental determination of compressive and tensile load behaviour of connecting rod made of cast iron. The various stresses are due to combustion and connecting rods mass of inertia respectively.***

Keywords: Connecting Rod, Vibration, Compression, Tension, Accelerometer, Modally Tuned Impact Hammer.

1. Introduction

The connecting rod is an important part of an automobile engine. The function of the connecting rod is to transfer the reciprocating motion of the piston into rotary motion of the crankshaft. the connecting rod undergoes high cyclic loading of order10^8 to 10^9 cycles and is subjected various stresses. The maximum stress occurs in the connecting rod near the piston and at the end of the shank. The tensile and compressive stresses are produced due to the gas pressure. So the connecting rods are designed generally for I-section to provide maximum rigidity with minimum weight. an intensive literature survey was undertaken for the work.[1]Abhinav goutam and Priya ajit describe the cause of failure of connecting rod by static analysis by fixing smaller end and applying load on bigger end. The stresses developed were used for analysis. the result showed the maximum stress point and section prone to failure. It is observed that area close to root of the smaller end is prone to failure, may be due to higher crushing load due to gudgeon pin assembly.The stress value maximum at this region and stresses are repetitive in nature so chances of failure are always higher close to this region.

[2] vivek Pathade,Bhumeshwar patel,Ajay N presented the stress analysis of connecting rod by FEM. The pressure is applied at small end keeping big end fixed. The maximum, minimum, stress are noted. The maximum stress occurs at piston end of connecting rod and minimum stresses at crank end. The maximum shear stress occurs at piston end and minimum at crank end. The maximum deformation occurs at piston end of connecting rod and minimum and crank end. For both cast iron and steel connecting rod. Comparing different results obtained from analysis they concluded that the connecting rod design is safe for both materials based on ultimate strength.[3]Mr.sahil, mr.Jiten described the static fatigue and modal analysis using the S-N approach by modified Goodman criteria, to determine the von-misses stresses,strains,fatigue life and modal frequency under different loading conditions, by fixing upper end and applying load at lower end. The deformation was maximum at smaller end and minimum at big end. Maximum equivalent elastic strain occurred at upper part of big end and minimum at lower part of big end. Maximum equivalent stress occurred at the shank and minimum at big end. maximum strain energy was observed at centre of shank and minimum at the lower part of big end. Webster et al. [4] performed three-dimensional finite element analysis (FEA) of a high-speed diesel engine connecting rod. They used maximum compressive load which was measured experimentally, and maximum tensile load which is essentially the inertia load of piston assembly mass in their analysis. Load distributions on the piston pin end and crank end were also determined experimentally.[5]M.M Noor,Julie, Rose Described the failure analysis of connecting rod made of different materials. The linear static analysis was carried out utilizing the Finite Element Analysis. They performed the hardness test and the fatigue test to determine the maximum and minimum stresses. In this paper a physical model of connecting rod is used to determine its natural frequency and the same is subjected to tensile and compressive loading conditions to determine the maximum loading conditions experimentally.

2. Scope and Objective

The connecting rod in automobiles is subjected to static loading conditions and vibrations while transmitting thrust from piston to crank shaft. Due to this the rod may fail during its working. In our present work we have made an attempt to determine the natural frequency of cast iron connecting rod. And the tensile and Compressive strengths of connecting rod it can withstand during its working. Experiments have been carried out to analyze the strength of connecting rod. Here we have made an Experimental attempt to determine the strength and vibrations in connecting rod to increase the life span of connecting rod. At the end of experiment we will be able to determine the vibrations produced and the strength of the connecting rod.

3. Experimental Set-Up

3.1 Frequency response function (FRF) measurement of connecting rod.

The frequency response function was carried out on the connecting rod to determine its resonant frequency. The test was carried out when the connecting rod was hung in condition. The connecting rod was excited with modally tuned impact hammer in broadband frequency range 0-4000Hz and the response was measured simultaneously to obtain FRF in real time. Following instruments were used for measurement

1. Data physics Abacus Analyzer
2. Accelerometer
3. Modally Tuned Impact Hammer.

Figure 1: Standard size cast iron connecting rod specimen

Frequency response function is a mathematical representation between the input and out put of system.

$H_f = Y_f / X_f$

H_f=Frequency response function.

Y_f=Out put of system in frequency domain.

X_f=Input of system in frequency domain.

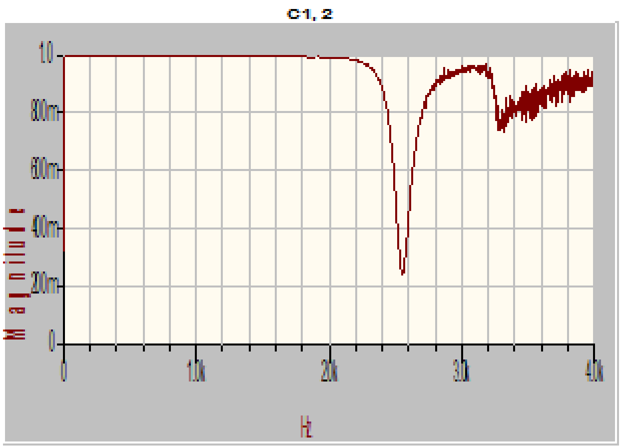

Figure 2: Frequency response graph

X-axis –frequency produced in range 0-4Khz
Y-axis-Amplitude

The connecting rod was hung in position and the force was input using a power hammer and the vibrations produced are recorded using accelerometer.

The graph indicates that the connecting rod can operate without any vibrations from equilibrium position. When the frequency reaches a value of 2530Hz there are some vibrations in rod. But the rod will not fail because it is a stiffer position of connecting rod. When the frequency reaches a value of 2748Hz there are more vibrations in rod .Here the connecting rod may fail because this position is the weaker position of connecting rod. This known as the Peak natural frequency or resonance frequency of connecting rod.

3.2 Determination of tensile strength

Figure 3: Experimental set-up for Tensile and compressive strength

The tensile strength of cast iron connecting rod is determined using the universal testing machine. This is done to determine the deflection produced in connecting rod with application of varying Tensile load. The specimen was placed in a fixture and fixed between the upper and lower jaw of UTM. Now the Tensile load is applied on the connecting rod till the connecting rod failed and the deflection produced in the connecting rod are noted. The test was carried on four number of specimens and mean value is considered.

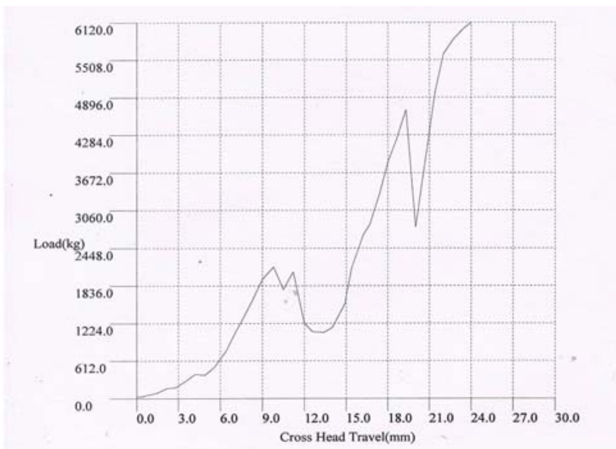

Figure 4: Graph representing Tensile Load V/S Deflection

The graph represents the deflection observed in the connecting rod due to application of Tensile load. The specimen was fixed between jaws of UTM and the load was increased gradually starting from zero until the specimen breaks. The value of deflection is noted at different load conditions. Finally the specimen breaks at a peak load of 6118.3kg and the deflection observed is 24mm.This shows that the connecting rod can operate safely until it reaches a peak Tensile load of 6118.30kg.

3.3 Determination of Compressive Strength

The compressive strength of connecting rod was determined using the Universal testing machine. This is done to determine the deflection produced in connecting rod with application of varying Compressive load. The specimen was placed in a fixture and fixed between the upper and lower jaw of UTM. Now the Compressive load is applied on the connecting rod till the connecting rod failed and the deflection produced in the connecting rod are noted. The test was carried on four number of specimens and mean value is considered.

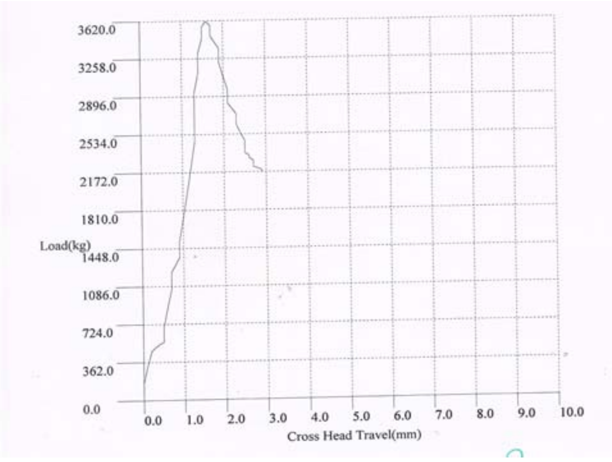

Figure 5: Graph representing compressive load V/S Deflection

The graph represents the deflection observed in the connecting rod due to application of compressive load.The specimen was fixed between jaws of UTM and the load was increased gradually starting from zero until the specimen breaks. The value of deflection is noted at different load conditions. Finally the specimen breaks at a peak load of 3615.91kgs and the deflection observed is 1.6mm. .This shows that the connecting rod can operate safely until it reaches a peak Compressive load of 3615.91kgs.

4. Results and Discussion

4.1 Results of Vibration Test

The testing is performed on a specimen made of cast iron. The force was input using a power hammer and frequencies of vibration are noted using accelerometer. The range of input frequency is from 0-4000Hz.And the significant resonant frequency was observed at 2748Hz and the obtained FRF are shown in Figure2 in form of graph. This indicates that the peak natural frequency or resonance frequency of specimen is 2748Hz above which if the specimen operates it will be subjected to failure.

4.2 Results of Tensile test

The tensile test was carried on four specimens and the mean value is considered. The test was carried on UTM.The specimen was fixed between the jaws of UTM using a fixture and the Tensile load was increased gradually starting from zero until the specimen breaks. The deflections produced in rod were noted. Finally at the load of 6118.30kgs the specimen breaks and is known as the maximum tensile strength of connecting rod. And the deflection produced in specimen is 24mm it is the maximum deflection the specimen undergoes before failure. The peak load and deflection are shown in Figure 4 in form of graph.

4.3 Results of Compression Test

The compression test was carried on four specimens and the mean value is considered. The test was carried on UTM. The specimen was fixed between the jaws of UTM using a fixture and the Compressive load was increased gradually starting from zero until the specimen breaks. The deflections produced in rod were noted. Finally at a load of 3615.91Kgs the specimen breaks and is known as the maximum compressive strength of connecting rod. And the deflection produced in specimen is 1.6mm it is the maximum deflection the specimen undergoes before failure. The peak load and deflection are shown in Figure 5 in the form of graph

5. Conclusion

The purpose of this experimental is to determine the natural frequency and the maximum Tensile and the compressive strength of a two wheeler connecting rod made of cast iron. To determine these there are few types of tests to be carried out. The Vibration test is carried out to determine the natural frequency of specimen which is found to be 2748Hz. After carrying out the Tensile test the maximum Tensile load the specimen can withstand is determined as 6118.30kgs and the deflection is 24mm before it breaks. The compressive test results show that the maximum compressive strength of specimen is 3615.91Kgs and deflection is 1.6mm.After knowing these the life cycle of specimen can be predicted.

6. Future Prospects

Experimental verification of the peak vibrations ,Loading were conducted the same can be validated using FEA softwares .We have considered only connecting Rods made of Cast Iron ,further it can be extended to other materials also. .Numerical Validation also can be done. Based on the results obtained one can go for optimization of material and cost.

7. Acknowledgement

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