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A Review Article on Connective Rod

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Abstract: Connecting rod is the vital part of the Internal Combustion Engine (IC Engine) that connects the piston and crankshaft by means of various pins. In addition, it transmits the power and converts the reciprocating movement to the rotational motion. The present work is based on detailing the connecting rod origin to the current researches or study done on it. This paper states the different kinds of materials used to manufacture the connecting rod. Besides, the kind of failure of the connecting rod is also explained in the current work. The factor of design of connecting rod is explained using equations and cross-section. Many researchers are studying the and carrying their research on connecting rod, that is also highlighted in this article.

I. INTRODUCTION

The need to travel on the basis of developments in wheels and cars, since the creation of the locomotives and diesel engines generating power, has been recognized by humans since the invention of the wheel. The mechanical component used therefore increases the chance of failure and maintenance and therefore requires case studies. In the beginning, rotor connection structures like connecting rods were designed to best meet the demands of motors depending on the capacity of power generation.

The connecting rods are widely used in different motors to transmit the piston thrust to the pipe shaft and translate the reciprocating piston movement into the rotational movement of the piston shaft. The pin-end, the hem and the crank-end are included. Pin and crank pinhole are machined to allow for the precise installation of rollers. The piston is connected with one end of the connecting rod using a piston pin. The other end is split around and revolves around the crankshaft to enable the shaft to be tightened. The two parts are clamped by two to four bolts according to the size of the large end. Connecting rods are subject to mass- and fuel-burning forces. Both of these forces cause axial and bending stress. Therefore, a connecting rod must be able to pass axial tension/compression and bending stresses caused by the piston and the centrifugal force. Bending stresses are due to eccentricity, crankshaft, case wall deformation, and rotary mass force. Figure 1 shows the picture of connecting rod.

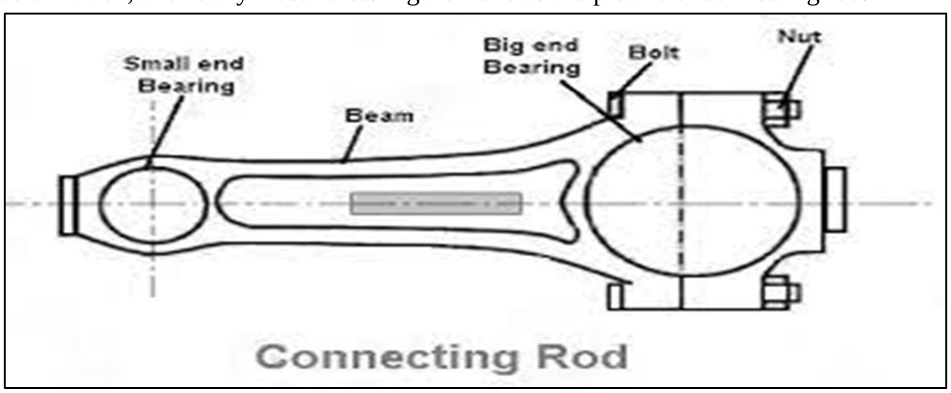

Figure 1 Connecting rod

The connecting rods are made of the following materials to obtain minimal weight and high strength:

1) Microalloyed steels
2) Sintered metals
3) High-grade aluminium
4) CFRP and titanium (for high-performance engines)

Connector rods that are mass-produced are forged, casted, or sintered. Forged rods display a better strength-to-weight ratio and lower costs than sintered rods. However, the manufacture is relatively costly.

II. LITERATURE REVIEW

The design and analysis of the connecting rod are described in their paper by Venu Gopal Vegi and Leela Krishna Vegi [3]. The current rods are made of carbon steel. CATIA software models the connecting rod models and ANSYS software testing. Analysis of the finite element is performed on a forged stain rod. Parameters such as Von mises stress, strain, distortion, safety factor and so on have been calculated and it has been found to have more safety, less weight and more rigidity than carbon stainless steel.

In his research, Vikas Gupta [4] changed the dimensions of the existing design of a tractor engine connector rod. The test was performed under loading of static and fatigue. For validation in few stress and fatigue parameters, the optimization was carried out under the same border and loading conditions. The critical regions are identified and enhanced by both static and fatigue analyses. The connecting rod was modelled and optimised for weight reduction, improved service life and production. The material was kept the same and a major change in Von mises stress was observed. At the critical point in static load conditions, 9.4 percent less stress was observed. Only five grammes, which is very small, have been reduced. From this, it can be concluded that the optimization can be considered not only for materials but also design parameters.

A. Afzal et al. [5] discussed the comparison of fatigue behaviour of the forged stainless steel and powder metal rods. The tests included strain-controlled tests of specimens obtained from the connecting rods and strain-controlled tests of the connecting rod bench. Two materials will evaluate and compare the monotonic, cyclical deformation behaviour and strain-controlled fatigue properties. FEA obtained stress concentration factors and the Goodman equation modified to take into account the average stress effect.

In an internal combustion engine, the connecting rod is the most stressed part. There are different stresses during its operation. More due to gas pressure and whipping stress is the effect of compressive stress. Two connecting rod samples made of Forged Steel were compared between Fanil Desai and all [6]. Static analysis was carried out using ANSYS software and universal testing machine experimental analysis (UTM). With the numerical results, experimental results were verified.

Ambrish Tiwari et al. [2] used numerical tools extremely during the development phase to reduce the weight and cost of forged steel connecting rods. There are therefore extremely important technological advantages, such as a reduction in the project lead times and costs of prototypes, to complete understanding of the mechanisms involved along with the reliability of the numerical methodology. The paper shows the complete FEA methodology to study the possibility of manufacturing forged steel connecting rod weight and cost reduction. Taking into account the modified Goodman diagram, fatigue studies were also performed on the theory of stress life.

Kuldeep B. replaced conventional rod joining materials with silicon carbide- and fly-ash-intensified aluminium-based composite materials. A comparative study between traditional materials and new materials showed that the weight and rigidity of new materials were lower. This reduced the weight by 43.48% and reduced the displacement by 75 percent [1].

In his study, Ramanpreet Singh used composites isotropic and orthotropic. CATIA v5, stress analysed by MSC. PATRAN was used for modelling the connection rod. For both materials with a tetrahedron with an element size of 4mm, linear static analysis was conducted to achieve stress results. Both materials have been compared, maintaining the same limiting conditions. The author concluded, when anisotropic (i.e. steel) material is replaced with orthotropic (i.e. E-glass/Epoxy), a 33.99 percent reduction in stress occurred. Also, the displacement rate was reduced by approximately 0.026% [7].

G.M. Sayeed Ahmed studied0 a broken joining rod is replaced with aluminium alloys and carbon fibre made of forged steel. In their work. In this respect, the authors have determined the weight of rods connected to the expectations was reduced. The fibres of carbon are strong and light in weight. The rods have been ideally tested and variable loads have also been applied. The rods have tested and performed well to their extreme capacities. The analysis was also performed on the aluminium crankshaft which produced excellent results and lower pressure on the connecting rod [8].

The existing rod is produced with iron alloys. S. Vijaya Kumar et al. Authors Replaced chrome steel and titanium connecting stalk material. The modelling is made with the software Creo Parametric 2.0 and analysed through ANSYS. Composites used for manufacturing contributed to weight and costs optimisation and improved their lifetime compared to their original design. The maximum stress for chromium steel and titanium was within the permissible stress limit [9].

III. FAILURE IN CONNECTING ROD

The connecting rod links the pistons to the crankshaft. It converts the piston linear motion to the crankshaft rotating movement. The reliable rod is extended and compressed on every stroke. The connecting rod may be shattered by this pressure, plus other factors. The broken rod can completely go through the motor block and ruin the motor - a condition called "throwing a rod."

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A. Pin Failure

The pin, which links the rod to the piston (the so-called piston pin, wrist pin, gudgeon pin), is heavily wearable. The connecting rod will stop connecting to the engine if this pin snaps. This leads to a catastrophic engine failure for some engines – the connecting rod goes through the engine block or the crankshaft is bent. It may be possible to save the engine if the engine stops immediately after a pin break.

B. Fatigue

Fatigue is the primary cause of broken rods - particularly in older engines. The constant compression during the power stroke and stretch during the exhaust stroke is eventually worn out over thousands of times a minute and is breaking down. It can accelerate this process if the oil is low or dirty. The engine can also accelerate the process by running hot. Sometimes, when it's a reconstructed engine and the mechanic uses cheap parts or wrong parts for the engine, a rather new engine can be weary.

C. Hydrolock

Hydrolock is a deformation of the rod connected to the piston chamber when it enters the water. This is usually after the car is pushed deep water, such as a street that was inundated. Where only a small amount of water gets into the cylinder, the car will sound like a knock or tap, and it can then be repaired. (The water can be removed and the gaskets replaced). If enough water enters the cylinder, but the connecting rod bends or bends when it takes all space at spark time. Hydrolock is much more frequent on boats than in automobiles since water is always run by boats.

D. Over Revving

The rod failures of new and high-performance engines can be caused primarily by reversals. The connecting rods are in danger of breaking up if the tachometer hits the red—even briefly. This is because the forces on a connecting rod dramatically increase during high revolutions. No matter if the tachometer is going into the red as the car travels at a high speed, falls too quickly or simply falls too quickly because the accelerator is pressed too far while the vehicle is neutral – the stresses at extremely high RPMs are simply too high.

IV. DESIGN OF CONNECTING ROD

The connecting rod consists of an eye on the small side to fit the piston pin, a long hem and a large ending to accommodate the crankpin split into two parts. Fig. 1 illustrates the construction of the connection rod. A rod connecting the push and pull forces from the piston pin to the crankpin has the basic function. The reciprocal piston motion is transmitted by the connecting rod to the crankshaft rotating motion. The oil is transferred from the crankpin to the piston pin and a splash or a splash of oil is provided for the assembly of the piston. By the drop forging process, the connecting rod of an IC engine is made and the outer surfaces are left endless. The two-piece conventional connector rod is present in most internal combustion engine systems. The entire bar is forged into one piece; for the final workmanship of the big body, the bearing cap is cut out, faced and bolted. The rod's small end is usually machined as a solid eye and later [10-12].

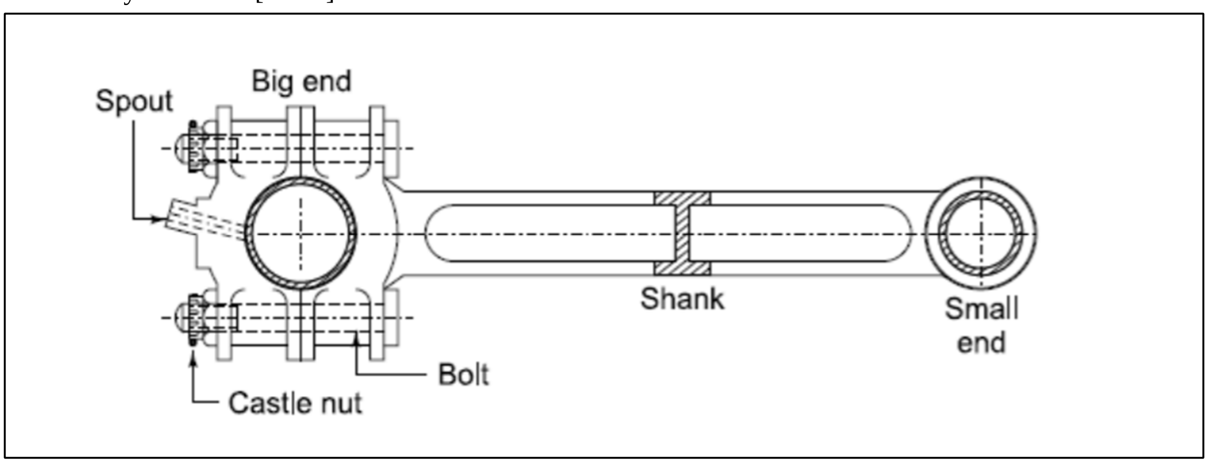

Figure 2 Connecting rod

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The connecting rod is a sleek motor component with a significant length and width. The axially compressive force is equal to the piston's maximum gas charge. The pressure is significant. The compression stress is significant. The connecting rod is therefore constructed as a column or a rod. Fig. 3 illustrates the hump of the connecting rod in two different levels of motion and a plane perpendicular to the moving plane. With reference to this figure, the following comments are made:

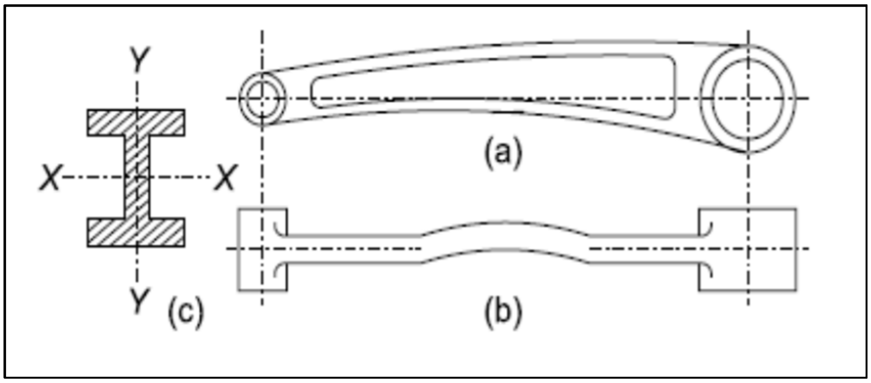

Figure 3 Buckling of Connecting rod

1) The connecting rod buckling in the motion plane is illustrated in Fig. 3 (a). The ends of the connecting rod are hanged in the pin and the piston pin in this plane. Thus, the end fixity coefficient (n) is one for the buckling around the XX-axis.
2) The connecting rod buckling on a plane perpendicular to the movement plane is shown in Fig. 3 (b). In this plane, due to a constraining effect of bearings on the pin and piston pin the ends of the connecting rod are fixed. Therefore, the end fixity coefficient (n) is four for the buckling around the YY-axis.
3) Therefore, for buckling about the YY axis the connecting rod is four times stronger than the buckling on the XX axis

4) If a connecting rod is designed to be as resistant to buckling in either plane,

$4I_{yy}=I_{xx}$ (1)

where, I = moment of inertia of cross-section (mm^4), substituting ($I = Ak^2$),

$K_{yy}^2=1/4k_{xx}^2$ (2)

where k = radius of gyration of cross-section (mm)

5) The above relationship demonstrates that the I-section is ideal for the connection rod. On the other hand, the YY-axis is unnecessarily robust in a circular cross-section. The typical ratios for the intersection between the rod for the IC engine are presented in Figure 4. For this section

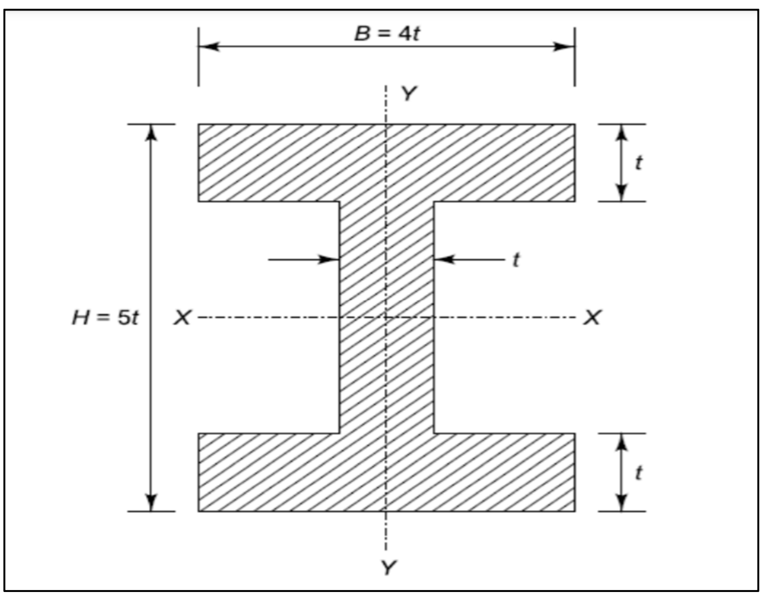

Figure 4 I Section

$A=11At^2$ (3)

Where, A – area of cross-section (mm^2)

$I_{xx}=(419/12)t^4$ (4)

$K_{xx}^2=3.17\ t^2$ (5)

$I_{yy}=(131/12)t^4$ (6)

$3.2\ I_{yy}=I_{xx}$ (7)

It is observed from expressions (1) and (7) that the proportions of I-sections of the connecting rod are satisfactory.

V. CONCLUSION

After studying the various literatures of connecting rods, the author concludes that most of the of work or researches are done using Finite Element Analysis (FEA). From the study it was found that a connecting rod must be able to withstand the axial tension/compression and bending stresses produced by the piston and centrifugal force. Besides, connector rods that are manufactured should be forged, casted, or sintered. Forged rods have a higher strength-to-weight ratio and are less expensive than sintered rods. The connecting rod should be lighter in weight and higher in strength. To have such characteristics, materials such as micro alloyed steels, sintered metals, high-grade aluminium, CFRP and titanium (for high-performance engines) should be utilized. Moreover, connecting rod is the key element of any Internal Combustion Engine (IC Engine).

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