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DESIGN ANALYSIS OF CONNECTING ROD FOR WEIGHT REDUCTION IN CASE OF A CI ENGINE – A REVIEW

Nilam P. Patil [*1], Pundlik N. Patil [2], Raghunath Y. Patil
[*] M.E. Student, SGDCOE, Jalgaon(M.S.)
Associate Professor, SGDCOE, Jalgaon(M.S.), India
H.O.D., (MED) SGDCOE, Jalgaon(M.S.), India

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ABSTRACT

Now a days internal combustion engines has a wide application in automobile and in different engineering field. Connecting rod is one of the important driving parts of the petrol and diesel engine. In this study we will discuss the detail review on the design analysis of the connecting rod for stresses produced under loading and suggest weight reduction opportunities. The function of the connecting rod is to transmit the piston thrust to the crankshaft. Therefore, connecting rod should capable to transmit different stresses caused by thrust and pull on the piston, it must be very strong, rigid and as light as possible. As per the literature survey it is observed that in many cases weight reduction of connecting rod was obtained by removing materials from certain regions. The widely used materials in connecting rod manufacturing are carbon steel, cast iron, wrought steel or powder metal etc. So there is a scope to try other materials like Titanium alloy, carbon fibre, aluminium alloy, glass fibre etc to produce light weight alternative. As these are light in weight, mass of the part will reduce. Therefore we can optimise the connecting rod for weight reduction with the use of such materials.

KEYWORDS: Connecting Rod, stresss, FEA, weight ratio, ANSYS.

I. INTRODUCTION

Every vehicle which uses internal combustion engine requires at least one connecting rod. Combustion in I.C.Engine produces very high load which transmits to crankshaft via connecting rod. So connecting rod is subjected to many stresses like shear stress, compressive stress, tensile stress, etc In the case of four stroke engines, the connecting rod is subjected to a complex state of loading. It undergoes high cyclic loads of the order of 10^8 to 10^9 cycles. During compression and power strokes the connecting rod is subjected to compressive loads and during the last part of the exhaust and the beginning of the suction strokes, to tensile loads therefore durability of this component has critical importance. Due to these reasons connecting rod has been the topic of research.

A connecting rod consists of a pin-end, a shank section, and a crank-end as shown in Figure. Pin-end and crank-end pinholes at the upper and lower ends are machined to permit accurate fitting of bearings. These holes must be parallel. The upper end of the connecting rod is connected to the piston by the piston pin. If the piston pin is locked in the piston pin bosses or if it floats in the piston and the connecting rod, the upper hole of the connecting rod will have a solid bearing (bushing) of bronze or a similar material. As the lower end of the connecting rod revolves with the crankshaft, the upper end is forced to turn back and forth on the piston pin. Although this movement is slight, the bushing is necessary because of the high pressure and temperatures. The lower hole in the connecting rod is split because it is to be clamped around the crankshaft. The bottom part, or cap, is made of the same material as the rod material and it is attached by two bolts. The surface that bears on the crankshaft is generally a bearing material in the form of a separate split shell. The two parts of the bearing are positioned in the rod and cap by dowel pins, projections, or short brass screws. Split bearings may be of the precision or semi precision type. The precision bearing is accurately finished to fit the crankpin and it does not require further fitting during installation. It is positioned by projections on the shell that match reliefs in the rod

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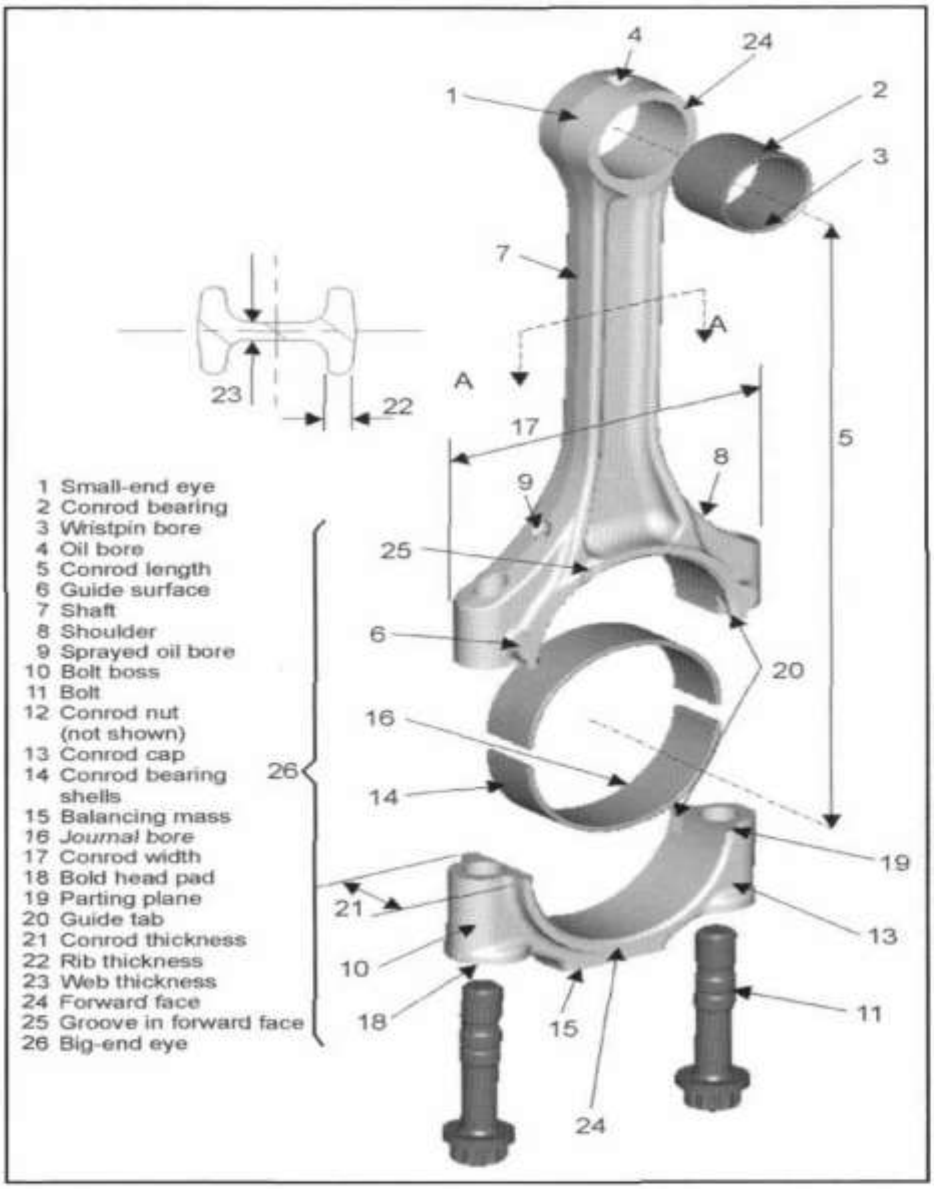
and cap. The projections prevent the bearings from moving sideways as well as it prevent rotary motion in the rod and cap.

The cross-section of the shank of the connecting rod may be Rectangular, Circular, Tubular, I-section or H-section as shown in following diagram.



Geometry for a connecting rod with straight split
(IC Engine Handbook, R Van Basshuysen)[10]

Connecting rod is the main component of the combustion engines. The main purpose of connecting rod is to transfer the energy from the pistons to crankshafts and convert the linear, reciprocating motion of a piston into the rotary motion of a crankshaft. During this engine produces very high load which transmits to crankshaft via connecting rod so connecting rod subjected to many stresses. The connecting rod of IC Engine undergoes through high cyclic loads, which range from high compressive loads due to compression and high tensile loads due to inertia forces. In order to reduce the forces exerted during operation, the connecting rod weight should be as little as possible if connecting rod weight is minimum, forces exerted during operation will be reduce and power transmitted will increase.

Normally connecting rod is made by forged steel, aluminium or cast iron. Though lot of work has been done to reduce connecting rod weight there is a scope to try other materials for connecting rod to produce light weight alternative. Therefore we can try new composite materials like Titanium alloy, carbon fibre, glass fibre etc. because these materials have very good structural, electrical and thermal properties. Also it has number of advantages as listed below; therefore we can select these materials for IC engine connecting rod.

- High strength or stiffness to weight' ratio.
- Due to greater reliability, there are fewer inspections and structural repairs.
- High resistance to fatigue and corrosion degradation.
- High resistance to impact damage.
- Directional tailoring capabilities to meet the design requirements. The fiber pattern can be laid in a manner that will tailor the structure to efficiently sustain.
- Improved friction and wear properties.
- Close tolerances can be achieved without machining.
- Manufacture and assembly are simplified because of part integration (joint/fastener reduction) thereby reducing cost.
- They have low thermal conductivity and low coefficient of thermal expansion and minimize thermal stresses.

II. LITERATURE REVIEW

[1] ***Hitesh Kumar, Vijay Kumar Sharma [April2015] [2]*** conducted, a static analysis on a connecting rod of a single cylinder 4- stroke petrol engine. In this study a connecting rod for I.C. Engine was designed by analytical method. On the basis of design a physical model was modelled in Pro-E (creo parametric 2.0). Connecting rod has been analyzed using FEA. Von-misses stress, strain, shear stress, deformation, and weight reduction etc, were calculated for a particular loading conditions using FEA Software and ANSYS WORKBENCH. They gave idea for weight reduction of rod by using new material like 1040 Carbon steel and 4340 Alloy steel. They carried same work for new materials also and compared former material and new material results

[2] ***D. Gopinathan, Ch V Sushma [2015] [8]*** did research to explore weight reduction opportunities for the production of Forged steel, Aluminium and Titanium connecting rods. First they did static load analysis of connecting rod for three materials and then they optimised forged steel connecting rod for weight reduction. First geometrical model was developed using CATIA. Then product model was analysed by using ANSYS software. Then analysis was compared for three materials for optimisation result.

[3] ***Mr. Shahrukh Shamim [Sept.2014] [3]*** analysed single cylinder four stroke petrol engine connecting rod. Static structural stress analysis was conducted on connecting rod model by using ANSYS software. Static Structural stress analysis was conducted on connecting rod made up of two different materials E-glass/Epoxy and Aluminium composite reinforced with Carbon nano tubes. And found that Connecting rod made from Al- 2 volume% CNTs has less weight than that of E-Glass/Epoxy also stress induced in the Al- 2 volume% CNTs composite is less than the E-Glass/Epoxy

[4] ***G.M. Sayeed Ahmed [Oct.2014] [7]*** replaced a broken connecting rod made of forged steel with aluminium alloys and carbon fiber. Connecting rods were manufactured by conventional method. Rods were tested in ideal conditions by applying variable loads. Authors found that weight of connecting rods was reduced and all performed to the level of expectation. Rods performed well at their extreme conditions.

[5] ***Abhinav Gautam [Nov.-Dec. 2013] [4]*** performed static stress analysis of connecting rod made up of SS 304 material used in Cummins NTA 885 BC engine they developed model in CATIA V5 software and imported to ANSYS WORKBENCH and presented the results of the material and reported that the area close to root of the smaller end of connecting rod is very prone to failure, may be due to higher crushing load due to gudgeon pin assembly.

[6] ***Pravardhan S. Shenoy [2005] [1]*** Performed optimization study on steel forged connecting rod by considering weight and production cost reduction. They compared results of forged steel connecting rod with C-70 steel connecting rod. Reduction in machining operations, achieved by change in material from forged steel to C-70, was a significant factor in manufacturing cost reduction. Weight reduction was achieved by using an iterative procedure. An estimate of the cost savings is also made. The study results in an optimized connecting rod that is 10% lighter and 25% less expensive, as compared to the

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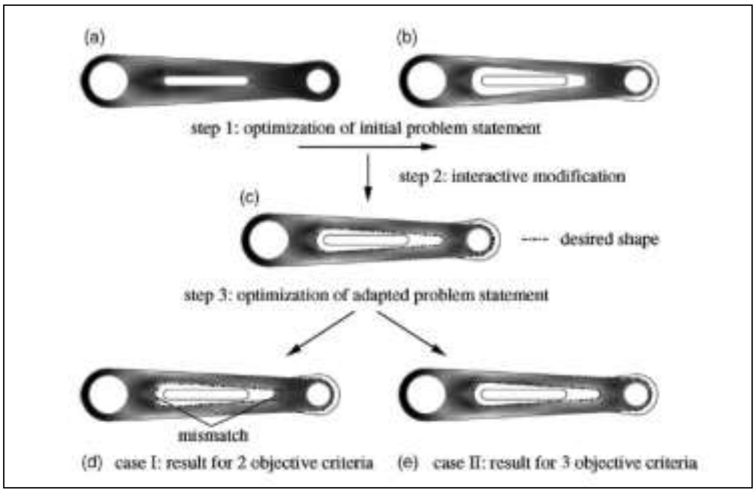
existing connecting rod. In this study weight optimization is performed under a cyclic load considering dynamic tensile load and static compressive load as the two extreme loads.

[7] ***Adila Afzal and Ali Fatemi [2004] [5]*** investigates and compares fatigue behaviour of forged steel and powder metal connecting rods. Experiments includes specimen testing with specimens obtained from the connecting rods, as well as load-controlled connecting rod bench testing. Predicted live results are compared with bench test results and include the effects of stress concentration, surface finish, and mean stress. The stress concentration factors were obtained from FEA,

[8] ***Kurt Maute, Michael Raulli [2004] [6]*** presents iterative method for the selection of design criteria and the formulation of optimization problems within a computer aided optimization process of engineering systems. Key component of the proposed method is the formulation of an inverse optimization problem for the purpose of determining the design preferences. These preferences are identified based on an interactive modification. A formulation of the inverse optimization problem is presented. For demonstrating the potential of proposed approach for problems, the shape of a connecting rod is optimized as shown in below figure.

Figure:

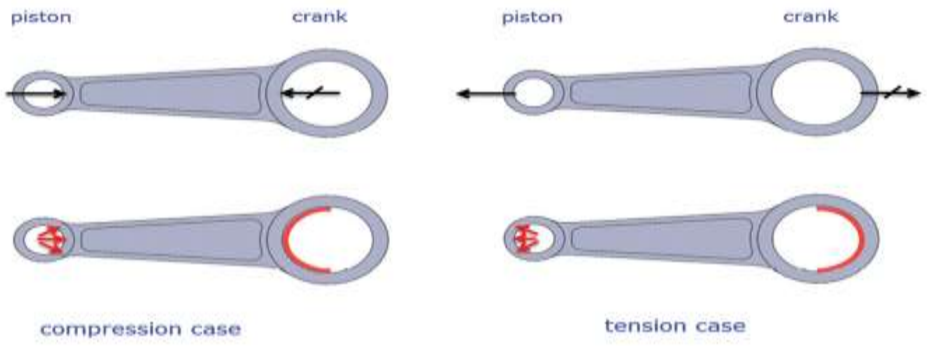


Iterative design procedure for connecting rod [6]

III. LOADING OF CONNECTING ROD

The connecting rod is subject to a load exerted by the gas forces inside the cylinder and the inertia of the moving masses. The lateral deflection in the connecting rod oscillation plane generates centrifugal forces. The accelerated motion and decelerated motion of the masses in the connecting rod and piston causes tensile strain in the shaft and at the transition from the shaft to the large eye. Thus, the connecting rod is subjected to alternating tensile and compressive forces. In diesel and turbocharged gasoline engines the magnitude of the compressive force exceeds that for the tensile force.

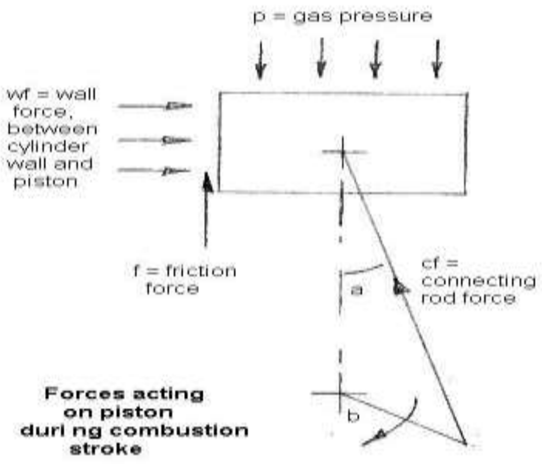
Figure:



Compression and tension load cases in connecting rod
(http://www.digitaleng.news) [12]

The inertial forces generated during accelerated and decelerated motion within a reciprocating engine's working cycle are influenced by the masses of the piston, the wrist pin, and the connecting rod. The reciprocating masses for the connecting rod are influenced by the inertial forces generated by them, for the smooth running of the engine. These reciprocating forces can be fully compensated only by providing additional compensating shafts. Thus, it is necessary to reduce the connecting rod mass and this can be done by optimizing the shape of the connecting rod shaft and, for example, by using a trapezoidal design for the small eye. Suitable FEM calculation processes make it possible to attain a more or less exact calculation of the mass forces that are exerted on connecting rod

Figure:



Forces acting on piston during combustion
(http://www.tech.plymouth.ac.uk) [11]

IV. CONCLUSION

Connecting rods are subjected to mass and gas forces, these two forces results in axial stresses. Therefore, a connecting rod must be capable of transmitting axial tension, axial compression, and bending stresses caused by the thrust and pull on the piston. A connecting rod is subjected to many millions of repetitive cyclic loadings. Therefore it is, typically designed for infinite life. The forces generated during operation of engine are influenced by weight of the piston and the connecting rod; therefore it is necessary to reduce connecting rod weight. By reviewing the above literatures it is observed that though a lot of work is done on forged steel connecting rod, so there is a scope to try other materials for connecting rod to produce light weight alternative.

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