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FAILURE ANALYSIS OF CI ENGINE CONNECTIND ROD DUE TO REPEATED STRESSES

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Abstract

A connecting rod works in variably complicated conditions, and is subjected to not only the pressure due to the connecting rod mechanism, but also due to the inertia forces. Its behavior is affected by the fatigue phenomenon due to the reversible cyclic loadings. When the repetitive stresses are developed in the connecting rod it leads to fatigue phenomenon which can cause dangerous ruptures and damage. Yield, fatigue and buckling characteristics are often used as evaluation indexes for the performance of engine connecting rods in mass reduction design to optimize vibration. Various rod cross-section like I section, + section, Rectangular section, Circular section and H section have important role in design and application. In this paper the design methodology is covered and FEA results for stresses have been presented and strain life theories studied.Connecting rod is an essential component of an internal combustion engine that transmits power from the piston to the crankshaft. It is subjected to high-stress forces and must be able to withstand repeated loading cycles during operation. In this document, we will perform a failure analysis of a connecting rod that failed due to repeated forces. The investigation will include a literature survey, a description of the operation, the results of the analysis, and references to support the findings.

KEYWORDS: Buckling, Connecting rod Shank, Design, Fatigue , Finite element method , Stress.

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1. INTRODUCTION

Connecting rods are widely used in variety of engines such as, in-line engines, opposed cylinder engines, radial engines and oppose-piston engines. A connecting rod consists of a pin- end, a shank section, and a crank-end as shown in Figure:1Pin-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 to permit it to be clamped around the crankshaft. The bottom part, or cap, is made of the same material as the rod and 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 maybe of the precision or semi precisiontype.The function of connecting rod is to translate the transverse motion to rotational motion. It is a part of the engine, which is subjected to millions of repetitive cyclic loadings. It should be strong enough to remain rigid under loading. Connecting rod is submitted to mass and gas forces. The superposition of these two forces results in the axial force, which acts on the connecting rod. The gas force is determined by the speed of rotation, the masses of the piston, gudgeon pin and oscillating part of the connecting rod consisting of the small end and the shank. Figure 1.2 shows axial loading (Fay) due to gas pressure and rotational mass forces. Bending moments (Mb,xy, Mb,zy) originates due to eccentricities, crankshaft, case wall deformation, and rotational mass force, which can be determined only by strain analyses in engine (Sonsino, 1996). Failure in the

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shank section as a result of these bending loads occurs in any part of the shank between piston-pin end and the crank-pin end. At the crank end fracture can occur at the threaded holes or notches for the location of headedbolts.

2. DESIGN OF CONNECTINGROD

In an internal combustion engine, most stressed part is connecting rod. There are different types of stresses induced in connecting rod. One of them is force of gas pressure which is induced by combustion of fuel in the cylinder so that a high compressive force is acted on the piston pin. And the other one is inertial force which is caused by reciprocating of piston. Connecting rod can be made of different type of materials. In modern era it is generally made of steel, but it can be made of aluminum (reducing the weight and the ability of absorbing high impact) or titanium alloy (for high performance engines) or cast iron for two wheelers like scooters, mopeds, etc. In this project study three materials Aluminium-360, Forged Steel, & Titanium Alloy are considered forHyper mesh.

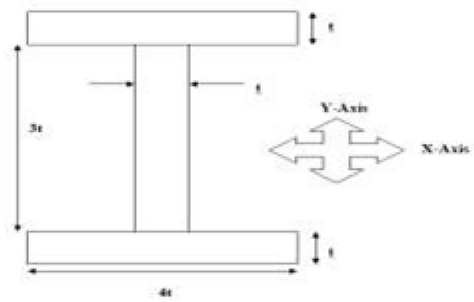

FIG 1 Moment of inertia of I section

Table 1- Specifications of Connecting rod.

Sr. No.	Parameters (mm)
1.	Thickness of the connecting rod (t) = 3.2
2.	Width of the section (B = 4t) = 12.8
3.	Height of the section(H = 5t) = 16
4.	Height at the big end = (1.1 to 1.125)H = 17.6
5.	Height at the small end = 0.9H to 0.75H = 14.4
6.	Inner diameter of the small end = 17.94
7.	Outer diameter of the small end = 31.94
8.	Inner diameter of the big end = 23.88
9.	Outer diameter of the big end = 47.72

3. SPECIFICATIONS OF CONNECTING ROD

In this project, study three materials i.e. Aluminium360, Forged Steel, &are considered for Hyper mesh.

Materials & Manufacturing Process

Drop-Forged

A forged steel connecting rod is a production of drop-forged closed due process. The round steel stock as being

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forged to a connecting rod. Hot working proportions the metal for forming the connecting rods. Fullerene, which is the portion of the die, is used in hammer forging primarily to reduce the cross section and lengthen a portion of the forging stock. The fullerene impression is often used in conjunction with an edge or edging impression. Mustering converts square section bar into a pure form to reduce the cross-section and lengthenit.

Blocking operation forms the connecting rod into its first definite shape. This involves hot working of the metal in several successive blows of the hammer, compelling the work piece to flow into and fill the blocking impression in the dies. Flash is produced, which is the unformed metal around the edge of the connecting rod that was forced away from blocking die impressions by the successive blows of the forging hammer. Flash is removed by different ways with trim dies in mechanical press or in special circumstances by sawing and grinding. The trimmed connecting rod is ready for heat-treating andmachining.

Heat treating:

After final forging and before machining, proper heat treatment methods are used to acquire optimum grain size, microstructure and mechanical properties.

PowderForging

Powder forging is a process in which powders such as iron and copper are compacted, heated and forged so that their density increases up to that of wrought steel.

The technology involves the following steps:

Stage I: A controlled amount of mixed powder used for connecting rods is automatically gravity-fed into a precision die and is compacted usually at room temperature and at high pressure up to 200 to 400 MPa. The resulting mass of powder is a green compact and has very little cohesive strength requiring furtheroperations.

Stage II: The green component is ejected out of the die–tool system and placed on wide endless mesh belt, which moves slowly through a controlled atmosphere-heating furnace. compacts are heated below the melting temperature of the base metal and held at the sintering temperature for an

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appropriate time and then cooled.

Stage III: Shot peening is implemented after forging. Before shot peening, some connecting rods receive primary milling/rework. Bad connecting rods are thrown to scrapbaskets.

Stage IV: Inspection: During this process presence of any cracks and flaws are inspected. Inspection of any flaw on the surface can be observed by white light. Magnetic particle inspection is done randomly to check for hidden cracks, fillet or inner contour machining, jamming or forging marks. Finally, the rods are inspected for weight and length, and any overweight connecting rods arerejected.

Comparison of Forged Steel and Powder Metal ConnectingRods

The two most competitive high volume manufacturing processes of connecting rods are forged steel and powder metal processes. There has been a significant increase in the production of powder metal connecting rods in North America in the last decade. The main driving force for this trend has been cost effectiveness of PM connecting rods resulting from near net shape manufacturing as well as fracture splitting of the cap from the rod, introduced in 1990. Near-net shape achieved in powder metal forged connecting rods results in substantial reduction in the material used to make them. In spite of the substantially lower weight of the material used, however, the cost of the powder forged rough stock could be higher than that for the conventional hot drop-forged rough stock, because of additional operations of powder formation, perform formation, reinterring, andsintering.

The manufacturing steps for the powder metal connecting rod. By comparing the steps in manufacturing processes it can be seen that the fracture splitting step is the main difference between conventional forged steel and powder metal connecting rod manufacturing processes.

4. FINITE ELEMENT MODELING

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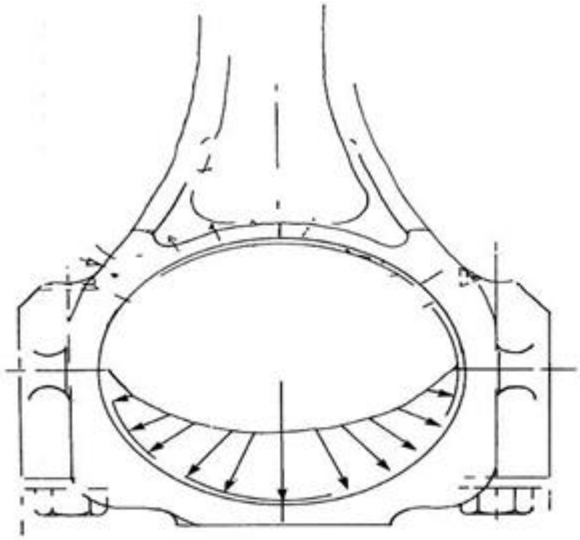


Fig: 2 Distribution of compression loading of connecting rods

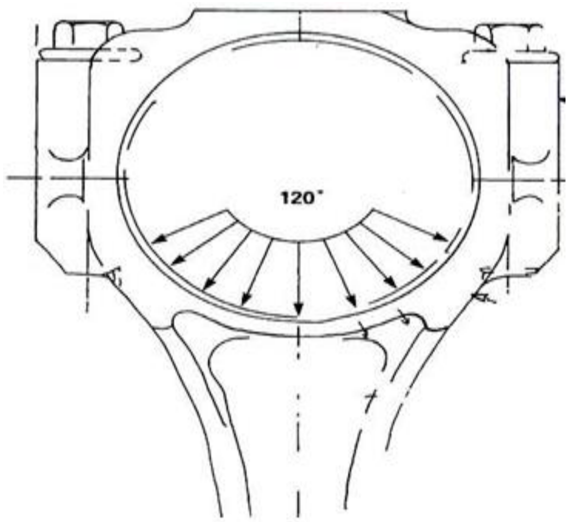
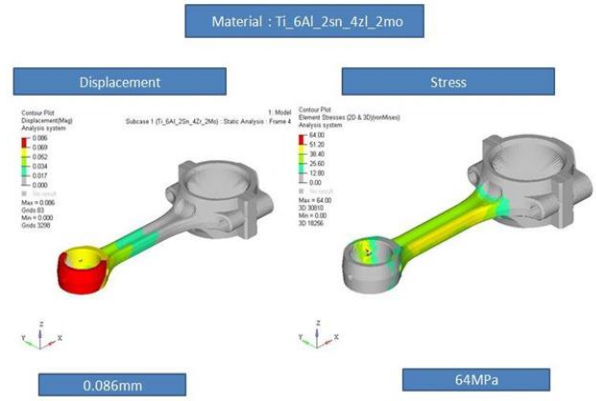


Fig: 3 Distribution of tension loading of connecting rod

5. RESULTS AND ANALYSIS



Results :

Material	Load case	Stress (MPa)	Displacement (mm)	Weight (gm)
Ti_6Al_2sn_4zr_2mo	Tensile load 5000N	63.14MPa	0.13 mm	681.6
Ti_6Al_7Nb	Tensile load 5000N	61.32MPa	0.14 mm	680.1
A_360	Tensile load 5000N	62.94MPa	0.22 mm	394.9
ELECKTON	Tensile load 5000N	65.21MPa	0.36 mm	270.2
Beryllium copper	Tensile load 5000N	64.11MPa	0.12 mm	1279
Optimization Results				
Ti_6Al_2sn_4zr_2mo	Tensile load 5000N	64MPa	0.086 mm	600.7
Ti_6Al_7Nb	Tensile load 5000N	62.73MPa	0.09 mm	599.3
A_360	Tensile load 5000N	63.84MPa	0.01 mm	348
ELECKTON	Tensile load 5000N	65.58MPa	0.23 mm	238.2
Beryllium copper	Tensile load 5000N	64.75MPa	0.08 mm	1127

6. CONCLUSION

This overview research report studies the possibilities of weight reduction in forged steel connecting rod. For weight reduction process, static strength was considered as a structural factor. First, the connecting rod was 3D modeled. After that load analysis was performed using ANSYS software. From the results of the study, following conclusions can be made. It was observed that connecting rod is designed at its maximum engine speed and maximum gas pressure. As per the results received from the finite element analysis, There is a large margin of material removal from big end area, small end area and area connecting to the small end of the connecting rod. As per the results received from the analytical calculations, there may be a scope of reduction in it's I-section thickness. It was observed that the new connecting rod geometry is lighter than the original connecting rod. It was also observed that the Titanium material has higher mechanical properties and better machinability and lower ductility and mainly has less weight compared to the steel

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