DESIGN, MODELING AND STRENGTH ANALYSIS OF CONNECTING ROD FOR 4 STROKE SINGLE CYLINDER 10 HP (7.35 KW) DIESEL ENGINE-A REVIEW

1AMITKUMAR B. SOLANKI, 2JIMMY MAIYA, 3NEETIN MISHRA, 4ANAND RATHOD

1,2,3,4Mechanical Engineering Department- Government Engineering College -Bhavnagar, G.T.U.-India
E-mail: 1solankiamit4239@gmail.com, 2jimmypmaiya@gmail.com, 3neetin96mishra@gmail.com, 4rathodanand043@gmail.com

Abstract - Every vehicle that uses an internal combustion engine at least requires one connecting rod depending upon the number of cycles of an engine. It undergoes high cyclic load that ranges from high compressive load due to combustion to high tensile load due to inertia. Due to these factors, 'connecting rod' has become the topic of research. Based upon research and findings, it was found that major failures occur in shank of connecting rod that results in bending, catastrophic failure occur due to crack initiation because of cyclic load, the application of high pressure and induced stress during strokes results in failure of both small and big ends. In order to determine desirable strength and durable alternate material for connecting rod various research papers has been reviewed, based upon those papers suitable alternate material such as Aluminium alloy 360, Alvesic etc. will be selected and modelling will be done using solidworks2016 3.0. Strength analysis will be carried out using ANSYS2016.

Keywords - Strength Analysis, Modeling, Design, Cost & Weight reduction, Connecting rod.

I. INTRODUCTION

In a reciprocating engine the connecting rod connect the piston to the crank or crankshaft together with the crank, 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 so the rod may rotate the crank through both halves of a revolution, i.e. Piston pushing and piston pulling. The small end attaches to the piston pin, gudgeon pin or wrist pin, which is currently most often press fit into the connecting rod but can swivel in the piston. The big end connects to the bearing journal on the crank throw, in most engines running on replaceable bearing shells accessible via the connecting rod bolts which hold the bearing "cap" onto the big end. Typically there is a pinhole bored through the bearing and the big end of the connecting rod so that pressurized lubricating motor oil squirts out onto the thrust side of the cylinder wall to lubricate the travel of the pistons and piston ring.

II. FORCES ACTING ON THE CONNECTING ROD

The various forces acting on the connecting rod are as follows: Forces on the piston due to gas pressure and inertia of the reciprocating parts.

1.1 Forces on the piston due to gas pressure and inertia of the reciprocating parts.

1.2 Force due to inertia of the connecting or inertia bending forces.

1.3 Force due to friction of the piston rings and of the piston.

1.4 Forces due to friction of the piston pin bearing and crankpin bearing.

III. MATERIALS & MANUFACTURING PROCESS

Kuldeep B et al[9]suggested replacing Carbon Steel connecting rod by aluminium based composite
material reinforced with silicon carbide and fly ash. Design and analysis was done using two different material namely hybrid alfasic and Al360 in which it was concluded that Alfesic material was 43.48% lighter than Al360.

G. Naga Malleshwara Rao [7] stated that for weight optimisation of connecting rod load analysis is must by choosing different material like Genetic Steel, Aluminium, Titanium and Cast Iron. It was mentioned that data collected from load analysis is used for F.E.A and following conclusion was made, there is considerable difference in the structural behaviour of the connecting rod between axial fatigue loading and static loading. There are also differences in the analytical results obtained from fatigue loading simulated by applying loads directly to the connecting rod. It is also found that the connecting rod made of genetic steel shows less amount of deflection and stresses than other material like Titanium, Cast Iron and Aluminium which are also studied in this study.

Dr. B.K. Roy et al [5] stated the two process used to manufacture connecting rod casting and forging. Elaboration was done to find that casting could have blow holes which are detrimental from durability and fatigue point of view. Whereas forging produce blowhole free and better rods. Various designs were analysed and outcomes are compared to come up with better results, safe design of rod under permissible limits of various parameters and safe stress. Following conclusions are reached static and fatigue both analysis are important as both showed up different aspects of factors. Various factors like stress, strain, deformation etc. are analysed to get good design parameters with taking into account permissible stresses and factors, which would have affected the design if not taken into account.

Dipak G Gotiwalie [3] in redesign of connecting rod for weight reduction, it is done using c70S6, the five critical points of connecting rod which are highlighted after fatigue testing and incorporation of few changes are considered for F.E.A of connecting rod for tensile and compressive loading for both small end and big end. In the process two end were fixed alternatively for determining various loads on the other one the less stresses area was considered. The less stress area are consider for weight reduction also design is supported by analytical calculation for its thickness and it was concluded that during fatigue testing, fatigue failure occurred at oil hole but is reduced/restricted after angle of chamfer is changed. Large margin of material removal from big end, small end & area connecting to small end. The reduction of I- section thickness can be achieved. C70S6 has higher mechanical property, machinability and ductility.

Mr. Shahrukh Shamin [13] described static stress analysis was conducted on connecting rod made up of two different materials viz E-glass/Epoxy and aluminium composite reinforced with carbon Nano tubes. ANSYS 14.0 was used for analyse the connecting rod after analysis it was concluded that the connecting rod made Al-2 Vol% CNTS has less weight than that of E-glass/Epoxy. Maximum von misses stresses for E-glass epoxy and Al-2 Vol% CNTS composite was 276.24 Mpa and 160.18 Mpa Respectively.

MarthanPalli haripriya et al [10] performed an optimisation study over forged steel and powdered steel connecting rod with a view to improve weight and production cost. They investigated and compared fatigue strength of both connecting rods and observed for connecting rod made of aluminium Al360 & carbon steel they observed that weight of Al360 connecting rod is four times lighter than of carbon steel & also reduction in eye section makes it 10 grams lighter and concluded that Al360 is better choice than carbon steel as it is light and strong. The stress value of Al360 are slightly less than carbon steel but weight and cost of carbon steel is very high then that of Al360.

IV. FAILURE ANALYSIS OF CONNECTING ROD.

Modes of fracture, microstructure were identified with help of electro microscope, investigation performed by C. Mazzuca et al [8] results suggested that fatigue loading is root cause for the failure of connecting rod, presence of scale & build up inclusion led to micro cracking and further fatigue loading results in failure. Additionally factrography tests revealed evidence of heat tinting, suggesting the thermal hotspot inside the material, which was contributing factor to its failure & cause of fracture. The scale build-up of inclusions on steel led to micro crack formation that propagated during fatigue loading until part fails. The conclusion suggest that crack propagation and fatigue loading was main reason for failure of connecting rod.

Fig 3. - (a) Digital microscopy reveals heat tinting marks on the fracture surface; (b) Close up showing heat tinting near surface, which suggests crack initiation point indicated by the red arrow[8].

Design, Modeling and Strength Analysis of Connecting Rod for 4 Stroke Single Cylinder 10 Hp (7.35 Kw) Diesel Engine-A Review
M.N. Mohammad [11] stated that catastrophic failure is attributed to the broken connecting rod’s shank especially when there is a probability of being pushed through the side of the crankcase. Observations made by FEM results showed the casting defect can develop under the ages of cyclic loading behaviour to start crack initiation as start point. The failure occurred due to fatigue crack growth mechanism as result of higher stress together with porosity, growth of fatigue crack at the end catastrophic failure.

An optimization study by Ali Fatemi et al [15] performed on a steel forged connecting rod with a consideration for improvement in weight and production cost. The structural factors considered for weight reduction during the optimization include the buckling load factor, stresses under the loads, bending stiffness, and axial stiffness. Comparison of FEA results for the existing connecting rod against the allowable stresses indicate that the shank region of the connecting rod offers the greatest potential for weight reduction it was also concluded that Fatigue strength was the most significant factor (i.e. design driving factor) in the design and optimization of the connecting rod. Stresses and displacements were observed to be significantly lower under conditions of assembly, when compared to stresses obtained from unassembled connecting rod subjected to cosine loading.

D Gopinath et al [4] performed modelling, analysis using CATIA and ANSYS11.0. The experimental procedure involves preparation of geometric model of forged steel, aluminium and titanium connecting rod and then analyse the same model with ANSYS. The aim is to explore weight reduction and cost optimisation opportunities. After carrying analysis the stress in each loading condition were studied and then the area were excess material can be removed were decided. The shank region of the connecting rod offered greatest potential for weight reduction. Mass of the optimized connecting rod is 483 grams and the optimized geometry is 10.38% lighter.

V. DESIGN CONSIDERATIONS FOR CONNECTING ROD.

Connecting rod made of lightweight material used in commercial vehicle by TATA motors was analysed. Prof N.P. Doshi et al [16] mentioned that stresses developed in the connecting rod under static loading with different loading condition of compression and tension at crank end & pin end of connecting rod. From analysis, it was concluded that the material could be reduced from those portion crank end & cap end as well as piston end, because after analysis it was observed that minimum stress among all loading conditions were found at crank end cap as well as piston end cap so reducing the material cost.

Before analysis, it was found that maximum stress develops at the fillet section of small end and big end. After Photo elastic investigation of I.C Engine connecting rod using Standard transmission polaroiscope. Prof. Vivek C. Pathade et al [17] found that stress induced in the small end of connecting rod are greater than the stresses induced at the big end. Also after analysis, it was concluded that major stresses are produced at both ends & negligible stresses are produced at mid sections.

Baiyan et al [1] performed non-linear F.E.A to evaluate local stresses near the mating faces and to know about mechanical properties they performed hardness and tensile tests the hardness is measured by Rockwell hardness tester and tensile tests are performed on universal testing machine CSS44100 using S.T.D samples of connecting rod they observed that fatigue is main mechanism of crack and failure of connecting rod they suggested to reduce some toughness in order to get higher yield strength and to prevent early cracks and failure, mating surface profile and assemble torque should be optimised.

VI. STRESS ANALYSIS OF CONNECTING ROD

Von Misses stress and total deformation of 2 different material aluminium and forged steel performed by R.A. Savanavar et al [18] suggested that the Al5083 has less weight then forged steel and the section of modulus of rod should be high enough to prevent high bending stress & eccentricities as well as deformation.

M.S. Shaari et al [14] stated that topology optimization is under consideration. Linear static analysis was carried out to obtain the stress strain state result. Mesh convergence is used to select best mesh. TET10 predicted higher maximum stress than (TET4) and maximum principal stress captured is the maximum stress. The crank end is suggested to be redesigned based on topology optimization result. The optimized connecting rod is 11.7% lighter and predicted low maximum stress compared to initial design. For future research, the optimization should cover on material optimization to increase the strength of connecting rod.
Gaba Piyush et al. [6] stated that reducing weight of connecting rod will eventually lead to reducing weight of the engine thus reducing inertia load and improving engine performance and fuel economy. Major stresses induced in the engine is combination of axial and bending stress thus the study deals with stress analysis of connecting rod and guidelines for its finite element simulation conclusion was made from fatigue behaviour of connecting rod 1. Mean end alternative stresses calculated for the connecting rod are on moderate level the required minimum Factor of safety is 1.5 the occurring one is 1.71 at the connection between shank and big end. 2. In order to achieve result-using F.E.M one has to use an acceptable element mesh with respect to the shape and size of the element to produce an acceptable mesh there are quality criteria that must be fulfilled.

VII. COST & WEIGHT REDUCTION

Mr. Ajinkya et al. [12] proposed weight optimization process through ANSYS software, modelling is done by parametric modelling and FEA is done under compressive load and static tensile load by giving standard boundary conditions. Condition made in face of results is that change in design and material results in significant effort on weight, as it achieves the objective of reducing the weight of the engine component, thus reducing inertia load, engine weight and improving engine performance and fuel economy. Fatigue strength was the most significant factor in the design and optimization of connecting rod. Christy V Vazhappilly [2] stated to explore cost optimisation opportunity by performing detail load analysis. Steel connecting rod is chosen change in material results into less machining and manufacturing costs. Two cyclic loads are under consideration according to the paper that are dynamic tensile and static compressive load. Study deals with determination of loads acting as a function of time. Existing connecting rod material can be replaced with new material. Composite material the fracture crack ability feature etc. Same performance can be expected in terms of component durability. After experimenting the data, it was conclude that the connecting rod can be design, analysed under a load ranging from tensile load, corresponding to various degree crank angle at maximum engine speed at one extreme load, and compressive load corresponding to the peak gas pressure at other extreme load. Fatigue strength is most significant factor and the portion, which develops less stress, is removed.

REFERENCES