Analysis & Optimization of IC Engine Connecting Rod

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Abstract— The main motto of this study is to analyse and optimize the Connecting Rod. In this paper, we come to know about the Connecting Rod in the better way. There is the parameter that has been defined in this section such as how it works in an engine, the chemistry of a Connecting Rod, Connecting Rod in a science. There is also a literature review in which research work of different researchers has been included. Also, the main motto of their research is how the efficiency & performance of an engine is improved. This can be achieved with the help of the optimization technique. Many of the researchers have reduces the size & weight of the Connecting Rod and determine their results. They have used different 3-D models. They were working with the software such as PROE, ANSYS, and CATIA. Optimization is basically the situation in which best outcome is used in order to improve the system whether it is efficiency or performance.

Key words: IC Engine Connecting Rod, Types, Material, Analysis

I. INTRODUCTION

Connecting rod is used to connect the piston to the crank or crankshaft in a reciprocating engine. Its main function of connecting rod is to transfer the motion from the piston to the crankshaft. Connecting rods convert rotating motion into reciprocating motion. The connecting rod is stiff; it may transmit the power from the piston to the crankshaft. The connecting rods are best known their use in I.C. Engine, such as in automotive sector. [1].

The automobile connecting rod is one of the most important components and is produced in high volume. The connecting rod connects the reciprocating piston to rotating crankshaft also transmitting the thrust of the piston to the crankshaft. Every vehicle with an IC engine requires one connecting rod depending upon the number of cylinders in the engine [2].

Connecting rod plays an important role between the piston and the crankshaft. Connecting rod of automotive should be lighter so that its fuel consumption is less and it provides comfort and safety to passengers, it leads to a decrease in the weight of the vehicle. Thus it results in the invention and implementation of quite new materials which are light and meet design requirements.

Lightweight connecting rods decrease in the force of inertia in an engine as it does not require a big counterweight on the crankshaft. Application of the metal matrix composite enables safety increase and advances that lead to efficient use of fuel and to obtain high engine power.

By carrying out the modifications to engine elements results in the effective reduction of weight, the increase of durability of a particular part, will lead to the decrease of overall engine weight, improvement in its traction parameters, economy and ecological conditions such as reduction in fuel consumption and emission of harmful substances into the atmosphere [3].

Every engine required connecting rod. It connects the piston to the crankshaft; convert the reciprocating motion of the piston in rotary motion by the crankshaft. The connecting rod goes under the high compressive load due to combustion and tensile load due to inertia. Stress analysis has become important for selection of material and manufacturing process [4].

A connecting rod is a link between the reciprocating pistons and rotating crankshaft. The small end of the connecting rod is connected to the piston by gudgeon pin. The big end of the connecting rod is connected to be crankshaft. The connecting road consists of an eye at the small end to connect the piston pin, a long shank, and a big end opening split into two parts to connect the crank pin. The basic function of the connecting rod is to transmit the push and pull forces from the piston pin to the crank pin. It also transfers lubricating oil from the crank pin to the piston pin and provides a splash or jet of oil to the piston assembly. There are two methods of lubrication of bearings at the two ends – splash lubrication and pressure feed lubrication [5].

Connecting rod is one of the important parts of the combustion engine and the main purpose of the connecting rod is to transfer the energy from the pistons to the crankshaft and convert the linear reciprocating motion of a piston into the rotary motion of a crankshaft. It connects the reciprocating piston to rotating crankshaft and some other design connected direct to the crosshead and then transmitting the thrust of the piston to the crankshaft of the combustion engine. The combustion engines connecting rod moves in two way rotating motion and connects both large and small end. The important property of the connecting rods must have the highest value of possible rigidity by keeping material weight as low as possible. In IC Engines used for the automobile sector, connecting rod is a produced in very large quantity and it is always subjected to complex loading. In the combustion engines bending stresses are due to eccentricities, crankshaft, rotational mass force and case wall deformation. A connecting rod must have capabilities of transmitting of axial tension at minimum axial compression [6].

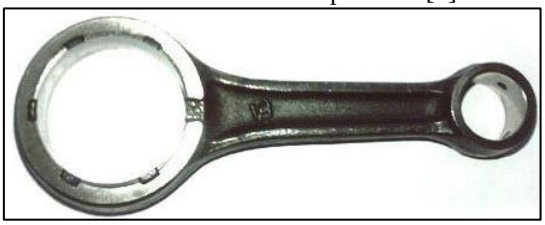

Fig. 1: Connecting Rod

II. LITERATURE REVIEW

Harsh et al. [1] in this study existing connecting rod of Bajaj Pulsar 150cc was taken. The material of the existing connecting rod is 20CrMo. The existing rod was heavy in

weight so, the existing connecting rod was replaced with the new composite material AL6061+B_4C. The model of the new connecting rod was prepared on the Parametric Modeling software and then the analysis of the connecting rod was done on the Finite Element Analysis (FEA) tool. By the FEA analysis, it was concluded that the weight of the connecting rod was reduced up to 106 grams.

Mohamad Gani et al. [2] describes the model and analyze the connecting rod. Aluminium connecting rod is replaced by Boron Silicate for Suzuki GS 150R motorbike. The model of the connecting rod is designed by using CATIA V5 Software and analyzed in ANSYS Workbench Software. Parameters included are von misses stress-strain, displacement and weight reduced for connecting rod. The material of existing connecting rod is replaced by Carbon steel to Aluminium Boron Carbide. They concluded that the equivalent stress for both materials is same. The number of cycles of Aluminium boron Silicide is ($2095*10^4$) is more than the existing carbon steel connecting rod ($7046.36*10^3$).

Kuldeep et al. [3] investigated that material of the connecting rod is replaced from carbon and aluminum alloy to Aluminum based composite material reinforced with Silicon carbide and fly ash. They designed a model and analyzed connecting rod. FEA analysis was carried out by using two materials. The parameters considered for their study are von misses stress-strain and displacement were obtained from ANSYS software. The new material results in 43.48% of weight, with a 75% reduction in displacement. They concluded that the weight of the connecting rod is reduced by changing the material of the existing connecting rod by Al360 to Hybrid ALFASiC composites.

Sandeep et al. [4] this paper explain about the failure of connecting rod. The existing connecting rod of Swaraj 724 Tractor was made of C70 alloy steel. The model of the connecting rod was prepared on the CATIA V5 Software. The analysis of the connecting rod was done by applying load on the bigger end and the smaller end is fixed. The failure of the connecting rod is by finding the maximum stress point in the connecting rod. The different loads are being applied on the connecting rod. Then, they concluded that the connecting rod of Swaraj 724 tractor was twisted from the center due to high crushing load.

Balaji et al. [5] investigated that the model and analysis of connecting rod. Connecting rod is replaced by AlSiC for 125cc motorbike. A parametric model of connecting rod is designed by using CREO software. The parameters like Von misses stress, strain, deformation and weight reduction is done by ANSYS software. They concluded that the optimization of connecting rod weight and manufacturing cost can be reduced.

Prof. Mane et al. [6] investigated design reduction of mass and cost for connecting rod made up of structural steel for 970cc 4-stroke four-cylinder engines. They mainly focused on FEA and optimization for design and mass. In this paper, I-section is designed using SOLIDWORKS and analyzed on ANSYS. It results in optimization of design and mass of connecting rod.

Dr. L.P. Singh et al. [7] investigate the stresses inducted in connecting rod of single cylinder 4-stroke petrol engine. The model of the connecting rod was designed on the SOLIDWORKS and the analysis was performed on the ANSYS Software. They concluded that the maximum pressure stress is obtained between piston end and the rod of connecting rod and at the piston end has more chances of failure as compared to the crank end.

G. Naga et al. [8] explains weight optimization in the connecting rod of the IC engine by various materials like Genetic steel, aluminum, titanium and cast iron. The model is designed in Pro-E and analysis is done on ANSYS. They perform the various load analysis, in static load and stress analysis of the connecting rod. Design optimization for suitable material to minimize the deflection. The load acting on the connecting rod as a function of time is obtained. The relation for obtaining the load for the connecting rod at the given constant speed of crankshaft is also determined. They concluded that the connecting rod can be designed and optimized under a compressing tensile load corresponding to 360^0 crank angles at the maximum engine speed as one extreme load and the crank pressure as the other extreme load which results to cost reduction and weight reduction. The bending stresses are accounted for tensile bending stresses about 266.86333 N/mm^2 and also found that connecting rod made up of genetic steel shows less deformation and stress then titanium, cast iron, and Aluminium.

Sourabh et al. [9] investigate the cost and material optimization of the connecting rod. They describe the various components of the IC engine such as the piston, crankshaft, and connecting rod. The model was designed and was analyzed on the ANSYS Software. The existing material was replaced with the steel alloy. After the analysis, they reduce the cost and weight of the connecting rod.

Fanil Desai et al. [10] investigates the compressive stress acting on connecting rod at different load condition. Two samples of connecting rods are taken for experimental an analysis. The static structural analysis is done using ANSYS and experimental analysis is conducted on connecting rod made up of forged steel. The aim of this study is that the performance of the connecting rod is shown under different load conditions. They concluded that the stress generated at shank is below the allowable limit. Experimental results are verified with the numerical results.

Sathiamurthi et al. [11] investigate the weight and cost reduction of the connecting rod. That can be achieved by performing a detailed load analysis. The study is performed on Steel connecting rod by the reduction in the machining operations, achieved by the change in materials. They consider the weight reduction under two cyclic loads compare dynamic tensile and static compressive as the two extreme loads which result in the reduction of weight and cost of the connecting rod.

Sujata et al. [12] demonstrate the analysis is performed on the connecting rod using various composite materials. They mainly focused on the material used for the connecting rod and structural analysis in static loading. The model is prepared by using SOLIDWORKS workbench and CATIA and analysis are done by using FEA software. They concluded that the weight reduction and increases the von misses stresses, decrease in von misses strain and reduction on deformation.

Amit Kumar et al. [13] investigate about the stress acting on connecting rod at the dynamic state of Bajaj Pulsar 150cc. The model of the connecting rod is designed by

CATIA and dynamic analysis is performed by the ANSYS 14.0 software. The main objective of their study is to reduce the cost and moment of inertia of a connecting rod. The parameters considered are von-misses stress, von-misses strain, and total deformation. They concluded that the weight of 42CrMo connecting rod is 11.67% less than 20CrMo and30CrMo connecting rod as only 6.42% less weight than 20CrMo.

Ramakrishna et al. [14] said that connecting rod is manufactured from the 4340 Alloy steel connecting rod is replaced by ALSiC-9 and also described the model of connecting rod in Pro-E and analysis is done in the ANSYS software. FEA analysis was considered with two materials. The von misses stress obtains from ANSYS software. Compare it with the formal material. It resulted in the reduction of 61.6560% of the weight of the connecting rod.

Nikhil et al. [15] in their study the material of connecting rod is replaced by aluminum-based composite material reinforced with silicon carbide and fly ash and they also describe the model and analysis of connecting rod. The parameters considered for their study are von misses stress and displacement. Compared to the existing material and the replaced material found to have less weight and better stiffness. It resulted in the reduction of 39.48% of weight, with 64.23% reduction in displacement.

Akbar H Khan et al. [16] the objective of this research is to study about the static structure and the experimental analysis of Bajaj Discover 100cc connecting rod using the finite analysis and the photo elasticity analysis method. The design of the connecting rod was prepared on the CREO 2.0. ANSYS 15.0 for the static structural analysis. Photo elasticity analysis method includes the casting of the photo elastic sheet using the Araldite AY 103 and Hardener HY991. The model of the connecting rod is prepared by the laser cutting machine. The analysis was carried out to find the maximum principal stress and the reasons for failures. They concluded that the material should be aided in the fillet. The chances of the connecting rod failure may be fillets of both ends.

Puran Singh et al [17] said that the computation of the strength and distortion characteristics of a connecting rod. FEM is used to analyze the connecting rod stress and deformation using ANSYS. For that fatigue and structural analysis will be performed. The axial compressive load is greater than the axial tensile load. They concluded that the maximum principal stress is 411.32Mpa which is less than yield compressive strength 530Mpa and the Compressive force is much greater than tensile force.

G.Sailaja and S. Irfan Sadaq [18] investigated the static and model analysis which is carried out to determine the dynamic behavior of connecting rod by considering deformation, strain, and stress which made up with the Beryllium Alloy. An analysis is carried out with ANSYS software. They concluded that the failure can occur due to higher crushing load due to the gudgeon pin assembly.

Bhandari et al. [19] in this paper the existing the connecting rod of Hero-CBZ was manufactured by using SCM-415. The 2-D drawing was drafted from the calculation and the dimensions of the connecting rod were measured by using a vernier caliper, screw gauge. The model was prepared on CREO and then the model is imported on the ANSYS for analysis. The FEA was performed on the ANSYS Workbench 13.0. He concluded that by increasing neck radius thickness at the crank end and pin end the life of connecting rod will be increased. The weight and cost of the connecting rod are also optimized.

III. FORCE ACTING ON THE CONNECTING ROD

a) The forces acting on the piston due to the gas pressure and inertia of reciprocating parts.
b) The force acts due to the inertia of the connecting rod or inertia bending force.
c) The force acts due to the friction of the piston and piston rings.
d) The force acts due to the piston pin bearing and crankpin bearing.

IV. TYPES OF MANUFACTURING PROCESSES OF CONNECTING RODS

a) Casting
b) Forging
c) Powder

V. ADVANTAGES OF CONNECTING ROD

a) It can carry a large number of loads.
b) It is working at high temperatures.
c) It has good mechanical properties.
d) It can carry compressive and bending loads.

VI. APPLICATIONS OF CONNECTING ROD

a) Most commonly used in engines in automobiles.
b) Used in all types of vehicles such as cars, trucks, bikes etc. where combustion engine is used.
c) Construction equipment like bulldozers, road rollers use internal combustion engines.

VII. CONCLUSION

a) Analysis and optimization of the connecting rod is being done
b) Material selection is also important of the connecting rod because it determines the durability and performance of IC engine.
c) Modeling is being done in 3D CAD software as well as on Solid Work.
d) Analysis of the connecting rod, how it works, types and design procedure.
e) Also came to know about various designing techniques and also how to analyze and produce the best outcome.

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