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A Review on Analysis of Piston, Connecting Rod and Crankshaft Assembly by Applying Different Materials

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Abstract— The purpose of this project is to improve the engine efficiency and structural as well as thermal behaviour of the piston, connecting rod and crankshaft assembly. Theoretical calculation of the piston, connecting rod and crankshaft is developed from Hero Splendor-Pro engine specifications. Modelling of parts and its assembly were done in PTC Creo Parametric 2.0 design software and Finite Element Analysis performed using analysis software ANSYS Workbench 18.1. In this research, structural and thermal analysis; and weight optimization of assembly are done by two different materials such as Aluminium alloy and Aluminium silicon carbide (AlSiC) for piston, Grey Cast iron and Aluminium silicon carbide (AlSiC) for connecting rod & High carbon steel and Forged steel for crankshaft. Structural analysis is to evaluate the total deformation, equivalent stress and equivalent elastic strain; and thermal analysis to evaluate the temperature distribution and total heat flux. By comparison of the result of analysis, we would be able to find which material is better for the assembly of IC engine.

Keywords— IC Engine Piston, Ceramic Coating, Composite material, FEA, ANSYS.

I. INTRODUCTION

Automobiles are being a basic necessity in this modern era and we all know very well, because of the increased use of vehicles, there is a requirement to improve performance and reduce cost of automobile components. For the betterment of these components we need to understand the new technologies which are helpful in development of components with improved build quality.

A Piston is a reciprocating component, contained within the cylinder in IC engines and piston connected with crankshaft by the connecting rod. Due to combustion of fuel, piston reciprocates and this reciprocating motion of piston, passes to crankshaft by the connecting rod which is converted into rotary motion. In this process, high thermal stress acts on the all components of assembly.

Therefore, to reduce the thermal stress acting on the all assembly components, we strive to improve the design or choose the best material for the piston, connecting rod and crankshaft.

II. LITERATURE REVIEW

G Gopal et al [1] designed and analyzed assembly of piston, connecting rod and crank shaft. The purpose of this study is to increase the engine speed by changing material of the piston, connecting rod and crankshaft assembly for an engine. Cast iron, manganese steel and high carbon steel are selected for piston, connecting rod and crankshaft respectively. The dimensions of parts; piston, connecting rod and crankshaft are calculated from 4 stroke air cooled SOHC 1598cc engine specifications of four wheeler vehicle. The parts developed and assembled in Pro/Engineer Wildfire software and mesh generated in Hyper-mesh. The Finite Element Analysis of the assembly such as structural analysis and thermal analysis is done using analysis software ANSYS. The structural analysis involved static structural analysis and dynamic structural analysis. For the static structural analysis, 12.26N/mm^2 of pressure and for dynamic structural analysis different pressure at 10s, 20s, 30s time steps are entered as boundary conditions while for thermal analysis 973K temperature and 0.000025W/m^{2}K film coefficient are given. From the result table, they found that their selected material suitable for components to operate the engine at high speed.

L. Karthik Chakravarthy, Dr. P. Srikanth [2] had performed assembly analysis of piston, connecting rod & crankshaft. The function of this article is to analyze the piston, connecting rod and crankshaft assembly by using two different materials for all parts. Piston, Connecting rod and Crankshaft of Suzuki GS150R 4 stroke air cooled 150cc engine is designed and assembled in Pro/Engineering software. Analysis is done for two materials: (Aluminum Alloy – Cast iron) for Piston, (Aluminum Alloy – Manganese steel) for Connecting Rod & (Nickel Chromium steel – High carbon steel) for Crankshaft using ANSYS. Boundary condition for the structural analysis and model analysis is 15.454N/mm^2 of pressure taken for the analysis. From the analysis, resultant stress is less than the permissible stress. So all parts designed by them are safe. By the comparison of the analysis result, cast iron for piston, manganese steel for connecting rod and high carbon steel for crankshaft gives the better results for assembly.

K. Venkatareddy, V. Chandrashekar Goud [3] had designed and analysed the piston by using composite materials. This paper describes about improving the efficiency of the engine by applying various composite materials such as grey cast iron, aluminium alloy, Al-SiC, aluminium oxide on piston. The piston is designed for 150 cc petrol engine and modelling is done by using design software SolidWorks 2016. The SolidWorks part file of piston is imported to ANSYS Workbench for the analysis. Boundary Condition of 1.5 MPa pressure force on piston crown for the structural analysis is given and for thermal analysis maximum temperature 400℃ at piston crown and minimum temperature 30℃ at bottom face are given. The Static structural analysis is to evaluate total deformation, maximum stress, maximum shear stress and strain. Steady state thermal analysis is to evaluate temperature distribution and total heat flux. From the resulting analysis, they concluded that the aluminium silicon carbide (Al-SiC) is efficient among the other applied materials to piston.

Abino John et al [4] designed and analysed piston by SiC composite material. They explained that fatigue damage of the aluminium piston like side wear and head cracks are caused by cyclic gas pressure due to poor hot strength and high coefficient of expansion of aluminium material. The material properties of Aluminium Silicon Carbide (AlSiC) collected by literature survey are compared with aluminium and it was found that AlSiC had better high temperature performance, dimensional stability, abrasion resistance, creep resistance and good stiffness to weight and strength to weight ratios. Initial piston 3D model created in CATIA V6 software. Thermal analysis such as temperature distribution, total heat flux and static structural analysis such as total deformation, normal stress distribution, shear stress distribution, equivalent stress distribution, normal and shear elastic strain distribution of the piston by both the materials were done using ANSYS 14.0. They obtained from the analysis, some of the issues faced by aluminium piston like deformation and temperature distribution can be avoided by the aluminium silicon carbide piston.

Leela Krishna Vegi, Venu Gopal Vegi [5] have worked on design and analysis of connecting rod using forged steel. In this work, they achieved more factor of safety, reduce the weight, increase the stiffness and reduce the stress by the forged steel material. The theoretical calculations of the connecting rod is done using air cooled 4-stroke 150cc Suzuki engine specification and initial 3D model developed in CATIA V5 R19 software. Finite element analysis of connecting rod for the carbon steel and forged steel material is performed using ANSYS software by importing CATIA model. They found that forged steel material has more number of life cycles and also it is cheaper than the existing connecting rod material, i.e., carbon steel.

Vikas Singh et al [6] have done design and analysis of connecting rod for different material using ANSYS Workbench 16.2. This work is about finding the best material for the connecting rod by the analysis process. Connecting rod is generally made by carbon steel and aluminium alloy materials but they select aluminium 360, forged steel, titanium alloy, magnesium alloy and beryllium alloy for the analysis. 3D modelling of connecting rod is done in SolidWorks 2016 and structural analysis performed using ANSYS 16.2. From the analysis, they conclude that beryllium alloy or magnesium alloy material connecting rod gave better performance in the engine.

M. GuruBramhananda Reddy et al [7] presented design and analysis of crankshaft by forged steel and composite material. In this article, the static simulation of crankshaft of a single cylinder 4-stroke diesel engine is discussed. 3-D model of crankshaft is developed using Pro/ENGINEER software and structural analysis for the forged steel and composite material is done in ANSYS. Analysis shows that composite material resist high stress than forged steel but manufacturing cost is higher than forged steel. So, forged steel is used for crankshaft.

Sasi Kiran Prabhala, K. Sunil Ratna Kumar [8] discussed about design and weight optimization of IC engine. The particular components of IC engine like piston, connecting rod and crankshaft are chosen for weight optimization. Generally these components are made of steel because of high strength. They think about replacing steel with aluminium which has low weight but not enough strength. So, decided to take aluminium alloy as it has less weight as well as required strength. All the component model are designed as per 4 stroke IC engine in Pro/E. Analysis and weight optimization is done in cosmos. From the analysis they observed that 5086-H32 aluminium alloy reduce the overall weight of the assembly and conclude that less power required to run the assembly. Also, it gives better mileage.

M. Praveen Kumar, Dr. S. Adinarayana [9] had done design optimization of piston of an IC engine and investigated about its influence on the overall assembly. In this project, explanation about stress optimization of assembly to avoid the failure by the structural loads. They designed assembly of the single cylinder high speed Kirloskar diesel engine in Autodesk Inventor software. Four different aluminium alloy materials such as A2618, A4032, Al- GHS 1300, Al 6066 were used for analysis. They found new material Tennalum for the piston which gives the best result than the conventional material.

M. M. Kasod, Prof. S. J. Parihar [10] carried out design and assembly of 4 cylinder engine components supporting it with thermal and stress analysis. The aim of the paper is to observe the stress variation and heat transformation from one component to other by the analysis of four cylinder engine assembly. For the analysis, piston, connecting rod and crankshaft model were designed in CATIA V5 software tool. The static structural and thermal analysis on assembly by applying the boundary condition is performed using ANSYS 14.0. Aluminium for piston and steel alloy for both connecting rod and crankshaft are taken for this process. They found through analysis of individual components whether whole assembly is feasible or not.

Dr. K.H. Jatkar, Mr. Sunil S. Dhanwe [11] had performed dynamic analysis of single cylinder petrol engine. The main objective of this research is to investigate the variation of the structural behaviour at surface of piston, connecting rod and crankshaft assembly by finite element analysis. They chose the structural steel material for the assembly and load calculation on the assembly is determined in MATLAB. 3D model created and analysis performed using ANSYS Workbench 11.0 software. For the analysis, applying 21kN pressure in downward direction on the piston top surface as the boundary condition. And analysed results when compared with analytical calculated result it is concluded that the analytical method done in MATLAB is more accurate.

III. CONCLUSIONS

By the literature survey of the articles we decide to work on improvement of the engine efficiency and the structural and thermal behaviour of the piston, connecting rod and crankshaft assembly using two different materials such as Aluminium alloy and Aluminium silicon carbide (AlSiC) for piston, Grey cast iron and Aluminium silicon carbide (AlSiC) for connecting rod & High carbon steel and Forged steel for crankshaft.

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