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# Review on Engine Piston Thermal Failure

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***Abstract-*** *In this Paper the stress distribution is evaluated on the four-stroke engine piston by using FEA. The finite element analysis is performed by using FEA software. The piston ring is one of the main components of an internal combustion engine. Its main purposes are to seal the combustion chamber of the engine, minimize the friction against the cylinder liner but also transfer heat from the piston to the cooled cylinder liner. Another important property of the piston ring is to evenly distribute oil along with the cylinder liner to avoid engine seizure. Energy conservation and efficiency have always been the quest of engineers concerned with internal combustion engines. The diesel engine generally offers better fuel economy than its counterpart petrol engine. Even the diesel engine rejects about two-thirds of the heat energy of the fuel, one-third to the coolant, and one-third to the exhaust, leaving only about one-third as useful power output. Theoretically, if the heat rejected could be reduced, then the thermal efficiency would be improved, at least up to the limit set by the second law of thermodynamics. Low Heat Rejection engines aim to do this by reducing the heat lost to the coolant. Thermal Barrier Coatings (TBCs) in diesel engines lead to advantages including higher power density, fuel efficiency.*

*Keywords:-* Piston, Structural Analysis, Stress, Heat, FEA, TBC.

## I. Introduction

The piston is one of the most important parts of a diesel engine, operating conditions are difficult, as they are exposed to the influence of thermal load on the operating system. As the most important part of the engine, the operating conditions of the piston, are likely to significantly affect the health and performance of the engine, so it is very important to perform a thermal analysis on the engine piston. Nowadays, the piston field temperature analysis function includes: read the conditions of the thermal boundary and calculate the rate of heat transfer to the engine piston [1-4], in the predictable distribution of the constant state piston temperature in diesel engines [5-7]. Calculate the temperature and temperature fields of a diesel engine piston [8]. In this paper, we present the basic theory of thermal analysis, with thermal analysis in a diesel engine, including the piston temperature field and the software used to analyze the feature. We compared the estimated temperature of the piston in many key areas for the calculated results and repeatedly changed the temperature parameters and the coefficient of heat exchange. From the results of the analysis, we found that the higher temperatures of the piston and the starting point of the circular motion are good.

Introduction Dual-injection diesel engines are more profitable to the fuel economy as compared to petrol engines. This means that diesel engines are Eco-friendly and have greater potential in future emissions laws due to their low carbon dioxide ($CO_2$) emissions. On the other hand, diesel engines have difficulty lowering nitrogen oxide (NOx) and particle particles (PM), and higher power requirements and lower fuel consumption remain diesel engines installed in commercial vehicles, such as trucks and buses. To meet these requirements, current diesel engines are required to increase high turbocharging, high-pressure manifold, and to improve airflow in the piston firebox. These materials lead to high thermal loads, especially on pistons. Therefore, piston cooling has been one of the determining factors in the construction of an efficient engine and accurate prediction of piston temperature is also important.

Fig.1.1. **A piston skirt seizure.**

The manufacturing of cylinders includes boring, honing and plateau honing which has received much attention from manufacturers in recent times. The process of the surface changes which occur during the running of the engine is related to the wearing action caused by the piston ring on the bore. This action takes place of transitional topography, where the surface generated exhibits the influence of the piston ring which modifies the machined surface.

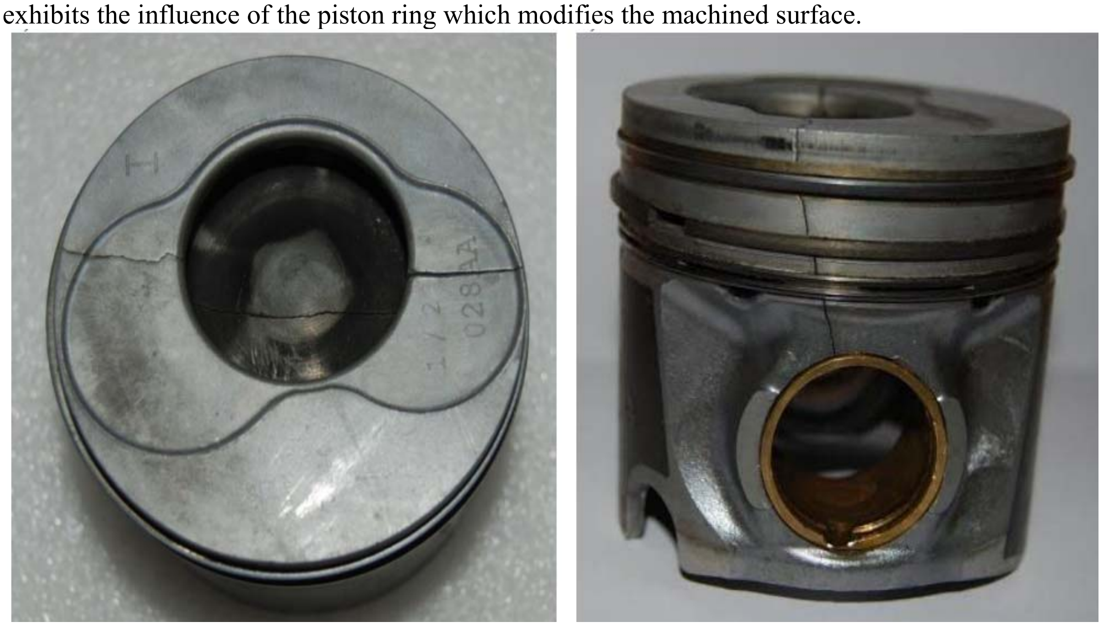

Fig.1.2. **A crack on the piston pin: a) cracked piston head; b) cracked piston skirt.**

## II. Literature Survey

Skopp, et al, [1] took a gander at the tribological lead of TinO2n−1 and TiO1.95−x coatings under lubed up conditions with uncoated case of dull cast press. The association of the sets with display motor oils in perspective of esters and polyglycols wereconsidered under mixed/confine oil using the BAM test strategy. Treatments were mechanical office fill motor oils, ester-containing oils with low-SAP (sulphur– ash– phosphor) and also bio-notox properties and furthermore polyglycole-based oils. Theester and polyglycole-based motor oils respond both to bio-no-tox criteria and were without polymer. They took after different frameworks to decrease zinc, phosphorus and sulfur to ensure a low searing stays content. In perspective of thecylinder ring/barrel liner multiplication BAM test outside of motors under conditions of mixed/restrain oil.

B. Zhang et al, [3] played out the outline and in addition test approval of a twofold acting freecylinder expander in which a slider-based control plot was utilized for understanding a full development process for theexpander. A model was created for deciding the geometric parameters of theexpander alongside the assistant blower. The outcomes demonstrated that theexpander worked steadily in an extensive variety of weight contrasts/proportions.

C. Friedrich an, et al, [4] directed investigations with covering advancement and model wear test results from PVD coatings on cylinder rings for burning motors. Cylinder rings were precedents for the use of thin movies usually utilized mechanical parts. The PVD CrxN coatings were saved by RF magnetron sputtering and portrayed by their basic mechanical properties like thickness, hardness, lingering pressure and bond, which are vital for the tribological conduct of thecovering substratecompound. Thecontact mechanics of the tribological framework cylinder ring– chamber were dictated by high mechanical stacking and changing geometry caused by the sliding kinematics. Subsequently, the scope of thickness was around 7 mm. Thechose rings were made of steel DIN 1.4112 (DIN X 90 Cr Mo V 18) with a drag breadth of 97.5 mm.

C.W. Huanga and C.H. Hsuehb [5]chose Piston-on-three-ball tests by the International Organization for Standardization to set up ISO 6872 for the assessment of the biaxial quality of dentistry– earthenware materials. The recipe received in ISO 6872 for thecrack load-biaxial quality relationship was an inexact condition initially inferred for cylinder on-ring trial of mono layered plates. This equation was changed and stretched out to the instance of multilayered circles subjected to cylinder on-ring loadings as of late. The motivation behind their examination was to assess the ampleness of applying the recipe for cylinder on-ring to cylinder on-three-ball tests for both mono layered and multilayered circles. Limited component investigations were performed to reenact both cylinder on-three-ball and cylinder on-ring tests. Diverse degrees of rubbing between theexamplesupporting surface and the stacking installation were considered in the reenactments. The outcomes relied upon contact when the plate was bolstered by a ring, anyway the outcomes ended up unfeeling to grinding when thecircle was upheld by three balls.

D. J. Picken and H. A. Hassaan [6] paper portrayed the hypothesis and utilization of a strategy for assessing the administration life of an inward ignition (i.c.) motor in view of test proof and the law of glue wear. A basic PC program portrayed, which anticipated the redesign life of an IC motor from its plan information and a run of the mill test of its specific running conditions. The utilization of the program for a motor generator set working on biogas at a ranch site utilized for instance. It was viewed as that the work revealed demonstrated that the farthest point of motor life happened when the wear of the barrel liner at the upper position of thecylinder ring ended up intemperate. In light of this, and accepting minimal oil here was conceivable to complete an estimation which anticipated motor life for some random application.

Dacheng Li, et al, [7] proposed a limit direction framework in light of a novel rotating control valve for responding refrigeration blower and intended out of the blue. The direction framework was mostly made out of a turning control valve and a versatile direction framework. The parameters for the plan and control of the revolving control valve are hypothetically decided. To confirm the achievability and viability of the proposed framework, a three-barrel responding blower was embraced as a test gadget. Exploratory outcomes demonstrated that the innovation could understand consistent stepless limit direction for the blower inside the scope of (0)10e100%, and control utilization diminished correspondingly with the heap decrease.

Dhananjay Kumar Srivastava et al,[8] firmly related theexecution of an ignition motor with the grating power and wear between chamber liner and cylinder rings. This grating power was fundamentally decreased by streamlining the surface geography of chamber liners. The analyses werecompleted for assessing wear and rubbing in mimicked motor conditions utilizing Cameron– Plint wear analyzers, Pin-on-plate analyzers, SRV analyzers, and so on. A non-terminating motor test system was created with a specificend goal to reproduce motor conditions to a closer degreecontrasted with these machines. This test system worked at comparable straight speed, stroke, and load as genuine motor and reproduced all motor working conditions, aside from terminating weights. Vitality dispersive investigation (EDS) was completed of liner and best ring for assessing materials exchange.

E.P. Becker and K.C Ludema [9] utilized a research center test system to recognize thecritical factors impacting barrel bore wear. Similar qualities of wear were seen in the test system as in running motors, despite the fact that the test system did not endeavor to copy every one of theconditions found inside a motor. Another photo of wear in barrels was exhibited, reliable with the information and past work on limit oil. The subjective model represented the advancement of the barrel running surface as far as creation and surfacechanges. The model was utilized to decide the relative significance of the numerous factors that can impact wear conduct, including commitments from ointment science, material properties, and mechanical stacking.

F.S. Silva [10] investigated theexhaustion harmed cylinders from petroleum/diesel motors, and vehicles including trains. The investigation of harms inception in thecylinder at thecrown, ring grooves, stick openings and skirt was evaluated. An evaluation was put forth through the Defenseexamines and additionally the investigation of the warm/mechanical exhaustion harms thecylinders. The pressure dissemination amid the ignition was resolved through the direct static pressureexamination, utilizing cosmos works". Worries at thecylinder crown, stick openings, scores and skirt was likewise decided. For the affirmation of the split inception locales, a fractographicexamine was additionally done. The weakness was an issue for the motor cylinders, in any case, it was not in charge of being the biggest piece of the harmed cylinders. Theconfinement of weight decrease advanced more slender dividers, which cause higher burdens. The need of fuel utilization decrease and more power was in inconsistency as another limitation.

G. Floweday et al, [11] Studed diesel motor cylinder disappointments, amid a seat dynamometer motor strength test, which was intended to assess the impacts of different energizes on the life of the fuel
framework segments in diesel motor autos. Amid the test, various cylinders, barrel heads and turbocharger disappointments wereexperienced. Theexamination went for finding the reasons of thecylinder disappointments amid the tests. Examination of the brokecylinders uncovered that because of intemperate thermo-mechanical stacking, thermo-mechanical weakness commencement occurred because of silicon stage splitting and resulting miniaturized scale break development. Smaller scale splits with dynamic arrangements prompt defects upto adequate size for starting theengendering by high cycle weariness systems.

Sunden and R. Schaub [12] displayed a determination of a portion of the more for all intents and purposes orientated standards of theeffective fabricate of dim cast press cylinder rings more prominent than 175 mm in distance across, and demonstrated that when considered with the sciences of quality of materials and diesel building, the subject of cylinder rings turns into an encapsulation of the moreextensive subject of tribology. A short portrayal of the most essential subjects of down to earth cylinder ring make, and a sign of the immense size and confounded nature of an industry which worries about one of the least expensive parts of a diesel motor has been given.

K Satish Kumar el al [13]In this Paper the stress distribution is evaluated on the four-stroke engine piston by using FEA. The finite element analysis is performed by using FEA software. The couple field analysis is carried out to calculate stresses and deflection due to thermal loads and gas pressure. These stresses will be calculated for two different materials. The results are compared for all the two materials and the best one is proposed. The materials used in this project are aluminum alloy, and SiC reinforced ZrB2 composite material. In this project, the natural frequency and Vibration mode of the piston and rings were also obtained and its vibration characteristics are analyzed.

Shahanwaz Adam Havaleel al. [14] As the main heating part in the engine, the piston works for a long time in high temperature and high load environment. The piston has the characteristics of a large heating area and poor heat dissipation, so the thermal load is the most serious problem. This thesis presents a numerical method using thermos-mechanical decoupled FEM (Finite Element Method) to calculate the thermal stress only caused by the uneven temperature distribution. In this work, the main emphasis is placed on the study of thermal behavior of functionally graded materials obtained through using a commercial code ANSYS on aluminum alloy piston surfaces. The analysis is carried out to reduce the stress concentration on the upper end of the piston i.e. (piston head/crown and piston skirt and sleeve).

Vinay V. Kuppast el al [15] The gas force due to the combustion in the cylinder of an IC engine will cause the piston to move with primary motion and secondary motion. The primary motion of the piston from TDC to BDC is linear. This motion is desired for the translation of motion of engine components. Secondary motion is due to the transverse motion of the piston while the piston moving from TDC to BDC and vice-versa. The secondary motion of the piston is considered as the main source for the piston slap, which in turn causes the impact on the cylinder walls resulting in engine vibration and noise. In the present study, an effort is made to understand the effect of the thermal load, generated by the combustion of fuel inside the cylinder, on the piston deformation and thermal stresses induced in the piston. This deformation of the piston inside the cylinder causes the gap between the cylinder and piston to vary and also the piston to move transversely along with impact forces. The transverse motion of the piston in the cylinder is observed experimentally by measuring the gap between the piston and cylinder at thrust side load conditions. Finite element analysis (FEA) is considered one of the best numerical tools to model and analyze physical systems. FEA is carried out to find the piston deformation due to thermal load on the piston for the temperature data obtained from experiments. The three-dimensional piston is modeled in CATIA V5 R19 and analyzed in ANSYS 12 solver. The simulation results are used to predict the effect of temperature on piston deformation and its secondary motion which are the principal source of engine vibration and noise.

S Pal el al [16] Energy conservation and efficiency have always been the quest of engineers concerned with internal combustion engines. The diesel engine generally offers better fuel economy than its counterpart petrol engine. Even the diesel engine rejects about two-thirds of the heat energy of the fuel, one-third to the coolant, and one-third to the exhaust, leaving only about one-third as useful power output. Theoretically, if the heat rejected could be reduced, then the thermal efficiency would be improved, at least up to the limit set by the second law of thermodynamics. Low Heat Rejection engines aim to do this by reducing the heat lost to the coolant. Thermal Barrier Coatings (TBCs) in diesel engines lead to advantages including higher power density, fuel efficiency, and multifuel capacity due to higher combustion chamber temperature easier for the manufacturers to choose the coating material for engine coating purposes and surface properties for operating them in their service period.

## III. **Objectives of the Research Work**

Piston rings have been in use for as long as combustion engines themselves. Despite this, ignorance or inadequate knowledge of piston rings is still frequently evident today. No other component is so critical when power loss and oil consumption are at stake. With no other component in the engine is the divide between expectations and utilized capital greater than when replacing piston rings. All too often, confidence in piston rings suffers due to the exaggerated demands made on them. As indicated earlier, structural designs of piston rings are not studied adequately. Hence, the scope of this project involves the following objectives:

A. Selecting appropriate two-wheeler piston rings for carrying out this study.

B. Analytical (structural) design of piston rings using analytical formulations available in the literature.

C. Finite Element Analysis of piston rings subjected to various loads acting on it.

D. Compare analytical and FE results.

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