ISSN : 2455-9679
SJIF Impact Factor : 6.008

ijrtsm

IJRTSM

INTERNATIONAL JOURNAL OF RECENT TECHNOLOGY SCIENCE & MANAGEMENT

"A STUDY DESIGN AND ANALYSIS ON PISTON OF DIESEL ENGINE BY USING FEA METHOD"

Anurag Singh Parihar [1], Trapti Sharma [2], Ranjeet Singh [3]

[1] *M.Tech Scholar , Dept. of Automobile Engineering, Rustamji Institute Of Technology, BSF Academy Tekanpur, MP, India*

[2,3] *Assistant Professor Dept. of Automobile Engineering, Rustamji Institute Of Technology, BSF Academy Tekanpur, MP, India*

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. 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 the cylinder liner in order to avoid engine seizure. There are two types of piston ring: compression ring and oil ring. Automobile reciprocating engines normally use three rings, two compression rings and one oil ring. Piston ring moves freely within its groove. Such movements depend on the forces and the moments acting on the piston ring system such as: the static ring tension from installation of piston ring in the cylinder liner, the gas pressure forces caused by cylinder pressure and blow-by gas, the hydrodynamic forces caused by lubricant film, the inertia forces related to component mass and engine speed, and asperity contact forces caused by a direct contact to the cylinder walls. Working conditions of piston rings are very demanding and it is desirable to understand the design of such component subjected to various loads. Recently, finite element analysis has played major role in automotive industry to design various components of automobile. Hence, With using computer aided design (CAD), software the structural model of a piston will be developed. this work aims to design and analyze the piston ring using commercial FEA tool like ANSYS. Structural designs of piston rings are not studied adequately. Hence, this work aims to study structural design and analysis of piston rings subjected to static loads.

Key Words: *Piston, Structural Analysis, Stress, CAD, FEA, ANSYS.*

I. INTRODUCTION

Piston as 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

ISSN : 2455-9679
SJIF Impact Factor : 6.008

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 (CO2) 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 turbo charging, 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 by manufacturers in recent times. The process of the surface changes which occurs during 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

ISSN : 2455-9679
SJIF Impact Factor : 6.008

This has been made possible by improving the design of piston and reducing the failure i.e. scuffing, sculling, seizure of piston etc. The piston is one of the continuous moving parts of engine, is of pivotal importance. Piston has high dynamic loaded speed and heavy reciprocating weight develop high inertia forces, which are undesirable. The following factors may be considered for proper functioning of piston in IC Engine:

1. The piston should have enormous strength and heat resistance properties to withstand gas pressure and inertia forces. They should have minimum weight to minimize the inertia forces.
2. The material of the piston should have good and quick dissipation of heat from the crown to the rings and bearing area to the cylinder walls. It should form an effective gas and oil seal.
3. Material of the piston must possess good wearing qualities, so that the piston is able to maintain sufficient surface-hardness unto the operating temperatures.
4. Piston should have rigid construction to withstand thermal, mechanical distortion and sufficient area to prevent undue wear. It has even expansion under thermal loads so should be free as possible from discontinuities.
5. Piston should form tribo-pairs and have high reciprocation speed without noise, minimum work of friction and have little or no tendency towards corrosion and pitting-up.

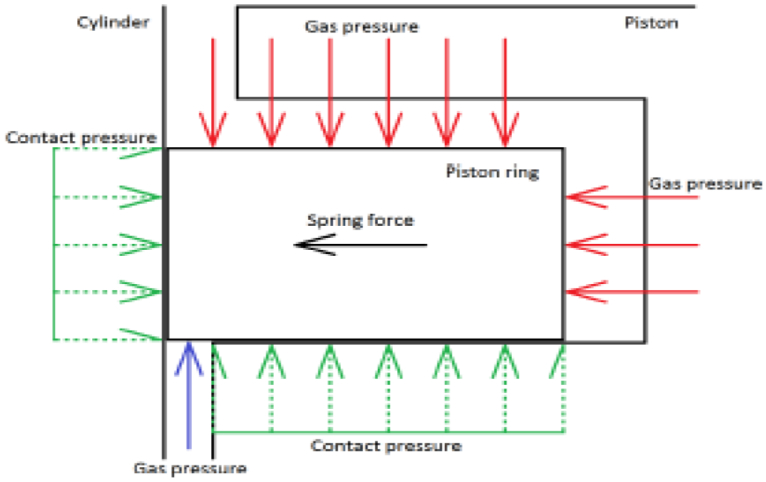

Fig.1.3 Force acting on Piston

II. LITERATURE REVIEW

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, [2] 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, [3] 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 on usually utilized mechanical parts. The PVD CrxN coatings were saved by RF magnetron sputtering and portrayed by their

ISSN : 2455-9679
SJIF Impact Factor : 6.008

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 [4] 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 wereconsidered 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 [5] 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, [6] 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,[7] 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 [8] 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.

ISSN : 2455-9679
SJIF Impact Factor : 6.008

F.S. Silva [9] 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, [10] 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 [11] 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 [12] 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 stres ses 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 aluminium alloy, and SiC reinforced ZrB_2 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. [13] As the main heating part in the engine, piston works for a long time in high temperature and high load environment. The piston has the characteristics of 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 by means of 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 [14] 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 in nature. This motion is desired for translation of motion of engine components. Secondary motion is due to the transverse motion of the piston while 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 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 piston and cylinder at thrust side load condition. Finite element analysis (FEA) is considered as one of the best numerical tools to model and analyze the physical systems. FEA is

ISSN : 2455-9679
SJIF Impact Factor : 6.008

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 effect of temperature on piston deformation and its secondary motion which are the principal source of engine vibration and noise.

S Pal el al [15] 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 choose the coating material for engine coating purposes and surface properties for operating them in their service period.

Subodh Kumar Sharma el al [16] Knowledge of piston and cylinder wall temperature is necessary to estimate the thermal stresses at different points; this gives an idea to the designer to take care of weaker cross section area. Along with that, this temperature also allows the calculation of heat losses through piston and cylinder wall. The proposed methodology has been successfully applied to a water-cooled four-stroke direct-injection diesel engine and it allows the estimation of the piston and cylinder wall temperature.The methodology described here combines numerical simulations based on FEM models and experimental procedures based on the use of thermocouples. Purposes of this investigation are to measure the distortion in the piston, temperature, and radial thermal stresses after thermal loading. To check the validity of the heat transfermodel,measure the temperature through directmeasurement using thermocouple wire at several points on the piston and cylinder wall. In order to prevent thermocouple wire entanglement, a suitable pathway was designed. Appropriate averaged thermal boundary conditions such as heat transfer coefficients were set on different surfaces for FE model. The study includes the effects of the thermal conductivity of the material of piston, piston rings, and combustion chamber wall. Results show variation of temperature, stresses, and deformation at various points on the piston.

F.S. Silva [17] Engine pistons are one of the most complex components among all automotive or other industry field components. The engine can be called the heart of a car and the piston may be considered the most important part of an engine. There are lots of research works proposing, for engine pistons, new geometries, materials and manufacturing techniques, and this evolution has undergone with a continuous improvement over the last decades and required thorough examination of the smallest details. Notwithstanding all these studies, there are a huge number of damaged pistons. Damage mechanisms have different origins and are mainly wear, temperature, and fatigue related. Among the fatigue damages, thermal fatigue and mechanical fatigue, either at room or at high temperature, play a prominent role. This work is concerned only with the analysis of fatigue-damaged pistons. Pistons from petrol and diesel engines, from automobiles, motorcycles and trains will be analyzed. Damages initiated at the crown, ring grooves, pin holes and skirt are assessed.

III. OBJECTIVE 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 in earlier, structural designs of piston rings are not studied adequately. Hence, the scope of this project involves following objectives:

1. Selecting appropriate two-wheeler piston rings for carrying out this study.
2. Analytical (structural) design of piston rings using analytical formulations available in literature.
3. Finite Element Analysis of piston rings subjected to various loads acting on it.
4. Compare analytical and FE results.

ISSN : 2455-9679
SJIF Impact Factor : 6.008

IV. Conclusion

1. Piston rings of reciprocating engines have several functions apart from sealing the gas pressure which affect performance of engine.
2. From literature it appears that piston ring can be designed using experimental, analytical and numerical techniques.
3. Structural design of piston rings using FEA is not studied adequately. Hence, design validation can be carried out using commercial FEA tools such as ANSYS, Abaqus, etc.

REFERENCES

1. Skopp a,1, N. Kelling a,1, M. Woydta,1, L.-M. Berger b,, Thermally sprayed titanium sub oxide coatings for piston ring/cylinder liners under mixed lubrication and dry-running conditions, Wear 262 (2007)1061–1070.
2. A. V. Sreenath And N. Raman, Running-In Wear Of A Compression Ignition Engine: Factors Influencing The Conformance Between Cylinder Liner And Piston Rings, Wear, 38 (1976) 271 –289.
3. B. Zhang, X. Peng ,Z. He, Z. Xing, P. Shu, Development of a double acting free piston expander for power recovery in trans critical CO2 cycle, Applied Thermal Engineering 27 (2007)1629–1636.
4. C. Friedrich a,,G. Berg a, E. Broszeit a, F. Rick b, J. Holland b, PVD CrxN coatings for tribological application on piston rings, Surface and Coatings Technology 97 (1997)661–668.
5. C.W. Huanga,, C.H. Hsuehb,c, Piston-on-three-ball versus piston-on-ring in evaluating the biaxial strength of dental ceramics, Dental materials 2 7 (2 0 1 1)e117–e123.
6. D. J. Picken; H. A. Hassaan, A Method for Estimating Overhaul Life of Internal Combustion Engines including Engines Operating, J. agric. Engng Res,28. (1983),139-147.
7. Dacheng Li a,, Haiqi Wub, Jinji Gao b, Experimental study on stepless capacity regulation for reciprocating compressor based on novel rotary control valve, International journal of refrigeration 36 (2013) 1701e1715.
8. Dhananjay Kumar Srivastava a, Avinash Kumar Agarwal a,,Jitendra Kumar b, Effect of liner surface properties on wear and friction in a non-firing engine simulator, Materials and Design 28 (2007)1632–1640.
9. E.P. Becker a,, K.C Ludema b, A qualitative empirical model of cylinder bore wear, Wear, 225-229 (1999)387-404.
10. F.S. Silva , Fatigue on engine pistons – A compendium of case studies, Engineering Failure Analysis 13 (2006) 480– 492.
11. G. Floweday a, S. Petrov b, R.B. Tait b,, J. Press c, Thermo-mechanical fatigue damage and failure of modern high performance diesel pistons, Engineering Failure Analysis 18 (2011)1664–1674.
12. H. Sunden and R. Schaub Ť , Piston rings for slow and speed diesel engines, Tribology International February1979.
13. K Satish Kumar[1] , "Design And Analysis Of I.C. Engine Piston And Piston-Ring On Composite Material Using Creo And Ansys Software" Journal Of Engineering And Science Vol. 01, Special Issue 01, July 2016
14. Shahanwaz Adam Havale[1], Prof. Santosh Wankhade[2] "Design, Thermal Analysis And Optimization Of A Piston Using Ansys" International Research Journal Of Engineering And Technology (Irjet)' Volume: 04 Issue: 12 | Dec-2017.
15. Vinay V. Kuppast, Dr.S.N.Kurbet, H.D.Umeshkumar, Adarsh B.C " Thermal Analysis of Piston for the Influence on Secondary motion" International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 3, Issue 3, May-Jun 2013, pp.1402-1407.
16. S Pal, A Deore, A Choudhary, V Madhwani and D Vijapuri" Analysis and experimental investigation of ceramic powder coating on aluminium piston" IOP Conference Series: Materials Science and Engineering,2017.
17. Subodh Kumar Sharma, P. K. Saini, and N. K. Samria " Experimental Thermal Analysis of Diesel Engine Piston and Cylinder Wall" Hindawi Publishing Corporation Journal of Engineering Volume 2015, Article ID 178652, 10 pages.

ISSN : 2455-9679
SJIF Impact Factor : 6.008

18. F.S. Silva "Fatigue on engine pistons – A compendium of case studies" Engineering Failure Analysis, Elsevier, 13 (2006), pp 480–492.