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A Review Study of Piston Thermal Analysis Using Finite Element Method

Azeem Khan, Asst. Prof. Amit Sharma
Department Mechanical Engineering
Shri Siddhi Vinayak Institute of Technology,
Bareilly.

Abstract- The preceding literature research detailed the internal combustion engines components, such as the piston. The piston transfers mechanical energy into the burned gas. The piston moves down the cylindrical line or sleeve. The design of a piston gasoline engine is the subject of current study. Engineers may use computer-assisted engineering equipment to update and design residual stress, structural response, thermal impacts, pre-treatment, and fatigue processing on the vehicle problem. By examining the analytical implications, we may determine if our planned piston is safe or no longer loaded. In the area of thermal assessment, many authors studied thermal flow and thermal temperature distribution. Wind energy generation is simulated using MATLAB/ SIMULINK in power system block set.

Keywords:- Internal Combustion (IC) Engines, Performance, Heat Transfer, Temperature Field of the Piston.

I. INTRODUCTION

A piston is part of the translation engine, which translates between other comparable machinery pumps, compressors and cylinders. It is the shifting element placed in a cylindrical position and is fuel proof by piston ring construction.

The piston is mechanically powered to transfer the energy of burned gases. Pistons are usually constructed in aluminium or forged iron materials, which are translated into cylinder lines or sleeves.
The study examines the architecture of a motorcycle piston gasoline engine.

Computer-assisted engineering systems allow engineers to set out and simulate residual pressure, structural reaction, thermal effects, pre-processing and influence of tiredness on the vehicle component.

This may assist people working in a steady state thermal assessment field to examine the thermal flux, thermal temperature distribution researched by different writers in the field of thermal testing.

II. FUNDAMENTAL OF PISTON

A piston is a cylindrical metal cylinder that operates throughout the cylinder to push the fluid within the cylinder. The pistons have rings on them to keep the gasoline and air out of the combustion chamber. The piston's earrings may be seen on the majority of cylindrical columns.

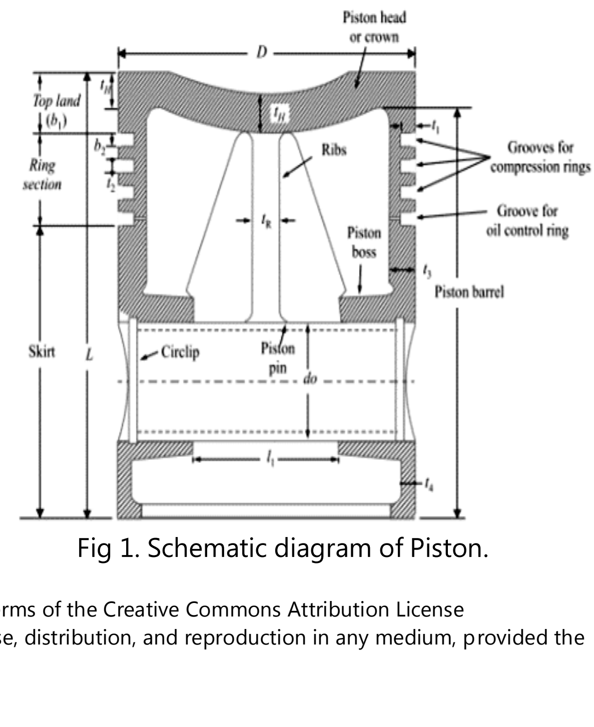

Fig 1. Schematic diagram of Piston.

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In general, compression spring rings act as a seal between pistons and cylinder walls, with one or more oil rings controlling the compression earrings. In any other scenario, the column head may be flat, lumpy, or stylish. It is possible to utilize cast or cast pistons. The piston's form, on the other hand, may be single-species.

Figure 2 depicts the piston engine's components. Hypereutectic pistons are a special kind of solid column. A piston engine and pneumatic hydraulic systems are both built around the piston.

The piston's heads form one of the walls of a cylindrical spreading chamber. The cylindrical head has inlet and exhaust valves for gases on the opposite wall. The energy from the expansion of a combustible fuel in the form of a linear reciprocal movement, typically a mixture of pets or diesel and air, is converted into mechanical energy as the piston moves inside the cylinder. The force is then transmitted to a cursor shaft through a rod and converted into a rotor movement, which is typically used to drive a gearbox via an engagement.

III. LITERATURE STUDY

A piston is found in reciprocating motors, pumps, compressors, and pneumatic cylinders in devices that are similar. It is the shifting element that is positioned in a cylindrical position and is made of fuel-resistant piston rings. The rising gas's energy is converted into mechanical energy by the piston. Inside the cylinder liner or sleeve, the pistons are often made of aluminum or forged iron alloys.

A motorbike piston gasoline engine will be studied as part of the donation research. Engineers may use computer-aided engineering software to design and simulate residual pressure, structural reactions, thermal implications, and pre-processing and post-processing fatigue designs on a vehicle component. The thermal flow and thermal distribution, which are discussed in a review of various thermal assessment authors, may be useful to individuals working in the area of constant thermal evaluation of pistons.

R. Sabarish et. al. (2019) this investigation of aluminum alloy pistons includes thermal analysis. For most of the twentieth century, internal combustion engines offered relatively inexpensive and reliable power sources for a broad range of applications, from domestic to industrial and transportation. DI Diesel engines have clearly outperformed all other engines in terms of thermal efficiency in both light- and heavy-duty vehicles. However, when the piston approaches TDC, the bowl shape has a significant impact on airflow, resulting in better atomization, mixing, and combustion.

Pistons, being the motor's main heating element, work at high temperatures and loads for extended periods of time. The piston has a large heating surface and poor heat dissipation, making it the most severe thermal load problem. The main goal of these experiments is to investigate the thermal behavior of functionally graded materials using the commercial ANSYS code on aluminum allocation piston surfaces. CREO software is used to build a structural model of a piston. In addition, ANSYS software is used to do the continuous thermal analysis. Simulations assisted by computers.

Krishnan et al. [2017] They have spent around a year researching lightweight materials such as advanced, high-strength steels, aluminium and magnesium alloys, plastics, and carbon-fiber reinforced materials. The piston's life is extended by using a new aluminium composite matrix that is the most vulnerable in the form of particulate carbide and that, with the exception of a minor difference in characteristics known as Al 6061 alloy, has the same overall performance in the strengthening of silicon carbide.

Aluminum and silicon carbide are used to create and test the piston in a 2:3 ratio. A parametric version of a piston is created using Autodesk Inventor, a 3-D modeling software. The ANSYS Workbench software tool also analyses its deformation behavior. The piston is composed in extremely harsh conditions and can resist large weights. It also provides a good preservation of strength for ageing. The temperature distribution of both pistons under strong loads is excellent. The Al SiC piston is chosen first because of its cheap and lower pressure and distortion.

Sinha et. Al. [2017] Piston was numerically examined using the ANSYS Workbench programmed to assess its thermo-methanorial capabilities under a given thermal and structural stress. To improve engine efficiency, the weight of the piston has been reduced by optimizing unique dimensions. In this optimization system, the pressure was further reduced to a safe level, and the process was carried out using the Solid Works software.

In order to improve the overall thermal performance of the piston, thermal barrier coatings (TBCs) were applied and their thermal mechanical performance evaluated using a couple field evaluations in ANSYS.

Gopal et. al. [2017] The mechanics of the piston, clamp rod, and crank shaft of a four-wheeled petrol engine were investigated. The components of the assembly must be stiff, and the assembly must move as a mechanism. As a result, the research should include a bendy-body evaluation and bendy-body analysis.

Since the engine reciprocals, the forces within the components must be calculated and these forces are utilized to determine the dynamic stresses inside the portion of concern, i.e. it is suggested that the components of the assembly be replaced with two new sets of materials, and that the parameters be checked using static, dynamic, and thermal evaluations.

The main components of the assembly, namely the engine piston, connecting rod, and crankshaft, are modeled and constructed according to the provided design in this research. ANSYS is used to do the Finite Element Analysis. Hyper Mesh is used to mesh the data.

Shehanazet. al. [2017] Thermal tests are performed on a piston constructed of Cast Aluminum and Titanium alloys. The ANSYS workbench is then used to conduct structural studies on titanium alloy and aluminum alloy pistons. The impact of the pistons' thermal behavior is studied. The primary goal is to study and evaluate the thermal stress distribution of the piston in an actual engine throughout the combustion process. This research continues by estimating the component's greater stress and critical region using finite element analysis.

ANASYS software is used to evaluate the column for thermal loads and mechanical loads in order to determine a displacement, thermal and stress suitability for the piston. The results are shown that when the piston is under the thermal load, the temperature transfer takes place at the top point of the piston and the pest is optimally stressed when the piston is attached to the thermal structure.

Pandey et. al. [2016] ANSYS software was used to investigate 4-stroke, S.I. engine piston design, evaluation, and optimization that is powerful and lightweight. Solid piston model has been applied using ANSYS 16.2 Geometric module, as well as Thermo-Mechanical (status structural analysis + steady state thermal analysis) to analyze stresses, general distortion, and factor of the distribution of safety in numerous sections of the piston in order to understand the impact due to gasoline strain and thermal version.

The Surface Response module was enhanced by Piston. The thickness of the piston barrel is lowered through 52.28%, the thickness of the crown head of the column is accelerated by 9.41%, the breadth of the top terrain, extended by 3.81%, the ring's axial thickness is accelerated by 2.38% and the radial thickness of the ring reduced through 5.31%.

Rao et. al. [2016] The piston model is being researched. The use of unigraphics and the results obtained by producing pistons using a vortex technique and aluminum-based mmc containing 5, 10, 15, and 53 micrometer fly ash particles are shown. We used the stir casting method to create the required form and complexity. Following casting, the component is subjected to suitable machining to get the desired form.

The findings indicate that this technique enhances the performance of the automobile. It is found that the revised piston model has more consequences than the original model. The tensions are decreased inside the redesigned model. Furthermore, the piston's stress is decreased in this version, while the piston's dependability increases. The conventional model and the modified model vary in terms of hardness, wear, and friction, as evaluated by various tests.

Vishal et. al. [2016] The piston ingredients have been tested to see how they affect the engine's overall performance and the piston's power. In both substances, the depth of tension on the bottom surface of the column is greatly expected. The maximum displacement is absorbed at the top of the pistons 4032 and A2618. Because of the thermal conductivity of the materials, the piston's largest temperature range is defined, and the entire maximum thermal flow of both materials is absorbed.

For comparison between alloys, somewhat comparable findings are determined. As a result, further study using advanced chemicals and other optimization tools may be conducted.

Venkata reddy et. al. [2016] They looked into the necessity to research the piston in order to improve engine performance. Pistons made mostly of alloy steels that exhibit grate resistance in the face of thermal and structural stresses.

For the assessment of structural load and thermal evaluation, we use our 2016 Solid Working Software Program to build a piston, using the use of various materials and piston composites in our ANSYS workbench software programmed.

Sundaram et. al. [2016] The 3D Model produced by CREO was examined after CAE study was conducted using the Ansys 14.5 and the thermal analysis was carried out with three distinct materials (Al 10% SiC, AL 20% SiC and AL 30% SiC).

From the results of ANSYS, it seems that aluminum with 10% SiC materials, better than aluminium alloys, with better temperature distribution, is thus the best appropriate piston-friendly aluminium of 10% SiC thermal analyze with 10% SiC material Aluminum with 10% SiC Material.

Attar et. al. [2016] Thermal stress reduction may be a key consideration in the design of the piston or piston head, which was investigated and evaluated using ANSYS software.

The main aim of this study is to improve the column's performance by lowering the piston weight. The substance of the piston has been decreased. After then, the piston obtained the finest feasible result. The piston skirt may also seem to have distorted during operation, resulting in a fracture at the piston head's top.

Due to deformation, the upper end of the piston is under the most stress. The problem worsens if the piston's stiffness is not always adequate, and the splitting typically happens at point A, which may also be split step by step and even with the vertical piston.

The distribution of stress on the piston is mostly due to column deformation. As a consequence, the piston curve has to be rigid enough to minimize distortion and therefore strain awareness.

John et. al. [2015] Aluminum Silicon Carbide (AlSiC) was studied in depth, and an aluminum matrix composite was developed for use in aluminum applications. A three-dimensional model was translated to CATIA v6 using ANSYS 14, and structural and thermal analyses were performed.

In contrast to aluminum, AlSiC offers excellent abrasion resistance, creep strength, dimensional balance, stiffness-to-weight ratios that are extremely acceptable, and excellent overall temperature performance. Manufacturing of pistons the usage of aluminum is very straight forward.

Devan et. al. [2015] They were looking for the heat distribution of different column materials. Because pistons are one of the most important and complex components of an internal combustion engine, it is critical to keep them in good working order. Pistons, in particular, are prone to failure in hot environments.

Different piston materials are considered in order to get the best heat dispersion. The AlSiC composite reduces total heat flow as compared to Al-Si, Al-Mg-Si, and Alloy, according to the evaluation impacts of different materials on the piston. The introduction of carbides in AlSiC alloys reduced the heat flux the greatest.

Sonar et. al. [2015] A thermal piston research was carried out, and certain procedures had an effect on the piston. The maximum allowable stress was applied, which may have caused the piston to deform. The variables that have the greatest influence on the piston have been investigated. The distribution of tension on the piston is mostly determined by piston deformation.

As a result, the piston crown should be stiff enough to minimize deformation and therefore stress awareness. Because the temperature has a strong influence on the deformation and pressure of the piston, the piston temperature should be reduced as the structure grows. KIRLOSKAR ENGINE employs the layout criteria in this study. If the piston industry uses these prototypes to build a piston, the present piston length and effectiveness may be better than the everyday piston design.

Singh et. al. [2015] The study was conducted with the aid of software CATIA and SOLIDWORKS, three-dimensional strong piston version, including the piston pin. The distribution and deformations of thermal stress, mechanical stresses and couplings are computed. Following this fatigue study, safety and the presence of the column assembly using ANSYS workbench software are investigated. A piston material is utilized as aluminum-silicon composite.

The findings of stress analysis also help improve the early architecture of the factor and also help reduce the time needed to manufacture the component and its value. The findings computed additionally indicate that the maximum thermal load is 96,014 MPa and that the maximum explosive pressure of the gasoline is 210,75 MPa. This fact shows that the explosive tension of gas fuel is the main driver of stress.

Srinadh et. al. [2015] They were studying to develop a 1300cc piston diesel engine and to bring three unique profile rings. The computations are a 2D graphic. The rings of piston and piston models the use of the software Pro/Engineer, The piston and piston rings are evaluated by using stress in structural analysis for the pressure and displacement. If you look at the consequences of analysis, you can decide whether or not our planned reverse load scenario is safe or not.

Temperature flow and the distribution of thermal temperatures is evaluated in the thermal analysis by using the temperatures on the piston. In addition, the structural and thermal study was conducted on the Cast iron, Aluminum Alloy A360 and Zamak piston and piston earrings version. By comparing each the cloth analysis and determining which tissue is best for piston and piston ring manufacturing. In addition to the programmed ANSYS, structural and thermal analysis was carried out.

Prasanth et. al. [2015] The thermal performance of the piston was evaluated using a composite steel matrix. Stir casting is being utilized to create an Al-Sic-graphite spectrum for usage in metal particle composites. The graphite expansion level is a measurement of how much graphite expands. While the allocation rate varies between 3-5wt%, SiC stays constant (i.e. 5 percent). The criteria were followed while assessing brinnel hardness, tensile homes, and composite effect energy. The network is susceptible to simple uniform appropriation due to micro structural representation. The addition of graphite to a composite has been demonstrated to increase its hardness by up to 5%. It was also believed that the graphite in Al amalgam contributed to the composite tension being enhanced by the composite tensile strength. The piston was designed using CATIA modeling, and finite element analysis was performed on the same model using pure aluminum and al-SiC software.

IV. CONCLUSION

The piston plays a major role in the engine performance; the piston material is made up of impacts on the strength of the piston. The maximum stress intensity is on the bottom surface of the piston crown in both the materials, as it is expected. Maximum displacement is absorbed on the top of the piston of aluminum alloy and grey cast iron Highest value of maximum temperature found in piston is due to thermal conductivity of the materials and the total maximum heat flux is absorbed in both the piston materials.

Thus, further research can be carried with the advance materials and different designing, analysis tools. Designs for which the analyses are carried out, the stresses and total deformations observed in concave shaped piston are larger than the convex shaped piston. So this justifies the usage of concave or cup shaped pistons in IC Engines which use diesel as fuel and for large sized engines.

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