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Performance Enhancement of Automobile Piston Through Weight Reduction via Static Structural Analysis-A Review Study

Ravi Kumar[1], Akshay Anand[2], B.S. Choudhary[3]
[1]M.Tech Student, Department of Mechanical Engineering, Millennium Institute of Technology, Bhopal (M.P.)
[2,3] Faculty, Department of Mechanical Engineering, Millennium Institute of Technology, Bhopal (M.P.)

Abstract:

Piston is an integral part of any automobile. Piston moves in a to and fro direction (between TDC & BDC or IDC to ODC) based on the position of engine assembly in order to control the in-flow & out-flow of the charge from the engine assembly. Piston is generally made from mild steel or aluminium alloy. When made from mild steel, weight of piston remains higher which needs to be lowered by changing the material of the piston. Current research paper revies several previous studies conducted in the concerned field. Results of the study conclude that piston has remained one of the prominent components as far as their optimization is concerned. Study also finds that several studies focusing on optimization of piston have been conducted. Composite materials have been identified as the probable substitute for the conventional material which is used for piston.

Keywords: *Piston, automobile, engine assembly, weight reduction, Composite materials, optimization*

Introduction

Automobile, byname auto, also called motorcar or car, a usually four-wheeled vehicle designed primarily for passenger transportation and commonly propelled by an internal-combustion engine (ICE) using a volatile fuel. For the propulsion purpose a fuel is burned inside the fuel and this burning of fuel is called combustion.

An internal combustion engine (ICE or IC engine) is a heat engine in which the combustion of a fuel occurs with an oxidizer (usually air) in a combustion chamber that is an integral part of the working fluid flow circuit. In an internal combustion engine, the expansion of the high-temperature and high-pressure gases produced by combustion applies direct force to some component of the engine. The force is applied typically to pistons, turbine blades, a rotor, or a nozzle. This force moves the component over a distance, transforming chemical energy into useful kinetic energy and is used to propel, move or power whatever the engine is attached to. This replaced the external combustion engine for applications where weight or size of the engine is important.

In contrast, in external combustion engines, such as steam or Stirling engines, energy is delivered to a working fluid not consisting of, mixed with, or contaminated by combustion products. Working fluids for external combustion engines include air, hot water, pressurized water or even liquid sodium, heated in a boiler.

A piston is a component of reciprocating engines, reciprocating pumps, gas compressors, hydraulic cylinders and pneumatic cylinders, among other similar mechanisms. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. In an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod and/or connecting rod. In a pump, the function is reversed and force is transferred from the crankshaft to the piston for the purpose of compressing or ejecting the fluid in the cylinder. In some engines, the piston also acts as a valve by covering and uncovering ports in the cylinder.

An internal combustion engine is acted upon by the pressure of the expanding combustion gases in the combustion chamber space at the top of the cylinder. This force then acts downwards through the connecting rod and onto the crankshaft. The connecting rod is attached to the piston by a swivelling Gudgeon pin (wrist pin). This pin is mounted within the piston: unlike the steam engine, there is no piston rod or crosshead (except big two stroke engines).

Structural analysis is the determination of the effects of loads on physical structures and their components. Structures subject to this type of analysis include all that must withstand loads, such as buildings, bridges, aircraft and ships. Structural analysis employs the fields of applied mechanics, materials science and applied mathematics to compute a structure's deformations, internal forces,

stresses, support reactions, accelerations, and stability. The results of the analysis are used to verify a structure's fitness for use, often precluding physical tests. Structural analysis is thus a key part of the engineering design of structures.

Literature Review

A. Nandha Kumar et al. (2019) In the present work describes the stress distribution and thermal stresses of Five different materials for piston by using finite element method (FEM), testing of mechanical properties. The parameters used for the simulation are operating gas pressure, temperature and material properties of piston. The specifications used for this study of these pistons belong to four stroke single cylinder engine of Bajaj Kawasaki motorcycle. The results predict the maximum stress and critical region on the different materials piston using FEA. Design by using Catia v5 software and analysis by using Ansys software in Ansys 15 Static and thermal analysis is performed. The suitable material is selected based on results of structural and thermal analysis on these Al-sic graphite, A7075, A6082, A4032, AL-ghy 1250 materials.

Ajay et al. (2018) The main purpose of the preliminary analyses presented in the book is to compare the behavior of the combustion engine piston made of different types of material under thermal load. FEA analysis is carried out using ANSYS software. Development of the finite element analysis model is also presented. The piston is loaded by a temperature field inside it. Appropriate average thermal boundaries conditions such as temperature were set on different surfaces of the 3D model. In this work, thermal analysis is investigated on a conventional diesel engine piston, made of multiple material at the multiple times. Using transient thermal workspace, we calculate heat flux in the piston and the temperature distribution on it. The analysis is carried out to know the thermal and mechanical load effect on the upper end of the piston, so that using this data we can increase life of the piston.

Amitanand B Suralikerimath et al. (2016) I.C engine piston is one of the most important and complex components in the engine. It is also sometimes referred as the heart of engine. It is widely used mainly in automotive and mechanical fields hence, a detailed study on its static behavior is important. This paper emphasizes on the static analysis of the piston head of a 4-stroke I.C engine. In the present work piston head is designed using CATIAV5R20 and this model is analysed in ANSYS 14.5 and a study on its static behavior is performed. Aluminium alloy has been selected as piston material for structural analysis. The theoretical stress values obtained is compared with the stress values obtained after the analysis in ANSYS 14.5.

CH. Venkata Rajam et al. (2013) An optimized piston which is lighter and stronger is coated with zirconium for bio-fuel. The low grade LHR engines are using ceramic coatings on piston, liner and cylinder head, while medium grade LHR engines provide air gap in the piston and other components. It is necessary to test the coated piston for withstanding the stresses and strains. In this paper, the coated piston undergone a von misses test by using ANSYS for load applied on the top. Analysis of the stress distribution was done on various parts of the coated piston for finding the stresses due to the gas pressure and thermal variations. Von misses stress is increased by 16% and deflection is increased after optimization. But all the parameters are well with in design consideration.

Durkaieswarn P et al. (2021) The main objective of this research work is to investigate and analyze the stress distribution of piston at actual engine condition. In this paper pressure analysis, thermal analysis and thermo-mechanical analysis is done. The parameter used for the analysis is operating gas pressure, temperature and material properties of piston. In I.C. Engine piston is most complex and important part therefore for smooth running of vehicle piston should be in proper working condition. Piston fails mainly due to mechanical stresses and thermal stresses. Analysis of piston is done with boundary conditions, which includes pressure on piston head during working condition and uneven temperature distribution from piston head to skirt. The analysis predicts that due to temperature whether the top surface of the piston may be damaged or broken during the operating conditions, because damaged or broken parts are so expensive to replace and generally are not easily available. The CAD model is created using PRO- E software. CAD model is then imported into ANSYS software for geometry and meshing purpose. The FEA performed by using ANSYS. Piston using thermal analysis and static analysis applied the temperature, pressure difference material like aluminium alloy and cast iron.

G.V.N. Kaushik (2019) In IC engine, Piston is one of the most important and complex part. With increasing power and performance of engine, higher thermal load and the thermal stresses are acting on piston, thereby, decreasing its life time. It is important to maintain Piston in good condition in order to maintain the proper functioning of the engine. Piston mainly fails due to thermal Conditions. In this paper 3D model of piston is developed, structural and thermal analysis is done by

ANSYS using 5 different materials to find out the temperature and thermal stress distribution, theoretically finding the total heat flux and compare with the practical values of different Piston Materials used.

Gopal, G. et al. (2017) The paper deals with study of an assembly of the Piston, Connecting rod and Crank shaft of a four-wheeler petrol engine. The components of the assembly have to be rigid and the assembly has to move as a mechanism. Hence, the analysis should involve a rigid-body analysis and flexible-body analysis. So, the forces in the components as the engine reciprocates have to be calculated and these forces are used to calculate the dynamic stresses in the component of interest i.e., the connecting rod. It is proposed to replace with two new sets of materials for the components of the assembly and check the parameters by performing the static, dynamic and thermal analysis. In this project, the main parts of the assembly i.e., engine piston, connecting rod and crankshaft are modelled and assembled as per the given design. And the Finite Element Analysis is done in Ansys. The meshing is done in Hypermesh.

Haixiang Yang et al. (2021) Piston secondary motion not only influences the side knocking of piston and frictional loss, but also influence the in-cylinder oil consumption and gas blow-by. An inline four-cylinder common rail diesel engine was chosen as the research object. Dynamic simulation model of piston assembly was built based on the piston and cylinder liner temperature field test. The impacts of pinhole offset, liner clearance and piston skirt ovality on piston secondary motion were researched. Based on the surface response method, the influence of multiple factors on friction power loss and slapping energy is estimated. The results indicate that: in-cylinder stress condition of piston will change with its structural parameters, then the secondary motion of piston will be affected as a result. Pinhole offset, liner clearance, piston skirt ovality and the interaction of the latter two all have significant effects on the friction power loss, while the slapping energy is significantly affected by liner clearance. Therefore, the parameters can be designed based on the significance level to optimize the secondary motion characteristics of the piston.

Hashim sheikh et al. (2020) In the present work, optimization of IC engine's piston with different materials has been done on the model of the piston with actual specifications of a two-wheeler vehicle. The modelling has been performed on CATIA V5R12 software and further analyses have been carried out on ANSYS thermal analysis workbench. The expected outcome from this project was to find the thermal load that is minimum temperature and maximum heat flux over the surface, and an attempt has been made to minimize the thermal load by optimizing the piston material to get some fruitful advantages. After analyses, it has been found the piston material AL 2024-T4 gives better temperature condition (239.29°C) but poor heat flux (0.39753 W/mm2) so this material is suggested for light or moderate vehicles where material AL 1100-O gives better heat flux (0.47726 W/mm2) but worst temperature condition (305.65°C) so this material is recommended for heavy vehicles.

IZUKA, R. C et al. (2020) Piston plays a very critical role in energy conversation as far as internal combustion engines are concern. Piston is a major component of the internal combustion engine and directly bears the high temperature and pressure developed due to combustion of fossil fuel in the combustion chamber. As a result, the piston is subjected to high thermal and structural stresses due to high temperature, reciprocating speed and loads fluctuations. If these stresses exceed the designed values, piston failure will occur. In this work, Aluminium alloy have been selected for structural and thermal analysis of piston and the stresses due to high combustion temperature are analysed using finite element method in order to predict areas of the piston susceptible to failure. The piston in this work is designed using SOLID WORKS and imported to ANSYS R19.1 software for thermal and structural analysis. The result obtained shows that finite element method offers a reliable means to predict failure characteristics of an aluminium alloy piston. The finite element result analyses indicate that the maximum stress is $3.2566 \times 106Pa$ and the maximum expected deformation is 1.7852mm.

J. Sunil et al. (2016) Automobile components are in great demand these days because of increased use of automobiles. The increased demand is due to improved performance and reduced cost of these components. R&D and testing engineers should develop critical components in shortest possible time to minimize launch time for new products. This necessitates understanding of new technologies and quick absorption in the development of new products. A piston is a moving component that is contained by a cylinder and is made gas-tight by piston rings. In an engine its purpose is to transfer from expanding gas in the cylinder to the crank shaft via piston rod and or connecting rod. As an important part in an engine piston endures the cyclic gas pressure and temperature at work and this working condition may cause the damage of the piston. The investigations indicate that greatest stress appears on the upper end of the piston and stress concentration is one of the mainly reason due to high temperature and pressure of fuel. The

features of the piston are piston head, piston pin bore, piston pin, skirt, groove ring, ring land and piston ring. Finite Element Analysis is a simulation technique which evaluates the behavior of components, equipment and structures for various loading conditions including applied forces, pressures and temperatures. Thus, a complex engineering problem with non-standard shape and geometry can be solved using finite element analysis where a closed form solution is not available. The finite element analysis methods result in the stress distribution, displacements and reaction loads at supports for the model. Finite element analysis techniques can be used for a number of scenarios as example mesh optimization, design optimization, material weight minimization, shape optimization and code compliance. Finite element analysis also has the capability to perform FEA for aircraft components, automotive components, engine components and other mechanical / structural components. The design for various components is checked for compliance against the ASME Code or other appropriate code. Finite Element Analysis is performed for both design and analysis / evaluation situations. Two-dimensional and three-dimensional FEA problems is addressed for structural, thermal, and thermal stress evaluations.

Jatender Datta et al. (2017) This paper describes the Thermal (Steady state) analysis of cast iron, cast alloy steel and carbon graphite pistons by using finite element Analysis (FEA). The parameters used for the simulation are operating gas temperature and material properties of pistons. The specifications used for the study of these pistons belong to four stroke 100cc hero bike engine. This paper illustrates the procedure for analytical design of cast iron, cast alloy steel and carbon graphite pistons using specifications of four stroke 100cc hero bike engine. The results predict the minimum and maximum value of GRADN: Resultant Temp Gradient on all of these pistons using FEA with applied the temperature 100°C on the top of piston. The 3Dmodelling of piston is done in Solidworks (Feature module) and Simulation module was used to mesh the pistons, thermal analysis with temperature applied on the top of piston head.

Kunal Saurabh (2017) This paper deals with the past literature survey which shows that in internal combustion engine components like piston, connecting rod and crankshaft are worked together more efficiently and more accurately. Here the materials are highly compared to their previous materials which are used in these components. This study deals with the various loads which are acting on these different-different components on their main loading sections. The objectives of this paper are to study costs and materials optimization with the help of stress analysis by FEA technique. The designation material of these components is steel alloy.

L. R. Pachpande et al. (2019) Piston plays a main role in energy conversion. Failure occurred of piston due to various thermal and mechanical stresses. The working condition of the piston is so worst in comparison of other parts of the internal combustion engine. The main objective of this work is to investigate and analyze the stress distribution of piston. Design and analysis of an IC engine piston using three different materials that are used in this project. Taking pulsar 220cc piston for making 3D model. Analysis is carried out on aluminium alloy have been selected for structural and thermal analysis of piston. In this project find that the value of displacement, Stress and Factor of safety of all 3 material. This result is compared. Finally find out which one is the suitable material on piston in these three materials. Design of the piston is carried out using CATIA v5, static analysis is performed using ANSYS 12 by Finite Element Analysis (FEA).

Lokesh Singh et al. (2015) A piston is a component of reciprocating engines. Its purpose is to transfer force form expanding gas in the cylinder to the crank shaft via piston rod and a connecting rod. It is one of the most complex components of an automobile. In some engines the piston also acts as a valve by covering and uncovering ports in the cylinder wall. In present, work a three-dimensional solid model of piston including piston pin is designed with the help of CATIA and SOLIDWORKS software. The thermal stresses, mechanical stresses and couples' thermo-mechanical stresses distribution and deformations are calculated. After that fatigue analysis was performed to investigate factor of safety and life of the piston assembly using ANSYS workbench software. Aluminium-silicon composite is used as piston material. The stress analysis results also help to improve component design at the early stage and also help in reducing time required to manufacture the piston component and its cost.

Mr. Jadhav Vishal et al. (2016) Recent advancement of technology leads to complex decision in the Engineering field. Thus, this paper entails the design and analysis of an IC engine piston using two different aluminium materials that are competitive in market. Piston plays a main role in energy conversation. Failure of piston due to various thermal and mechanical stresses is common and so expensive to replace. The specifications used for this work is related to four stroke single cylinder engine of Hero Karizma ZMR motorcycle. Design of the piston is carried out using SOLIDWORKS software, thermal and stress analysis is performed using Finite

Element Analysis (FEA). The best aluminium alloy material is selected based on thermal and stress analysis results. The analysis results are used to optimize piston geometry of best aluminium alloy

Mr. Ratnakar Lande et al. (2021) FEA is used in this research to describe the stress distribution of a seizure on a piston four stroke engine. Computer-aided design (CAD) software is used to do the finite element analysis. The major goal is to explore and analyse the thermal stress distribution of the piston during the combustion process in a real engine. The mesh optimization is described in this study, which uses a finite element analysis technique to anticipate the component's greater stress and critical region. The piston's upper end, which includes the piston head/crown, as well as the piston skirt and sleeve, is optimised to reduce stress concentration. The structural model of a piston will be developed using computer-aided design (CAD) and Pro/ENGINEER software. Furthermore, the finite element analysis was carried out with the ANSYS software.

Mr. Sajid Tamboli et al. (2018) Gudgeon pin connects the piston and the small end of the connecting rod of engines. The wear of the Gudgeon pin and connecting rod concern for the company. In this Way frictional stress and Von-mises stresses are produced on Pin and they are determined by finite element analysis tool ANSYS. Fatigue life of pin is determined using fatigue analysis tool.

P. Viswabharathy et al. (2017) In this paper, the wok is carried out to measure the stress and temperature distribution on the top surface of the piston. In I.C. Engine piston is most complex and important part therefore for smooth running of vehicle piston should be in proper working condition. Pistons fail mainly due to mechanical stresses and thermal stresses. Analysis of piston is done with boundary conditions, which includes pressure on piston head during working condition and uneven temperature distribution from piston head to skirt. The analysis predicts that due to temperature whether the top surface of the piston may be damaged or broken during the operating conditions, because damaged or broken parts are so expensive to replace and generally are not easily available. The CAD model is created using CREO3.0 TOOL. CAD model is imported into the Hyper Mesh for geometry cleaning and meshing purpose. The FEA is performed by using RADIOSS. The topology optimization of the model is done using Opti Struct module of Hyper Works software.

Pagadala Siddiraju et al. (2021) In the present work describes the stress distribution and thermal stresses of Five different materials for piston by using finite element method (FEM), testing of mechanical properties. The parameters used for the simulation are operating gas pressure, temperature and material properties of piston. The specifications used for this study of these pistons belong to four stroke single cylinder engine of Pulsar 220cc motorcycle. The results predict the maximum stress and critical region on the different materials piston using FEA. Design by using Catia v5 software and analysis by using Ansys software in Ansys 16.0 Static and thermal analysis is performed. The suitable material is selected based on results of structural and thermal analysis on these Al-sic graphite, A7075, A6082, A4032, AL-ghy 1250 materials.

Prashant Kumar et al. (2019) The cylinder is one among the most basic parts in a reciprocating Engine, reciprocating siphons, gas blowers and pneumatic barrels, among other comparable mechanisms in which it changes over the substance imperativeness acquired by the consuming of fuel into supportive (work) mechanical control. The present proposition manages the properties of cylinder material identified with heat. Primary issue anticipated that would be found in the framework of the broad cylinder is the distortion, because of weight and temperature. The glow starting from the exhaust gases will be the essential reason for deformation. The most critical part is that less time is required to outline the cylinder and only a couple.

R. SABARISH et al. (2019) In this study thermal analysis on piston made of aluminium alloy are absorbed Internal combustion engines have been a relatively inexpensive and reliable source of power for applications ranging from domestic use to large scale industrial and transportation applications for most of the twentieth century. DI Diesel engines, having the evident benefit of a higher thermal efficiency than all other engines, have served for both light- duty and heavy-duty vehicles. But when the piston moves towards Top Dead Centre (TDC), the bowl geometry has a significant effect on air flow thereby resulting in better atomization, better mixing and better combustion. 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. In this work, the main emphasis is placed on the study of thermal behaviour of functionally graded materials obtained by means of using a commercial code ANSYS on aluminium alloy piston surfaces. Using CREO software the structural model of a piston will be developed. Furthermore, the steady state thermal analysis is done using Computer Aided Simulation software ANSYS.

Rishu Kumar et al. (2020) FEA approach is used in this study to analyze the performance of piston with different material and compression ratio. Staticthermo based FEM technique is used using ANSYS. Aluminium alloy and SiC-reinforced ZrB2 composite material is selected for analysis and performance comparison. The model of piston is designed in CATIA software. Stress, strain, deformation, temperature and heat flux were the main performance characteristics. Results indicate that performance of SiC reinforced ZrB2 piston is found better than aluminium alloy piston in terms of Stress, strain, deformation, temperature and heat flux.

S N Kurbet et al. (2013) The engine vibration is considered as the major source of engine noise which deteriorates the engine performance and increases the pollution. The noise from the engine comprises of mechanical and combustion noise. Combustion noise is primarily due to rapid pressure fluctuations in the combustion chamber. The mechanical noise is due to mechanical impact forces during both motions of piston viz. primary and secondary motions. In this study the effect of the piston secondary motion is taken for the analysis considering combustion pressure contributing to the dynamics of the piston. The Kirloskar Diesel Engine is considered for the present study. The geometrical modeling of the engine is done using CATIA V-5 modeling tool. The finite element meshing is done using Hypermesh 9.0 meshing tool. This work analysis is carried out in ANSYS 10 commercial finite element analysis software. To understand the complex behavior of the piston in motion relative to the other engine parts, viz., connecting rod, crankshaft, a Multi Body Dynamic (MBD) analysis is carried out. This analysis showed the occurrence of piston tilt near TDC and BDC. The stress and displacement results are viewed and analysed using HyperView. The analysis results can effectively be used to optimize piston geometry and hence lateral forces are minimized to obtain minimum tilt of the piston. The minimization of the piston tilt eventually leads to the reduction of engine noise.

S. Bhattacharya et al. (2014) Due to the inherent nature of combustion in the Cylinder of a Conventional Internal combustion engine, stress variation as well as a certain temperature distribution sets up in the entire piston. Analysis of piston is required because of its shape and it is subjected to both structural and thermal loads. In the present study, piston of a two-stroke spark ignition internal combustion engine having maximum power of 6.5 kW at 5500 RPM, has been designed and analysed. The piston made up of Aluminium 4032 alloy is designed by conventional approach and then both thermal and transient structural analysis have been carried out. The piston has been modelled in CATIA and analysed using ANSYS Workbench. In order to improve the design of piston, two alternative designs have been considered by providing openings at the skirt region of the piston. The analysis showed that this modification improved the thermal performance of the piston. An alternative design with large openings at the skirt region showed the best thermal performance.

S. Rajakumar et al. (2020) A design of piston of an internal combustion engine involves selection of appropriate materials. The piston material needs to have great fatigue resistance and good heat transfer properties with low weight. The results of structural and thermal calculations using finite element analysis are compared on aluminium alloy, carbon graphite and tungsten as piston materials. The theoretical value of stress is used to find the mechanical strength of materials. The total heat fluxes on the materials are also used to estimate their thermal behaviors. It is found that either carbon graphite or tungsten may be used instead of aluminium alloy.

Sachin S Raj et al. (2018) The cylinder liner and piston rings having frictional losses in the account of 20% of mechanical losses. The frictional losses can be reduced in the piston rings and cylinder liners, it causes higher efficiency and lower fuel consumption. The piston, piston rings and cylinder liners can also work at the higher temperatures and higher pressures and it reduces the frictional losses. In this project the design of piston, piston rings and cylinder liners are modelled in solid works 2015. The design of the engine parts is complex and efficiency is related to the type of material. The material is taken as ALUMINIUM-FLYASHALUMINA composite. Here the analysis is made in the ANSYS 14.5 software where structural and thermal analysis of the piston can be determined.

Sandeep K. Kourav et al. (2015) This paper describes the stress distribution of the piston four stroke engines by using FEM. The main objectives are to investigate and analyze the thermal stress and maximum or minimum principal stresses, Vanishes stresses distribution on engine piston at the real engine condition during combustion process. The paper describes the optimization techniques with using finite element analysis technique (FEM) to predict the higher stress and critical region on that component. The stress concentration on the piston head, piston skirt and sleeve are reduced by optimization with using computer aided design, Pro-E/Creo software the structural model of a piston will

be developed. Furthermore, the FEM analysis is done using Computer Aided Simulation software.

Sheikh Naim Sheikh Yusuf et al. (2015) This paper describes the stress distribution of two different aluminium alloys piston by using CAE Tools. The specifications used for the study of these pistons belong to four stroke single cylinder engine of Bajaj Pulsar 150cc motorcycle. This paper illustrates the procedure for analytical design of two different aluminium alloy pistons. The results predict the maximum stress and critical region on the different aluminium alloy pistons using CAE Tools. It is important to locate the critical area of concentrated stress for appropriate modifications. A parametric model of Piston is modelled using PTC Creo Parametric 2.0 software and analysis of that model is carried out by using ANSYS 14.5 Software. The best aluminium alloy material is selected based on parameters like Von misses Stress and strain, Deformation, Factor of safety and weight reduction for two-wheeler piston were done in ANSYS 14.5 software.

Shuoguo Zhao (2012) The piston is a "heart" of the engine and its working condition is the worst one of the key parts of the engine in the working environment. So, it is very important for structural analysis of the piston. This paper analyses and calculates the piston by Pro-E software to gain a result, which improves and optimizes the structure of the piston.

Siliveri Naresh et al. (2015) this project mainly deals with the design and analysis of I.C engine piston. Piston is a component of reciprocating engines, reciprocating pumps, gas compressors and pneumatic cylinders among other similar mechanisms.in an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod or connecting rod. Here the piston is designed, analysed and the manufacturing process has been studied. Piston temperature has considerable influence on efficiency, emission, performance of the engine. Purpose of the investigation is measurement of piston transient temperature at several points on the piston, from cold start to steady condition and comparison with the results of finite element analysis.in this project the piston is modelled and assembled with the help of CATIA software and component is meshed and analysis is done in ANSYS software and the thermal and static behaviour is studied and the results are tabulated. The various two materials aluminium alloy A360 and alloy 242.in this project work has been taken up on the following aspects to cover the research gaps to present the results based on the systematic studies. Temperature distribution and heat flow through the piston of the engine, FEA analysis of the piston to measure temperature at the points where it is not possible to find out practically and to observe the heat flow inside the piston.

Vaishali R. Nimbarte et al. (2015) The main objective of this research work is to investigate and analyze the stress distribution of piston at actual engine condition. In this paper pressure analysis, thermal analysis and thermo-mechanical analysis is done. The parameter used for the analysis is operating gas pressure, temperature and material properties of piston. In I.C. Engine piston is most complex and important part therefore for smooth running of vehicle piston should be in proper working condition. Piston fails mainly due to mechanical stresses and thermal stresses. Analysis of piston is done with boundary conditions, which includes pressure on piston head during working condition and uneven temperature distribution from piston head to skirt. The analysis predicts that due to temperature whether the top surface of the piston may be damaged or broken during the operating conditions, because damaged or broken parts are so expensive to replace and generally are not easily available. The CAD model is created using PRO-E software. CAD model is then imported into ANSYS software for geometry and meshing purpose. The FEA performed by using ANSYS12.

Vinay V. Kuppast et al. (2013) 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 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 modelled in CATIA V5 R19 and analysed 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.

Yash Dhamecha et al. (2020) This paper describes the comparative study of pistons made of three different materials by using Finite Element Method (FEM) and attempts to figure out whether the material used in the piston of supercars can be used in a motorbike or not. The parameters used for the simulation are operating gas pressure, temperature and material properties of piston. The specifications used for the study of these pistons belong to four stroke single cylinder engine of Bajaj Pulsar 220 cc. This project illustrates the procedure for analytical design of two aluminium alloy and one titanium alloy piston. The dimensions are obtained and a 3-D CAD model on CREO 3.0 is prepared. Static structural and thermal stress analyses are performed by using ANSYS 16.0. The results predict the maximum stress and critical region on the pistons using FEA. The best material is then selected on basis of these results and a comparison is made with the titanium alloy to find out whether the titanium alloy is suitable for motorbikes or not.

Yenugupalli Anil Kumar et al. (2017) Piston is the one of the most important components of the engine. We should use light weight material like Aluminium, Titanium to design the piston so as to reduce the weight because improved engine designs require optimized engine components. Along with less weight of the piston, rejection of waste also has a great concern. If we could eliminate the excess heat before it heats up engine components, we can improve component life by eliminating thermal stress and cooling requirements, for this purpose ceramic pistons are developed, these pistons are very costly but they don't conduct heat and are prone to thermal stress We all know that cost of high strength metals is very high so use of automobile components made with high strength alloys is limited to luxuries and sports cars, so, we need low-cost designs. It is impossible to make a low-cost design using high strength super alloy to meet the design requirements. So, we are proposing a tri metallic design to reduce the cost and improve life of the component in this study we are developing a tri - metallic piston, the dimensions of the piston are taken by reverse engineering using a re-bored piston, models of a regular piston and bimetallic piston and tri metallic piston are prepared using Catia and are tested under same boundary conditions in Ansys. Several combinations of tri metals are used and design modifications are done to minimize the stress and deformations in the piston without effecting its purpose. This study is mainly concentrated on thermal deformations induced in the piston sub assembly.

Conclusions

Several previous studies have been conducted in order to optimize the overall performance enhancement through weight reduction of piston using Static structural analysis for different alternate materials. Some of the prominent conclusions drawn from studying previous researches are presented here for reference-

- Several researches have already been conducted for optimization of automobile pistons via Static Structural Analysis on ANSYS. Most of the researches have focused on using materials like Aluminium Alloy, composite materials & alloys of some other materials.
- Most of the studies have focused on conducting Software simulation and analysis for the given purpose.
- In most of the previous analysis aluminium alloys have emerged to be the alternate material for conventional material.
- Several modelling softwares like CATIA, Solidworks, Creo etc. have been used for modelling purposes.
- Most of the times, two heelers have been employed for analysis purpose. Analysis for other types of automobiles have very seldom been seen.

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