REVIEW PAPER ON DESIGN AND ANALYSIS OF IC ENGINE PISTON WITH DIFFERENT MATERIAL

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Abstract:
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

***Key words*:**
FEA, FEM, Piston, Stress, thermal analysis, Al-sic graphite A7075

1. Introduction

The piston is a "heart" of an automobile engine. It is one of the main components of the engine and is in difficult conditions. The piston's function is to maintain the pressure of the gas pressure, causing the crankshafts through the piston rod. The pistons are working at high temperature, high pressure, high speed and poor lubrication. The instantaneous temperature of up to 2500 K can be directly connected to the piston with the gas at a high temperature. Due to the high temperature in a fitting design, the temperature of the surface of the piston can reach 600 ~ 700K when the piston is functioning on the engine and the temperature is unjustifiable. The upper part of the piston supports the gas pressure, in particular the work pressure.

2. Literature Survey

An optimized piston which is lighter and stronger is coated with zirconium for bio-fuel. In this paper [1], 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 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 PRO-E software. CAD model is then imported into ANSYS software for geometry and meshing purpose. The FEA performed by using ANSYS12. [2] In this present work a piston and piston ring are designed for a single cylinder four stroke petrol engine using CATIA V5R20 software. Complete design is imported to ANSYS 14.5 software then analysis is performed. Three different materials have been selected for structural and thermal analysis of piston. For piston ring two different materials are selected and structural and thermal analysis is performed using ANSYS 14.5 software. Results are shown and a comparison is made to find the most suited design [3] This paper describes the stress distribution and thermal stresses of three different aluminum alloys piston by using finite element method (FEM). 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 Kawasaki motorcycle. This paper illustrates the procedure for analytical design of three aluminum alloy pistons using specifications of four stroke single cylinder engine of Bajaj Kawasaki motorcycle. The results predict the maximum stress and critical region on the different aluminum alloy pistons using FEA.

It is important to locate the critical area of concentrated stress for appropriate modifications. Static and thermal stress analysis is performed by using ANSYS 12.1. The best aluminum alloy material is selected based on stress analysis results. The analysis results are used to optimize piston geometry of best aluminum alloy [4] This paper describes the stress distribution and thermal stresses of three different aluminum alloys piston by using finite element method (FEM). 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 Kawasaki motorcycle. This paper illustrates the procedure for analytical design of three aluminum alloy pistons using specifications of four stroke single cylinder engine of Bajaj Kawasaki motorcycle. The results predict the maximum stress and critical region on the different aluminum alloy pistons using FEA. It is important to locate the critical area of concentrated stress for appropriate modifications. Static and thermal stress analysis is performed by using ANSYS 12.1. The best aluminum alloy material is selected based on stress analysis results. The analysis results are used to optimize piston geometry of best aluminum alloy. [5] In this study, firstly, thermal analyses are investigated on a conventional (uncoated) diesel piston, made of aluminium silicon alloy for design 1 and design 2 parameters. Secondly, thermal analyses are performed on piston, coated with Zirconium material by means of using a commercial code, namely ANSYS. The effects of coating on the thermal behaviours of the pistons are investigated. The finite element analysis is performed by using computer aided design software. The main objective is to investigate and analyze the thermal stress distribution of piston at the real engine condition during combustion process. This thesis describes the mesh optimization by using finite element analysis technique to predict the higher stress and critical region on the component. In this work, the main emphasis is placed on the study of thermal behaviour of functionally graded coatings obtained by means of using a commercial code, ANSYS on aluminium and zirconium coated aluminium 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). With using computer aided design NX/Catia software the structural model of a piston will be developed. Furthermore, the finite element analysis is done using Computer Aided Simulation software ANSYS.

3. Project Overview

1. **Have sufficient mechanical strength and stiffness.**
2. **Can effectively block the heat reached the piston head.**
3. **High temperature corrosion resistance.**
4. **Dimensions as compact as possible, in order to reduce the weight of the piston.**

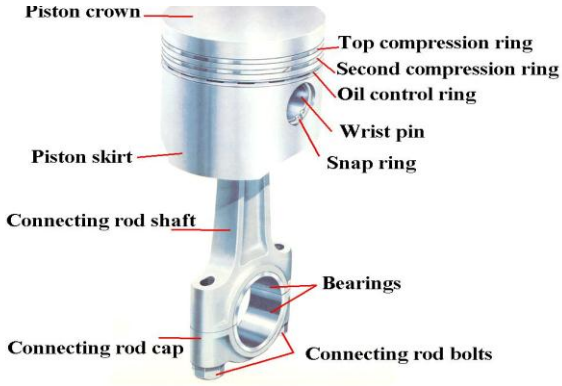

Figure 3.1 Piston Design features

3.2 Properties of Materials:

3.2.1 AL4032:

Aluminum alloys are known for strong corrosion resistance. These alloys are sensitive to high temperatures ranging between 200 and 250°C (392 and 482°F), and tend to lose some of its strength. However, the strength of Aluminium/Aluminum alloys can be enhanced at subzero temperatures, making them ideal low-temperature alloys. Aluminium/Aluminum 4032 alloy is a wrought alloy type. The following datasheet will provide more details about Aluminium/Aluminum 4032 alloy.4032 aluminum is an alloy of aluminum, further classified within the 4000 series (aluminum-silicon wrought alloy). It is typically furnished in the T6 temper. 4032 is the Aluminum Association (AA) designation for this material. In European standards, it will typically be given as EN AW-4032. Additionally, the EN chemical designation is AlSi12,5MgCuNi. And the British Standard (BS) designation is DTD324B.

3.1.1. AL6082:

Aluminium alloy6082 aluminium alloy is an alloy in the wrought aluminium-magnesium-silicon family (6000 or 6xxx series). It is one of the more popular alloys in its series (alongside alloys 6005, 6061, and 6063), although it is not strongly featured in ASTM (North American) standards. It is typically formed by extrusion and rolling, but as a wrought alloy it is not used in casting. It can also be forged and clad, but that is not common practice with this alloy. It cannot be work hardened, but is commonly heat treated to produce tempers with a higher strength but lower ductility.

3.3.3 AL7075:

Aluminum alloy 7075 is an aluminum alloy, with zinc as the primary alloying element. It is strong, with a strength comparable to many steels, and has good fatigue strength and average machinability. It has lower resistance to corrosion than many other Al alloys, but has significantly better corrosion resistance than the 2000 alloys. Its relatively high cost limits its use to applications where cheaper alloys are not suitable. 7075 aluminum alloy's composition roughly includes 5.6– 6.1% zinc, 2.1–2.5% magnesium, 1.2–1.6% copper and less than a half percent of silicon, iron, manganese, titanium, chromium, and other metals. It is produced in many tempers, some of which are 7075-0, 7075-T6, 7075-T651.

3.3.4 AL-SIC graphite material:

Preparation of AL-SICGRAPHITES SPECIMEN Stir Casting technique is a method of producing composite materials, in which a scattered stage (fired particles, short filaments) is blended with a liquid metal by method for mechanical mixing with the help of stirrer. The liquid state composite material is cast by permanent die casting method. In this Stir casting technique has been used to prepare the work-piece samples of Al-Sic-Graphite hybrid metal matrix Composite material and accomplish the required properties of that composite material. The vortex stir casting is best approach to create an accurate mixing of the silicon carbide and graphite material in the matrix, the aluminium material was stacked in a crucible and it was placed into a resistance furnace at various temperature levels.

Figure 1.0 AL-SIC graphite

S.NO	Parameters	Al-sic graphite	A7075	A6082	A4032
1	Density (kg/m^3)	2711.4	2761.9	2700	2684.95
2	Poisons ratio(μ)	0.34	0.33	0.33	0.3
3	Young's modulus (Gpa)	74	73	71	82
4	Ultimate Tensile strength (Mpa)	193.38	512	330	380
5	Thermal Conductivity (k)(w/m°C)	147	130	180	154
6	Specific heat (J/Kg°c)	826	860	890	870

Table 2 Material Properties

3.3 Problem Identification:

A piston is a component of reciprocating IC-engines. 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. Piston endures the cyclic gas pressure and the inertial forces at work, and this working condition may cause the fatigue damage of piston, such as piston side wear, piston head cracks and so on working condition of the piston of an internal combustion engine is so worst are high chances of failure of piston due to wear and tear. So there is necessary to analyze area of maximum stress concentration, strain, deformation and temperature distribution and heat flux on piston. The objective of the present work is to design and analysis of piston made UP of A4032, Al-GHY1250,AL6082,AL7075,ALSIC GRAPHITE.

4. Experimentation:

4.1 Structural Static Analysis:

A static analysis calculates the effects of study loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time varying loads. A static analysis can however include steady inertia loads and time varying loads that can be approximated as static equivalent loads. Static analysis is used to determine the displacements, stresses, strains and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed, i.e. the loads and the structure's responses are assumed to vary slowly with respect to time. The kinds of loading that can be applied in static analysis include:

4.2 Procedure of Static Analysis and Thermal Analysis:

Create the geometry in catia workbench and save the file in igs format and open ansys workbench apply engineering data (material properties), create or import the geometry, apply model (meshing), apply boundary conditions(setup) shown the results(stress, deformation, heat flux).

4.3 Analysis of Piston:

Frictionless support at pin bore areas and fixed all degree of freedom. Downward pressure (18.66 MPa) due to gas load acting on piston head. The piston is analyzed by giving the constraints they are Pressure or structural analysis and Thermal analysis.

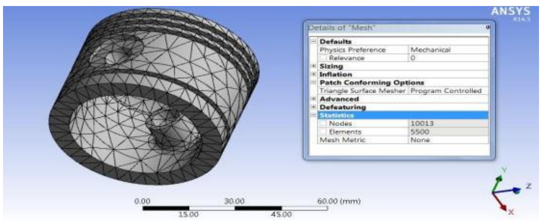

Figure 4.1 Mesh body

4.4 Structural Analysis of Piston: Combustion of gases in the combustion chamber exerts pressure on the head of the piston during power stroke. The pressure force will be taken as boundary condition in structural analysis. Fixed support has given at surface of pin hole. Due to the piston will move from TDC to BDC with the help of fixed support at pin hole. So whatever the load is applying on piston due to gas explosion that force causes to material.

4.5 Boundary conditions and in static analysis:

i. Maximum pressure load at the top surface of the piston crown 18.66 Mpa

ii. Temperature at the top surface of the piston crown 1400 K

iii. Piston pin holes are fixed DX = DY = DZ = 0

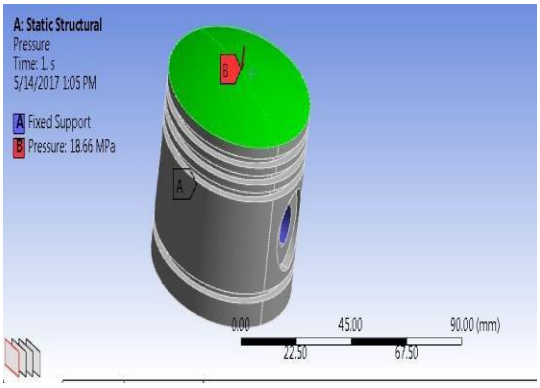

Figure 4.2 Boundry conditions of static analysis

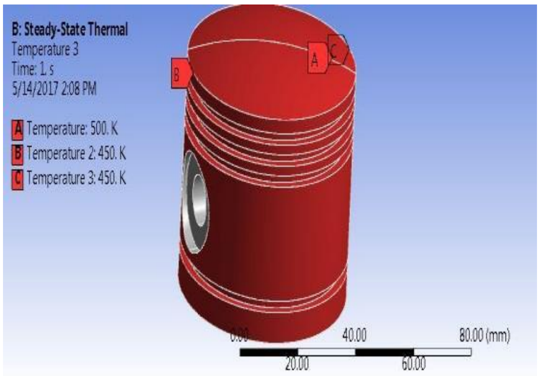

Figure 4.3 Boundary conditions of thermal analysis

5. Results and Discussion:

The constructed piston in catia is analyzed using ANSYS V15.0 and the results are depicted below. Combustion of gases in the combustion chamber exerts pressure on the head of the piston during power stroke. Fixed support has given at surface of pinhole. Because the piston will move from top dead center to bottom dead centre with the help of fixed support at pinhole.

6. **Conclusion:**

In structural analysis, and in thermal analysis the pistons were analyzed to find out the equivalent (von-mises) stress, equivalent elastic strain, total deformation heat flux and temperature distribution. The suitable material can be based on the result of structural and thermal analysis on the Al-sic graphite A7075,A6082,A4032,AL-ghy1250 material.

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