THERMAL ANALYSIS OF ALUMINIUM COMPOSITE PISTON

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ABSTRACT

In an automobile engine, piston plays a major role in generating power as well as transferring power to the crankshaft. In order to increase the efficiency of the engine, we need to concentrate more on design or material used for the piston. In this paper we are investigating and concentrating on selecting a material for the piston which suitably fits and makes the engine more efficient and increase the efficiency. In order to increase the efficiency, we are concentrating on ceramic for the piston which increase the life as well as effectiveness of the piston . Here we analyzed the piston using Aluminium-Nickel Chromium and Aluminium-Silicon Nitride, then compared both the materials for selecting the most preferable material. We modeled the piston using CATIA v5R20 and analyzed using ANSYS 18.1.

Keywords: *I.C Engine, Ceramic, Thermal analysis*

INTRODUCTION

The I.C Engine was developed in the year 1800s. In Internal Combustion engine the chemical energy is converted to thermal energy and then to mechanical energy. Thus the invention of Internal Combustion engine leads to evolution of many technologies around us. And also this Internal Combustion engine helps in transforming industries and transportation. This helps in growth of industries like automobile, manufacturing, etc,.

The Internal Combustion engine, compressors, pneumatic cylinders etc, comprises piston within the cylinder. The piston is a component that moves within the cylinder against the walls during all strokes, and the major function of a cylinder is to transfer energy from the expansion stroke to the crank shaft through connecting rod

The increased usage of automobiles increases the demand for the engine components. This increased need the engine component is because of reduction in cost and improvised performance. This asks the R&D and testing engineers to develop the engine components as fast as possible to introduce in the market. As an important component in an engine the piston has to withstand inertial stresses and high thermal stress that is occurred during the combustion stroke. Exposure to this stresses often lead to fatigue damage and failure.

LITERATURE SURVEY

DESCRIPTION:

Sachin et al. (2019) stated in their paper about the investigation and analyze of 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.

DESCRIPTION:

K. VenkataReddy et al. stated 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.

DESCRIPTION:

V. Krishnamoorthi et al.(2017) describes the stress distribution of the piston four stroke engines by using FEM. The main objectives isto investigate and analyze the thermal stress and maximum orminimum 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-ENGINEER/ CREO software the structural model of a piston will be developed. Furthermore, the FEM analysis is done using Computer Aided Simulation software.

DESCRIPTION:

M. Rakshith et al.(2019) states the 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.

DISCRIPTION:

A.R. Baker et al(1987) stated component of reciprocating engines, reciprocating pumps, compressors 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. The piston transforms the energy of the expanding gasses into mechanical energy. The piston rides in the cylinder liner or sleeve. Pistons are commonly made of aluminum or cast iron alloys. The present project to design a piston for 1300cc diesel engine car and taken 3 different profile rings. A 2D drawing is created from the calculations. The piston and piston rings are modeled using Pro/Engineer software, the stress and displacement are analyzed for the piston and piston rings by applying pressure on it in Structural analysis. By observing the analysis results, we can decide whether our designed piston is safe or not under applied load conditions. The thermal flux, thermal temperature distribution is analyzed by applying temperatures on the piston surface in Thermal analysis. The structural and thermal analysis were also done on the piston and piston rings model using Cast iron, Aluminum Alloy A360 and Zamak. By comparing both the material analysis and decided which material is better for piston.

OBJECTIVE

To select and analyze a material for its ability to withstand thermal stresses, which can be most suitably preferred for piston material.

PROBLEM STATEMENT

The piston material should be highly resistant to wear and tear resistant which ensures increased lifetime of the piston and it should also have good thermal conductivity.

METHODOLOGY

MATERIAL AND ITS PROPERITIES

MATERIAL : Aluminium-Silicon Nitride(Al-si_3N_4)

PROPERITIES :

- Highly resistance to wear and tear (increased life-time)
- Good Thermal Conductivity (70W/mK)

ANSYS ANALYSIS OF PISTON

Aluminium-Silicon-Nitride:

HEAT FLUX

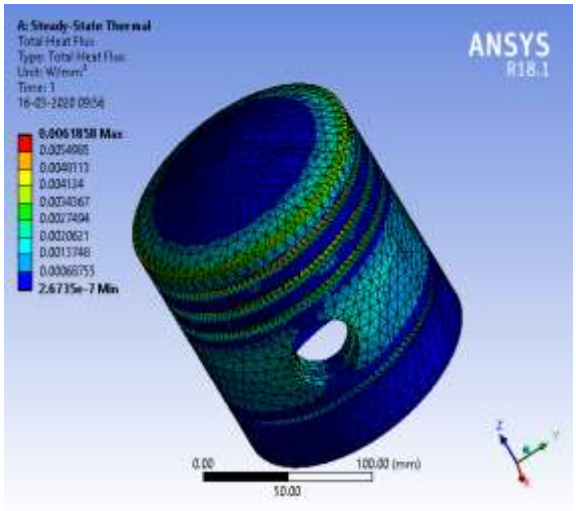

Fig.1

DIRECTIONAL HEAT FLUX

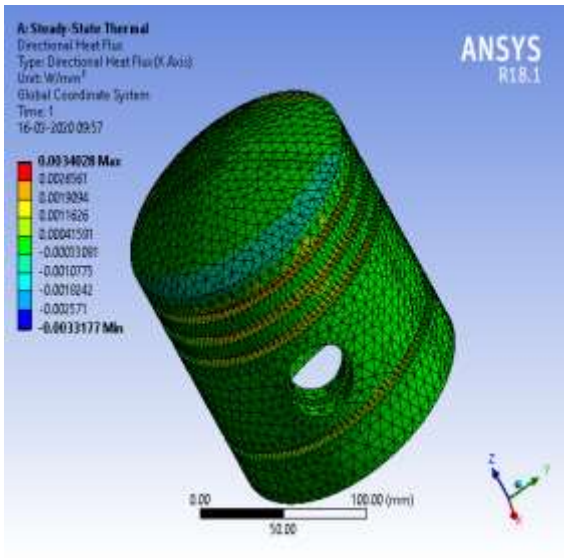

Fig.2

TEMPERATURE DISTRIBUTION

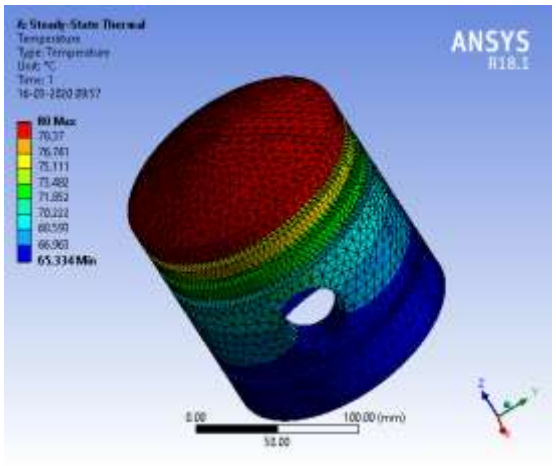

Fig.3

Aluminium-Nickel-Chromium:

TOTAL HEAT FLUX

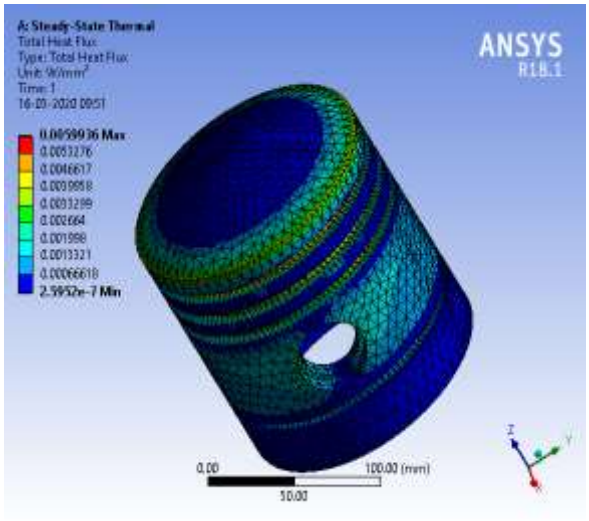

Fig.4

DIRECTIONAL HEAT FLUX

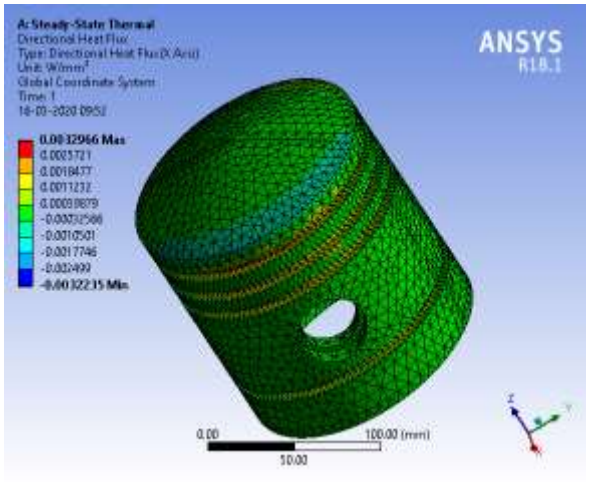

Fig.5

TEMPERATURE DISTRIBUTION

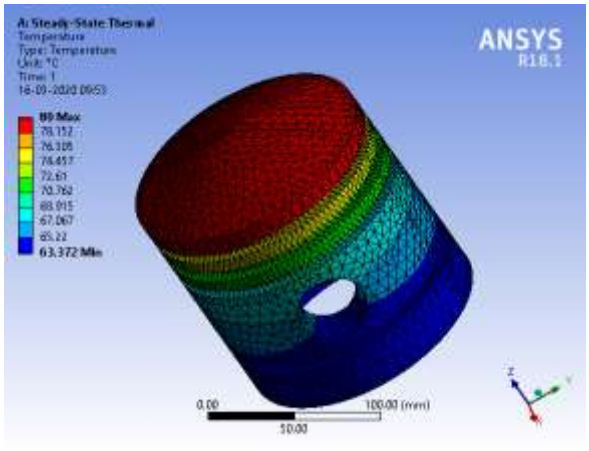

Fig.6

TABLE OF FIGURES

FIG.NO	FIGURE NAME	DESCRIPTION
1,4	Total Heat Flux	These images describes heat flux in the piston for applied temperature(80^{o}C)
2,5	Directional Heat Flux	These images describes directional heat flux in the piston for applied temperature(80^{o}C)
3,6	Temperature Distribution	These images describes Temperature Distribution in the piston for applied temperature(80^{o}C)

SILICON NITRIDE THERMAL PROPERITIES:

ThermalConductivity	4.5Wm^-1C^-1
Density	4900kgm^-3
SpecificHeat	800Jkg^-1C^-1

RESULT:

S.N0	MATERIAL	TOTAL HEAT FLUX
1	AL-Si3-N4	5.926e4
2	Aluminium Nickel Chromium	6.609e4

CONCLUSION:

- Thermal Analysis of the piston is done.
- Modeling of the piston is done using CATIA V5R20
- The CATIA part file is converted IGS file and imported in to ANSYS workbench.

From the analysis and table it is concluded that aluminium-silicon-nitride is showing efficient results.

Hence aluminium-silicon-nitride is preferable than aluminium-nickel-chromium.

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