Comparison in Thermal Analysis Of Piston By Using Different Aluminum Alloy Materials

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ABSTRACT

This study's main objective was to figure out how stressed the pistons were under actual engine settings. In this study, we investigate variables including pressure, heat, and mechanical work. The research made use of the operating gas pressure, temperature, and material properties of the piston. However, since the majority of pistons are constructed of forged aluminium and low carbon steels, we will employ thermal analysis to look at the different aluminium alloys used to make pistons in this study. An internal combustion engine cannot run correctly unless the piston is in great working condition due to its importance. Most piston failures are caused by mechanical or thermal stresses. Piston analysis makes use of boundary conditions such operating pressure on the piston head and the temperature difference between the piston head and skirt. The top surface of the piston may get cracked or broken due to temperature changes during working conditions, which might be very expensive and labor-intensive to repair. To protect them from higher heat, we coat their tops with ceramic. The CAD model is created using CATIA. The ANSYS programme must then be used to import the CAD model for geometry and meshing. For the FEA, ANSYS 14.5 was utilised.

Keywords: Automobile, Engine, Temperature withstand, Thermal analysis , Aluminium alloy , aluminium 7068 , aluminium 2024.

1. INTRODUCTION

An internal combustion engine's piston is a component that produces power via reciprocating motion. It is the part that moves and is enclosed in a cylinder, which is sealed by piston rings. A piston rod's job is to transfer the force created by the expanding gas in the cylinder to the engine's crankshaft. Pistons may get exhausted when they are exposed to cyclic gas pressure and inertial stresses while working [1]–[5]. This damage may lead to side wear, fractures in the piston head, and other similar events. Because of this, the piston design optimization process demands strict consideration to a number of factors. The pressure force acting at the piston's top as well as a thermal analysis of the piston at different temperatures and stroke lengths are utilised as parameters in this project. If this study contributes to improvements in the piston design process, design engineers may benefit. In this study, we compute the various stresses using pressure analysis, temperature analysis, and thermo-mechanical analysis in order to identify the potential regions of piston damage. Finding the ideal piston design via analysis is straightforward. [6]-[10].

2. MATERIAL PROPERTIES

The chemical element aluminium has the atomic number 13 and the symbol Al. It is a member of the boron group. It is a ductile, silvery white metal that is soft. After oxygen and silicon, aluminium is the third most common element and the most common metal in the Earth's crust. According to Table 1, its weight accounts for around 8% of the Earth's solid surface. With a silvery to dull grey appearance that changes depending on surface roughness, aluminium is a soft, strong, lightweight, ductile, and malleable metal.

Table.1. Aluminium Material Properties

1	**Molecular formula**	**AL**
2	Atomic Number	13
3	Standard atomic Weight	26.9815385
4	Density	2.70 g•cm−3
5	Melting point	933.47 K, 660.32 °C,1220.58 °F
6	Boiling point	2743 K, 2470 °C, 4478 °F
7	Thermal conductivity	237 W·m -1·K-1
8	Young's modulus	70 GPa
9	Bulk modulus	76 Gpa
10	Poisson ratio	0.35

Because a thin coating of aluminium oxide accumulates on the surface of aluminium when it is exposed to air, this metal may have high corrosion resistance. Due to galvanic interactions with alloyed copper, even the strongest aluminium alloys have a lower corrosion resistance.

Aluminium is oxidized by water to produce hydrogen and heat:

$$2\ Al + 3\ H_2O \rightarrow Al_2O_3 + 3\ H_{2alu}$$

2.ALUMINIUM 2024 ALLOY

Table.2. Mechanical Properties

Density	2780	Kg/m3
Ultimate tensile strength	469	Mpa
Yield tensile strength	324	Mpa
Modulus of elastisity	73.1	Gpa
Shear modulus	28	Gpa
Shear strength	283	Mpa
Fatigue strength	138	Mpa

3. METHODOLOGY

Computer Aided Designing (CAD) is a technique that enables you to use a computer to create, edit, analyse, and optimise designs.

Computer Aided Engineering (CAE) is a technique for analysing, simulating, or studying the behaviour of a CAD model created by a computer.

Computer Aided Manufacturing (CAM) is a manufacturing system that use computers to plan, monitor, and manage activities.

ANSYS is a programme for mechanical design. It's a simple-to-use parametric solid modelling design tool with a feature-based graphical user interface. You may utilise automated or user-defined relations to capture design intent while creating entirely associative 3-D solid models with or without limitations.

4. WORKING PRINCIPLE

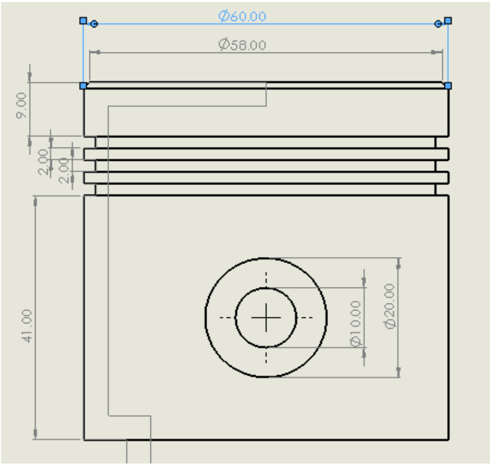

Figure.1. 2D diagram of piston using AUTO CAD

5. 3D IN ANSYS

ANSYS can take CAD data and turn it into geometry thanks to its "preprocessing" features. In the same preprocessing step, a finite element model, or mesh, is created, which is required for subsequent computing. The outcomes of establishing loadings and conducting analysis may be inspected using numerical and graphical representations.

Because of its extensive range of contact approaches, time-based loading characteristics, and nonlinear material models, ANSYS is able to complete complicated engineering studies rapidly, safely, and realistically.

In engineering, transferring heat from one place to another and between various bodies is a typical operation. A difference in temperature (a temperature gradient) causes this movement, which goes from hotter to colder places.

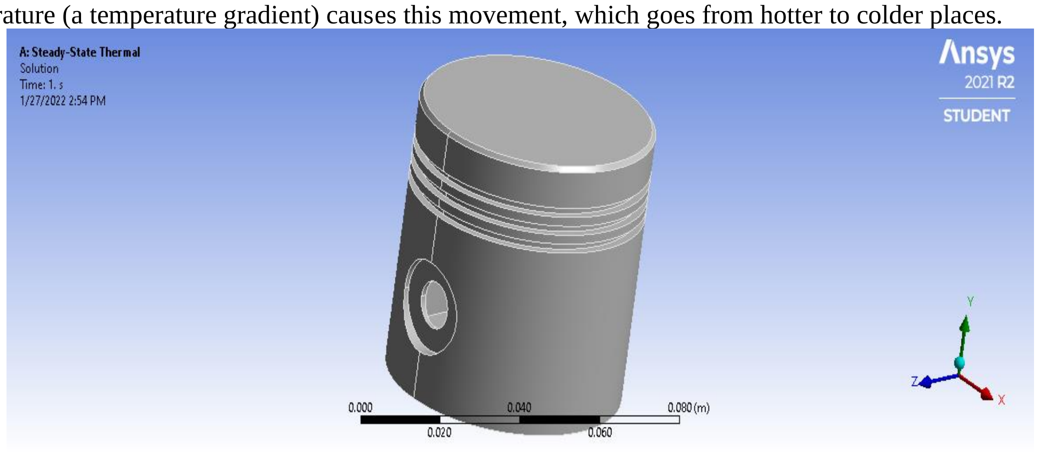

Figure.2. 3D diagram of piston

ANSYS Workbench is a platform that combines simulation and parametric CAD technologies with unmatched automation and performance. The excellence of ANSYS Workbench is due to the creators' considerable knowledge of the ANSYS solver algorithms. Additionally, the goal of ANSYS Workbench is to assure and improve the virtual environment of the product.

Because of its extensive range of contact approaches, time-based loading characteristics, and nonlinear material models, ANSYS is able to complete complicated engineering studies rapidly, safely, and realistically.

In engineering, transferring heat from one place to another and between various bodies is a typical operation. Because of the temperature differential, this transmission flows from warmer to colder places.

Temperature fluctuations induce mechanical stresses and strains in bodies owing to the coefficient of thermal expansion (sometimes abbreviated CTE in engineering literature)

The rate of heat transfer is related to the temperature differential between the two surfaces as well as the materials' thermal resistance.

6. THERMAL ANALYSIS OF ALUMINIUM 2024 ALLOY PISTON

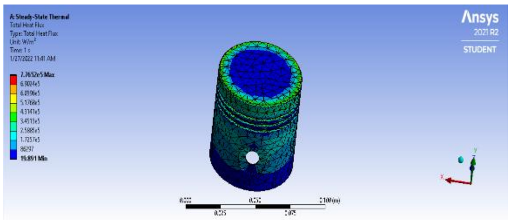

Figure.3. Total heat flux of Aluminium 2024 piston

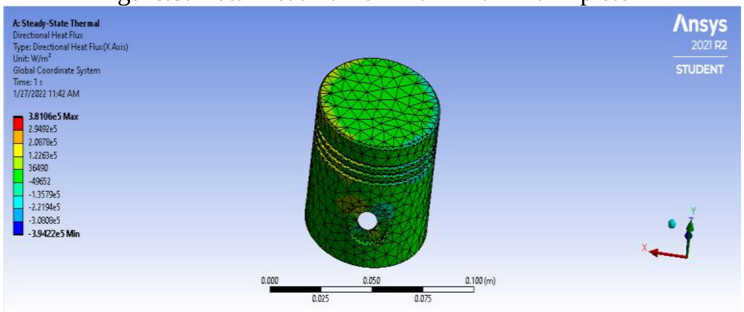

Figure.4. Directional heat flux of Aluminium 2024 piston

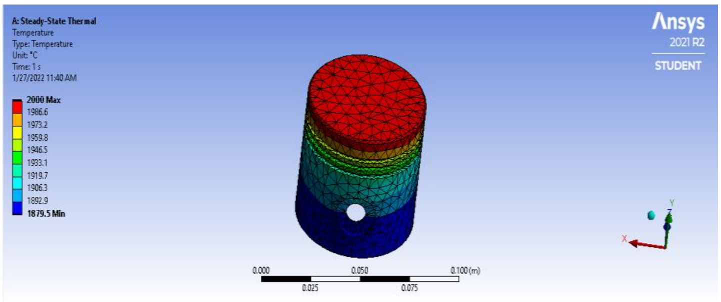

Figure.5. Temperature distribution of Aluminium 2024 piston

7. CONLCUSION

The data obtained is used to create three-dimensional piston models. The 3D model was created using CATIA V5R20 software. The piston's thermal analysis will be conducted using ANSYS WORKBENCH 14.5 once these models have been imported. We used a 10mm element size and a relevance of 100 while constructing the mesh, which results in an extremely tiny mesh. The input temperature is supplied into the top of the piston for thermal analysis, and convection is applied to the whole piston surface. After that, the total heat transfer, directional heat flow, and temperature distribution are all calculated. The findings are compared, and the aluminium 7068 alloy is demonstrated to produce superior outcomes depending on the criteria.

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