DESIGN AND ANALYSIS OF PISTON USING VARIOUS MATERIALS

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Abstract -An element of reciprocating engines is a piston. Its function is to use a connecting rod to transfer force from the expanding gas in the cylinder to the crankshaft. It is one of the most intricate parts of a car. This article uses the finite element technique (FEM) to analyse the structural integrity of three distinct piston materials. Al-2618, AL-4032, and AL-7178 are the three distinct materials.

SOLIDWORKS software is used for modelling different piston materials, and ANSYS software is used for finite element analysis. Utilising ANSYS WORKBENCH, static structural and steady state thermal analysis is carried out. Using FEA, the findings show what the equivalent stress, total deformation, and total heat flux will be on various piston materials. Stress analysis is used to choose the optimum material.

1.INTRODUCTION

One of the most intricate and significant components of an engine are the pistons. The piston's job is to transmit gas pressure while rotating the crankshaft via the piston pin. In addition, piston will work under high temperatures, and high-pressure conditions, with high-speed rotational velocity values. An internal combustion engine's piston is a reciprocating part that moves within the cylinder and transmits force from the cylinder's expanding gases to the crankshaft through a connecting rod. The piston can endure both the gas's cyclical pressure and the forces of inertia at work.

There are different parts in the piston some of them are divided according to there functions some of them are the top surface of the piston is called as crown, The design of the crown is based on the requirements of the engine combustion chamber, and the surface of the crown is essentially in convex or concave forms.. the bottom surface of the piston is called as the piston skirt.

Mainly piston consists of three grooves which are used to implement the rings known as piston rings. The main function of the rings is to make easy flow of the fuel through the cylinder, also for the reduction of the wear in the piston it act as a oil lubricating, and they absorb the pressure developed inside the chamber and protects the piston by wearing process

1.1 Literature Review

[1] Design and Analysis of Piston of Internal Combustion Engine on Various Materials Using CAE Tool ANSYS was a work presented by G. Siva Prasad, K. Dinesh Achari, E. Dileep Kumar Goud, M. Nagaraju, and K. Srikanth. In this article, writers discussed several materials. Al alloy 4032, alloy steel AISI4340, and titanium Ti-6A1-4V. Al-alloy material is suited for real-time applications, according to the paper's authors, who also transmit that it reduces fuel consumption, based on its structural and thermal behaviour.

[2]Pagadala Siddiraju and Koppula Venkateswarareddy presented a paper titled "Design and Analysis of the Piston by Using Five Different Materials." In this paper, the authors developed the pulsar 220 piston and by comparing the results of their structural and thermal analyses, they came to the conclusion that the ALSIC material is superior to the other materials. Also, they demonstrated the superiority of this alloy over conventional alloys.

[3] Yenugupalli In their paper, "Design and Analysis of Modular Piston by Using Couple Field Analysis," Anil Kumar and A.Sridhar Reddy discussed a tri-metallic piston, taking into account its dimensions through reverse engineering. Regular pistons, bimetallic pistons, and trimetallic pistons were created using Catia, and they were all analysed using the same boundary conditions in AnsysLastly, authors think According to the findings, a modular piston outperforms a single piece piston in all boundary conditions and lowers the cost of manufacturing a piston..

[4] Vibhandik et al. (2014) used CAE tools to analyse, optimise, and study the deformation of a piston's thermal stresses. The piston utilised in the investigation came from TATA Motors and was used in a car with a diesel engine. He ordered thermal evaluations of both the conventional diesel piston and the upgraded piston made of an alloy of titanium and aluminium. structural steel is used to make the typical diesel piston. The main objective of this analysis is to increase the piston's lifespan by reducing the stress concentration at the piston's upper end. After doing the research, he came to the conclusion that titanium can improve piston quality and has higher thermal properties, but because it is expensive for large-scale applications, it can only be used in a small number of applications.

[5] Ch. Venkata Rajam et al. (2013) concentrated on the design analysis and optimization of a piston using CATIA and ANSYS. He has optimised while considering each parameter. Reducing the mass of the piston was the aim of the optimization procedure. In this analysis, a ceramic crown covering is created. The piston's diameter and length are both held constant during optimization since heat flow does not change length. Because thickness affects volume more than length and diameter do, the piston's volume altered after being subjected to temperature and pressure stressors. To lighten the piston with less material, the material is removed.

[6] V. V. Mukkawar et al. (2015) describe the stress distribution of two different Al alloys using CAE tools. In this study, a four-stroke, single-cylinder piston from a Bajaj Pulsar 220 cc motorcycle was used. The AL-GHY 1250 piston, he had concluded, exhibits less distortion than a typical piston. With this alloy, mass reduction is possible. If the same working circumstances are maintained, the safety factor can rise by up to 27%. When the two materials were used in tests, Al-GHY 1250 surpassed the conventional alloy Al-2618, according to the study.

[7] C. Singh et al. (2014) found that when piston thermal performance and surface roughness of the liner surface grow, so does the function coefficient in their study on piston failure in I.C. engines. The stress values obtained from FEA are compared to the piston's material properties, such as its composition in zirconium and aluminium alloy.

[8] Using the CAE tool ANSYS on diverse materials, design and analysis of internal combustion engine pistons. The main focuses of this study's analysis are the piston's design and analysis Build the piston model while offering design criteria for modelling, such as PRO-E. Constraints affecting the piston's operating state are then applied after entering the piston's model in the analysis application ANSYS in IGES format. The analysis of the results is then completed for the various parameters (temperature, stress, and deformation). Cast iron alloy AISI4340, titanium Ti-6A1-4V, and aluminium alloy 4032 are among the various materials. The Al alloy is suited for I.C.Engine pistons, according to analysis of the various material pistons.

1.2 Methodology

- Modelling piston with the help of solid works tool
- Gathering material properties of each material
- Al-2618, al-4032, al-7178 material values like density, young is modulus and poison ratio and yield strength and thermal conductivity values.
- solid work model exporting with "step" format saving
- using structural boundary conditions to calculate results like deformation, stress, strain, and safety factor value.
- Thermal boundary conditions will be used to calculate temperature and heat flux values.
- Talking about the maximum pressure bearing capacity of each material above the piston.

- Lastly, the thesis was finalised with the necessary tables and figures and the best possible material.

1.3. Piston design

Using Solidworks, the 3D piston model was created in accordance with the guidelines in the data handbook and machine design. The realisation of the 2D drawing and the imposition of the geometric and dimensions constraints were the first steps in the modelling of the solid model. After creating the sketches, a solid model is created.

Fig 1: Piston 3D model

MESHING

In order to transfer load from one end to the other in real time, each material is coupled with atoms and molecules; in Ansys, the meshing option is available to build elements and nodes. Here, tetra elements were used to form the full meshing, and the element size is considered to be 1mm. The elements and nodes will transfer the load from one node to another node through element .

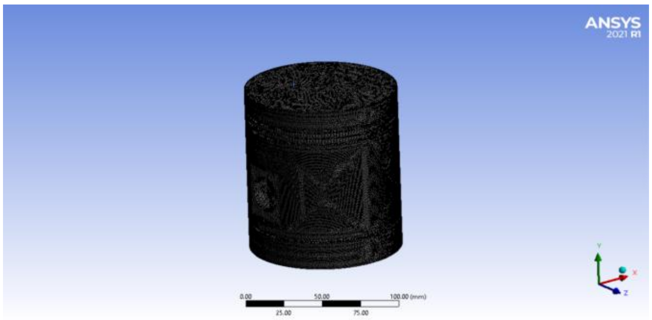


Fig 2: Meshing of the model

APPLYING BOUNDRY CONDITIONS

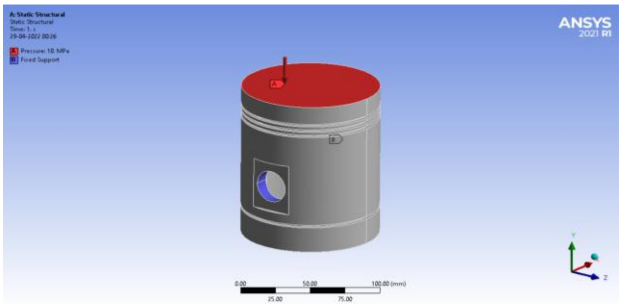


Fig 3: Boundry condition applyed

1.4. RESULTS

AL-4032

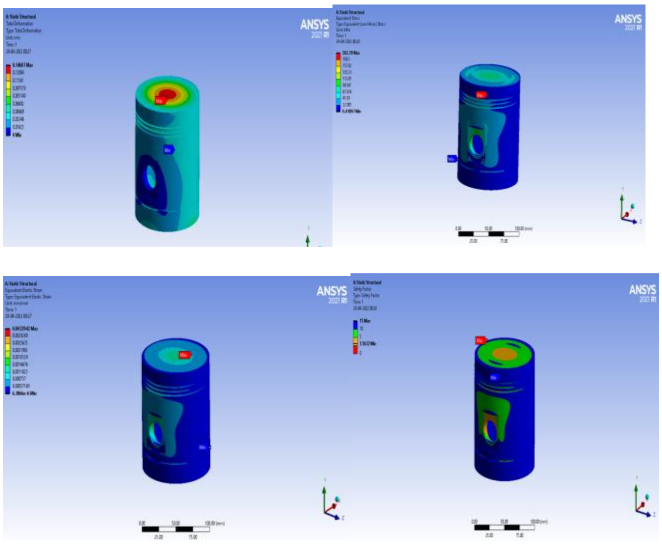
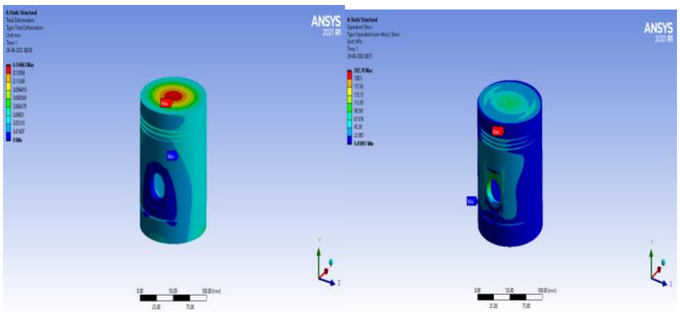


Fig 4: Deformation, stress, strain, safety factor of AL-4032

AL-2618



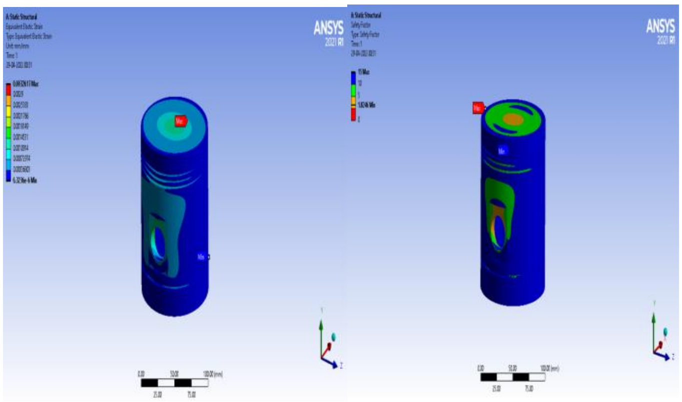


Fig 5: Deformation, stress, strain safety factor of AL-2618

Al-7178

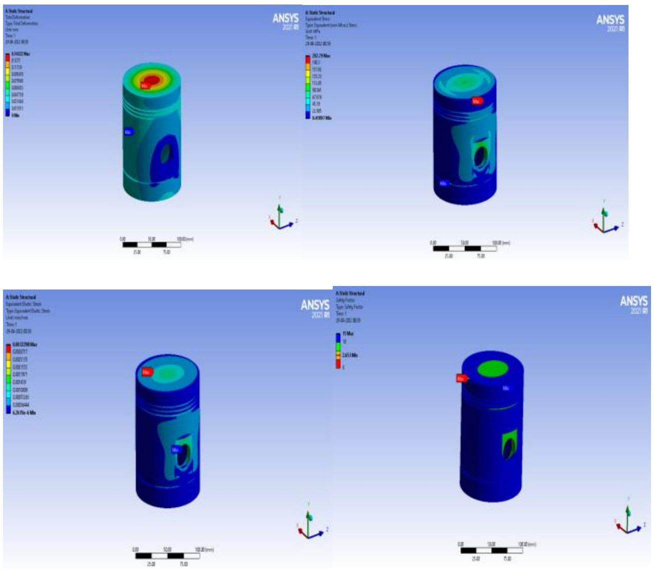


Fig 6:Deformation, stress, strain, safety factor of AL-7178

TABLES

	Al-4032	Al-2618	Al-7178
Deformation (mm)	0.14607	0.14463	0.14322
Stress (Mpa)	202.79	202.79	202.79
Strain	0.0032942	0.0032617	0.0032298
Safety factor	1.5632	1.8246	2.653

Table 1: Results of the analysis

GRAPHS

Fig 7: Graphs of deformation , stress , strain and safety factor

1.5.THERMAL ANALYSIS

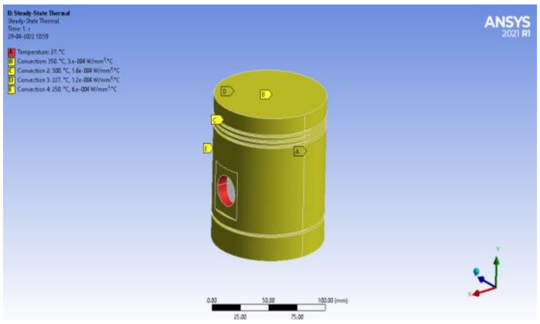


Fig 8: Thermal analysis of piston

RESULTS

AL-2618

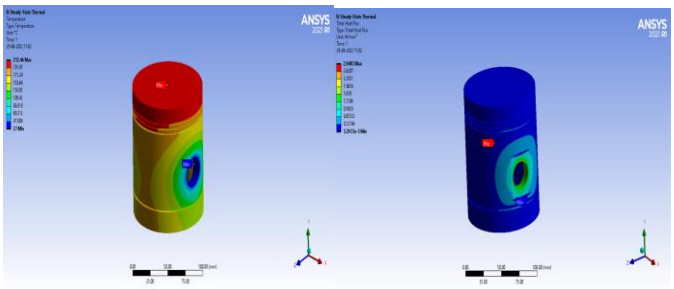


Fig 9: Total temperature and heat flux of AL-2618

Al-4032

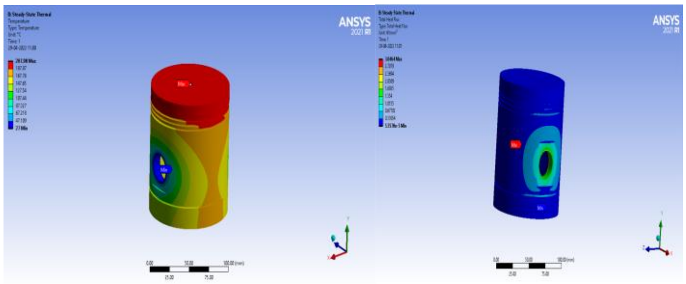


Fig 10: Total temperature and heat flux of AL-4032

AL-7178

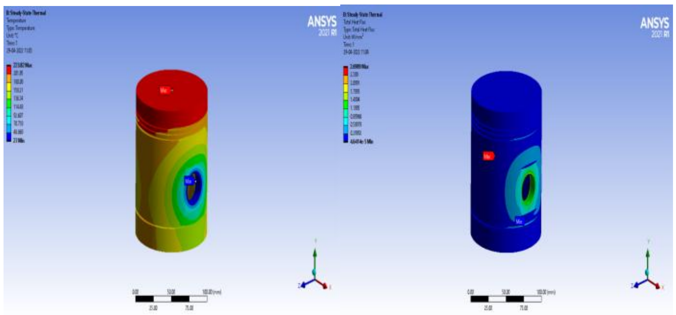


Fig 11: Total temperature and heat flux of AL-7178

Table

	Al-4032	Al-2618	Al-7178
Total temperature (*C)	207.98	212.46	223.82
Heat flux (w/mm^2)	3.0464	2.9483	2.6989

Table 2: Results of thermal analysis

GRAPHS

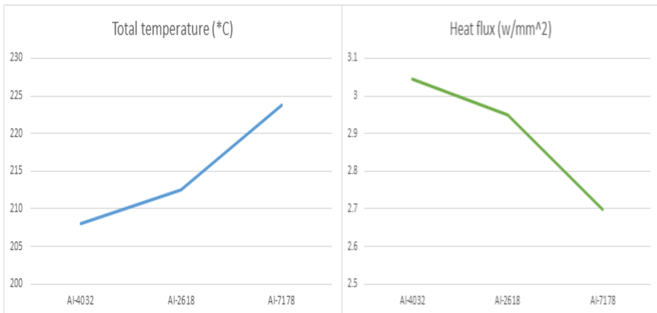


Fig 12: Graphs of Total temperature and heat flux

1.6. CONCLUSIONS

Three materials were employed to analyse the piston in this thesis: Al-2618, Al-4032, and Al-7178. The piston model was constructed with the aid of the Solid Works tool, and it was analysed with the assistance of Ansys Workbench. Each material in this thesis was examined using three separate boundary conditions: structural, thermal. thermal analysis results make it simple to determine how a material observes temperature or how much heat it can transport per unit area

Al-4032 material has a minimum factor of safety value of 1.5 at this load, and according to design constraints, any object should maintain a minimum factor of safety value above 1.5. This information comes from the results of structural analysis. Al-4032 material can withstand a maximum amount of pressure of 10Mpa on top of the piston. Al-7178 material can endure a maximum pressure of 17.5Mpa, whereas Al-2618 material can tolerate a maximum pressure of 12Mpa.

According to the findings of the thermal analysis, the al-4032 material has a high heat transfer rate when compared to the other two materials. Al-7178 material has the least amount of heat transfer rate values, and Al-2618 material has the second-highest values. It indicates that while al-7178material has greater strength values and can withstand high pressure values, its heat transfer rate, values are weak.

Finally, among all al-2618 material is performing better in each condition, and it give optimum results.

REFERENCES

[1] G.Siva Prasad, K.Dinesh Achari, E.Dileep Kumar Goud, M.Nagaraju, K.Srikanth Design and Analysis of Piston of Internal Combustion Engine on Different Materials Using CAE Tool ANSYS,

[2] Pagadala siddiraju, koppula venkateswarareddy design and analysis of the piston by using five different materials

[3] Yenugupalli Anil Kumar, A.Sridhar Reddy Design and Analysis of Modular Piston by Using Couple Field Analysis,

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