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DESIGN AND ANALYSIS OF I.C. ENGINE PISTON

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Abstract: A piston is a reciprocating component of an engine which is used to convert the chemical energy obtained by the combustion of fuel into mechanical power. The purpose of the piston is to transfer the energy to crankshaft via connecting rod. The main objective of this work is to design and analyse the stress distribution and perform structural analysis on the piston and determine the factor of safety of the piston for various materials. Design of the piston is carried out using Creo Parametric 5.0 software. Structural analysis is performed using ANSYS on four different materials and the factor of safety for each material is determined. Failure of piston occurs due to various thermal and mechanical stresses. Hence by determining the factor of safety of the materials, the material with the highest factor of safety is used to improve the efficiency and life span of piston.

Keywords: Factor of safety, Creo parametric 5.0, ANSYS, structural analysis.

I.INTRODUCTION

Piston is one of the mechanical components, invented by German scientist Nicholas August Otto in the year 1866. Piston is considered to be one of the most important parts in a reciprocating Engine, reciprocating pumps, gas compressors and pneumatic cylinders, among the other similar mechanisms in which it helps to convert the chemical energy obtained by the combustion of fuel into useful mechanical power. A piston is a reciprocating component of an engine which is used to convert the chemical energy obtained by the combustion of fuel into mechanical power. The purpose of the piston is to transfer the energy to crankshaft via connecting rod. In the working condition piston produce the stress and deformation due to periodic load effect which produce from high gas pressure, high speed reciprocating motion of the inertia force and lateral pressure. In an I.C. engine, during the combustion stroke the fuel gets ignited. During the combustion process, high pressure and high temperature are developed in the engine cylinder. By the chemical reaction of burning the gas and high temperature generated make the piston expand and induces thermal stress and results in thermal deformation. The thermal deformation and mechanical deformation cause piston cracks, thermal deformation and mechanical deformation occurs which results in failure of piston. Therefore, it is very essential to analyse the stress distribution, thermal load, mechanical load in order to minimize the mechanical stresses and thermal stresses and increase the efficiency of the piston.

II.METHODOLOGY

1. Design the I.C. engine piston in Creo Parametric 5.0 software.
2. Import the piston model into ANSYS in .iges format.
3. Perform structural analysis to the piston in Ansys.
4. Determine the factor of safety for different materials of piston.
5. Choose the material with the highest factor of safety.

III.DESIGN OF PISTON

Creo is a parametric CAD software. A parametric software is the one in which a single parameter of the design will have change on the other properties. This feature is very useful in companies that work in R&D. Since most automobile and aerospace industries need to be competitive, using Creo saves them development time of a new product. PTC Creo is a suite of design software that focuses on CAD prototyping. It includes a whole bunch of modules that provide scalable design solutions. Since it is robust, Creo maximizes innovation and enables designers to develop prototypes just the way they envision. The various modules and add-ons enhance the utility of the software. It allows product developers to produce high-quality product designs within the shortest time possible. Being a robust software, PTC Creo optimizes product development by allowing users to create, develop, and prepare for manufacturing using a single development

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environment. The design of piston is carried out in Creo Parametric 5.0 software as per the dimensions of piston of Pulsar 200. The designed piston model is as shown in fig.1.

Fig. 1 Piston designed in Creo

IV.MATERIALS

The materials selected for the analysis of the piston are

- Aluminium alloy 4032
- Nickel chromium
- Phosphor Bronze
- Aluminium Alloy 2024

V.ANALYSIS

Finite Element Analysis (FEA) is a complex numerical method used to solve complicated problems which contain a number of variable inputs such as boundary conditions, applied loads and support types. It is a far more complicated, yet accurate method to run structural analysis compared to hand calculations. FEA requires that the structure is broken up into smaller parts (or elements) which can be evaluated individually for a more accurate estimate of the solution. This can be an extremely difficult and time-consuming process to set up and run. It is common that an FEA model will comprise of matrices thousands of entries - making it pretty much impossible to be evaluated by human calculations.
The analysis of I.C. engine piston is carried out using ANSYS. The piston designed in Creo is imported into ANSYS and structural and thermal analysis is performed on the selected materials.

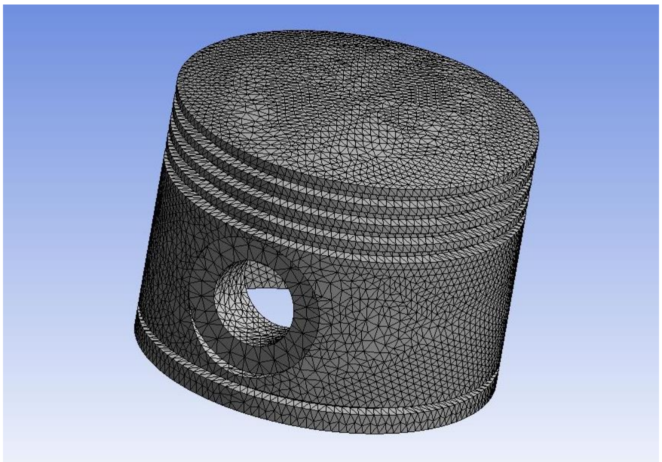

Fig. 2 Mesh generation of the piston model

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A pressure of 15MPa is applied on the piston head to perform the structural analysis on the selected materials i.e., Aluminium alloy 4032, Nickel chromium, Phosphor Bronze, Aluminium Alloy 2024. The results obtained in ANSYS are shown in below figures. The total deformation and factor of safety of all the four materials obtained are as shown below.

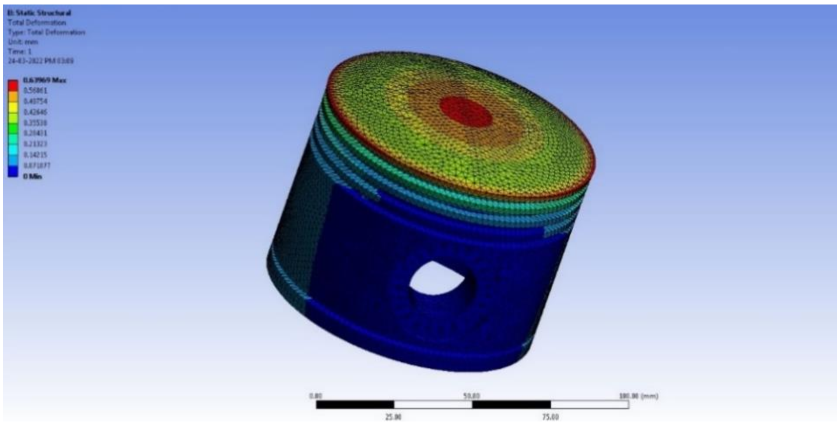

Fig.3 Total deformation of Aluminium Alloy 4032

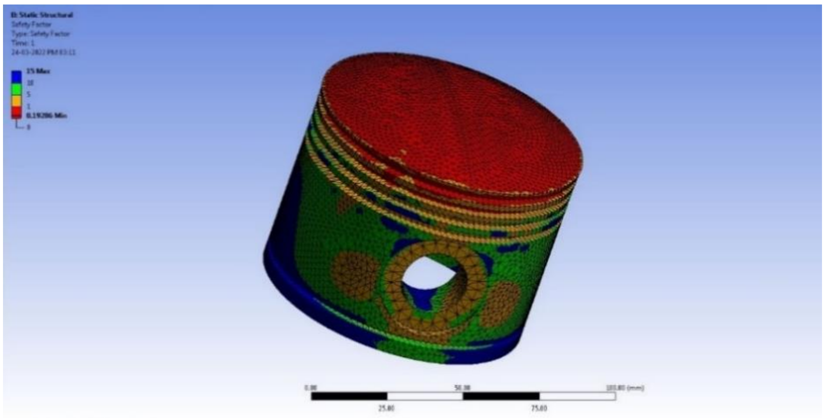

Fig.4 Factor of Safety of Aluminium Alloy 4032

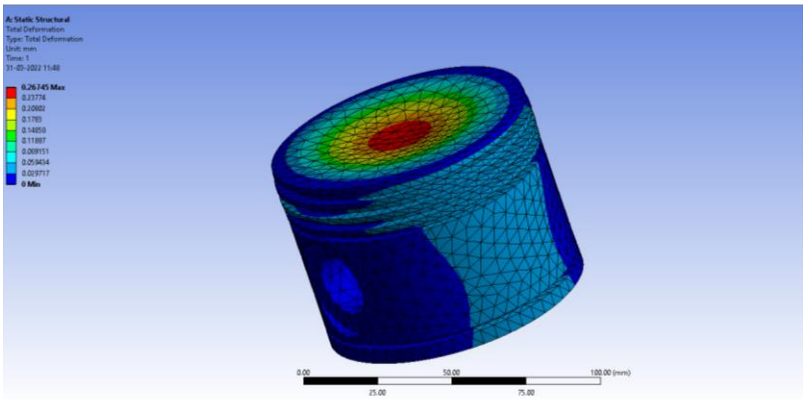

Fig.5 Total deformation of Nickel Chromium

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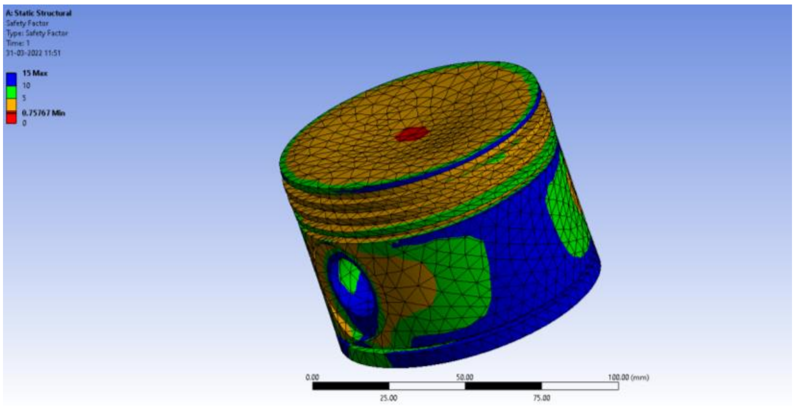

Fig.6 Factor of Safety of Nickel Chromium

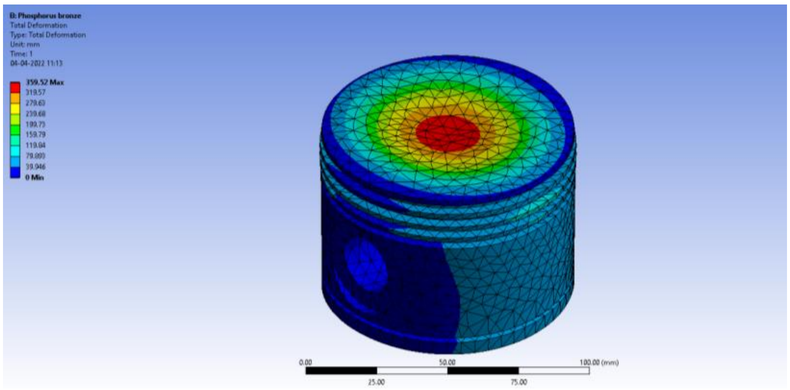

Fig.7 Total deformation of Phosphor Bronze

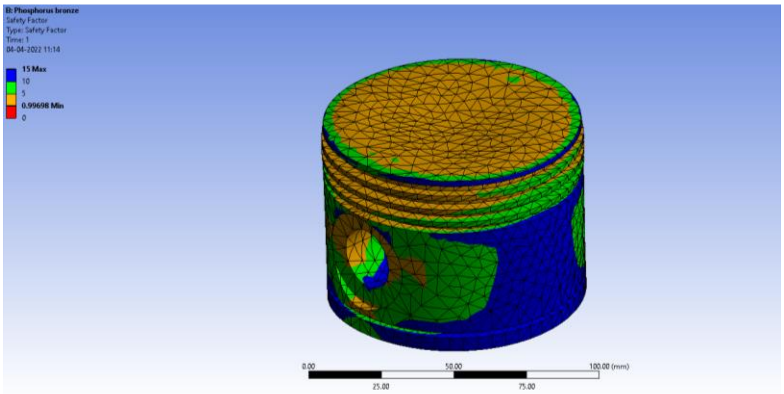

Fig.8 Factor of Safety of Phosphor Bronze

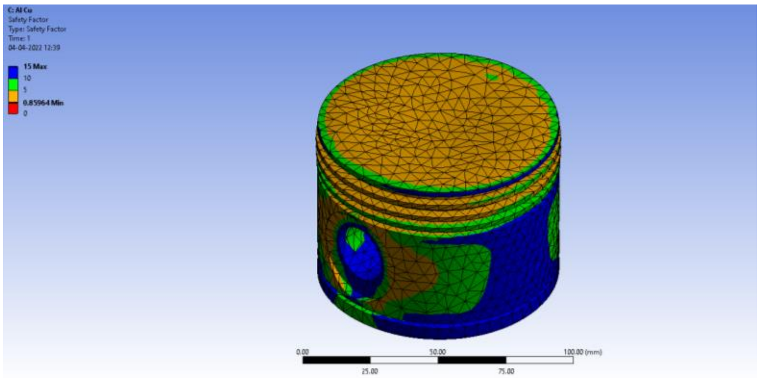

Fig.9 Total deformation of Aluminium alloy 2024

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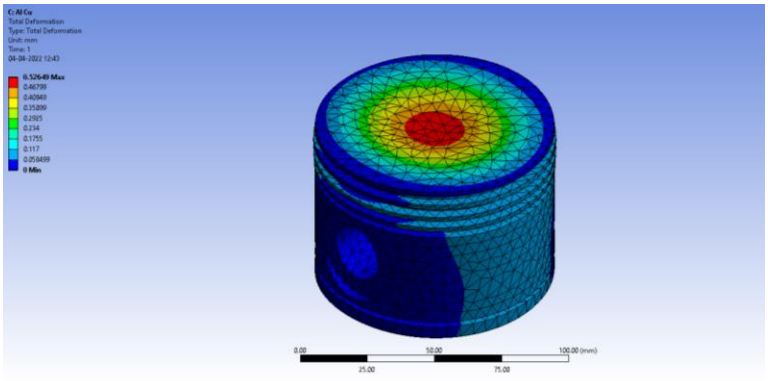

Fig.10 Factor of Safety of Aluminium alloy 2024

The equivalent stress, total deformation and factor of safety obtained for various materials are tabulated in Table I

TABLE I STRUCTURAL ANALYSIS OF PISTON

S. No.	Material	Von-mises Stress (MPa)	Total Deformation (mm)	Factor of Safety
1.	Aluminium alloy 4032	139.49	0.63	5.21
2.	Nickel Chromium	80.40	0.26	6.83
3.	Phosphor Bronze	82.91	0.35	7.28
4.	Aluminium alloy 2024	77.57	0.52	7.20

VI.CONCLUSIONS

A piston was designed in Creo Parametric 5.0 and it was imported into ANSYS in the .iges file format and a load of 15MPa is applied on to the piston head and the total deformation and the factor of safety for Aluminium alloy 4032, Nickel Chromium, Phosphor Bronze, Aluminium alloy 2024 materials has been determined. From the experiments it has been concluded that the piston made of Aluminium Alloy 2024 and Phosphor Bronze have better factor of safety and thus can be more efficient during the working. So, by choosing Aluminium Alloy 2024 and Phosphor Bronze as material for the manufacturing of piston the life span and efficiency of piston can be improved. The total deformation occurred for a phosphor bronze piston is very less i.e., 0.35mm and the deformation for Aluminium Alloy 2024 is 0.52mm. The factor of safety of Phosphor Bronze piston obtained is 7.28 and the factor of safety of Aluminium Alloy 2024 is 7.20. Hence by using Phosphor Bronze or Aluminium Alloy 2024 the efficiency of piston can be improved.

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