Design and Analysis of Piston Using Different Materials

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Abstract: The piston is the main part of the engine which helps in the combustion of fuel in an internal combustion engine. The piston is a casted part. The piston is to be casted extremely strong and sturdy because a little damage/failure in the casting process of this part can cause damage to the whole engine and thereby the vehicle. The piston is mostly made of cast iron and sometimes alluminium. There were some experiments going on to make the piston by using different materials to make it more efficient. In this project we design a prototype of the piston by using CATIA V5 software and analyse the properties of the material by using ANSYS software. Our main aim in this project is to design and analyse the different properties of piston made of different materials.

KEYWORDS:2D sketching,constraining,3D design

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I.INTRODUCTION

A piston is a reciprocating component used in vehicle engines, hydraulic pumps,compressors and pneumatic cylinders etc.,. In a vehicle engine the purpose of the piston is to transfer force from expanding gas to crank shaft via connecting rod/piston rod. In a pump the work is done vise versa. In some engines piston itself works as a valve for opening and closing ports in the cylinder.

Pistons are usually cast or forged from alluminium alloys. For better strength and fatigue life, some racing pistonsmay be forged instead. Billet pistons are also used in racing engines because they do not rely on the size and architecture of available forgings, allowing for last-minute design changes. Although not commonly visible to the naked eye, pistons themselves are designed with a certain level of ovality and profile taper, meaning they are not perfectly round, and their diameter is larger near the bottom of the skirt than at the crown.

Early pistons were of cast iron, but there were obvious benefits for engine balancing if a lighter alloy could be used. To produce pistons that could survive engine combustion temperatures, it was necessary to develop new alloys such as Y alloy and Hiduminium, specifically for use as pistons.

STRUCTURE OF PAPER

The paper is organized as follows: In Section 1, the introduction of the paper is provided along with the structure, important terms, objectives and overall description. In Section 2 we discuss related work. In Section 3 we have the complete information about 2D sketching and the tools used. Section 4 shares information about converting the 2D sketch into 3D design and analyzing the piston. In section 5 we will know about the design and structural analysis of the piston. Finally in section 6 we will know about the idea and methodology of the project in a brief.

OBJECTIVES

The piston is a part of the engine which helps in the combustion of an internal combustion engine. Sometimes the pistons that are used in the engine may fail or may not be much efficient. That causes in the wastage of fuel.

This project helps to minimize the problem by virtually designing the piston by different materials and analyzing the forces on it by using some software. This helps to develop the design and construction of the piston and can be able to get good efficiency.

2.RELATED WORK

There are numerous works that have been done related to piston.

1. Sir Harry Ralph Richardwas an English engineer who was one of the foremost engine designers and researchers in the early years of development of the internal combustion engine. He worked on different types of engines namely Mk V Tank engine, comet diesel combustion engine etc.,.
2. Philip Edward Irving was an Australian engineer and worked on motorcycle engines.

However there has been little to no work put into the viability of piston to get a little more efficiency.

3. 2D SKETCHING

The design and analysis of the piston that is made of different materials is discussed briefly in this paper. Now we will know about 2D-sketching,profile tool,3point arc &constraining.

Using the CATIA V5 software a two dimensional model of the piston is drawn. After opening the software select the work bench option from the mechanical design. There we can give the name to the project as piston. There a work area is shown displaying different planes XY,YZ& ZX. There select a plane on which the work is desired to be done.Then select the sketch tool from the work bench. In sketch tool we will find different options. Among these options using profile and 3point arc a two dimensional view of the piston is drawn on one side of the axis.

Profile tool:

Profile option in the cattie is used to draw any shape or any profile according to the requirement. It allows the user to use as many points as we need. It also provides pre defined shapes to the user. One can use those shapes and give specific dimensions.

3-point arc:

A 3point arc is a tool that can be used to draw arcs made of 3 points. And those arcs can be of any radius. We can give 3 radii to 3 arcs.

Constraining:

The constraining option is used as a tool to fix the position of the sketch that the user draws. Using this option the motion of the sketch is stopped. To stop the movement of the sketch the dimensions are to be given with respect to the origin or the axis that use used to draw the sketch.

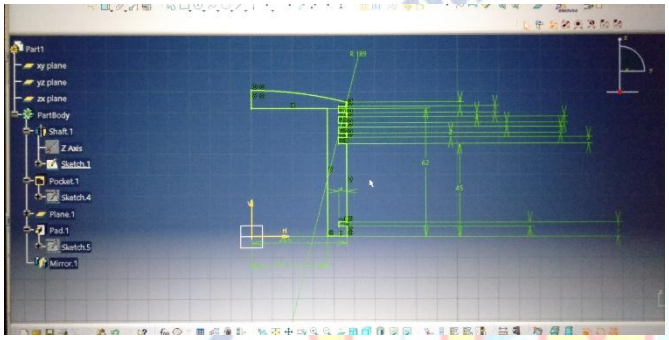


Fig 3.1 constraining of 2D sketch

4.3D CONVERSION

After sketching the two dimensional view of the piston select the shaft command from the work area and select the related axis so that we get the three dimensional view of the piston. Now draw a circle on the certain plane of the piston by required radius. Using the pocket command make a hole on the piston upto a required depth. The hole is to be constrained by giving certain dimensions to the circle.

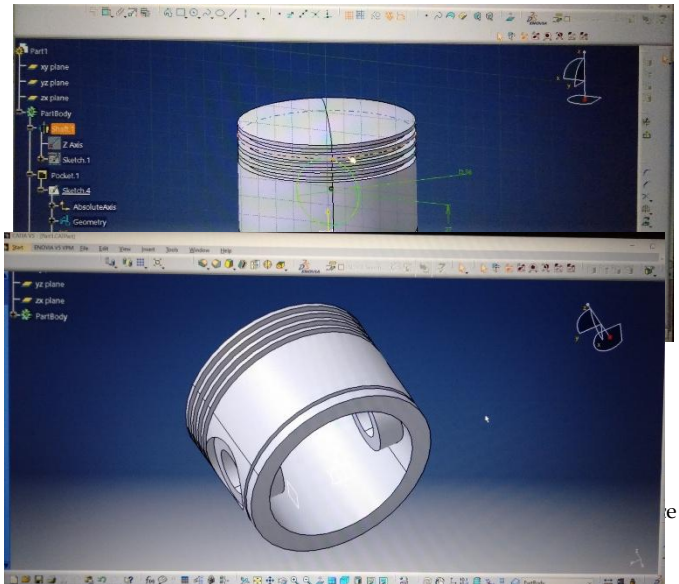


Fig4.1 Design of piston before making hole

Fig4.2 Design of piston after making holes

5. ANALYSING

5.1 DESIGN ANALYSIS:

Finite Element Analysis (FEA) was first developed in 1943 by R. Courant, who utilized the Ritz method of numerical analysis and minimization of vibrational calculus to obtain approximate solutions to vibration systems. Shortly thereafter, a paper published in 1956 by M. J. Turner, R. W. Clough, H. C. Martin, and L. J. Topp established a broader definition of numerical analysis. The paper centered on the "stiffness and deflection of complex structures". By the early 70's, FEA was limited to expensive mainframe computers generally owned by the aeronautics, automotive, defense, and nuclear industries. Since the rapid decline in the cost of computers and the phenomenal increase in computing power, FEA has been developed to an incredible precision. Present day supercomputers are now able to produce accurate results for all kinds of parameters.

5.2 STRUCTURE ANALYSIS:

Structural analysis is the determination of the effects of loads on physical structures and their components. Structures subject to this type of analysis include all that must withstand loads, such as buildings, bridges, vehicles, machinery, furniture, attire, soil strata, prostheses and biological tissue. Structural analysis incorporates the fields of applied mechanics, materials science and applied mathematics to compute a structure's deformations, internal forces, stresses, support reactions, accelerations, and stability. The results of the analysis are used to verify a structure's fitness for use, often saving physical tests. Structural analysis is thus a key part of the engineering design.

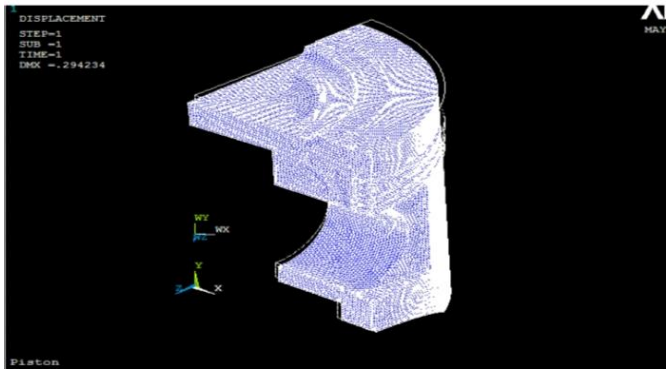


Fig5.2.1 structural analysis of piston

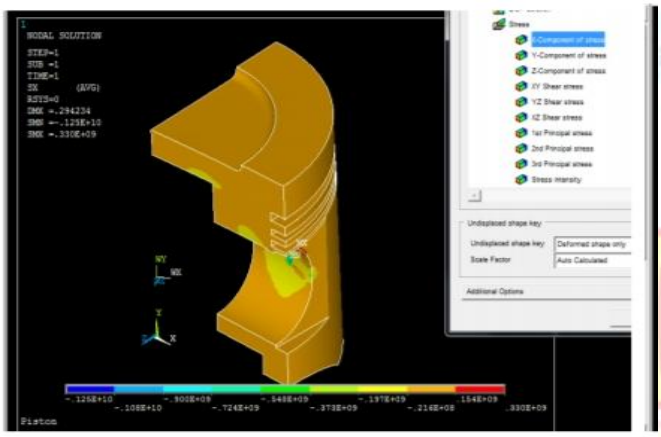


Fig5.2.2

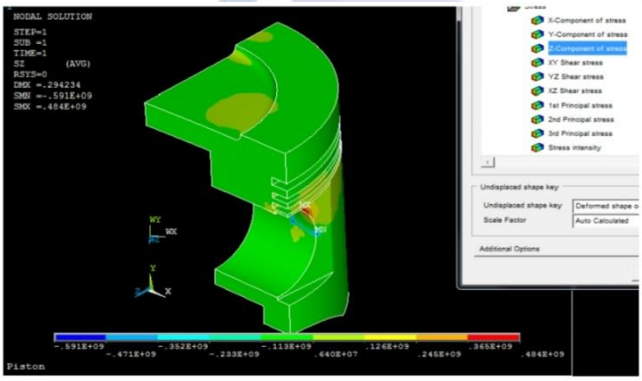


Fig5.2.3

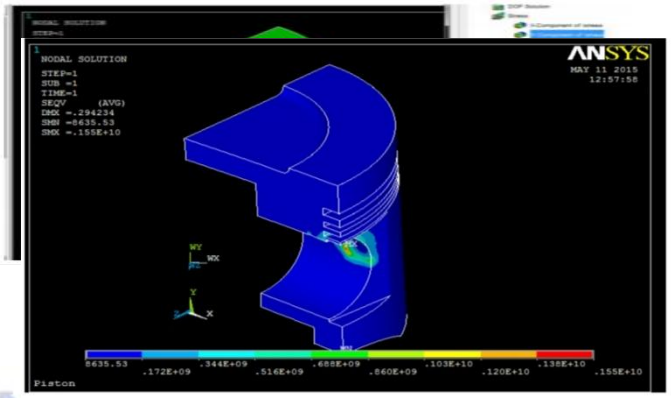


Fig5.2.4

(Fig 5.2.2 , 5.2.3& 5.2.4 stress analysis in different directions)

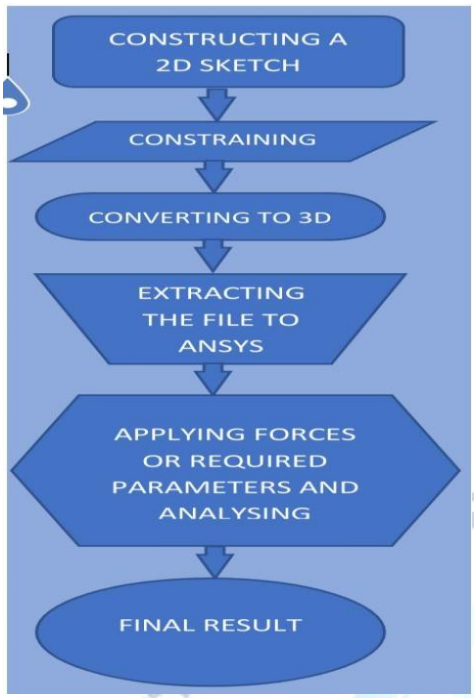
Fig5.2.5 vomnisses stress

6.METHODOLOGY

The objective of this project is to allow an efficient, cost effective and a convenient material for the manufacturing of a piston. The idea is to get the result about how different materials show their properties to manufacture a piston. With the help of designing software named as catia V5 and analysis software called ansys the piston is drawn and analyzed. The design software uses the data that is given by the user and gives the sketch of required shape. The designed sketch from the catia software is extracted and then transferred into the ansys software. In the analysis software i.e. ansys the properties of the material used for making piston are analyzed by giving some values of forces etc.,.

Process Description

The following diagram makes it easier to understand how we proceed.



- We should design a two dimensional sketch of the piston using the CATIA V5 software.
- Then the designed sketch is to be constrained to stop the movement of the sketch.
- The constrained 2D sketch is to be converted into 3D.
- After that the file should be extracted to ansys to analyse the parameters for the piston made of different materials.
- Then the required forces are to be applied on the piston for analyzingit's parameters.
- Finally we get the required results after analyzing the piston for different materials.

VI. FUTURE SCOPE AND CONCLUSION

The design and analysis of a piston is done in this paper by using CATIA V5 and ANSYS softwares. This will help to get an idea about the piston made of different materials and also to know whether the design is safe or not . So that any other further changes can be done accordingly. This design and analysis can be done more efficiently and effectively in the future according to the latest technology.

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