DESIGN AND ANALYSIS OF AIR ENGINE PISTON

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Abstract

There is a demand for safer, cleaner and more affordable air engines and found to be of greater importance. Few years before, the European Union took a action for the design and construction of efficient and environmental friendly air engines. T Student, Department of Mechanical Engineering, CMR College of Engineering & Technology, Hyderabad, India he benefits of this type of engine are focused on to reduced pollutants and decreased fuel consumption. In a wheeled vehicle engine system comprising a compressed air powered engine and tank assemblies, an engine connects to the vehicle drive wheels and is powered by compressed air and operates without emitting air pollutants and the tank assembly comprises a replaceable and/or rechargeable main air tank assembly containing air at high pressure andrecoverytanksbothsoconnectedtotheengineandarrangedsuchthattorecoverandstoreenergyofthe vehicle and engine developed during braking and high speed engine operation which was not fully utilize to propel the vehicle. This presentation is very helpful for finding the difference between the design of air engine with design of SI and CI engine. This paper is also very useful for developing and design of piston for further an analysis.

Keywords: Air Engine, Fuel Consumption, SI and CI Engines, Air pollutants

1. INTRODUCTION:

Piston is considered to be one of the most important parts in a reciprocating engine in which it helps to convert the chemical energy obtained by the combustion of fuel into useful mechanicalpower.Thepurposeofthepistonistoprovideameansofconveyingtheexpansionofthegasesto the crankshaft via the connecting rod, without loss of gas from above or oil from below. Piston is essentially a cylindrical plug that moves up and down in the cylinder. It is equipped with piston rings to provide a good seal between the cylinder wall and piston. Although the piston appears to be a simple part, it is actually quite complex from the design stand point. The piston must be as strong as possible; however, its weight should be minimized as far as possible in order to reduce the inertia due to its reciprocating mass. Materials used for pistons must satisfy many requirements. Besides the requirement of high strength under fluctuating temperature conditions, low specific gravity, high heat conductivity, a favorable wear characteristic and heat expansion all play an important role in determining the piston materials to be used. The material used for pistons is mainly aluminum alloy. Aluminum pistons can be either cast or forged. Cast iron is also used for piston. Aluminum is inferior to Cast iron in strength and wearing qualities, and its greaterco-efficientofexpansionnecessitatesgreaterclearanceinthecylindertoavoidtheriskofseizure.**PISTON TESTING**: The most important mission for the designer and test engineer has always been the investigation of stresses and deformations on components subjected to operating load conditions. For this, the internal combustion engine piston is a typical example. The external forces a piston is subjected to make it evident that such a complex structure cannot be calculated easily on a piece of paper. This is why the strength-related design of pistons was for many years based on empirical development. The two most important methods used to determine the StressdistributionanddeformationsonPistonsComputer-aidedcalculationsutilizingthe*finite-elementprocedure*Investigationsofmodel bodiesutilizingthe*photo-elasticstressanalysisprocedure*.In the *Finite Element method*, the model body is divided into a finite number of elements. On the junction lines, the elements are tied to the adjacent elements by nodes. Consequently, they experience uniform shifting. By connecting the equations for individual elements, a stiffness matrix for the entire body is obtained. Depending on whether high or low stresses are expected, the network can be either wide or narrow meshed. Photo-elastic Stress analysis represents an experimental analogy method. In the case of 2- dimensional photo elastic stress analysis method, pre cast plates of uniform thickness are used. from these plates, there Levant sections of a piston are produced. Under load, the occurring stresses are obtained by way of the deformation. During observation under polarized light, interference lines appear which are proportional to the stresses.

2. PROBLEM FORMULATION AND GAP

A piston is a component of reciprocating CI-engines. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. In an engine, its main purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod. Piston endures the cyclic gas pressure and the inside mechanical/thermal forces at work, and this operating condition may cause the fatigue damage of piston, like piston side wear, piston head cracks and soon.

3. OBJECTIVES

- Create Thermal analysis of the component
- Apply different types of materials
- Apply different types of loads
- Generate the results as per required

Approach

In CAE approach, some steps are same as that of conventional method. Here additionally conceptions, concepts are converted into engineering drawing, but it is then modeled on computer. Geometric model of product is made by the utilization of solid work software like CAD which enables better visualization of simple as well as complex models. These models then further utilities for computerized analysis by using different CAE tools (FEA/CFD software's) depending upon the application before the prototype has been made to check whether the components is going to work according to its intended function. After that once congruous results are obtained the final practical testing is carried out. Figure show the CAE approach for design a machine component.

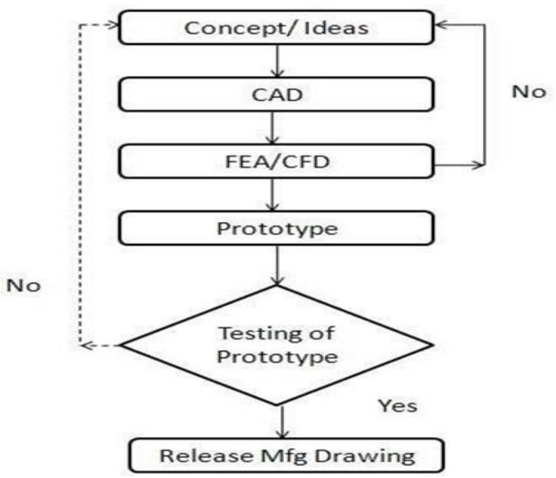
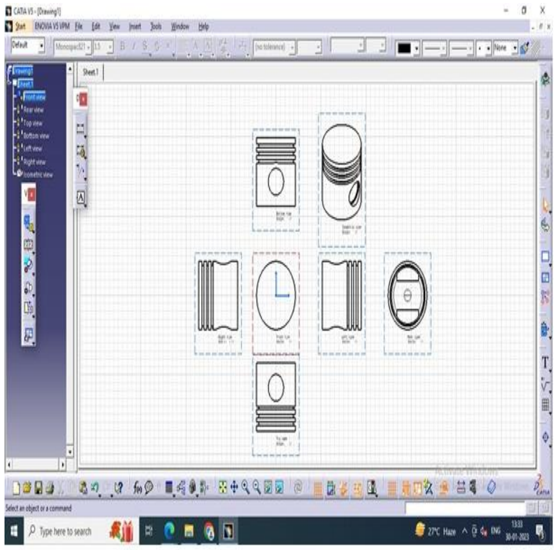
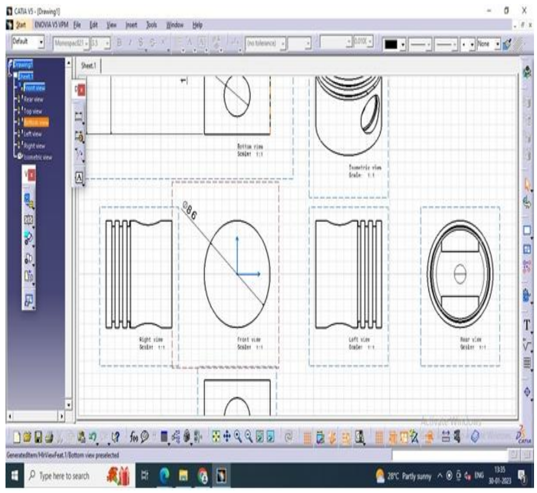


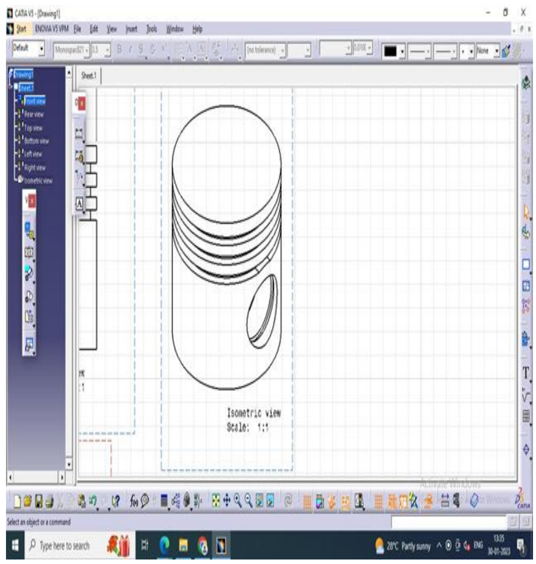
Figure4 CAEapproach

4. PISTON DIMENSIONS

Figure 8 : Dimensions







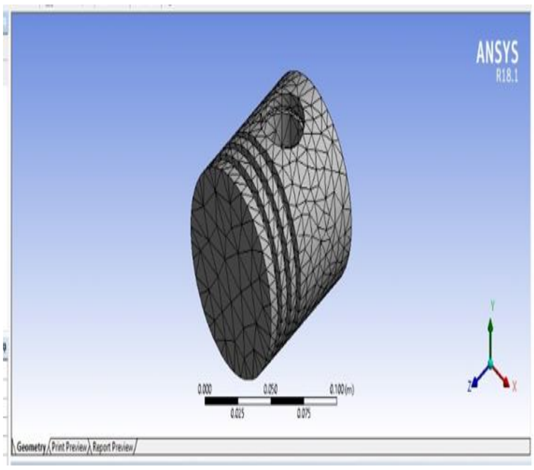
The Figure 9 is shown below:

5. DESIGN OF PISTON IN CATIA SOFWARE

MATERIALSANDTHEIRPROPERTIESI NANSYS

Forpiston:

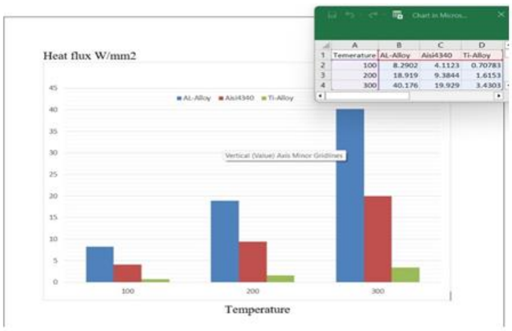
	Al alloy 4032	AISI4340 Alloy Steel	Titanium Ti-6Al-4V
Poisson ratio	0.35	0.28	0.342
Modulus of elasticity(GPa)	79	210	113.8
Thermal conductivity (w/m k)	155	44.5	6.7
Ultimate tensile strength MPa	380	745	950
Yield tensile strength MPa	315	470	880
Density g/cc	2.68	7.8	4.43



6. MESHED MODEL OF PISTON

RESULT

The heat flux of a piston depends on the specific application and operating conditions, including the engine's thermal efficiency, power output, and combustion temperature. However, in general, titanium, aluminum, and alloy steel have different thermal properties that affect their heat flux performance. Titanium has a relatively low thermal conductivity compared to aluminum and alloy steel, meaning it is less effective at dissipating heat. Therefore, it may not be the best choice for high-temperature applications where heat dissipation is critical.Aluminum has a high thermal conductivity, making it effective at dissipating heat. This makes it a good choice for high-performance applications where heat management is crucial. Alloy steel has a lower thermal conductivity than aluminum, but its higher density makes it more resistant to deformation at high temperatures. This makes it a suitable choice for applications where high strength and durability are required, such as high-pressure engines.Overall, the heat flux performance of each material depends on the specific requirements of the application. In general, aluminum is a good choice for applications where high thermal conductivity is needed, while alloy steel is preferred in applications where high strength and durability are required. Titanium may be suitable for applications where high strength and lightweight are critical, but its lower thermal conductivity may limit its heat flux performance.



Thermal analysis of piston shows that the value of maximum temperature is same for all the materials at the top surface of the piston crown, but minimum value of temperature in the piston made of titanium alloy. The highest value of minimum temperature is found in the piston of Al alloy. This is due to thermal conductivity of the materials. Minimum temperature is in the skirt of the piston is observed as shown in figure. Figures shows that max total heat flux is observed in piston of Al alloy and piston of titanium alloy shows the lowest value of max total heat flux along the edges.

7. CONCLUSION

The conclusion for the three materials (titanium, aluminum, and alloy steel) for a piston application: Titanium is a high-strength and lightweight material, making it suitable for applications where weight reduction is critical. However, its low thermal conductivity may limit its heat flux performance in high-temperature applications. Aluminum is a widely used material for pistons due to its high thermal conductivity, lightweight, and cost-effectiveness. It is suitable for most internal combustion engine applications where heat dissipation is critical. Alloy steel is a suitable material for applications where high strength and durability are required, such as high-pressure engines. It has a lower thermal conductivity than aluminum, but its higher density makes it more resistant to deformation at high temperatures. In conclusion, the choice of material for a piston depends on the specific requirements and constraints of the application. Titanium may be suitable for applications where weight reduction is critical, while aluminum and alloy steel are suitable for most internal combustion engine applications. Ultimately, the selection of the appropriate material for a piston requires careful consideration of factors such as weight, thermal conductivity, strength, durability, and cost.It is concluded from the above study that using CATIAV5R20 software design and modeling become easier. Only few steps are needed to make drawing in three dimensions. Same can be imported to ANSYS for analysis. Piston made of three different materials Al alloy 4032, AISI 4340 Alloy steel and Titanium Ti-6Al-4V (Grade 5) are analyzed. Maximum temperature is found at the centre of the top surface of the piston crown. This is equal for all materials. Depending on the thermal conductivity of the materials, heat transfer rate is found maximum in Al alloy piston and minimum in Ti alloy piston. For the given loading conditions, Al alloy piston is found most suitable. But when the loading pattern changes, other materials may be considered. With the advancement in material science, very light weight materials with good thermal and mechanical properties can be used for fail safe design of the I.C. engine. This will reduce the fuel consumption and protect the environment.

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