Design And Analysis of Piston Using Different Profiles

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Abstract- *A piston is an integral part of an engine which reciprocates at very high speed thus producing combustion resulting in movement of the vehicle. The main purpose of piston is to transmit power from gas in cylinder to crank shaft through connecting rod. The piston is a reciprocating component which is sliding from top to bottom for the combustion process.*

In an Internal combustion engine the mixture preparation plays a vital role which affects the combustion chamber, performance and emission characteristics. The mixture preparation mainly depends upon the combustion chamber geometry. Therefore, in this study, the pistons are analyzed based on the different profiles and materials. In this project the model is designed using Creo - 4.0. The Thermal analysis is carried out on a four-stroke engine using Ansys workbench - 15.0.

Keywords- Piston, Creo-4.0, Ansys 15.0, Thermal

I. INTRODUCTION

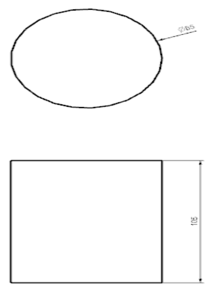
The piston is considered to be one of the main components in an I.C engine. Since the piston failure is primarily caused due to mechanical and thermal stresses, hence this report analyses the thermal propagation through a piston. The piston is one of the important component in I.C engine's, compressors and cylinders. The performance of the piston depends on the piston profiles. The piston profiles are used widely based on the manufacture requirement.

TYPES OF PISTON PROFILES:

Flat top:

The flat top piston is a type of piston where the top face of the piston i.e. piston head is flat in shape.Flat piston top with a flat surface is simple for design and easy to manufacture. It is widely used in the aircraft engines and rarely used in the diesel

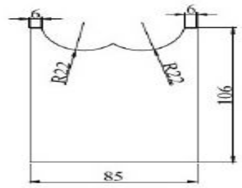
Engine piston. The manufacture cost of flat top piston is less.



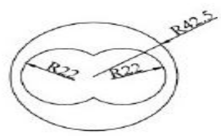
Double concave:

Double Concave piston has a concave top surface, which is conducive to the burning of combustible mixture. The shapes of concave are double in the top of piston head.

Double Concave top engine piston is commonly used in the diesel engines.

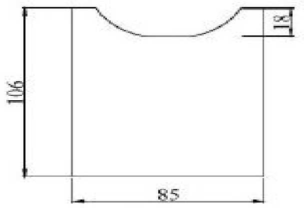


Double concave

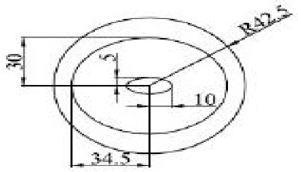


Elliptical:

The elliptical shape piston is oval shaped and it is a mirror image of another half. The elliptical piston is designed to be an elliptical shape when cold. As the engine reaches operating temperature, the piston pin bore area expands more than other thinner areas of the piston. At operating temperature, the piston shape becomes a circular shape, which matches the cylinder bore for improved sealing and combustion efficiency.

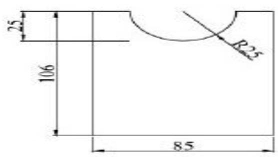


Elliptical

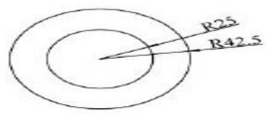


Hemispherical:

A hemispherical pistonis a type of piston chamber in reciprocating internal combustion engine with a domed cylinder head. The hemispherical shape provides a number of advantages over a reverse-flow cylinder head but comes up short in others, particularly in carburet engines. The performance of hemispherical piston is better in diesel engines



Hemispherical



II. MATERIALS

INTRODUCTION:

According to the requirement of the piston design, the material of piston should meet the following requirements:

1) High-intensity heat. When the temperature is 300~400degree, it has also enough mechanical properties to prevent the parts damaged.
2) Good thermal conductivity and poor heat absorptive. Not only reduce the temperature ofthe top and ring, but also reduce the thermal stress.
3) The expansion coefficient is small. Keep the small gap with the piston and cylinder.
4) The Specific gravity is small. Reduce the reciprocating inertia force of the piston group to reduce the mechanical load of the crankshaft and connecting rod.
5) Good wear properties.
6) Good manufacturability and cheap.

The materials used for manufacturing of piston are mainly of cast aluminum alloy. The reason for choosing cast aluminum alloy is because of its light weight and thermal conductivity.

Based on the related researches, aluminium alloy is mostly used material in making car pistons, and experiments using other material such as cast iron, cast steel, ceramics and carbon. Generally piston is made of Cast Aluminium alloy (B390), by using the die casting process. It has less weight and thermal conductivity and the limitation of this material is it has less strength and high coefficient of thermal expansion, to avoid these limitations we have used Composite materials of Reinforced metal matrix composites of Al-SiC12 and Al-Mg-Si .

CAST ALUMINIUM (B390) ALLOY:

B390 is an aluminium alloy with high hardness and good wear resistance. This alloy is suitable for many applications including internal combustion engine pistons and cylinder bodies for compressors and brakes.

PROPERTIES OF CAST ALUMINUM ALLOY:

Property	Value
Thermal conductivity	120 w/m-k

Chemical Composition:

METALS	% COMPOSITION
Copper	4to5
Magnesium	0.45to0.65
Iron	1.3
Zinc	1.5
Nickel	0.1
Manganese	0.5
Silicon	16to18
Other materials	0.2
Aluminium	72.7to79.6

Al–Mg-Si ALLOY:

Al-Mg-Si alloys are widely used in motor vehicles' and aerospace industries due to their plasticity and corrosion resistance, light weight and medium strength after appropriate working processes (such as rolling and extrusion) and heat treatments including mainly solution, quenching and aging treatments. In recent years, the strengthening mechanisms of Al-Mg-Si alloys after various working processes and heat treatments have been studied by many researchers.

PROPERTIES OF Al–Mg-Si ALLOY:

Property	Value
Thermal conductivity	200 w/m-k

Chemical Composition:

METALS	% COMPOSITION
Silicon (Si)	6.5 to7.5
Iron(Fe)	0.12
Copper (Cu)	0.1
Manganese(Mn)	0.05
Magnesium(Mg)	0.3 to 0.45
Zinc (Zn)	0.05
Titanium(Ti)	0.2
Aluminium(Al)	92.68 to 91.53

Al-SiC12 ALLOY:

AL-Sic is a metal matrix composite consisting of aluminum matrix with silicon carbide particles. It has high thermal conductivity (180–200 W/m K), and its thermal expansion can be adjusted to match other materials. Due to good thermal properties aluminum metal matrix with silicon carbide can be used for manufacturing of pistons.

PROPERTIES OF AL-SIC12 ALLOY:

Property	Value
Thermal conductivity	170 w/m-k

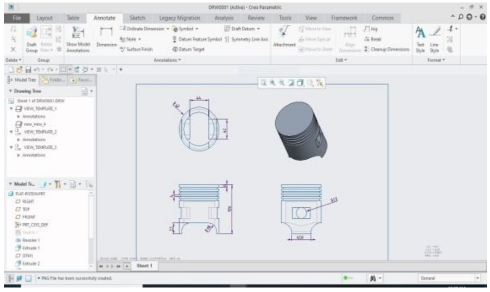
A-356.2 ALLOY PERCENTAGE COMPOSITION:

METAL	%COMPOSITION
Al of A356.2 alloy	63
Sic	37

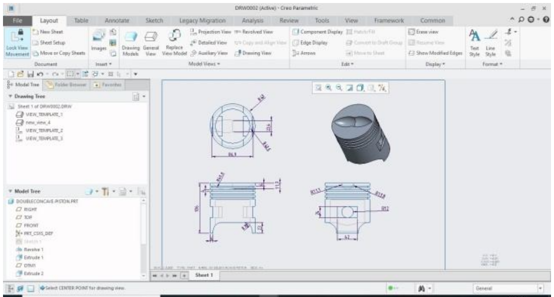
PERCENTAGE COMPOSITION OF Al-SiC12 ALLOY:

METALS	% COMPOSITION
Silicon	6.5to7.5
Iron	0.12
Copper	0.1
Manganese	0.05
Magnesium	0.3to0.5
Zinc	0.05
Titanium	0.2
Aluminium	91.53to92.68

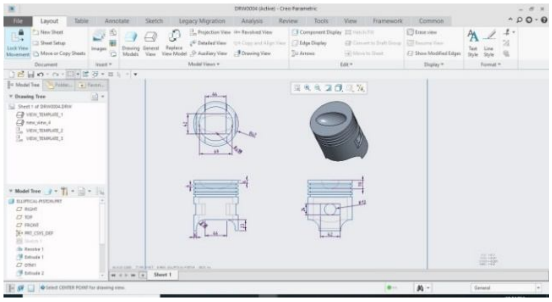
MODELING



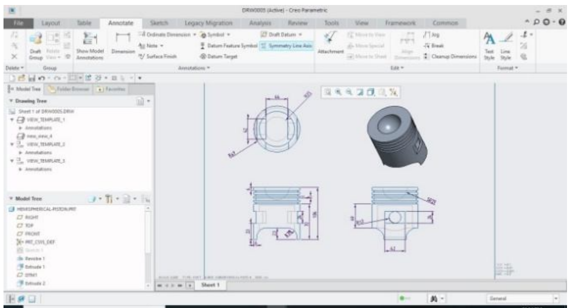
3d model and detailing of flat piston



3d model and detailing of double concave piston



3d model and detailing of elliptical piston

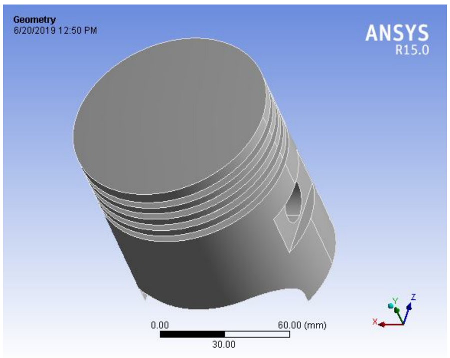


3d model and detailing of hemispherical piston

III. ANALYSIS

Importing the Model:

In this step the CRE-O model is to be imported into ANSYS workbench as follows, Select the steady state thermal module and select geometry and insert the model which is in iges format.



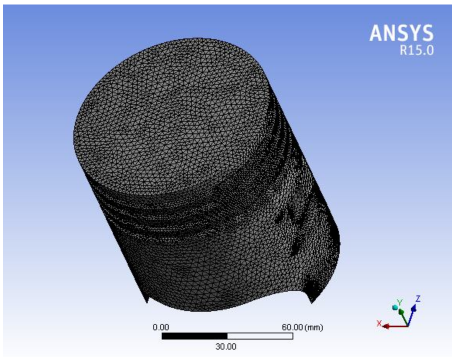
Model Imported from Cre-o

Defining Material Properties:

To define material properties for the analysis, following steps are used. The main menu is chosen select model and click on corresponding bodies in tree and then create new material enter the values again select simulation tab and select material.

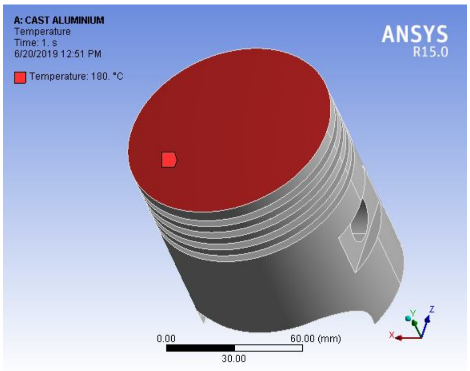
Meshing the model

To mesh the model, select mesh and click on sizing and change the advance change function as ON proximity and curvature as size function by this fine meshing is developed and click on generate mesh.

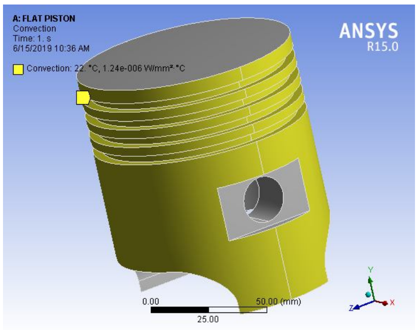


Meshed model

Thermal Analysis:

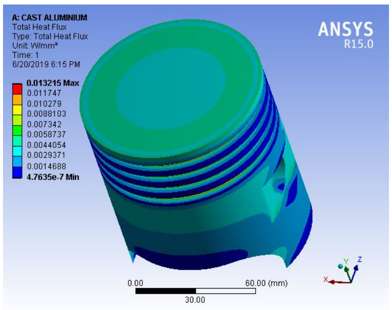


Temperature

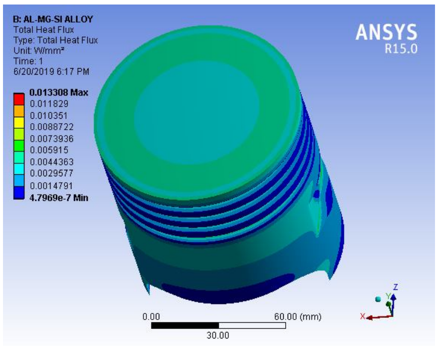


Heat convection

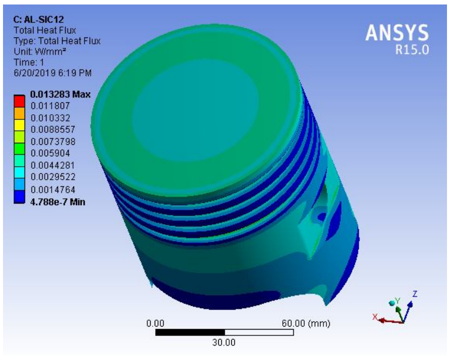
Flat piston:



Cast aluminium heat flux

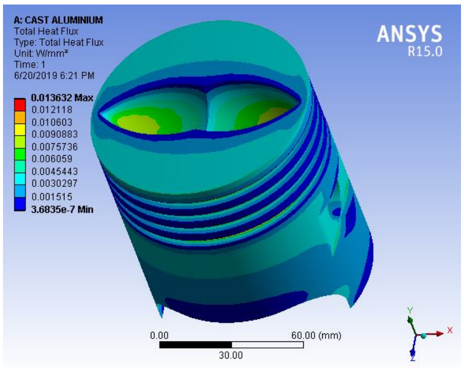


AL-MG-SI heat flux

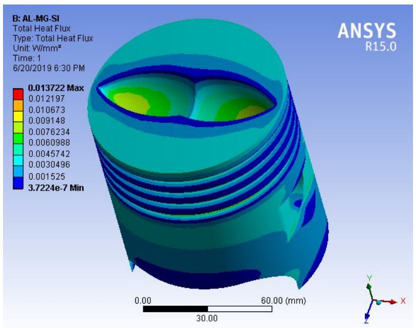


AL-SIC12 heat flux

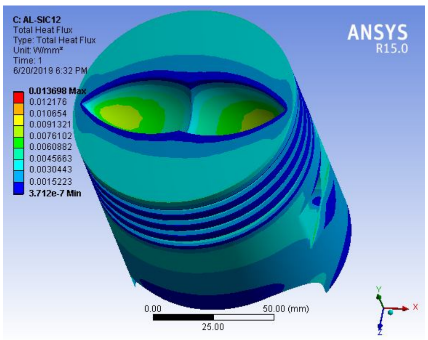
Double concave piston:



Cast aluminium heat flux

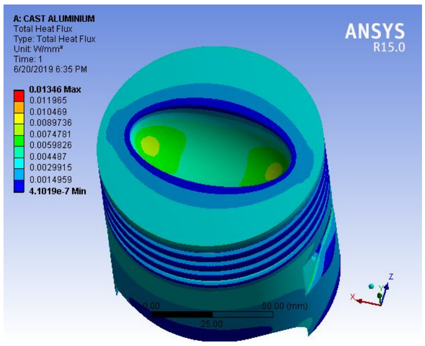


AL-MG-SI heat flux

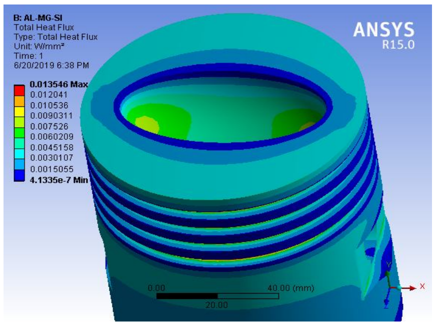


AL-SIC12 heat flux

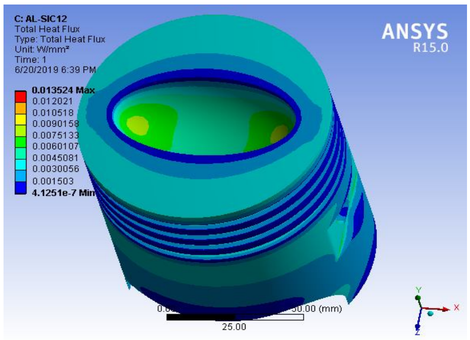
Elliptical piston:



Cast aluminium heat flux

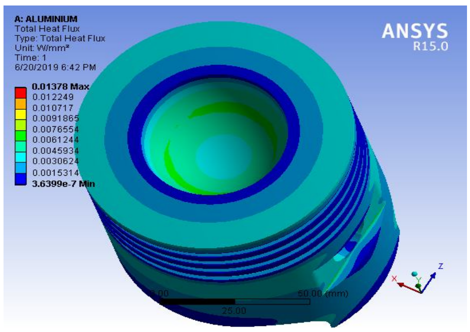


AL-MG-SI heat flux

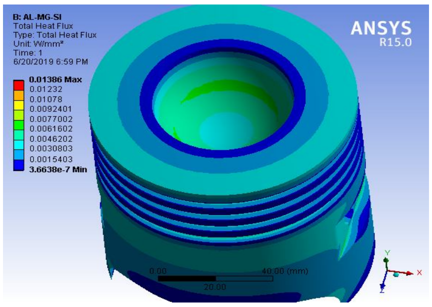


AL-SIC12 heat flux

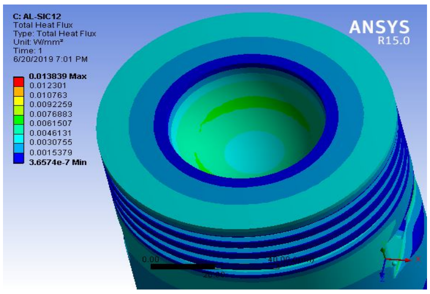
Hemispherical piston:



Cast aluminium heat flux



AL-MG-SI heat flux

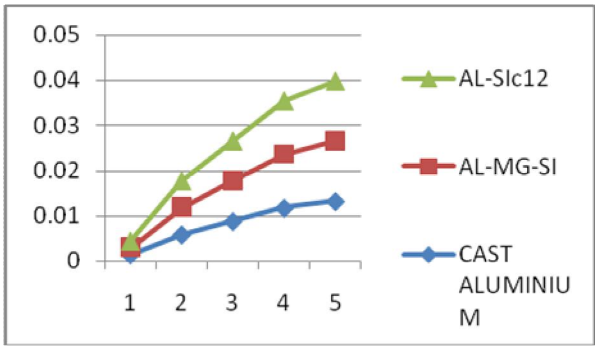


AL-SIC12 heat flux

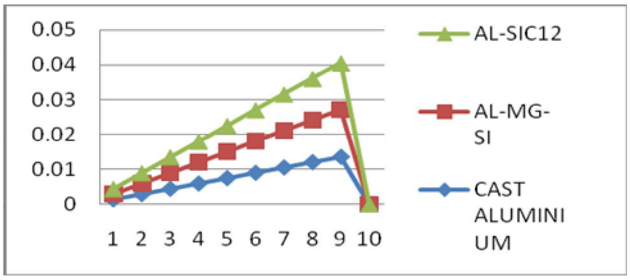
IV. TABLES AND GRAPHS

TYPE OF PISTON	MATERIALS	TOTAL HEAT FLUX(w/mm2)
FLAT	CAST ALUMINIUM	0.013215
	AL-MG-SI	0.13308
	AL-SIC12	0.013283
DOUBLE CONCAVE	CAST ALUMINIUM	0.013632
	AL-MG-SI	0.13722
	AL-SIC12	0.013698
ELLIPTICAL	CAST ALUMINIUM	0.01346
	AL-MG-SI	0.013546
	AL-SIC12	0.013524
HEMISPHERICAL	CAST ALUMINIUM	0.01378
	AL-MG-SI	0.01386
	AL-SIC12	0.013839

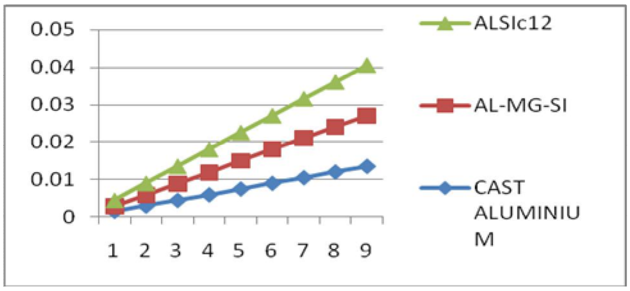
Total heat flux graphs for different pistons and materials:



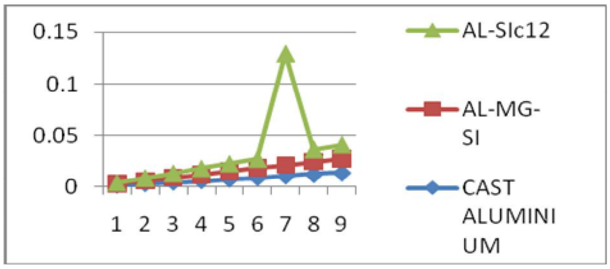
Flat piston



Double concave piston



Elliptical piston



Hemispherical piston

V. RESULTS

From the above analysis results, the flat piston can be replaced by the hemispherical piston. The thermal analysis is carried out by using the materials cast aluminium, AL-MG-SI, AL-SIC12.

From the above results we conclude that AL-MG-SI is the preferred material, while comparing with cast aluminium and AL-SIC12.

From the thermal analysis, it is clear that the AL-MG-SI is preferred and total heat flux value is high for the hemispherical piston.

VI. CONCLUSION

From the thermal analysis it was concluded that the piston with hemispherical profile is better, while comparing with the materials AL-MG-SI is proposed because it has high heat flux while comparing to cast aluminium and AL-SIC12.

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