

Design of S.I Engine Piston and Thermal Analysis with Different Materials by Usign Fea

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ABSTRACT

The project MODELLING AND ANALYSIS OF PISTON in S.I engine according to the forces acting on it from the gases, which are released during the combustion. The piston head acts as a particular case and hence the piston is analyzed for the stresses developed due to the conditions.

At first, the piston is designed according to the specifications. After the designing, the model is subjected to certain conditions. Mainly piston is connected to connecting rod and that connecting rod is engaged to crank shaft. According to the conditions we have checked the stresses acting on it and checked analysis of the model.

After the analyzing the changes are done to the model if required.

In the analysis a model of piston of the s.i engine is generated using software CATIA, the analysis of the piston is generated using Ansys. It will takes thermal analysis on piston with different materials and find the heat flux. The result are calculated and tabulated below and the heat flux acting on the body are shown using with different materials (aluminum alloy and aluminum oxide (composite material)).

INTRODUCTION:

The **internal combustion engine** is an engine in which the combustion of a fuel (normally a fossil fuel) occurs

with an oxidizer (usually air) in a combustion chamber that is an integral part of the working fluid flow circuit. In an internal combustion engine (ICE) the expansion of the high-temperature and high-pressure gases produced by combustion apply direct force to some component of the engine. The force is applied typically to pistons, turbine blades, or a nozzle.

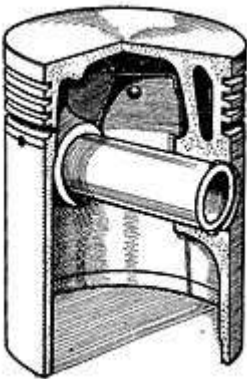
This force moves the component over a distance, transforming chemical energy into useful mechanical energy. The first commercially successful internal combustion engine was created by Étienne Lenoir.

SOME TYPES OF I.C ENGINES PISTONS



A **piston** is a component of reciprocating engines, reciprocating pumps, gas compressors and pneumatic cylinders, among other similar mechanisms. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. In an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod and/or connecting rod. In a pump, the function is reversed and force is transferred from the crankshaft to the piston for the purpose of compressing or ejecting the fluid in the cylinder. In some engines, the piston also acts as a valve by covering and uncovering ports in the cylinder wall.

Internal combustion engines



Internal combustion engine piston, sectioned to show the gudgeon pin.

An internal combustion engine is acted upon by the pressure of the expanding combustion gases in the combustion chamber space at the top of the cylinder. This force then acts downwards through the connecting rod and onto the crankshaft. The connecting rod is attached to the piston by a swivelling gudgeon pin (US: wrist pin). This pin is mounted within the piston: unlike the steam engine, there is no piston rod or crosshead (except big two stroke engines).

The pin itself is of hardened steel and is fixed in the piston, but free to move in the connecting rod. A few designs use a 'fully floating' design that is loose in both components. All pins must be prevented from moving sideways and the ends of the pin digging into the cylinder wall, usually by circlips.

Gas sealing is achieved by the use of piston rings. These are a number of narrow iron rings, fitted loosely into grooves in the piston, just below the crown. The rings are split at a point in the rim, allowing them to press against the cylinder with a light spring pressure. Two types of ring are used: the

upper rings have solid faces and provide gas sealing; lower rings have narrow edges and a U-shaped profile, to act as oil scrapers. There are many proprietary and detail design features associated with piston rings.

Pistons are cast from aluminum alloys. For better strength and fatigue life, some racing pistons may be forged instead. 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.

A few early gas engines, had double-acting cylinders, but otherwise effectively all internal combustion engine pistons are single-acting. During World War II, the US submarine *Pompano*^[note 2] was fitted with a prototype of the infamously unreliable H.O.R. double-acting two-stroke diesel engine. Although compact, for use in a cramped submarine, this design of engine was not repeated.

Trunk pistons

Trunk pistons are long relative to their diameter. They act both as a piston and cylindrical crosshead. As the connecting rod is angled for much of its rotation, there is also a side force that reacts along the side of the piston against the cylinder wall. A longer piston helps to support this.

Trunk pistons have been a common design of piston since the early days of the reciprocating internal combustion engine. They were used for both petrol and diesel engines, although high speed engines have

now adopted the lighter weight slipper piston.

A characteristic of most trunk pistons, particularly for diesel engines, is that they have a groove for an oil ring below the gudgeon pin, in addition to the rings between the gudgeon pin and crown.

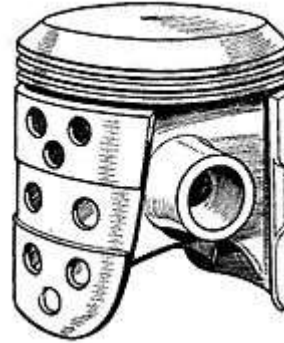
The name 'trunk piston' derives from the 'trunk engine', an early design of marine steam engine. To make these more compact, they avoided the steam engine's usual piston rod with separate crosshead and were instead the first engine design to place the gudgeon pin directly within the piston. Otherwise these trunk engine pistons bore little resemblance to the trunk piston; they were extremely large diameter and double-acting. Their 'trunk' was a narrow cylinder mounted in the centre of the piston.

Crosshead pistons

Large slow-speed Diesel engines may require additional support for the side forces on the piston. These engines typically use crosshead pistons. The main piston has a large piston rod extending downwards from the piston to what is effectively a second smaller-diameter piston. The main piston is responsible for gas sealing and carries the piston rings. The smaller piston is purely a mechanical guide. It runs within a small cylinder as a trunk guide and also carries the gudgeon pin.

Because of the additional weight of these pistons, they are not used for high-speed engines.

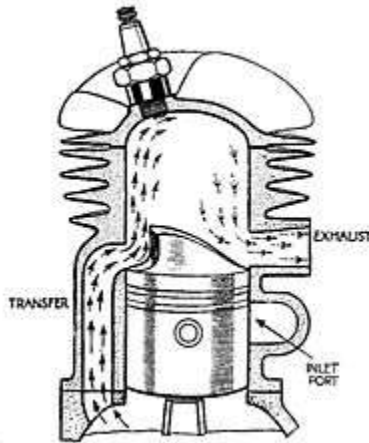
Slipper pistons



Slipper piston

A **slipper piston** is a piston for a petrol engine that has been reduced in size and weight as much as possible. In the extreme case, they are reduced to the piston crown, support for the piston rings, and just enough of the piston skirt remaining to leave two lands so as to stop the piston rocking in the bore. The sides of the piston skirt around the gudgeon pin are reduced away from the cylinder wall. The purpose is mostly to reduce the reciprocating mass, thus making it easier to balance the engine and so permit high speeds. A secondary benefit may be some reduction in friction with the cylinder wall, since the area of the skirt, which slides up and down in the cylinder is reduced by half. However most friction is due to the piston rings, which are the parts which actually fit the tightest in the bore and the bearing surfaces of the wrist pin, the benefit is reduced.

Deflector pistons



Two-stroke deflector piston

Deflector pistons are used in two-stroke engines with crankcase compression, where the gas flow within the cylinder must be carefully directed in order to provide efficient scavenging. With cross scavenging, the transfer (inlet to the cylinder) and exhaust ports are on directly facing sides of the cylinder wall. To prevent the incoming mixture passing straight across from one port to the other, the piston has a raised rib on its crown. This is intended to deflect the incoming mixture upwards, around the combustion chamber. Much effort, and many different designs of piston crown, went into developing improved scavenging. The crowns developed from a simple rib to a large asymmetric bulge, usually with a steep face on the inlet side and a gentle curve on the exhaust. Despite this, cross scavenging was never as effective as hoped. Most engines today use Schnuerle porting instead. This places a pair of transfer ports in the sides of the cylinder and encourages gas flow to rotate around a vertical axis, rather than a horizontal axis.

Piston and Piston Rings

A *piston* is a cylindrical engine component that slides back and forth in the cylinder bore by forces produced during the combustion process. The piston acts as a movable end of the combustion chamber. The stationary end of the combustion chamber is the cylinder head. Pistons are commonly made of a cast aluminum alloy for excellent and lightweight thermal conductivity. *Thermal conductivity* is the ability of a material to conduct and transfer heat. Aluminum expands when heated, and proper clearance must be provided to maintain free piston movement in the cylinder bore. Insufficient clearance can cause the piston to seize in the cylinder. Excessive clearance can cause a loss of compression and an increase in piston noise.

Piston features include the piston head, piston pin bore, piston pin, skirt, ring grooves, ring lands, and piston rings. The *piston head* is the top surface (closest to the cylinder head) of the piston which is subjected to tremendous forces and heat during normal engine operation.

A *piston pin bore* is a through hole in the side of the piston perpendicular to piston travel that receives the piston pin. A *piston pin* is a hollow shaft that connects the small end of the connecting rod to the piston. The *skirt* of a piston is the portion of the piston closest to the crankshaft that helps align the piston as it moves in the cylinder bore. Some skirts have profiles cut into them to reduce piston mass and to provide clearance for the rotating crankshaft counterweights.

A *ring groove* is a recessed area located around the perimeter of the piston that is used to retain a piston ring. *Ring lands* are the two parallel surfaces of the ring groove which function as the sealing surface for the piston ring. A *piston ring* is an expandable split ring used to provide a seal between the piston and the cylinder wall. Piston rings are commonly made from cast iron. Cast iron retains the integrity of its original shape under heat, load, and other dynamic forces. Piston rings seal the combustion chamber, conduct heat from the piston to the cylinder wall, and return oil to the crankcase. Piston ring size and configuration vary depending on engine design and cylinder material.

Piston rings commonly used on small engines include the compression ring, wiper ring, and oil ring. A *compression ring* is the piston ring located in the ring groove closest to the piston head.

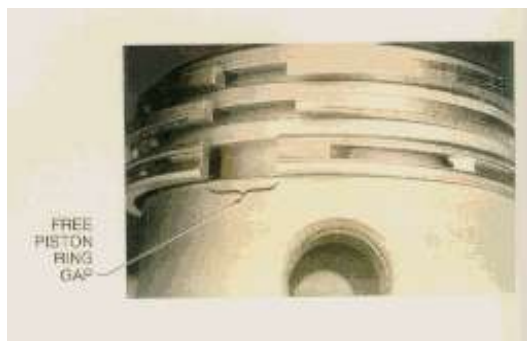
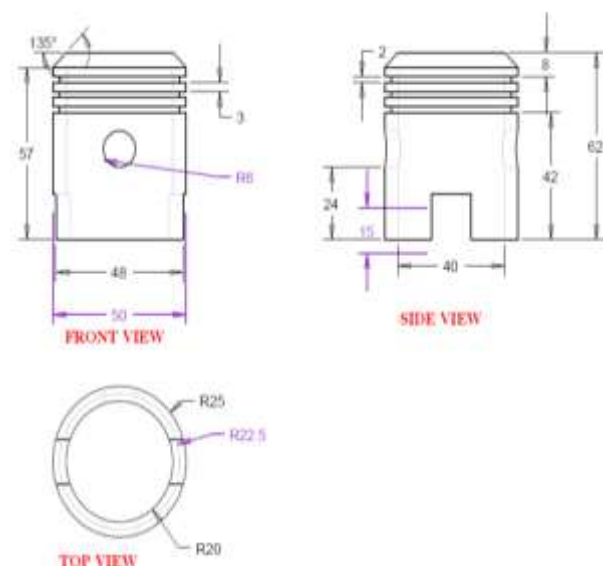


Figure 5 - Piston Ring Gap

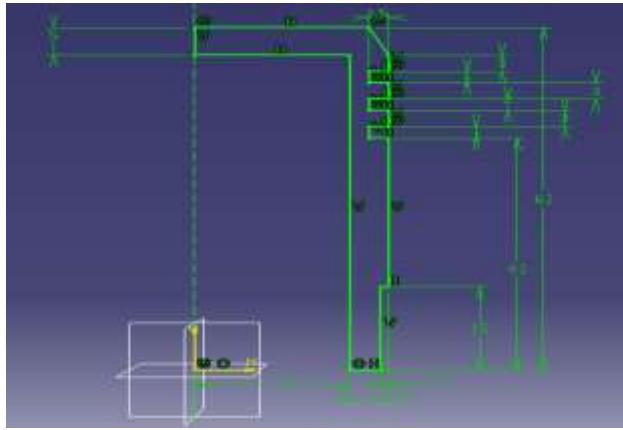
pressure is the internal spring force that expands a piston ring based on the design and properties of the material used. Inherent pressure requires a significant force needed to compress a piston ring to a smaller diameter. Inherent pressure is determined by the uncompressed or free piston ring gap. Free piston ring gap is the distance between the two ends of a piston ring in an uncompressed state. Typically, the greater the free piston ring gap, the more force the piston ring applies when compressed in the cylinder bore. .

Dimensions of the piston

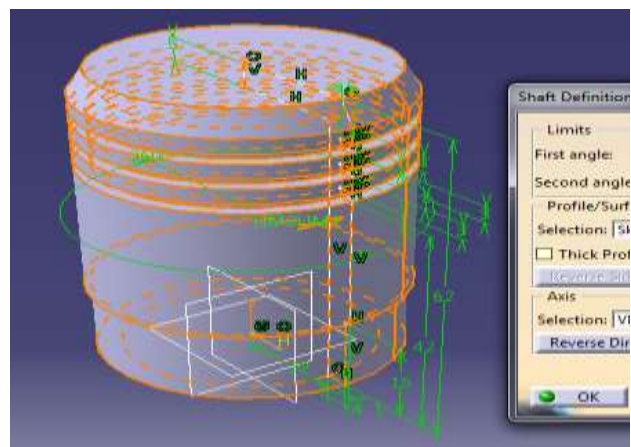


HOW TO DRAW A PISTON IN CATIA

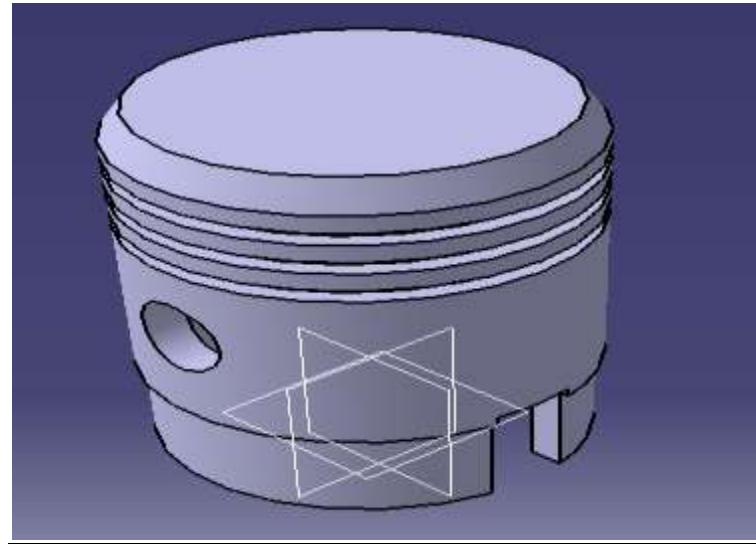
Piston rings seal the combustion chamber, transferring heat to the cylinder wall and controlling oil consumption. A piston ring seals the combustion chamber through inherent and applied pressure. Inherent



Revolve the drawn the figure using command shaft



Final piston



ANSYS RESULTS

Thermal analysis of piston with aluminium alloy

FIGURE
Model (A4) > Mesh > Figure

1

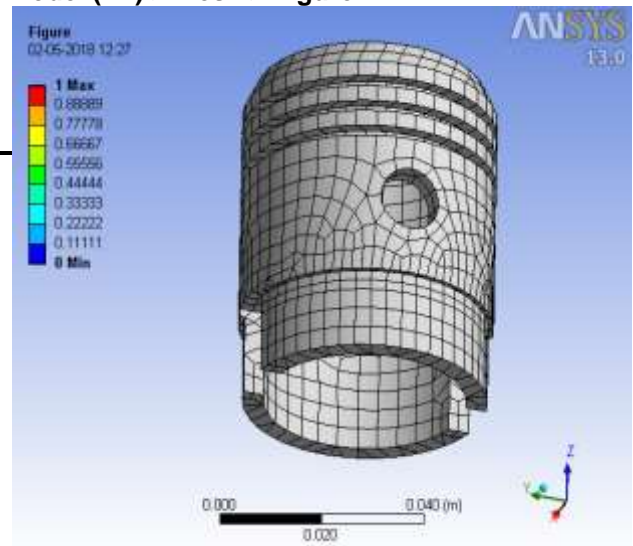
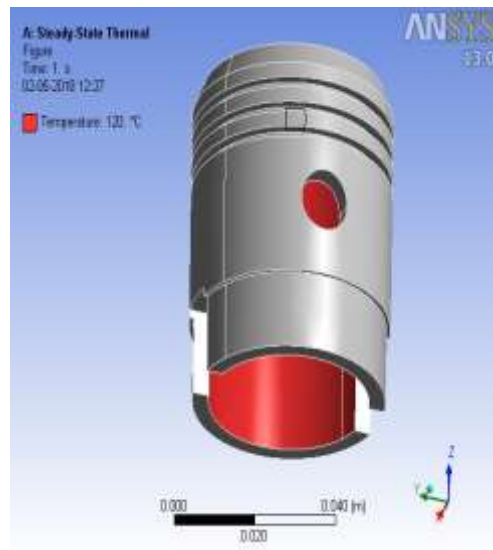
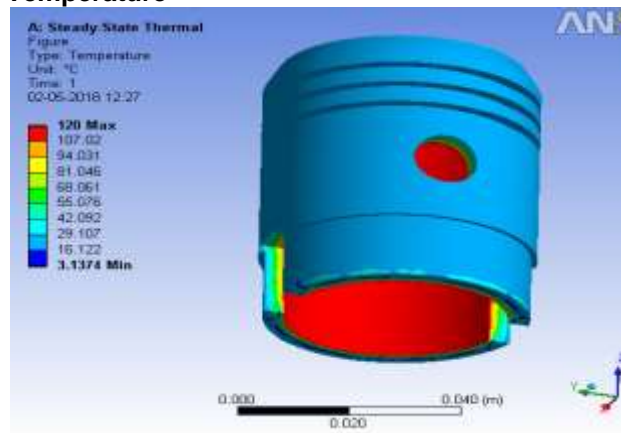


FIGURE
Model (A4) > Steady-State Thermal (A5) > Temperature > Figure

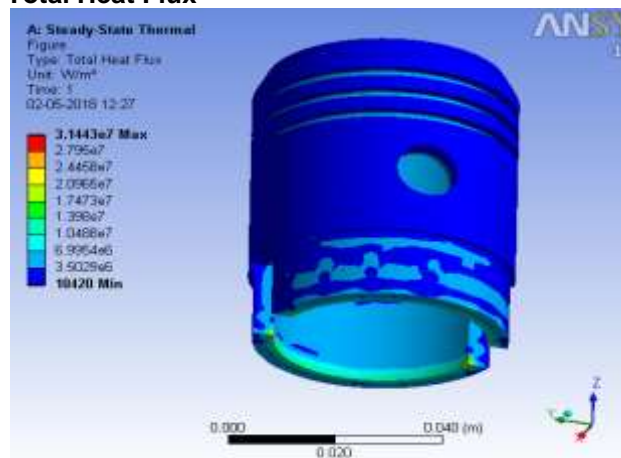
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Temperature

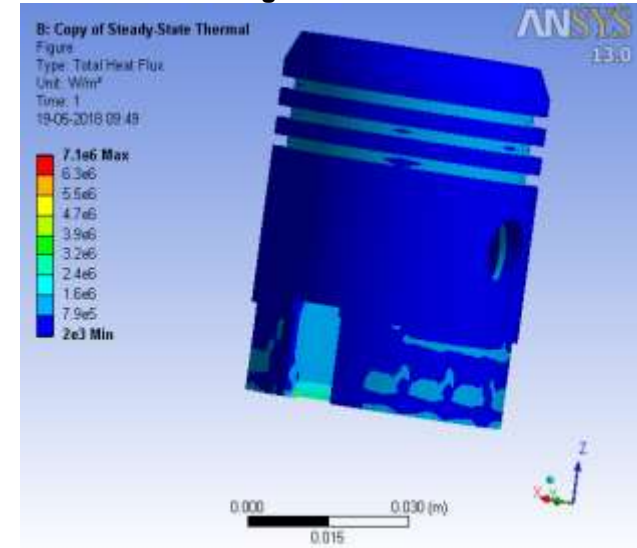


Total Heat Flux



2nd material aluminium oxide

Total Heat Flux > Figure



RESULTS

MATERIALS	TOTAL HEAT FLUX
ALUMINIUM ALLOY	3.14e7
ALUMINIUM OXIDE	7.1e6

Conclusion:

In this project a model of piston of the s.i engine is generated using software CATIA, the analysis of the piston is generated using Ansys. It is applied with temperature. The result are calculated and tabulated above and the heat flux on the body are shown using with different materials (aluminum alloy and aluminum oxide (composite material)).

According to the two materials, Al₂O₃ is the better heat absorber and less time to take cooling also, better material in thermal conditions.

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