

# FEA analysis on Piston of IC engine with Coatings of Composite Materials

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## ABSTRACT

Materials made out of composites are being focused in the direction of advancement of exclusive and enhanced designs since they have several benefits such as cost effectiveness, easy in access as well as have better mechanical as well as chemical properties. Composites comprised of silica, oxides of titanium and aluminium are favored so as to have higher resistivity to wear when it comes to hardness, better resistance to corrosion and improved thermal conductivity when compared to several other alloys of metal. Layer of composites are utilized for the purpose of hindering wear. In the present work, a model of piston is created and experiment has been carried out regarding the material composition, as well as value for hardness by simulation method. The impact of size of particle and their quantity in numbers dispersed is observed. Casting process is responsible for the deposition of SiC particles over Al. the current research includes modelling of piston, its meshing and simulation which is performed on ANSYS tool also it involves the study for thermal and static behavior. The results are presented in tabulated form. The results include several stresses acting on the piston. The present work is based on covering the research gaps in this sector and provides solution based on simulation results. In order to enhance the effectiveness of the engine, there is requirement for researching further more regarding the behavior of the piston. By checking the thermal and structure based simulations, it is easy in identifying whether the proposed material is safe in designing the piston under the conditions of loading. The final result outcomes are compared. This investigation aids any individual to explore the steady state thermal workbench analysis in reference to piston.

**Key Words:** Internal Combustion (IC) Engines, Ansys, FEM, CAD, Performance, Heat transfer, Temperature piston.

## 1. INTRODUCTION

An engine based on internal combustion **or internal combustion engine (ICE)** is a engine of heat type where the burning of the fuel incorporates by means of air which is also termed as oxidizer in a chamber of burning that is an essential piece of the working liquid stream circuit. Within the internal combustion engine, the enhancement comprising the elevated-temperature and high-weight gases delivered by ignition smears through power to some part of the engine. The power is connected normally to cylinders, turbine sharp

edges, rotor or a spout. This power moves the part over a separation, changing compound vitality into valuable mechanical vitality.

An IC engine is characterized as an engine in which the multiple verve regarding the fuel is cleared within the engine and utilized straightforwardly for mechanical work, rather than an outside combustion engine in which a different combustor is utilized to copy the fuel.

The IC engine was considered and created in the late 1800s. It has significantly affected society and is viewed as a standout amongst the most noteworthy developments of the only remaining century. The IC engine has been the establishment for the effective advancement of numerous business innovations. e.g., think about how this kind of engine has changed the transportation business, permitting the innovation and improvement of vehicles, dispatch, trucks, planes and prepares and so on.

IC engines can convey control in the range from 0.01 kW to  $20 \times 10^3$  kW, contingent upon their stroke length. The total in the commercial center with electric engines, gas turbines, and steam engines. The significant applications are in the vehicle (car and truck, railroad, marine, transport, air ship, home use and stationary territories. By far most of IC engines are created for vehicular applications, requiring a power yield on the request of 102 kW.

The segments of a responding IC engine, square, cylinder, cylinder skirt, valves, crankshaft and associating bar have remained essentially unaltered since the late 1800s. The fundamental contrasts between another engine and one constructed 100 years back are the warm proficiency and the emanation level. For a long time, IC engine look into was gone for improving warm effectiveness and diminishing commotion and vibration. As a result, the warm effectiveness has expanded from about 10% to values as high as half. Since 1970, with acknowledgment of the significance of air quality, there has additionally been a lot of work given to lessening discharges from engines. As of now, emanation control necessities are one of the main considerations in the plan and task of IC engines.

## Literature Review

**R.Prabou et.al (2018)** the work includes, material association test, as well as hardness test, of similar layers regarding composite are finished. The outcome with respect to size of atom and quantity of particles in number dispersed is characterized. The composites based on Sic have been spread on the Al by the method of tossing. The consequent castings are analyzed using checking electron microscopy and hardness tests. The chamber is exhibited using Pro-E wild flame 4.0 showing and analyzed using ANSYS 14.5 proliferation programming for Aluminum (Pure) and Aluminum-SiC and the results were inspected.

**Abino John et al (2015)** In an engine the motivation behind the cylinder is to exchange power from growing gas in the chamber to the wrench shaft by means of a cylinder bar. Cylinder needs to bear the cyclic gas weight and the inertial powers at work, and this working condition may cause the exhaustion harm of the cylinder, for example, cylinder side wear, cylinder head splits, etc. Generally the cylinders are made of

Aluminum for lightweight, warm conductivity. However, it has poor hot quality and high coefficient of development makes it less reasonable for high temperature applications. In this venture, Aluminum Silicon Carbide (AlSiC), an aluminum framework composite is utilized as an option for aluminum. A 3D model was made utilizing CATIA v6 and Structural and warm examination was done on ANSYS 14. Contrasted with Aluminum, AlSiC has better scraped spot opposition, creep obstruction, dimensional soundness, astoundingly great firmness to-weight and solidarity to-weight proportions and better high temperature execution. Creation of cylinder utilizing AlSiC is likewise simpler than utilizing Aluminum

**Shubham Shrivastava, Shikar Upadhyay, [2016]** – In this present work, chamber square was made in 3D programming Solidworks in which opposite balances are mounted. After that adjustments is done in engine chamber square balances, thickness is diminished from 3 mm to 2 mm. with the goal that weight will diminished, second thing to pick material which needs to supplant the current materials, in this examination aluminum compound 1050 is picked for warm investigation to assess the better warmth exchange rate. In first case because of alteration weight of square decreased to 13.2 %, in second case because of material change weight diminished to 2.1 % without trading off with quality.

**K. Sundaram, N. Palanikumar, [Nov. 2016]** – the work includes tests fopr making the material, test for hardness value, regarding similar composites are operated. The influence of the size of molecules and the quantity of particles in numerals are responsible for this. The particiles of SiC are layered upon Al material by the method of throwing. The subsequent castings are considered utilizing investigative electron microscopy as well as test for determining hardness. The cylinder is demonstrating utilizing Pro-E displaying and examining utilizing ANSYS recreation programming for Aluminum (Pure) and Aluminum-SiC and the outcomes were talked about. In this undertaking, 3D Model is set up in CREO and after that CAE examination is performed by Ansys 14.5 and three unique materials (Al with 10% SiC, AL with 20% SiC and AL With 30% SiC) for cylinder are taken into warm investigation. From the outcome acquired from Ansys, It Seems that the Aluminum with 10% SiC material having better temperature circulation in both enduring state warm examination just as transient state warm investigation. Subsequently aluminum with 10% SiC Material is superior to anything Aluminum amalgam Material along these lines Aluminum with 10% SiC Material is most appropriate for cylinder.

## Methodology

### a. Problem identification

After point by point writing overview, it is been seen that the vast majority of the exploration researchers had chipped away at the limiting the weight and swelling impact delivered amid working of IC Engine. Some have concentrated on streamlining the conduct of cylinder with shifting distinctive power. Furthermore, for this, they had picked reenactment, numerical technique or test setup.

## b. Model generation

The software tool CATIA-V6 is utilized so as to create the model. It provides a series of tools which allows to create complete digital form of presentation of the actual product to be modeled. The tool comprises of both 2D as well as 3D structures which are combined and linked with several workbenches and area of applications such as industries, piping geometry, wireframe modelling etc. This software helped in the creation of the model of the piston in the current work, which is later utilized to observe results after analysis.

## c. Study of parameters

i. **Temperature:** A temperature is an objective comparative measurement of warm in addition with icy. It is measured by a thermometer.

Several scales and units are present so as to calibrate temperature, the basic generally utilized is being Celsius (denoted as °C; formerly called centigrade), Fahrenheit (denoted as °F), and, especially in science, Kelvin (denoted as K).

ii. **Heat Flux:** If axial pushing force is exerted on the side walls, this reduces radial tensile stress and the risk of rupturing reduces to a great extent.

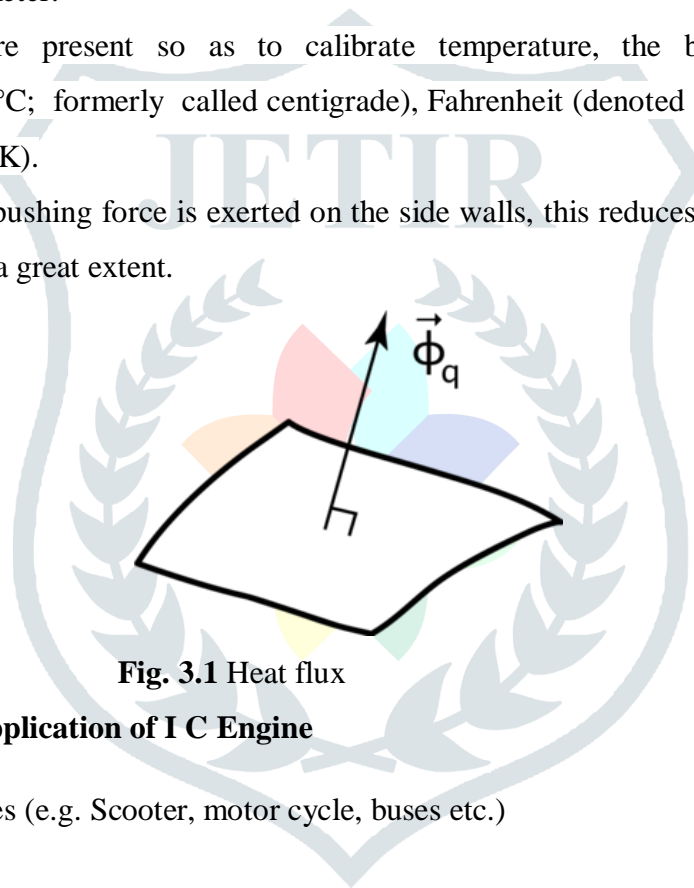


Fig. 3.1 Heat flux

## d. Study of existing application of I C Engine

- Road Vehicles (e.g. Scooter, motor cycle, buses etc.)
- Aircraft
- Motorboats
- Small machines (lawn movers, chainsaws and portable engine – generators)

## e. Selection of material for sheet metal

Most researchers have used different alloy steel materials for their study. I am using **Cast Iron, Pure aluminium (Al), Al-Si-Graphite, Aluminium Alloys - 6061, steel - 1008 and 1020** for my analysis.

## f. Selection of simulation process:

It is the impersonation/portrayal of the task of any genuine world-world procedure or a framework after some time. It tends to be now and again used to speak to the inevitable genuine impacts of elective conditions and strategy. It very well may be utilized for execution improvement, wellbeing building, testing and so on. One

of the significant issue identified with recreation incorporate legitimate wellspring of data and pertinent determination of key attributes and practices

**g. Application of FEA on deep drawing process.**

Finite element method is one of the most effective methods regarding simulation and optimization process. It has a wide variety of applications in manufacturing industries.

**h. Conclusion:** At the end, this can be concluded that the material (Al-SiC-Graphite) used for the piston is having best behavior under both steady state thermal analysis as well as under steady state structural analysis.

#### 4. Material used

Materials used for our result are Grey Cast Iron, Pure aluminium (Al), Al-SiC-Graphite, Aluminium Alloys - 6061, steel - 1008 and 1020.

The investigation of material properties of the material utilized in cylinder is imperative to comprehend conduct of I C Engine. Great tribological properties of composite materials utilized in ignition motor segments are associated with high hardness and wear opposition of clay fortifying particles and the geology of the outside of the composite after the completing treatment. In this work various parameters that are used for the getting optimized result are as follows:

S. No.	Property	Materials					
		Grey Cast Iron	Al-alloy 6061	Steel 1008	Steel 1020	Pure aluminum (Al)	Aluminium Al-SiC-Graphite (SiC 25%, Graphite 4%)
1	Density (kg/m <sup>3</sup> )	7060	2650	7950	7870	2680	2720
2	Poisson's ratio	0.26	0.34	0.3	0.29	0.34	0.34
3	Ultimate tensile strength(MPa)	235	220	340	394.72	165	260
4	Young's modulus(MPa)	12400	71000	210000	200000	71000	74000
5	Specific heat(J/kg°C)	460	897	450	486	910	850
6	Thermal conductivity(w/mmK)	0.048	0.34	0.0652	0.0519	0.151	0.025

**Table 4.1 Material Properties**

## 5. Result

In the present work, several factors which are utilized to obtain an optimized outcome result are mentioned. The section below are the results obtained by the simulation performed on ANSYS tool.

### ➤ Meshing condition

Nodes – 217999

Elements - 132921

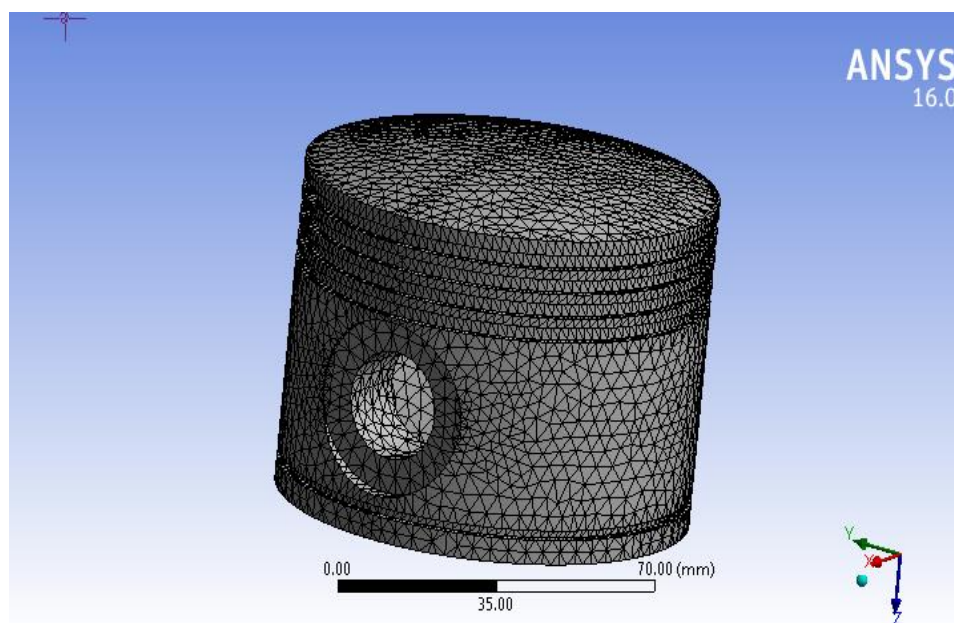


Fig. 5.1.1 Model Meshing

### 5.1 Steady State Thermal Analysis

Material	Heat Flux	
	Maximum	Minimum
Cast Iron	0.094392	0.00022802
Pure Aluminium	0.106930	0.00020703
Steel 1008	0.087625	0.00029490
Steel 1020	0.100840	0.00020130
Steel 6061	0.102722	0.00019682
Al – SiC – Graphite	0.099402	0.00028648

Table 5.1 variation of heat flux within different materials

### Maximum Heat Flux

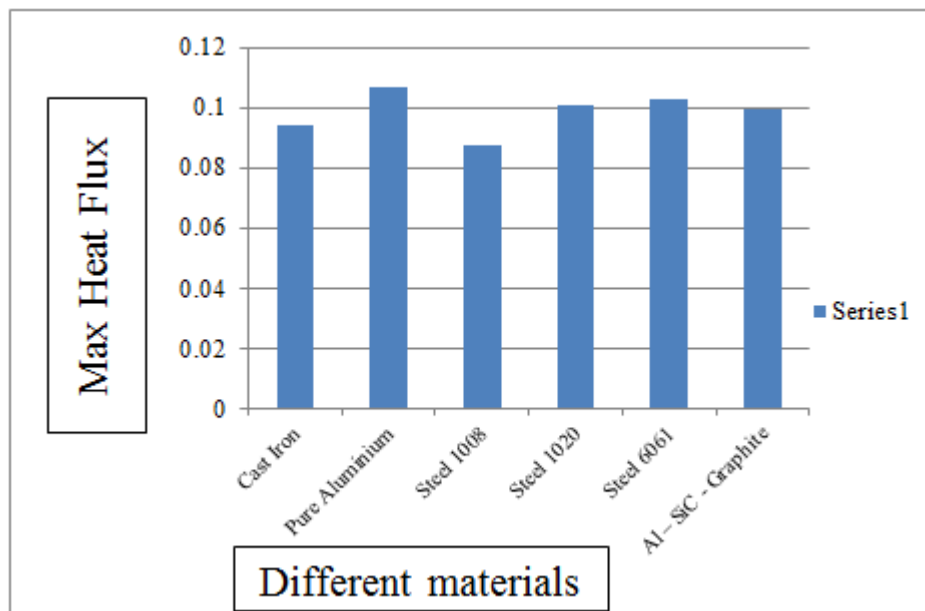


Fig 5.1 variation of maximum heat flux within different materials

## 6.1 Conclusion

Although there are a lot of experimental studies regarding the internal combustion engines process, still there is small researches based on mathematical calculation dependent on the 3D geometry and aimed at static as well as thermal behavior and simulation of piston design that uses gasoline as fuel. The paper includes 3D FEM regarding the head of a piston utilized in traditional petrol based engines. The obtained data showed the working of piston comprised with several materials; along the consideration of transfer of heat by means of conduction. Also, the behavior of the piston was observed under steady state structural analysis. The materials used are Cast Iron, Pure Aluminium, Steel 1008, Steel 1020, aluminum 6061 and Al-Si-Graphite. The standard model for our analysis is generated in CATIA V5 software. And later on, the analysis portion of the work is performed in ANSYS V16.0. And the results obtained for different material taken into consideration are compared in brief.

The results found throughout thermal in addition with structural analysis, it might be said that the steel 1020 has exposed additional dissimilarity which is not suited for the operation if I. C. Engine. Al – Si - Graphite solid has revealed regular outcomes which are best suited for I C Engine comprising a motorcycle. So, the preferred material is Al – SiC – Graphite.

## 6.2 Future scope

Different new materials are coming up Now A days and that too with a great deal of new properties. In a future parcel of new materials will be utilized so as to improve the I C Engine execution. Numerous imperfections identified with the cylinder will be limited. Likewise, this work will be useful for the individual doing work in this field.

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