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Design and Analysis of Cylinder and Cylinder Head of 6-Stroke SI Engine for Weight Reduction

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ABSTRACT

This project focuses on the design and thermal analysis of a six-cylinder engine using SolidWorks for 3D design and ANSYS for thermal analysis. The 3D design in SolidWorks involves creating a detailed model of the engine, considering factors such as dimensions, materials, and assembly. The thermal analysis in ANSYS aims to simulate and evaluate the heat distribution and thermal performance of the engine under various operating conditions.

The integration of SolidWorks and ANSYS allows for a comprehensive approach to engine development, combining detailed design with advanced thermal analysis. By leveraging the capabilities of these software tools, this project aims to optimize the performance, efficiency, and reliability of the six-cylinder engine design. The results of the thermal analysis will provide valuable insights into the engine's thermal behavior, aiding in the refinement of its design for enhanced performance and durability.

KEYWORDS: IC engine, cylinder, cylinder head, ansys, solid works, analysis

1. INTRODUCTION

An internal combustion engine (ICE) is a heat engine where the combustion of a 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, the expansion of the high-temperature and high-pressure gases produced by combustion applies direct force to some component of the engine. The force is applied typically to pistons, turbine blades, rotor 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 around 1859[1] and the first modern internal combustion engine was created in 1876 by Nikolaus Otto (see Otto engine).The term internal combustion engine usually refers to an engine in which combustion is intermittent, such as the more familiar four-stroke and two-stroke piston engines, along with variants, such as the six-stroke piston engine and the Wankel rotary engine. A second class of internal combustion engines use continuous combustion: gas turbines, jet engines and most rocket engines, each of which are internal combustion engines on the same principle as previously described.[1][2] Firearms are also a form of internal combustion engine.[2]

In contrast, in external combustion engines, such as steam or Stirling engines, energy is delivered to a working fluid not consisting of, mixed with, or contaminated by combustion products. Working fluids can be air, hot water, pressurized water or even liquid sodium, heated in a boiler. ICEs are usually powered by energy-dense fuels such as gasoline or diesel fuel, liquids derived from fossil fuels. While there are many stationary applications, most ICEs are used in mobile applications and are the dominant power supply for vehicles such as cars, aircraft, and boats.We almost take our Internal Combustion Engines for granted,don't we? All we do is buy our vehicles, hop in, and drive around. There is, however, a history of development to know about. The compact, well-toned, powerful, and surprisingly quiet engine that seems to be purr under your vehicle's hood just wasn't the tame beast it seems to be now. It was loud, it used to roar, and it used to be rather bulky. In fact, one of the very first engines that had been conceived wasn't even like the engine we know so well of today. An internal combustion engine is defined as an engine in which the chemical energy of the fuel is released inside the engine and used directly for mechanical work, as opposed to an external combustion engine in which a separate combustor is used to burn the fuel.

2. OVERVIEW OF COMPONENT

Fig 1: Full Ic engine

2.1 Main components of the engine

2.1.1 Piston

Piston is one of the main parts in the engine. Its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a connecting rod. Since the piston is the main reciprocating part of an engine, its movement creates an imbalance. This imbalance generally manifests itself as a vibration, which causes the engine to be perceivably harsh. The friction between the walls of the cylinder and the piston rings eventually results in wear, reducing the effective life of the mechanism

Fig 2: piston

2.1. 2Piston Rings

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.

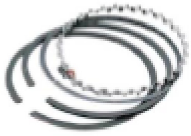


Fig. 3: piston rings

2.1.3. Connecting Rod

The connecting rod is a major link inside of a combustion engine. It connects the piston to the crankshaft and is responsible for transferring power from the piston to the crankshaft and sending it to the transmission. There are different types of materials and production methods used in the creation of connecting rods. The most common types of connecting rods are steel and aluminum. The most common type of manufacturing processes is casting, forging and powdered metallurgy.

Fig.no.4: connecting rod.

2.1.4. Crankshaft

The crankshaft is the part of an engine which translates reciprocating linear piston motion into rotation. To convert the reciprocating motion into rotation, the crankshaft has crankpins, additional bearing surfaces whose axis is offset from that of the crank, to which the "big ends" of the connecting rod from each cylinder attach.

Fig.no.5 crank shaft

2.1.5 Camshaft

Camshaft is frequently called "brain" of the engine. This is so because its job is to open and closed at just the right time during engine rotation, so that the maximum power and efficient cleanout of exhaust to be obtained. The camshaft drives the distributor to electrically synchronize spark ignition. Camshafts do their work through eccentric "lobes" that actuate the components of the valve train. The camshaft itself is forged from one piece of steel, on which the lobes are ground.

Fig.no.6: cam shaft

3. MODELLING OF CYLINDER AND CYINDER HEAD

3.1 DESIGN OF V6 Engine

Solid Works is a solid modeling computer-aided design (CAD) and computer-aided engineering (CAE) computer program that runs on Microsoft Windows. Solid Works is published by Dassault systems. More than 3,246,750 product designers and engineers worldwide, representing 240,010 organizations, use SOLIDWORKSto bringtheir designs to life–from the coolest gadgets to innovations that deliver a better tomorrow. Dassault Systems SOLIDWORKS Corp. offers complete 3D software tools that let you create, simulate, publish, and manage your data. SOLIDWORKS products are easy to learn and use and work together to help you design products better, faster, and more cost-effectively. The SOLIDWORKS focus on ease-of-use allowsmore engineers, designers and other technology professionals than ever before to take advantage of 3D in bringing their designs to life.The design of V6 engine was performed using the solid work.

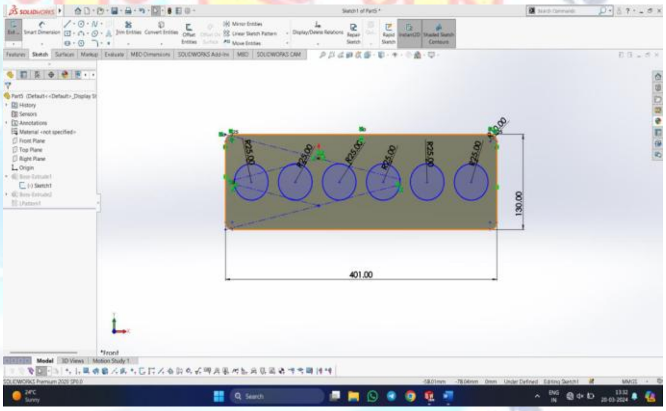


FIG 6: PISTON HOLE DESINGIN

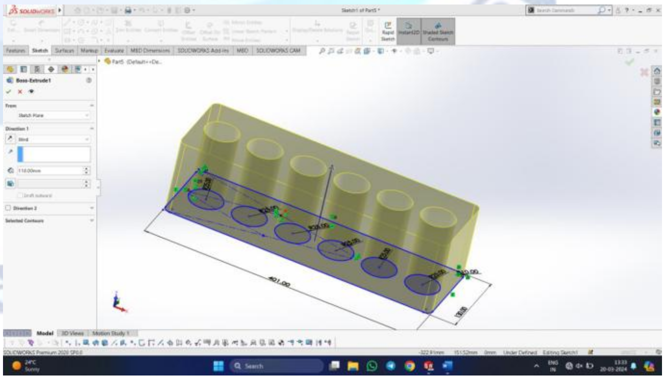


FIG 7:3D VIEW OF 6CYLINDER IC ENGINE

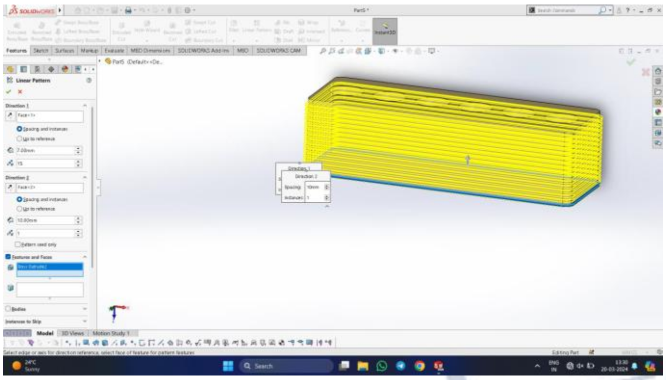


FIG 8: ENGINE FINS DESIGN

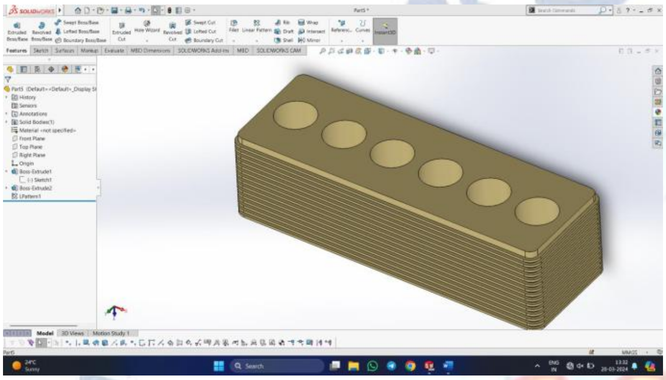


FIG 9: CYLINDER HEAD

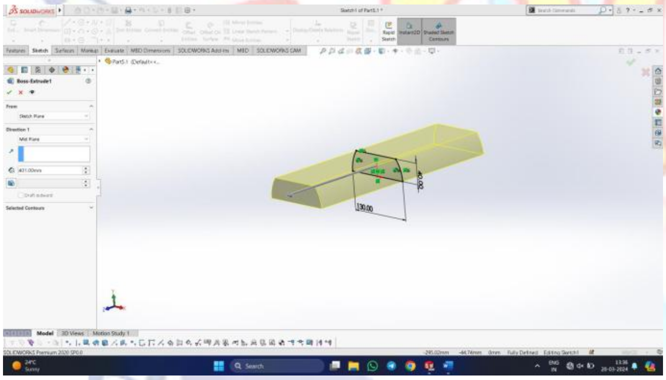


FIG 10: EXTRUDE OF SKETCH

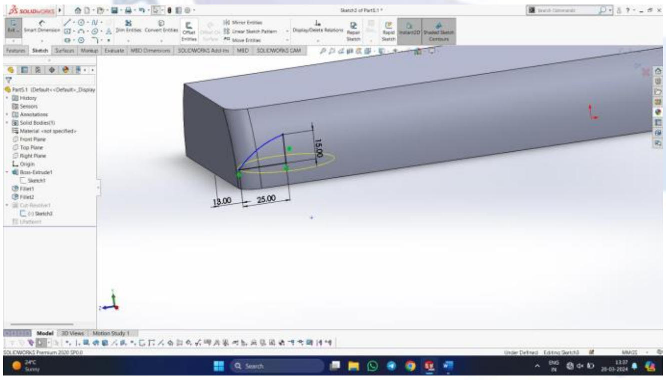


FIG 11:EDITION OF CYLINDER HEAD

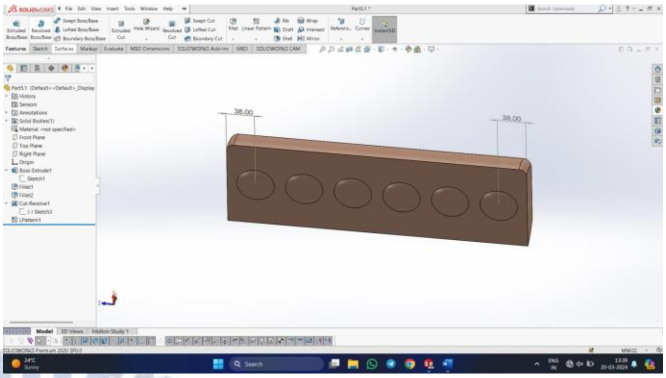


Fig 12:modeled component of cylinder head

4. RESULTS AND ANALYSIS

4.1 meshing of cylinder & cylinder head

Ansys is general purpose software package. Finite element numerical method of a deconstructing a complex system into very small pieces (user designated size) called element. The software implements equations that governs the behavior of these elements and solver them all; creating a comprehensive explanation of how the system acts. These results than can be presented in tabulate or graphical forms. This type of analysis is typically used for the designed and optimization of system for too complex to analyse by hand. Systems that make fir into this category are too complex due to their geometry, or governing equations.

The analysis will performed on aluminum alloy , structural steel and gray cast iron

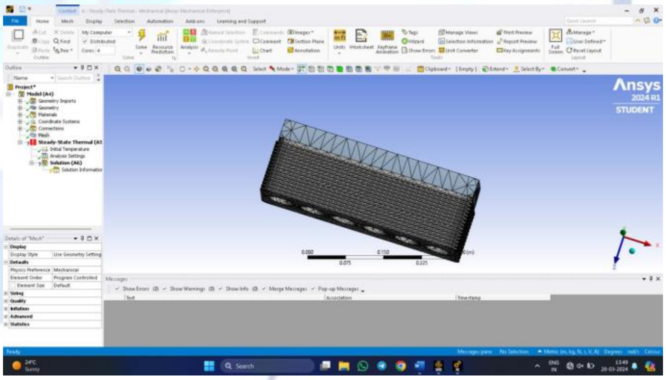


Fig.no.13- Meshing OF Engine Cylinder

4.2 Thermal Analysis

A thermal analysis calculates the temperature distribution and related thermal quantities in a system component. Typical thermal quantities of interest are:

- The temperature distributions
- The amount of heat lost or gained.
- Thermal gradients
- Thermal fluxes.

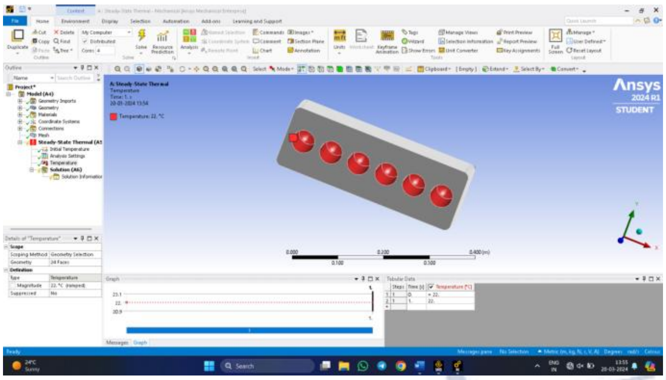


Fig.no.14:-Boundary condition for application of Temperature

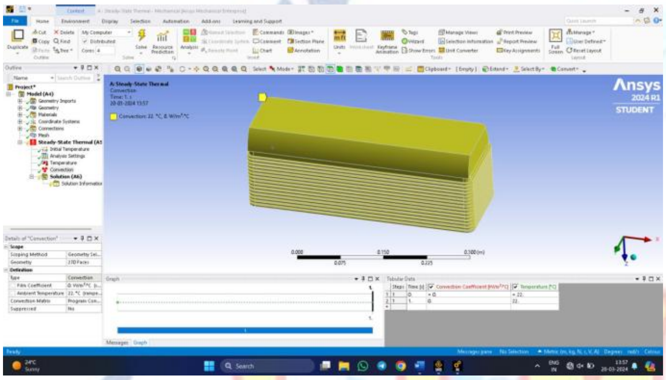
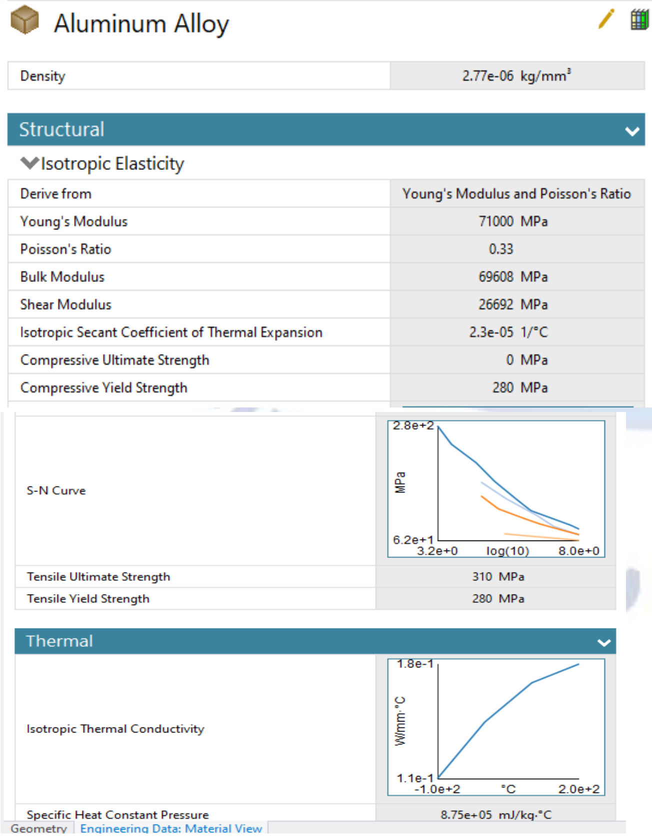


Fig.no.15:-application of Convection

4.3. Aluminum Alloy

TABLE 1: Properties of aluminium alloy



Aluminum Alloy

Density	2.77e-06 kg/mm^3

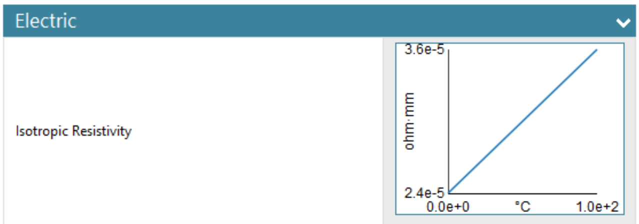
Structural

Isotropic Elasticity

Derive from	Young's Modulus and Poisson's Ratio
Young's Modulus	71000 MPa
Poisson's Ratio	0.33
Bulk Modulus	69608 MPa
Shear Modulus	26692 MPa
Isotropic Secant Coefficient of Thermal Expansion	2.3e-05 1/°C
Compressive Ultimate Strength	0 MPa
Compressive Yield Strength	280 MPa
S-N Curve	
Tensile Ultimate Strength	310 MPa
Tensile Yield Strength	280 MPa

Thermal

Isotropic Thermal Conductivity	
Specific Heat Constant Pressure	8.75e+05 mJ/kg·°C



Electric

Isotropic Resistivity	

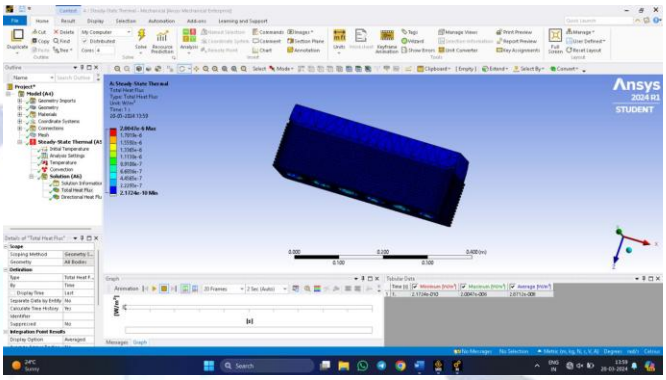


Fig.no.16:-Total Heat Flux for aluminum alloy

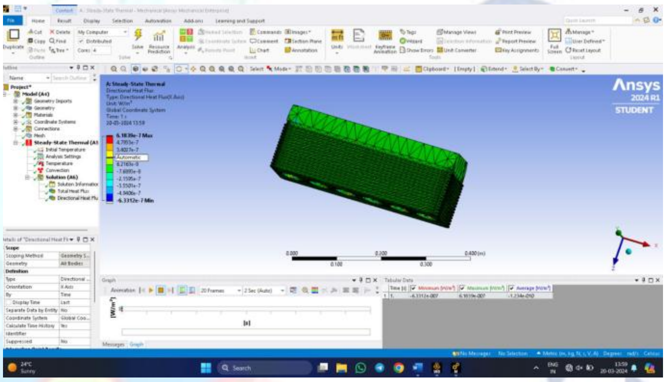
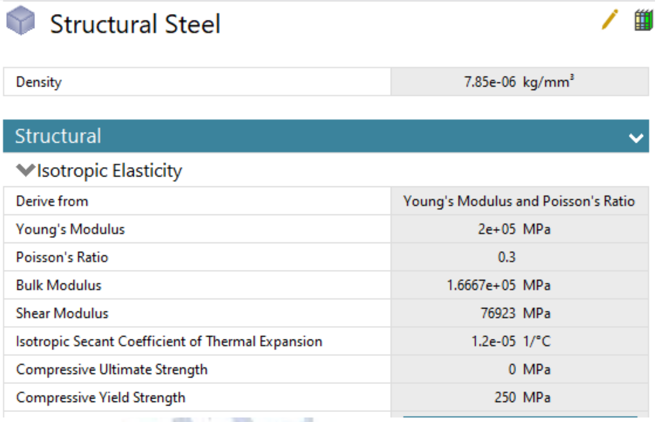


Fig.no17 :-Directional Heat Flux

TABLE 2: STRUCTURAL STEEL



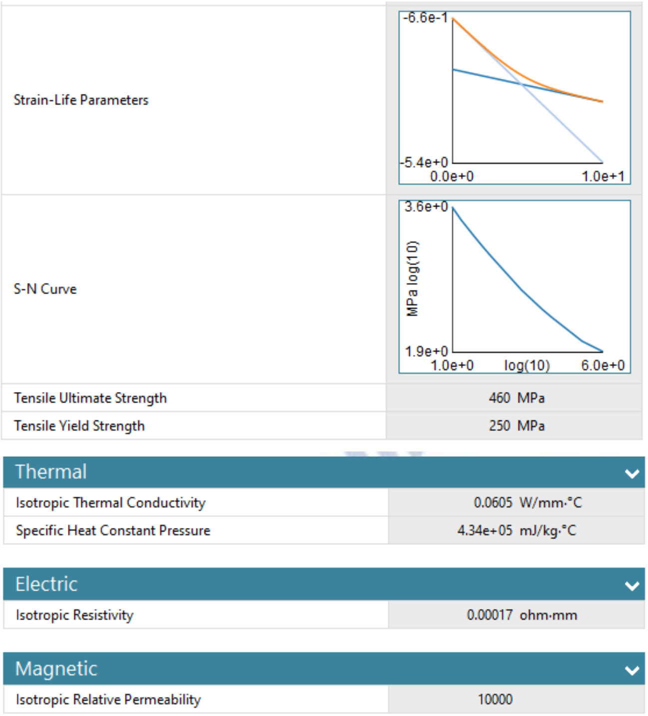
Structural Steel

Density	7.85e-06 kg/mm^3

Structural

Isotropic Elasticity

Derive from	Young's Modulus and Poisson's Ratio
Young's Modulus	2e+05 MPa
Poisson's Ratio	0.3
Bulk Modulus	1.6667e+05 MPa
Shear Modulus	76923 MPa
Isotropic Secant Coefficient of Thermal Expansion	1.2e-05 1/°C
Compressive Ultimate Strength	0 MPa
Compressive Yield Strength	250 MPa



Strain-Life Parameters	
S-N Curve	
Tensile Ultimate Strength	460 MPa
Tensile Yield Strength	250 MPa

Thermal

Isotropic Thermal Conductivity	0.0605 W/mm·°C
Specific Heat Constant Pressure	4.34e+05 mJ/kg·°C

Electric

Isotropic Resistivity	0.00017 ohm·mm

Magnetic

Isotropic Relative Permeability	10000

4.3 RESULT SUMMARY

TABLE 2:RESULT SUMMARY OF DIFFERENT MATERIALS

ALUMINUM	**Minimum**	**Maximum**	**Units**	**Times(s)**
Temperature	182.63	500.	°C	1.
Total heat flux	-3.6659e-005	37.561	w/mm²	1.
Directional heat flux	-35.174	34.832	w/mm²	1.
STRUCTURALSTEEL				
Temperature	-93.706	406.22	°C	1.
Total heat flux	5.5797e-006	7.7969	w/mm²	1.
Directional heat flux	-7.2907	7.3909	w/mm²	1.
GRAY CAST IRON				
Temperature	-99.95	442.69	°C	1.
Total heat flux	4.0612e-006	6.3774	w/mm²	1.
Directional heat flux	-6.2829	6.3774	w/mm²	1.

5. CONCLUSION

Familiarized with designing tool CATIA (sketcher, part assembly, drafting), analysis method ANSYS (Mechanical APDL, ANSYS workbench). Successfully completed designing components of IC ENGINE and assembling them by CATIA, performed steady state thermal analysis on PISTON using ANSYS.

The fundamental concepts and design methods concerned with four stroke six cylinder engine have been studied in this project aluminum alloy is the best material and the results found by the use of this anaiytical method are nearly equal to the actual dimensions used now a days.

The material used are aluminium alloy, structural steel,gray castiron, among this material aluminum alloy is the best material, because it have the properties of low weight, high thermal conductivity & greater flux.

Hence it provides a fast procedure to design a engine which can be further improved by the use of various software and methods. The most important part is that very less time is required to design the engine and only a few basic specifications of the engine.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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