# DESIGN AND ANALYSIS OF 4-STROKE IC ENGINE COMBUSTION CHAMBER

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**Abstract**: An IC engine is one in which the combustion of fuel takes place inside the engine cylinder. IC engine uses either petrol or diesel as their fuel. In petrol engines (S.I engines) the correct proportion of air and petrol is mixed in the carburetor and fed to engine cylinder where it is ignited by means of a spark plug. The steps involved in a 4 stroke IC engine are suction stroke, compression stroke, and expansion stroke and exhaust stroke. One of the main components in an IC engine is the combustion chamber. The design of a combustion chamber has an important influence upon the engine performance and its knock and air swirl properties. Design of a combustion chamber involves the shape of the combustion chamber, location of the spark plug and its position of the combustion chamber head. The present work a study about the influence of combustion upon the performance and emission of an engine. Analysis is carried out on an engine using single cylinder combustion chamber which is four stroke engine cylinders. Performance parameters are calculated. CATIA is parametric used for design and ANSYS software used to perform analysis of combustion chamber model.

## 1. Introduction:

A combustion chamber is that part of an internal combustion engine (ICE) in which the fuel/air mix is burned. ICEs typically comprise reciprocating piston engines, rotary engines, gas turbines and jet turbines. The combustion process increases the internal energy of a gas, which translates into an increase in temperature, pressure, or volume depending on the configuration.

In an enclosure, for example the cylinder of a reciprocating engine, the volume is controlled and the combustion creates an increase in pressure. In a continuous flow system, for example a jet engine combustor, the pressure is controlled and the combustion creates an increase in volume. This increase in pressure or volume can be used to do work, for example, to move a piston on a crankshaft or a turbine disc in a gas turbine. If the gas velocity changes, thrust is produced, such as in the nozzle of a rocket engine.

### Head types

Various shapes of combustion chamber have been used, such as: L-head (or flathead) for side-valve engines; "bathtub", "hemispherical", and "wedge" for overhead valve engines; and "pent-roof" for engines having 3, 4 or 5 valves per cylinder. The shape of the

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chamber has a marked effect on power output, efficiency and emissions; the designer's objectives are to burn all of the mixture as completely as possible while avoiding excessive temperatures (which create NOx). This is best achieved with a compact rather than elongated chamber.

**Swirl & Squish**

The intake valve/port is usually placed to give the mixture a pronounced "swirl" (the term is preferable to "turbulence", which implies movement without overall pattern) above the rising piston, improving mixing and combustion. The shape of the piston top also affects the amount of swirl. Another design feature to promote turbulence for good fuel/air mixing is "squish", where the fuel/air mix is "squished" at high pressure by the rising piston. Where swirl is particularly important, combustion chambers in the piston may be favored.

**Flame front**

Ignition typically occurs around 15 degrees before top dead centre. The spark plug must be sited so that the flame front can progress throughout the combustion chamber. Good design should avoid narrow crevices where stagnant "end gas" can become trapped, as this gas may detonate violently after the main charge, adding little useful work and potentially damaging the engine.

## II - LITERATURE SURVEY

The literature survey regarding use of additive with fuel in-cylinder turbulence inducement aspect investigated are reviewed and discussed in this chapter.

The increase in demand for petroleum fuels and consequent depletion of their reserves has given rise to the need for investigating new energy resources or finding the optimum way of using the present resources. In this regard, two approaches are pursued

a) improving refining processes for producing better quality fuel from different crude oils, that is, tailoring fuel at the refining stage, and

b) Using some additives for improving the quality of existing fuels to a desired level, which is, improving performance of available fuel.

The effects of fuel quality variations on diesel engine emissions is complicated by the wide variation of the engine response to the fuel quality changes and the extent of inter-correlation of the various fuel variables. In engine literature, many investigators have reported. Betroli et al. (1993) suggest that the particulate emission reduction could be attained using the ash less additive technology. The different fuel characteristics are given in Table 2.1. They found that it is necessary to use a conditioning period prior to emission tests.

Kouremenous et al. (1999) examined the effect of the fuel composition and physical properties on the mechanism of combustion and pollutant formation. A number of fuels having different density, viscosity, chemical composition, (especially aromatics type), are used in their investigation and found that the fuel properties namely density and viscosity are more important than fuel composition (aromatics) in respect of engine performance and emissions. The total aromatic content, however, has more influence on

 

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engine performance and emissions rather than the individual aromatics.

Hajdukovic et al. (2000) reported that the toxicity of diesel fuel is generally attributed to soluble aromatic compounds. Alkyl derivatives of benzene and polycyclic aromatic hydrocarbons are considered as most harmful. New oxygen and nitrogen derivatives of hydrocarbons are formed as a result of oxidative and pyrolytic processes during combustion.

**III - OBJECTIVES AND METHODOLOGY**

The objective of this project work is to successfully develop a design of a combustion chamber for thermal analysis. The mechanism is to be reliable, simple, cost-effective and practically feasible. The aim of this combustion chamber is to provide constrained thermodynamic optimization, so as to enable the required measurement of design for combustion chamber. This system is also supposed to enhance the comfort temperature and the favorable conditions.

Initially the design was adopted from an already existing combustion chamber and minor changes were made to suite our purpose, first devised was based on using the level of temperature of the system. This mechanism was later taken in testing phase due to following conditions.

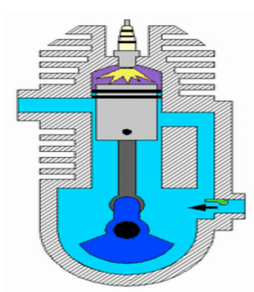
1. Heat transfer coefficient on the combustion chamber has been obtained.
2. Pressure drop on the combustion chamber have been obtained.
3. Combustion chamber process has to be obtained.
4. Carry out design and optimization of combustion chamber by thermal analysis method.

Due to these conditions, the design was changed and a fully new design was defined. The model also uses the same mechanism setup. The software to be used in design is Catia V5 and testing of design is Ansys.

**IV - DESCRIPTION OF THE PROJECT**

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 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. Firearms are also a form of internal combustion engine.

## V - DESIGN METHODOLOGY OF IC ENGINE COMBUSTION CHAMBER

CATIA (Computer Aided Three-dimensional Interactive Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Dassault Systems. Written in the C++ programming language, CATIA is the cornerstone of the Dassault Systems product lifecycle management software suite. CATIA competes in the high-end CAD/CAM/CAE market with Cero Elements/Pro and NX (Unigraphics).


Sets of workbenches can be composed according to the user's preferences. Therefore Dassault Systems offers three different software installation versions. The platform P1 contains the basic features and is used for training courses or when reduced functionality is needed. For process orientated work the platform P2 is the appropriate one. It enables, apart from the basic design features, analysis tools and production related functions. P3 comprises specific advanced scopes such as the implementation of external software packages.

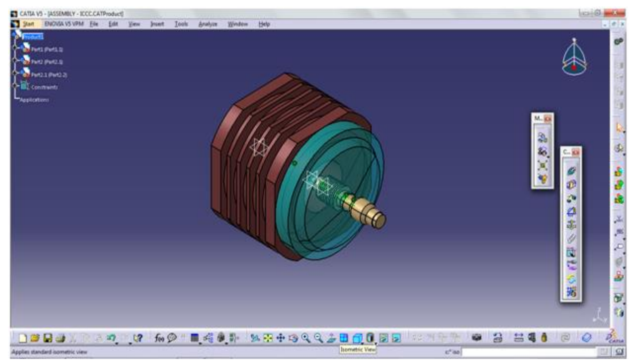


**Fig: Model design in CATIA-V5**

## VI - ANALYSIS OF IC ENGINE COMBUSTION CHAMBER

### 6.1 Procedure for FE Analysis Using ANSYS:

The analysis of the IC Engine Combustion Chamber is done using ANSYS. For compete assembly is not required, is to carried out by applying moments at the circulation of the temperature along which axis we need to mention. Fixing location is bottom legs.

### 6.2 Preprocessor

In this stage the following steps were executed:

- **Import file in ANSYS window**

  File Menu > Import> STEP > Click ok for the popped up dialog box > Click

  Browse" and choose the file saved from CATIAV5R20 > Click ok to import the file

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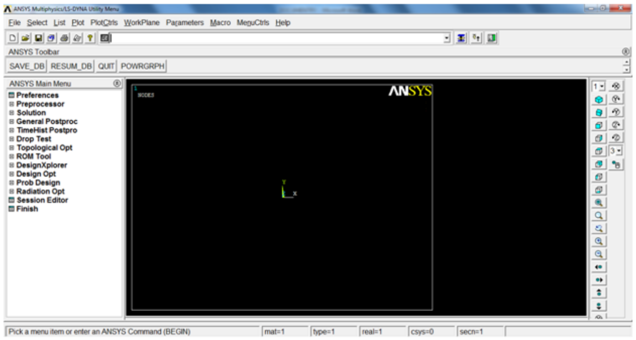


**Fig: Import panel in Ansys.**

**6.2.1 Meshing:**

Mesh generation is the practice of generating a polygonal or polyhedral mesh that approximates a geometric domain. The term "grid generation" is often used interchangeably. Typical uses are for rendering to a computer screen as finite element analysis or computational fluid dynamics. The input model form can vary greatly but common sources are CAD, NURBS, B-rep and STL (file format). The field is highly interdisciplinary, with contributions found in mathematics, computer science, and engineering.

Three-dimensional meshes created for finite element analysis need to consist of tetrahedral, pyramids, prisms or hexahedra. Those used for the finite volume method can consist of arbitrary polyhedral. Those used for finite difference methods usually need to consist of piecewise structured arrays of hexahedra known as multi-block structured meshes.

Meshing is an integral part of the computer-aided engineering (CAE) simulation process. The mesh influences the accuracy, convergence and speed of the solution. Furthermore, the time it takes to create a mesh model is often a significant portion of the time it takes to get results from a CAE solution. Therefore, the better and more automated the meshing tools, the better the solution. From easy, automatic meshing to a highly crafted mesh, ANSYS provides the ultimate solution. Powerful automation capabilities ease the initial meshing of a new geometry by keying off physics preferences and using smart defaults so that a mesh can be obtained upon first try. Additionally, users are able to update immediately to a parameter change, making the handoff from CAD to CAE seamless and aiding in up-front design. Once the best design is found, meshing technologies from, ANSYS provide the flexibility to produce meshes that range in complexity from pure hex meshes to highly detailed Hybrid meshes.

**VII - DISCUSSION ON ANALYSYS RESULT**

**7.1 Results of Thermal Gradient:**

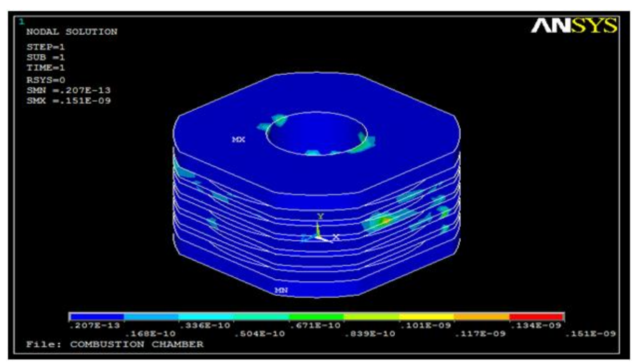


**Fig: 7.1: Thermal Gradient Analysis of Combustion Chamber – Steel**

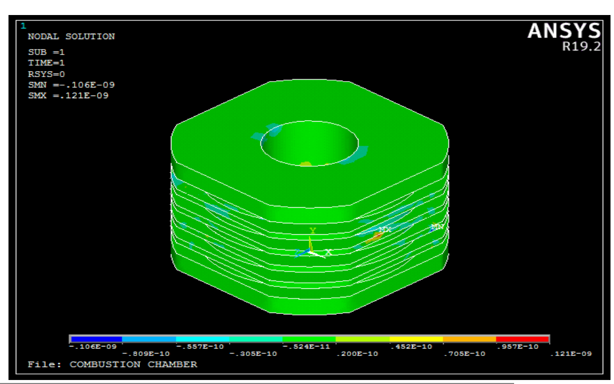

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**Fig: 7.2: Thermal Gradient Analysis of Combustion Chamber – Beryllium**

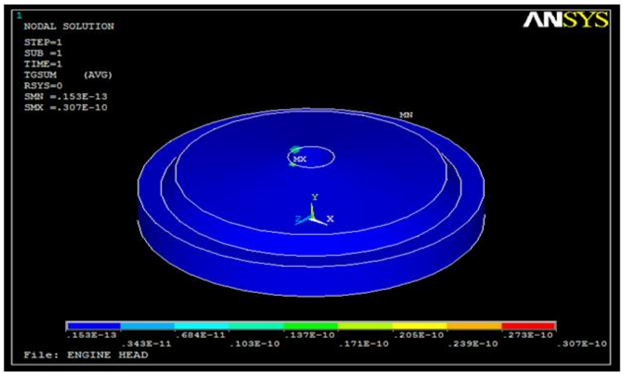


**Fig: 7.3: Thermal Gradient Analysis of Engine Head**

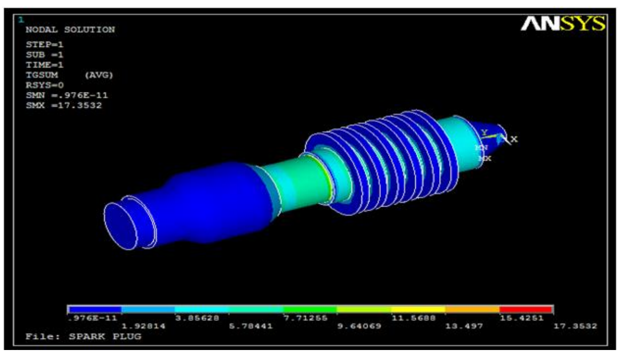


**Fig: 7.4: Thermal Gradient Analysis of Spark Plug**

## 7.2 Results of Thermal Flux:

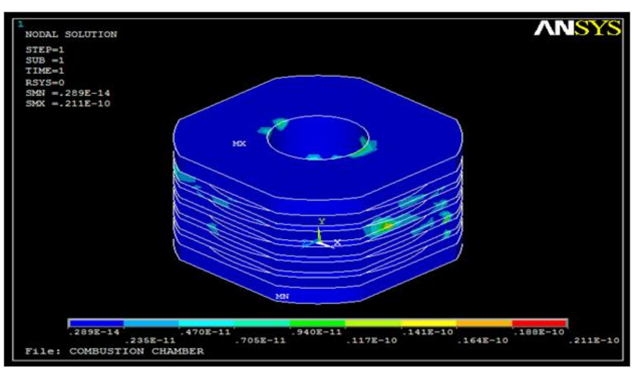


**Fig: 7.5: Thermal Flux Analysis of Combustion Chamber – Steel**

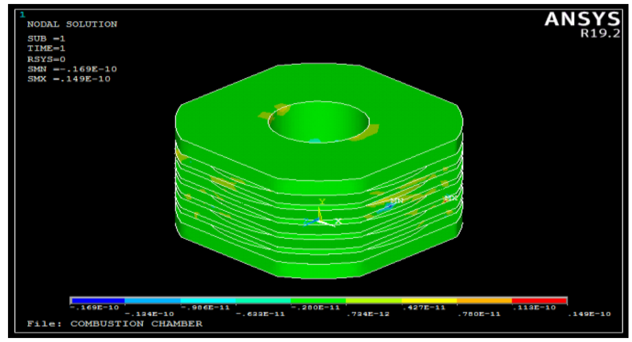


**Fig: 7.6: Thermal Flux Analysis of Combustion Chamber – Beryllium**

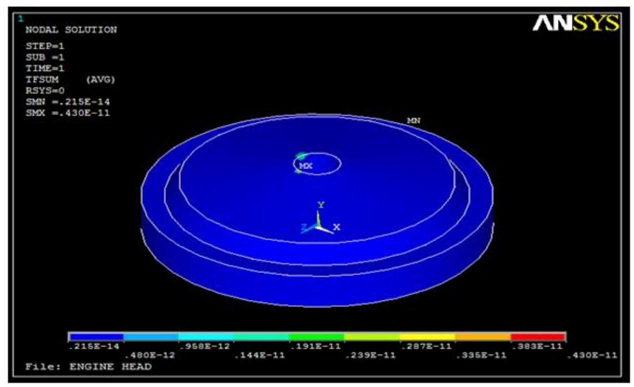


**Fig: 7.7: Thermal Flux Analysis of Engine Head**

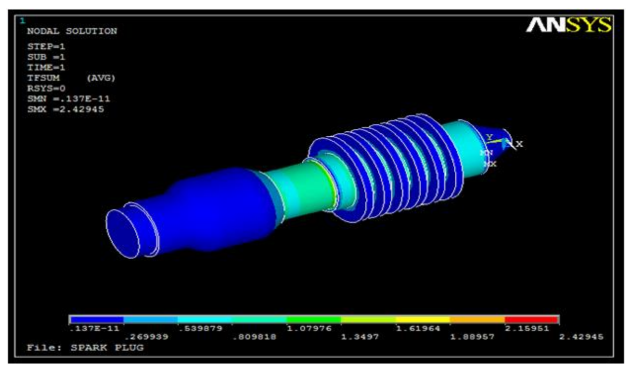


**Fig: 7.8: Thermal Flux Analysis of Spark Plug**

## Results of Heat Flow:

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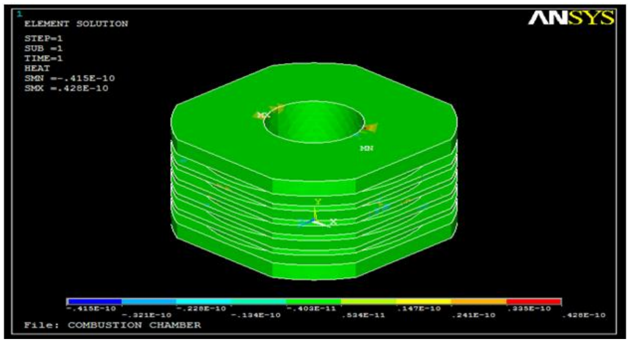


**Fig: 7.9: Heat Flow Analysis of Combustion Chamber – Steel**

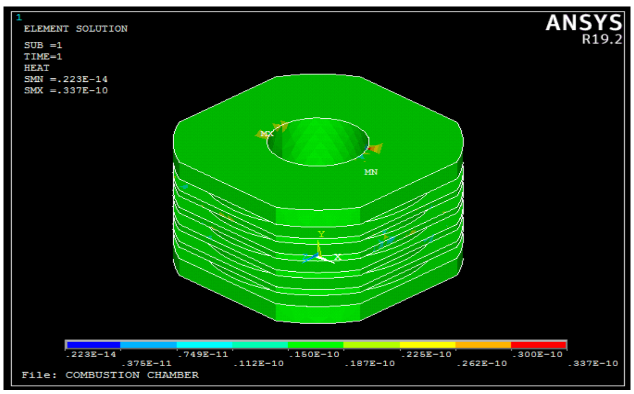


**Fig: 7.10: Heat Flow Analysis of Combustion Chamber – Beryllium**

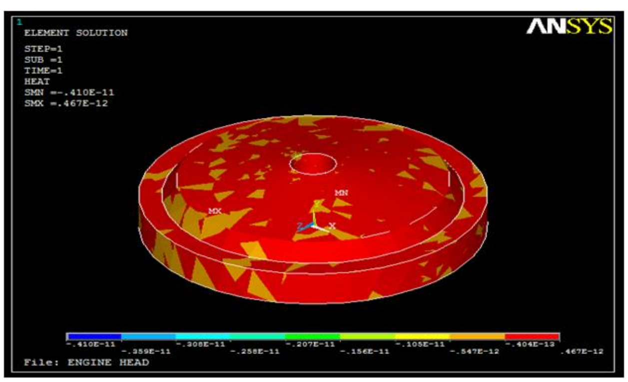


**Fig: 7.11: Heat Flow Analysis of Engine Head**

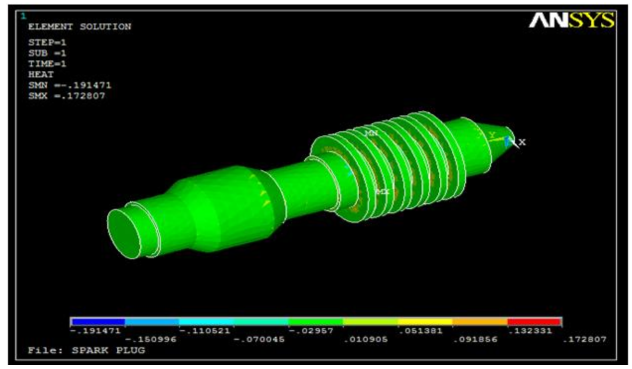


**Fig: 7.12: Heat Flow Analysis of Spark Plug**

## VIII - CONCLUSION

It can be seen from the above result that, our objective of IC Engine Combustion Chamber using constrained thermodynamic optimization with fins which has been successful. As shown above figures the maximum Thermal gradient is coming, this solution solving with the help of Ansys software so that the maximum Thermal gradient for the components.

The maximum Thermal flux is coming, this solution solving with the help of Ansys software so that the maximum Thermal flux for the below components. The maximum Heat flow for the components is listed below.

| S.No | Component | Thermal Gradient | Thermal Flux | Heat Flow |
|---|---|---|---|---|
| 01 | Combustion Chamber (Steel) | 0.151E-09 | 0.211E-10 | 0.428E-10 |
| 02 | Combustion Chamber (Beryllium) | 0.121E-09 | 0.149E-10 | 0.337E-10 |
| 03 | Engine Head | 0.307E-10 | 0.430E-11 | 0.467E-12 |
| 04 | Spark Plug | 17.3532 | 2.4294 | 0.1728 |

Therefore, according to the above analysis, beryllium have obtained better results among the steel material be used for these as an alternative. So we can conclude our design parameters are approximately correct. The design of the IC Engine Combustion Chamber mechanism worked flawlessly in analysis as well, all these facts point to the completion of our objective in high esteem.

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