DESIGN AND ANALYSIS OF I.C ENGINE COMBUSTION CHAMBER USING CFD

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ABSTRACT: Internal combustion engines are seen each day in vehicles, vehicles, and buses. The name inner combustion refers additionally to gas turbines except that the name is generally carried out to reciprocating inner combustion (I.C.) engines like the ones observed in normal cars. There are basically styles of I.C. Ignition engines, those which need a spark plug, and those that rely upon compression of a liquid. Spark ignition engines take a mixture of fuel and air, compress it, and ignite it the use of a spark plug. In this thesis, the combustion chamber is designed in line with the IC engine specs and analyzed for its heat switch price the use of Finite Element evaluation software ANSYS and calculate emissions . Modeling may be done in CREO parametric software. CFD analysis to determine the stress drop, speed and heat switch coefficient and to finding the emissions (O2, N2) of methane and ethane (mass fraction, mole fraction and mole concentration of methane and ethane).

INTRODUCTION

Diesel engines paintings by compressing most effective the air. The diesel inner combustion engine differs from the gasoline powered Otto cycle by the usage of fantastically compressed warm air to ignite the gas in place of the usage of a spark plug (compression ignition in place of spark ignition).

MAJOR ADVANTAGES

Diesel engines have several advantages over other inner combustion engines:

- Diesel gasoline has higher electricity density and a smaller volume of gasoline is needed to carry out a specific amount of labor.

- Diesel engines inject the gasoline without delay into the combustion chamber, have no intake air restrictions apart from air filters and intake plumbing and haven't any consumption manifold vacuum to feature parasitic load and pumping losses as a consequence of the pistons being pulled downward towards intake machine vacuum. Cylinder filling with atmospheric air is aided and volumetric efficiency is elevated for the equal cause.

- Diesel fuel has better lubrication properties than petrol as well. Indeed, in unit injectors, the gasoline is employed for three distinct functions: injector lubrication, injector cooling and injection for combustion.
Since the diesel engine makes use of less gasoline than the petrol engine in line with unit distance, the diesel produces much less carbon dioxide (CO2) according to unit distance. Recent advances in production and adjustments inside the political climate have expanded the availability and cognizance of biodiesel, an alternative to petroleum-derived diesel gasoline with a much decrease net-sum emission of CO2, because of the absorption of CO2 by way of vegetation used to supply the gas. However, the use of waste vegetable oil, sawmill waste from controlled forests in Finland, and advances in the production of vegetable oil from algae demonstrate excellent promise in providing feed shares for sustainable biodiesel that aren't in competition with food production.

II. PROBLEM DESCRIPTION

In this thesis, the combustion chamber is designed in step with the IC engine specifications and analyzed for its heat switch price the use of Finite Element analysis software ANSYS and calculate emissions.

Modeling will be completed in CREO parametric software. CFD analysis to determine the pressure drop, speed and heat transfer coefficient and to finding the emissions (O2, N2) of methane and ethane (mass fraction, mole fraction and mole awareness of methane and ethane).

III. LITERATURE REVIEW

[1] Combustion Chambers in CI Engines: A Review Arka Ghosh B. Tech. (Mechanical Engineering), SRM University, Kattankulathur, T.N., India – 603203 CI engines are widely utilized in desk bound as well as cell programs. Stationary applications consist of typical gen-set, etc. And cellular applications consist of heavy cars, forestry equipments, etc. As well as different programs in day-to-day existence. Since the turbulence is important for better mixing and the reality that it could be controlled via form of the combustion chamber, makes this evaluation paper necessary. This paper re-visits and attracts on the necessities of combustion chamber, their design, have an effect on in combustion procedure, timing, and so forth. This paper is supposed to emphasise studies on newer designs requirement for combustion chambers. CI engines discover huge packages due to their robustness, high compression ratio and for this reason high thermal efficiency and usage of non-volatile gasoline typically diesel oil.

INTRODUCTION TO CAD

Computer-aided layout (CAD) is the usage of pc systems (or workstations) to resource in the introduction, change, analysis, or optimization of a design. CAD software program is used to growth the productivity of the fashion designer, improve the best of design, improve communications thru documentation, and to create a database for production. CAD output is often within the form of digital files for print, machining, or different manufacturing operations. The time period CADD (for Computer Aided Design and Drafting) is likewise used.
INTRODUCTION TO CREO

PTC CREO, previously called Pro/ENGINEER, is 3D modeling software used in mechanical engineering, layout, production, and in CAD drafting service companies. It became one of the first three-D CAD modeling programs that used a rule-based totally parametric machine. Using parameters, dimensions and features to seize the conduct of the product, it could optimize the improvement product in addition to the layout itself.

Input parameter of CFD domain

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crank shaft speed</td>
<td>1550 rpm</td>
</tr>
<tr>
<td>Crank radius</td>
<td>56 mm</td>
</tr>
<tr>
<td>Bore</td>
<td>85 mm</td>
</tr>
<tr>
<td>Stroke</td>
<td>85 mm</td>
</tr>
<tr>
<td>Fuel</td>
<td>Diesel C10H26</td>
</tr>
</tbody>
</table>

MODELING

The geometry of the C.I engine is modeled in CREO3.0 software.

ORIGINAL MODEL

Original model of combustion chamber

Draw a required combustion chamber profile that should be in closed loops then its convert into 3D surface by using fill option.

MODIFIED MODEL

INTRODUCTION TO FEA

Finite detail analysis is a technique of solving, typically about, sure troubles in engineering and technology. It is used specifically for problems for which no genuine solution, expressible in a few mathematical form, is available. As such, it's far a numerical in preference to an analytical approach. Methods of this kind are wanted due to the fact analytical techniques cannot cope with the real, complex troubles that are met with in engineering. For instance, engineering electricity of materials or the mathematical concept of elasticity may be used to calculate analytically the stresses and traces in a bent beam, however neither will be very a hit in locating out what is going on in part of a vehicle suspension device for the duration of cornering.

CFD ANALYSIS OF COMBUSTION CHAMBER

Computational method and Boundary situation

For CFD evaluation viscous popular k-e RNG fashionable version is enabled for considering volumetric reaction and eddy dissipation. Domain is subjected to movement of piston appropriate boundary situation for piston, cylinder, fluid and cylinder walls. Combustion manner in a C.I engine involves the brief injection of finely atomized liquid fuel into the air at excessive temperature and pressure. Boundary condition area of the injector, length of the injector, injection temperature and pressure, mass flow rate are having vast effect in diesel combustion modeling. The injection mass waft charge parameters and Engine specs are given underneath Table 1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine Speed</td>
<td>1550 rpm</td>
</tr>
<tr>
<td>Mass Flow Rate</td>
<td>0.00111055 kg/s</td>
</tr>
<tr>
<td>Spray Cone Angle</td>
<td>55 Deg.</td>
</tr>
<tr>
<td>Start Crank Angle</td>
<td>360 Deg.</td>
</tr>
<tr>
<td>Stop Crank Angle</td>
<td>720 Deg.</td>
</tr>
</tbody>
</table>

Imported model

The geometry of the C.I engine is modeled in CREO software. that file is converted into IGES format to import in ANSYS software. The model of combustion chamber is saved in IGES format which can be directly imported into ANSYS workbench. The model imported to ANSYS workbench.
Imported CFD domain combustion chamber original model shows in fluid flow fluent

**Meshed model**

The meshing is done on the model with 859 number of nodes and 781 numbers of tetrahedral elements.

**Inlet and outlet conditions**

Boundary conditions are a required component of the mathematical model. Boundaries direct motion of flow. Specify fluxes into the computational domain, e.g. mass, momentum, and energy. Fluid and solid regions are represented by cell zones. Material and source terms are assigned to cell zones. Boundaries and internal surfaces are represented by face zones. Boundary data are assigned to face zones.

**FLUID – METHANE + AIR**

**Pressure**

According to the pressure plot the maximum pressure value 1.09e-01 Pa and minimum pressure value 5.47e-03. The maximum pressure at inlet condition of combustion chamber and minimum pressure value at outlet conditions of the combustion chamber.

**Velocity**

According to the velocity plot the maximum velocity value 2.88e-01 Pa and minimum velocity value 1.44e-02. The maximum velocity at upper middle portion of combustion chamber and minimum velocity value at lower right side of the combustion chamber.

**Heat transfer coefficient**

According to the Heat transfer coefficient plot the maximum velocity value 6.00e+01 w/m²-k and minimum Heat transfer coefficient value 3.00e+00 w/m²-k. The maximum Heat transfer coefficient at complete boundary of combustion chamber and minimum Heat transfer coefficient value at inside of the combustion chamber.

**Mass fraction of O₂**

**Mass fraction of N₂**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Original model</th>
<th>Reference model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure (Pa)</td>
<td>1.09e-01</td>
<td>5.47e-03</td>
</tr>
<tr>
<td>Velocity (m/s)</td>
<td>2.88e-01</td>
<td>1.44e-02</td>
</tr>
<tr>
<td>Heat transfer coefficient (w/m²-k)</td>
<td>6.00e+01</td>
<td>3.00e+00</td>
</tr>
<tr>
<td>mass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>O₂</td>
<td>7.16e-01</td>
<td>7.88e-01</td>
</tr>
<tr>
<td>N₂</td>
<td>5.31e-09</td>
<td>6.00e-09</td>
</tr>
<tr>
<td>CH₄C₂H₆</td>
<td>5.13e-08</td>
<td>5.00e-08</td>
</tr>
<tr>
<td>CH₄C₂H₆</td>
<td>2.32e-01</td>
<td>2.00e-01</td>
</tr>
<tr>
<td>CH₄C₂H₆</td>
<td>2.66e-01</td>
<td>2.00e-01</td>
</tr>
<tr>
<td>CH₄C₂H₆</td>
<td>1.30e-01</td>
<td>1.24e-01</td>
</tr>
<tr>
<td>CH₄C₂H₆</td>
<td>3.43e-01</td>
<td>3.04e-03</td>
</tr>
<tr>
<td>CH₄C₂H₆</td>
<td>3.25e-01</td>
<td>2.34e-03</td>
</tr>
</tbody>
</table>
From the above result table when we notice that results like Pressure (Pa), Velocity (m/s), Heat transfer coefficient (w/m²-k), mass fraction (O₂, N₂ & CH₄/ C₂H₆) mole fraction (O₂, N₂ & CH₄/ C₂H₆) Mass concentration (O₂, N₂ & CH₄/ C₂H₆) for different fluids (methane & ethane) from the above data the mass concentration of combustion more for methane + air fluid.

MODIFIED MODEL OF COMBUSTION CHAMBER

Imported model

Meshed model

Inlet and outlet conditions

FLUID – METHANE + AIR
Pressure

Velocity

Heat transfer coefficient

FLUID – ETHANE + AIR
Pressure

Velocity
Heat transfer coefficient

Mole fraction of CO₂

Mass fraction of CO₂

Mole fraction of H₂O

Mass fraction of H₂O

Mole fraction of C₂H₆

Mass fraction of C₂H₆

Molar concentration of CO₂
From the above result table when we notice that results like Pressure(Pa), Velocity (m/s), Heat transfer coefficient (w/m²-k), mass fraction (O₂, N₂ & CH₄/ C₂H₆), mole fraction (O₂, N₂ & CH₄/ C₂H₆), Mass concentration (O₂, N₂ & CH₄/ C₂H₆) for different fluids (methane & ethane) from the above data the mass concentration of combustion more for methane + air fluid.

CONCLUSION

In this thesis, the combustion chamber is designed according to the IC engine specifications and analyzed for its heat transfer rate using Finite Element analysis software ANSYS and calculate emissions. Modeling will be done in CREO parametric software. CFD analysis to determine the pressure drop, velocity and heat transfer coefficient and to finding the emissions (O₂, N₂) of methane and ethane (mass fraction, mole fraction and mole concentration of methane and ethane).

By observing the CFD analysis of combustion chamber the original model have emission of methane and ethane for original and modified model. Compare with the combustion chamber models the mass concentration value and heat transfer coefficient value is more for modified model of combustion chamber. And when we compare the fluids of combustion chamber the mass concentration of methane value is more.

So it can be concluded the combustion chamber modified model and fluid methane+ air combination fluid is better performance.

REFERENCES


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[8] Combustion traits of a swirl chamber type diesel engine† Gyeung Ho Choi1, Jae Cheon Lee2, Tae Yun Kwon3, Chang Uk Ha4, Jong Soon Lee4, Yon Jong Chung5, Yong Hoon Chang6 and Sung Bin Han6,