CFD ANALYSIS OF PISTONBOWLS GEOMETRY FOR C.I. DIRECT INJECTION ENGINE USING FEA TECHNIQUE

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Abstract: When it comes to CI engines that run on diesel, the two main pollutants are nitrogen oxides (NOx) and soot. The efficiency of combustion engines may be enhanced by adjusting the air and fuel mixture. One of the several methods to optimise the air-fuel combination within a cylinder is to change the shape of the piston bowl. A number of scholars have investigated combustion chambers and various piston bowl geometries. A direct-injection diesel engine's performance and emissions are impacted by the shape of the piston bowl, as shown in this study. A variety of piston bowl designs, including hemispherical (HCC), shallow depth (SCC), and toroidal (TCC), have been developed and analysed using the CAE tool ANSYS workbench and the computer-aided design (CAD) programme CATIA. Their combination qualities are also computed for Karanja oil and Diesel, the base fluid. Karanja and Diesel are used in varying proportions by volume, with values ranging from 0.2% to 0.4%. In order to conduct analysis, the characteristics of nanofluids are first determined by theoretical calculations. Different geometries are subjected to computational fluid dynamics (CFD) study at varying fluid volume fractions, while geometries using piston bowls and various composite materials (such as armide fibre and carbon fibre) are subjected to thermal analysis.

INTRODUCTION

When compared to spark ignition engines, compression ignition engines are better suited for heavy-duty applications because of their longer lifespan and greater thermal efficiency [1, 2]. The high levels of oxides of nitrogen (NOx) and particulate matter (PM) emissions from conventional diesel combustion (CDC) engines, however, are making it more difficult for these engines to comply with pollution standards [3]. Due to advancements in the precision and adaptability of common-rail injection systems, low-temperature combustion (LTC) ideas like HCCI [5-7] and partially premixed combustion (PPC) [8,9], RCCI [10,11], intelligent charge compression ignition (ICCI) [12,13], and diesel methanol dual fuel (DMDF) [14–16] have been thoroughly studied. To create a stratified fuel/air mixture that is quite low before ignition starts, these LTC engines typically pump one fuel straight into the cylinder during the intake/compression stroke [17]. For this reason, much as CDC engines, LTC engines always need a high CR in order to ignite the lean mixture. The stratification of the mixture inside the cylinder causes staged combustion, which, without the need for costly after-treatment technologies, allows for the simultaneous achievement of high thermal efficiency and low NOx and PM emissions [1,5]. In direct-injection compression ignition (DICI) engines, less reactive fuels, such as petrol, have a longer ignition delay and better fuel-air mixing than diesel fuel [18]. This has a significant impact on load extension and knock management. Nevertheless, fuel

Due to their poor fuel reactivity, DICI

engines produce a lot of unburned hydrocarbons (UHC) and carbon monoxide (CO) emissions and have trouble coldstarting at low loads [19,20]. Optimising fuel distribution in the cylinder is a challenging task for gasoline DICI engines. Several factors influence this process, including the fuel injection system, injection strategy, injector-nozzle design parameters, fuel physical and chemical properties, the shape of the combustion chamber (the piston bowl), and operating conditions (such as intake pressure and temperature). For these reasons, further advancements are necessary.

1. LITERATUREREVIEW

Using ethanol in varying quantities (1%, 3%, and 5% on volume basis), Arumugam et.al. [21] created rice bran oil methyl ester and tested it in a diesel engine. The findings shown that emissions of CO2, NOx, and HC are reduced and emissions of CO and NOx are affected by an increase in the percentage of biodiesel in the fuel mixture. Reportedly, emissions of ethanol-B20ROME blends decrease emissions of the two main gases responsible for climate change: CO2 and NOx. After adding 1, 3, and 5% ethanol to B20ROME.

Researchers Senthil, R., et. al. [22] looked into how a single-cylinder direct-injection Diesel engine ran on Annona methyl ester fuel containing antioxidants including p-phenylenediamine, a-tocopherol acetate, 1,4-dioxane, and l-ascorbic acid, as well as its combustion characteristics, emissions, and performance. A significant reduction in NOx emissions was seen when anti-oxidant compounds were used. The best antioxidant addition for reducing NOx emissions by up to 42.15 percent compared to pure biodiesel is p-phenylenedimineadditive at a concentration of 0.010% m. Dear Mark, Research by Robert Ellis [23] shows that a change to the combustion chamber, namely the installation of a piston bowl, may greatly enhance the efficiency of fuel and air mixing, leading to a dramatic increase in the rate of peak pressure heat release.

In an effort to enhance mixture formation, Montajir et al. [24] have tried to alter the shape of the combustion chamber. They discovered that the reentrant cavity with the rounded lip spreads the spray out more and creates more spray overall. A bottom corner radius, they discovered, boosts spray volume and helps disperse gasoline that has built up there.

Performance, combustion, and emissions of an ethanol-diesel mixture in a diesel engine were investigated by Gnanamoorhi et al. [25] in relation to the influence of combustion chamber geometry. At high compression ratios of 19.5:1, the toroidal combustion chamber is said to produce superior swirl, turbulence, and squish than the hemispherical cavity chamber. Not only that, but the toroidal combustion chamber reportedly increases the peak pressure in the cylinder and the peak heat release rate, and the brake thermal efficiency is 33%. Additionally, it is determined that the toroidal combustion chamber lowered 60% of CO emissions, 20% of HC emissions, 40% of NOx emissions, and 90% of smoke emissions when compared to the hemispherical combustion chamber. In a hemispherical and toroidal combustion chamber, Viswanathan et.al. [26] studied the performance and emission characteristics of a mixture of 20% orange oil methyl ester and 80% diesel. The toroidal combustion chamber engine supposedly reduces emissions of HC and NOx. The hemispherical combustion chamber engine, on the other hand, produces less smoke. The diesel engine's BTE was found to be enhanced and exhaust gas emissions were greatly decreased at full load owing to the improvement of air turbulence motion by the internal jets, according to Rajan and Senthilkumar's [27] testing of the engine's performance with Jatropha methyl ester and internal jets.

In their study, Saito et al. [28] examined the combustion process, engine performance, and emissions of nitrogen oxides and smoke from diesel engines using both traditional and re-entrant combustion chambers. According to reports, a re-entrant combustion chamber improves combustion by increasing turbulence and in-cylinder velocity.
The effects of the piston bowl shape on the combustion and exhaust parameters of a diesel engine fuelled with biodiesel and diesel mixes were quantitatively examined by Li et al. [29]. When using biodiesel in the Omega combustion chamber, they found that CO emissions were reduced and NO emissions were greater.
In order to decrease exhaust emissions, Prasad et al. [30] conducted a numerical study on the impact of a high swirl generating piston. Optimal injection timing was determined to be 8.6 degrees CA bTDC, which reduced soot levels by 85% and NOx emissions by 27% compared to the basic engine.
Using a diesel engine fuelled with 20% Pongamia biodiesel, Jaichandar and Annamalai [31] investigated the impact of injection pressure and a reentrant combustion chamber. With a higher injection pressure of 220 bar and enhanced combustion, they found that NO emissions were raised while CO, UBHC, and smoke were decreased in the reentrant combustion chamber. Biodiesel has a lower brake specific fuel consumption rate and a higher brake thermal efficiency compared to diesel engines with a hemispherical bowl piston geometry. So, this study's overarching goal is to compare diesel engine performance with that of a 25% corn biodiesel mix as well as to diesel alone by examining the combined impact of changing injection pressure and combustion chamber shape.
The impact of an internal jet-induced piston bowl using emulsified diesel fuel was experimentally studied by Wamankar and Murugan [32]. Due to swirl variation and fuel-air interaction, the researcher was able to obtain a greater decrease in emissions with this redesigned piston bowl. The primary objective of this article is to show how diesel and biodiesel fuels may have their combustion bowl profiles modified to optimise performance and emission behaviour.
The toroidal and shallow depth re-entrant combustion bowl, powered by pongamia biodiesel, was experimentally explored by Jaichandar and Annamalai [33]. The researchers concluded that reentrant bowls enhanced mixture formation via enhanced fuel-air contact, which in turn improved performance characteristics.
The effects of a changed combustion bowl profile on a diesel engine run by Calophylluminophyllum methyl ester were investigated by Ramesh Bapu et al. [34]. The results of this experiment show that the performance qualities of the bowl are improved because to the better squish flow that occurs in bowls with a smaller diameter to depth ratio.
Researchers Li et al. [35] used a computational fluid dynamics (CFD) tool and a biodiesel-powered diesel engine with three distinct combustion bowls—a hemispherical, a shallow-depth, and an omega combustion cylinder—to study the effects of piston bowl geometry on fuel efficiency. According to this study, high-speed engines were achieved by using the Omega Combustion chamber, which exhibited superior squish motion. The engine's performance was enhanced by using

a full combination of fuel and air, which was made possible by the three-geometry of the piston.

This is the result of the "CFD analysis of in-cylinder flow and air-fuel interaction on different combustion chamber geometry in DISI Engine" that B. Harshavardhan and J. M. Mallikarjuna[36] worked on. They got the job done by adjusting the crank angle and engine speed. They used an engine speed of 1500 rpm. Their research led them to the conclusion that, out of the three piston shapes tested—flat, dome with centre bowl, and pentroof offset bowl—the flat piston had the highest tumble ratio.

Flat Piston (FP) has a higher Turbulent Kinetic Energy (TKE) of roughly 12.56% compared to POBP, which has a flat piston with a central bowl and disperses TKE across the combustion chamber. Neither the turbulent kinetic energy nor the turbulent intensity contours of the four geometries were examined.

In their study titled "Influence of in-cylinder air swirl on diesel engines performance and emissions," V. V. PrathibaBharathi and G. prasanthi[37] found that improved and complete combustion increases cylinder pressure, reduces smoke, and improves fuel economy. Controlled complete combustion also reduces carbon deposits in the combustion chamber, piston crown, and exhaust system. However, we have not yet examined the pressure and velocity contours. In their study titled "Investigation on flow field in simplified piston bowls for Direct Injection diesel engine," Jinou Song, Chunde Yao, Yike Liu, and ZejunJiang[39] found that squish flow is a key component in the process of turbulence creation close to the TDC. It is important to design the piston bowl configurations to correspond with the contour lines of the turbulence during compression because the interaction among the swirl, squish, bowl shape, and turbulence is much more prominent for the flow fields in the combustion chambers.

According to research by C. Morley, R. J. Price, N. P. Tait, and C. R. McDonald [40] on "Understanding how fuels behave in engines," variations in fuel composition may cause deposits to accumulate in the engine's combustion chamber, which can have a major impact on the engine's performance. Combustion chamber deposits in petrol engines may increase NOx and hydro carbon emissions, however the deposit-forming propensity of fuel components is quite variable.

1.1 PROBLEMDESCRIPTION

This project aims to create a 3D model of the piston bowl geometries using the CATIA cad tool and conduct finite element analysis. The model will study the CFD and structural behaviour of three different piston bowl profiles: hemispherical combustion chamber (HCC), shallow depth combustion chamber (SCC), and toroidal combustion chamber (TCC).

1.2 Themethodologyfollowedintheprojectisas follows:

- Studythe literature review
- Createa3D modelofthepistonbowl geometriesusingparametricsoftware CATIA
- ConvertthesurfacemodelintoParasolidfileandimportthemodelinto ANSYStodo analysis.
- Performstaticanalysisonthedifferentgeometriesatdifferentmaterialsistobe determine the deformation, stress and strain.
- PerformThermalanalysisonthedifferentgeometriesatdifferentmaterialsistobe determine the Temperature distribution and heat flux.
- Perform CFD analysis on the existing model of the piston bowl geometry for Velocity inlettofindouttheTurbulenceintensity,pressuredropandEmissions(NOx, CO….etc).

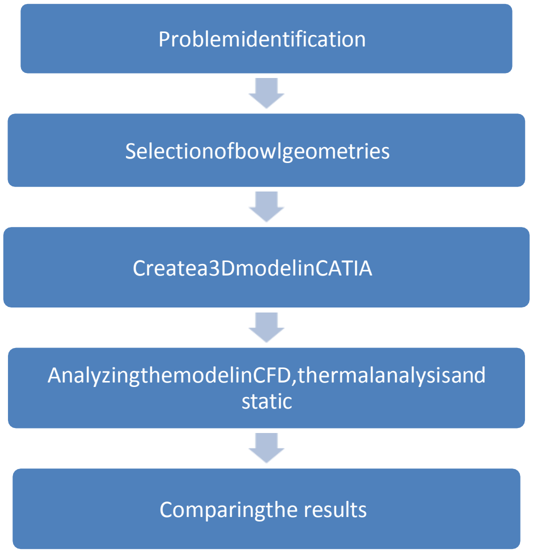


Fig:1FlowChartofWork

2. MATERIALSANDMETHODS

Renewable resources, such as animal fats and vegetable oils, are used to make biodiesel. Diesel engines may run on it either mixed with diesel or straight up. Diesel fuel with a biodiesel mix produces less hazardous gases than diesel fuel alone. More than 70% of India's petroleum products are imported; the country is a developing nation. Energy security, lower import bills, more employment, and less hazardous petrol emissions are all benefits of producing biodiesel from local resources. India cannot afford to produce biodiesel from edible oil because of its high cost. India is a great place to get non-edible oil seeds, such as Jatropha, Karanja, Mahua, Sal, Neem, and many more. When compared to edible oils, its price is lower. Among them, Karanja shows promise as a primary ingredient in biodiesel. With little maintenance, karanja trees may flourish along canal edges, roadsides, and agricultural property borders.

Table:1ThermoPhysical PropertiesofFluids

Specification	**Diesel**	**Karanja**
Density(kg/m^3)	959	920
Thermal conductivity(w/m-k)	0.13	0.0168
Specificheat(j/kg-k)	2220	1572
Viscosity(kg/m-s)	0.006123	0.003831

2.1 CalculationstoDeterminePropertiesofFluidbyChangingVolumeFractions

Density Of Fluid

$$\rho_f=\Phi\times\rho_k+[(1-\Phi)\times\rho_d] \qquad \text{Eq(1)}$$

SpecificHeatOfFluid

$$C_{pnf} = \frac{\Phi\times\rho k\times Cpk+(1-\Phi)(\rho d\times Cpd)}{\Phi\times\rho k+(1-\Phi)\times\rho d} \qquad \text{Eq(2)}$$

ViscosityofFluid

$$\mu_{nf} = \mu_w(1+2.5\varphi) \qquad \text{Eq(3)}$$

ThermalConductivityOfFluid

$$K_{nf} = \frac{Kk+2kd+2(Kk-Kd)(1+\beta)^3\times\Phi}{Kk+2Kd-(Kk-Kd)(1+\beta)^3\times\phi}\times K_d \qquad \text{Eq(4)}$$

Table2:fromEq(1,2,3and4)calculatingtheThermoPhysicalPropertiesofDieselfuelmixed with karanja oil at different volume fractions

Volume fraction(ϕ)	**Density (kg/m^3)**	**Specificheat (j/kg-k)**	**Thermal conductivity(w/m-k)**	**Viscosity (kg/m-s)**
B10	951.21	2094.650	0.13944	0.00918
B15	947.3	2031.202	0.14433	0.01071
B20	943.4	1967.229	0.149349	0.01224

2.2 MATERIALSUSEDINPISTON

Cast iron pistons have a much lower coefficient of thermal expansion than aluminium ones, but they lose a lot of power since they're heavier. The temporal density of cast iron 2.5 is higher than that of aluminium pistons. To avoid piston seizing during prolonged heavy load engine running, a larger gap between the piston and cylinder wall is required when using an aluminium piston (compared to a cast iron piston) due to the aluminum's approximately 2.5 times higher coefficient of thermal expansion.

2.2.1 Aluminumalloy

Because of passivation, aluminium is able to withstand corrosion and has a low density, making it an exceptional metal. Aerospace, transportation, and other industries rely heavily on structural components manufactured from aluminium and its alloys. The oxides and sulphates of aluminium are the most valuable chemicals, based on weight alone. Aluminium is a fascinating metal since it is pliable, lightweight, robust, ductile, and somewhat soft. With 59% the thermal and electrical conductivity of copper and just 30% of copper's density, aluminium is an excellent electrical and thermal conductor. Aluminium has the potential to be a superconductor, with a critical magnetic field of around 100 gauss and a superconducting critical temperature of 1.2 kelvin.

2.3 Comparisonbetween aluminumalloyandcastiron

Pistons made of aluminium alloys have a high heat conductivity—almost four times that of cast iron—so they transmit heat quickly and protect the crown or head of the piston from becoming too hot in the middle. A larger gap must be maintained between the cylinder wall and the aluminium piston (compared to a cast iron piston) to avoid piston siezing while the engine operates continuously under strong loads, as the coefficient of thermal expansion for aluminium is about 2.5 times that of cast iron.

Table:3Thermal,PhysicalandmechanicalPropertiesofmaterials

Specification	**Castiron**	**Aluminum alloy**
Density(kg/m^3)	7200	2700
Thermal conductivity(w/m-k)	52	155
Youngs modulus (Mpa)	24400	68000
Possionratio	0.26	0.3

3. MODELINGANDSIMULATION

3.1 CATIAPARAMETRIC SOFTWARE

Computer Aided Design (CAD) is the use of computer software to design a product or an object. Computer Aided Manufacturing (CAM) is the use of computer software and hardware to plan, manage and control the operations of a manufacturing plant. Computer Aided Engineering is the use of computer software to solve engineering problems and analyze products created using CAD.CATIAisanacronymforComputerAidedThree-dimensionalInteractiveApplication.Itis one of the leading 3D software used by organizations in multiple industries ranging from aerospace, automobile to consumer products. CATIA is a multi platform 3D software suite developed by Dassault Systems, encompassing CAD, CAM as well as CAE.

3.2 ANSYS

The governing equations in ANSYS Forte follow mainly the Continuity equation, Momentum equation (Navier Stokes equation) and Energy equation to solve computational fluid dynamics problem.

Theconservation equationforspecies isgiven by:

$$\frac{\partial\rho}{\partial t}k+\mathrm{A}\cdot\rho ku=\mathrm{A}\cdot \rho DT\mathrm{A}\rho k\rho+ \rho kc+\rho ksk=1,\cdots,K \qquad (5)$$

Where: ρ isthedensity, subscript k isthespeciesindex,K isthetotal numberofspecies, u is the flow velocity vector. Application of Fick's Law of diffusion results in a mixture-averaged turbulent diffusion coefficient DT. ρkc and ρk s are source terms due to chemical reactions and spray evaporation, respectively. The summation of Equation 1 over all species gives the continuity equation for the total fluid

$$\frac{\partial \rho}{\partial t}+A\cdot(\rho\cdot u)=\rho \quad (6)$$

Steady-state thermal analyses calculate the effects of steady thermal loads on a system or component.Usersoften perform asteady-stateanalysisbeforedoinga transientthermalanalysis, to help establish initial conditions. A steady-state analysis also can be the last step of a transient thermal analysis; performed after all transient effects have diminished. ANSYS can be used to determine temperatures, thermal gradients, heat flow rates, and heat fluxes in an object that are caused by thermal loads that do not vary over time.

Computational fluid dynamics, usually abbreviated as CFD, is a branch of fluid mechanics that uses numerical methods and algorithms to solve and analyze problems that involve fluid flows. Computersareusedtoperformthecalculationsrequiredtosimulatetheinteractionofliquids and gases with surfaces defined by boundary conditions. With high-speed supercomputers, better solutions can be achieved. Ongoing research yields software that improves the accuracy and speed of complex simulation scenarios such as transonic or turbulent flows. Initial experimental validation of such software is performed using a wind tunnel with the final validation coming in full-scale testing, e.g. flight tests

.DesignsofCFDDomains

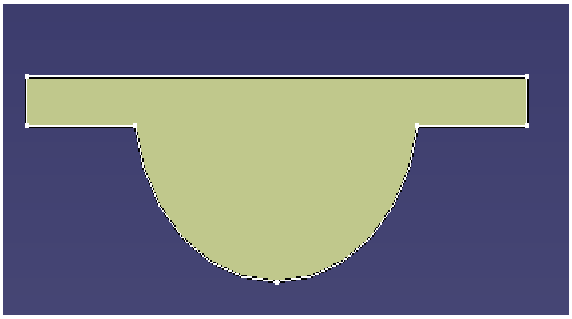


Fig:2hemisphericalchamber

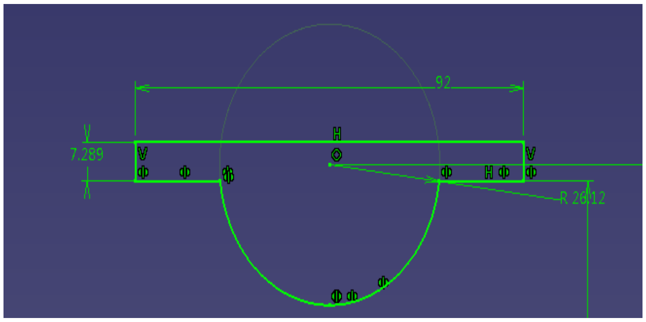


Fig:32Ddrawingofhemisphericalchamber

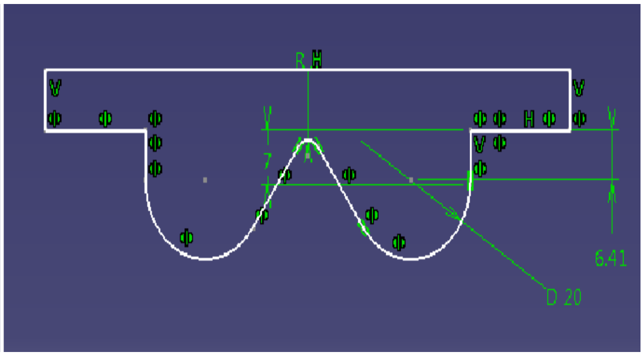


Fig:4ToroidalChamber Fig:52DdrawingofToroidalChamber

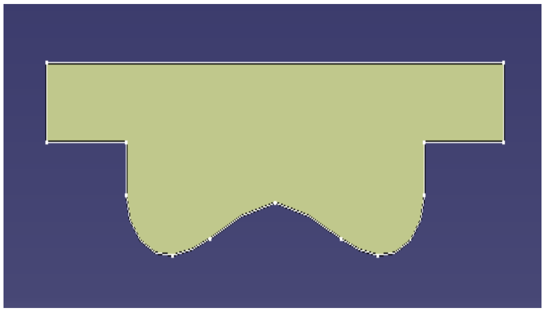


Fig:6Shallowdepthchamber

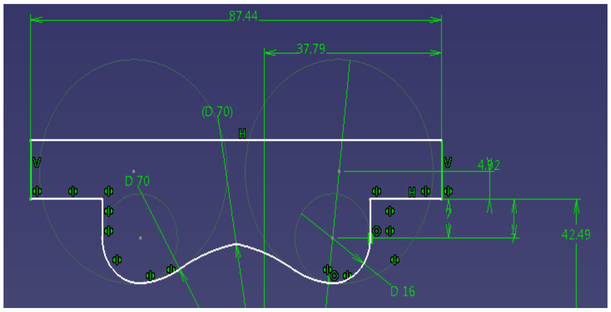


Fig:72DdrawingofShallowdepthchamber

3DMODELOFPISTONBOWLGEOMETRIES

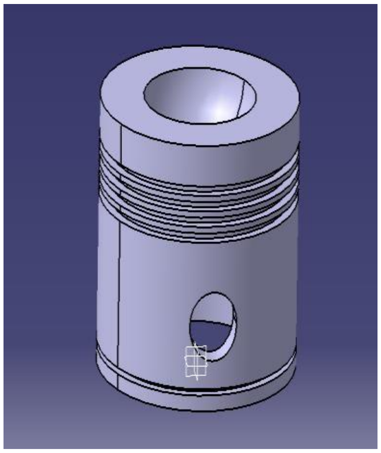


Fig:8hemisphericalchamber

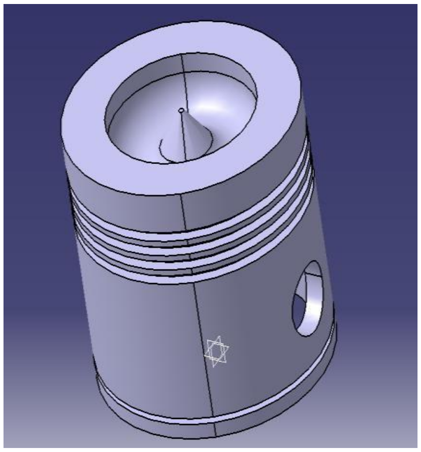


Fig:9ToroidalChamber

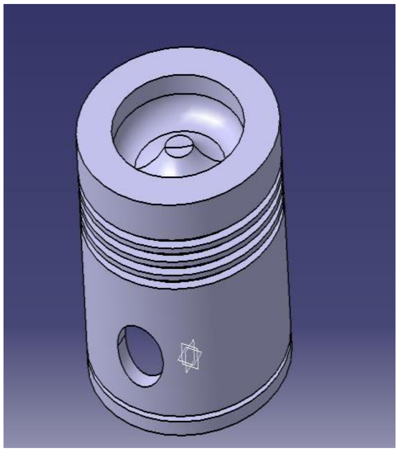


Fig:10Shallowdepthchamber

4. RESULTSANDDISCUSSIONS

4.1 GridmodelsofHCC,TCC,and SCC

Gridindependencyischeckingtheresultforsolutionisindependentfromdifferentmeshtypes and size, result is only depend the CFD domain's Boundary conditions.

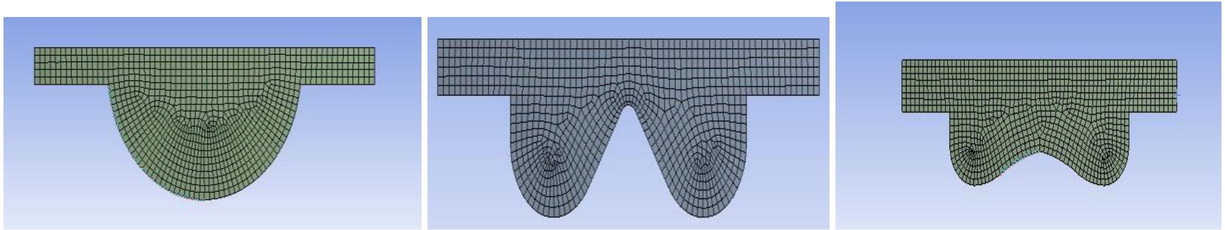
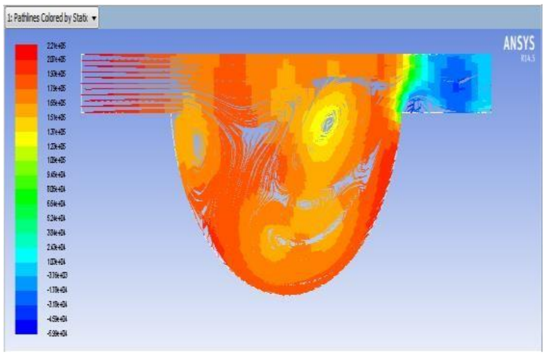


Fig:11meshingmodelsofHCC,TCCandSCCpistonbowlgeometries

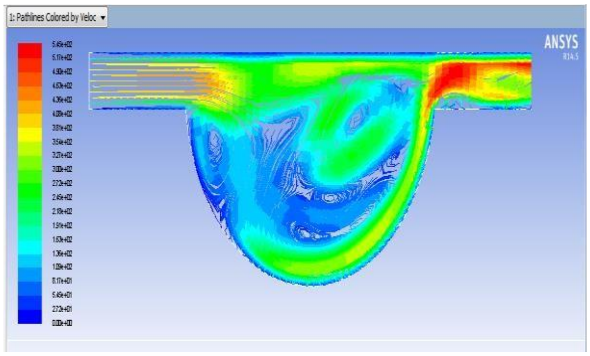
The model is designed with the help of CATIA and then import on ANSYS for Meshing and analysis. The analysis by CFD approach is used in order to calculating pressure, turbulence intensity,velocity,N_2plotsandCO_2.Formeshing,thefluidringisdividedintotwoconnected volumes. Then all thickness edges aremeshed with 360 intervals. A tetrahedral structure mesh is used. So the total number of nodes and elements is 21264and 109297.

Table4: Inputparameter ofCFDdomain

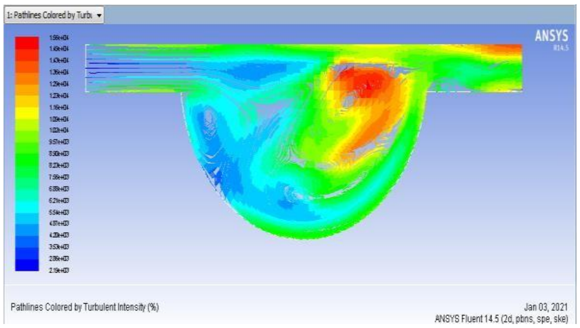
Parameter	**Magnitude**
Crankshaftspeed	1500
Crank radius	47
Bore	85
Stroke	85
Fuel	Diesel+B20(karanjaoil)



(a)

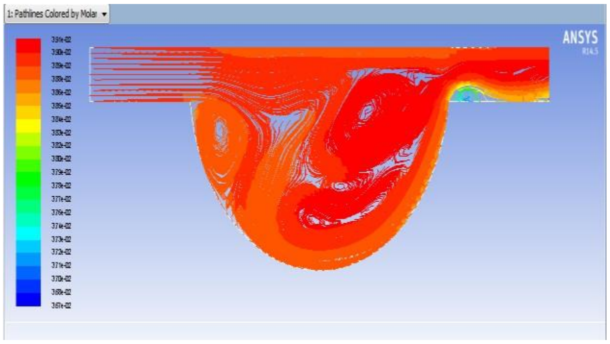


(b)

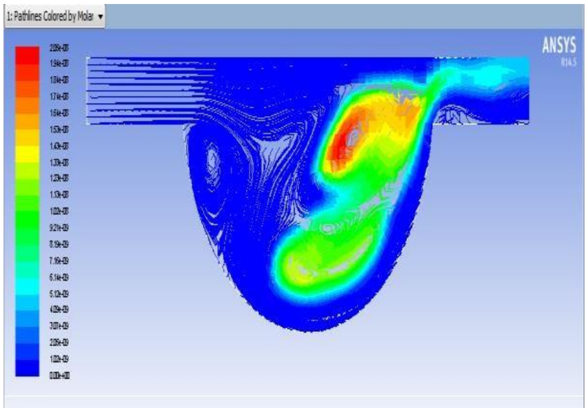


Pathlines Colored by Turbulent Intensity (%)
Jan 03, 2021
ANSYS Fluent 14.5 (2d, pbns, spe, ske)

(c)

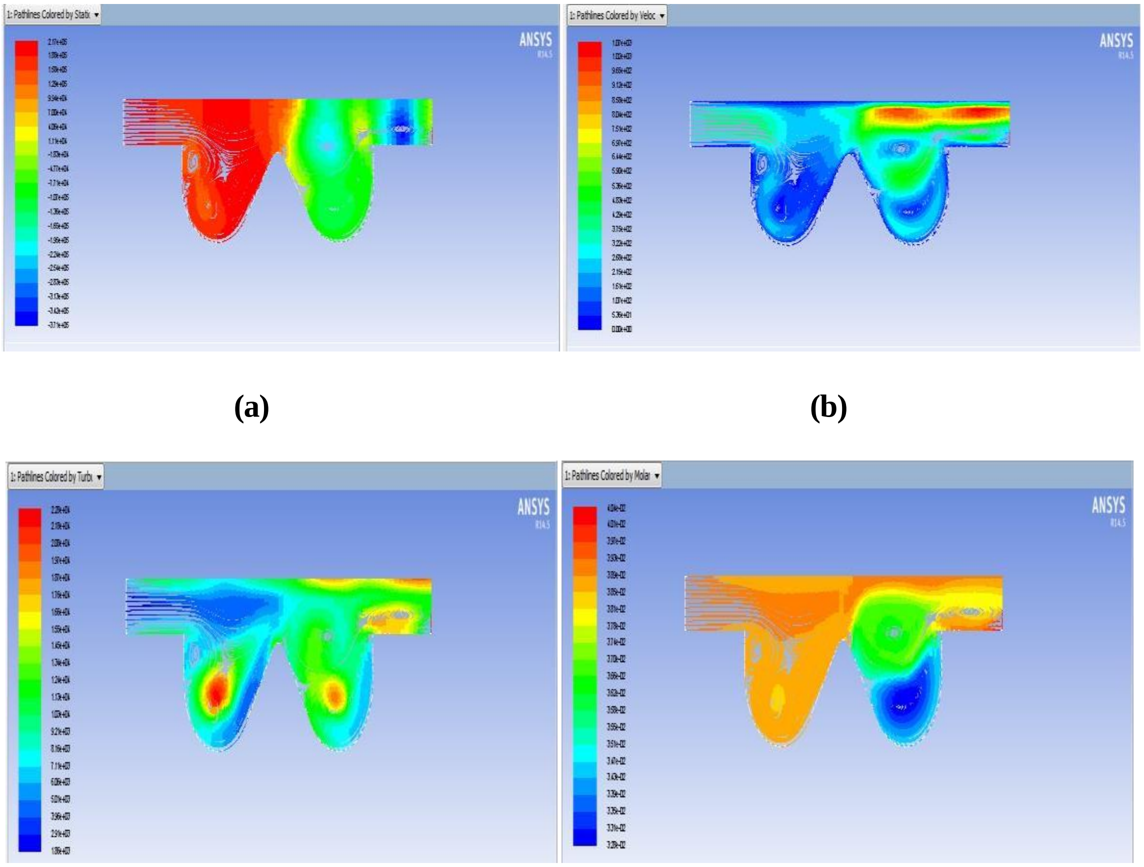


(d)



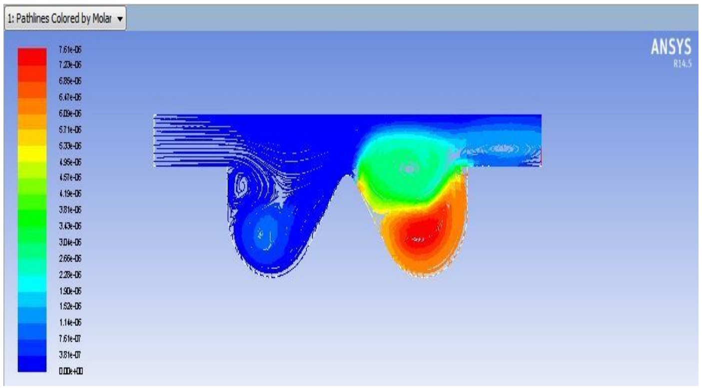
(e)

Fig: 12 The following above figures geometry is HCC at fluid diesel+B20, Path lines counter plots(a)pressureplot(b)velocityplot(c)Turbulenceintensity(d)molarconcentrationofN$_2$(e) molar concentration of CO$_2$



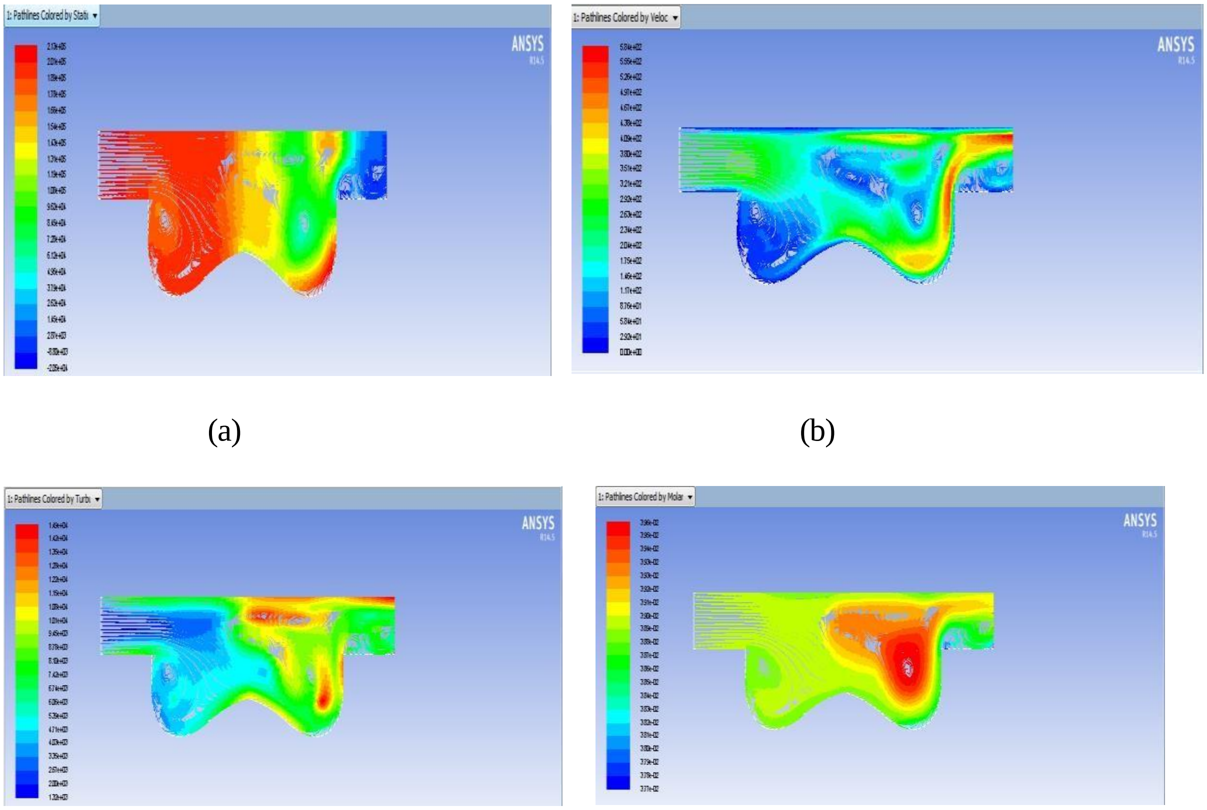
(a) **(b)**

(c) (d)



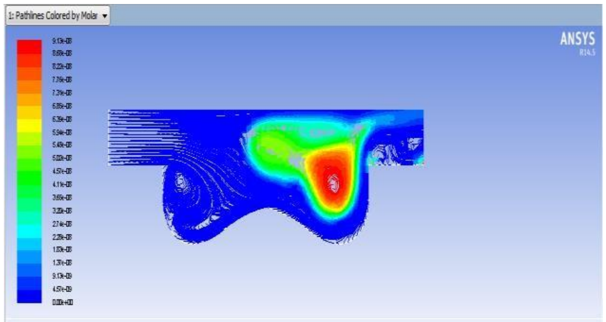
(e)

Fig: 13 The following above figures geometry is TCC at fluid diesel+B20, Path lines counter plots(a)pressureplot(b)velocityplot(c)Turbulenceintensity(d)molarconcentrationofN$_2$(e) molar concentration of CO$_2$



(a) (b)

(c) (d)



(e)

Fig: 14 The following above figures geometry is SCC at fluid diesel+B20, Path lines counter plots(a)pressureplot(b)velocityplot(c)Turbulenceintensity(d)molarconcentrationofN_2(e) molar concentration of CO_2

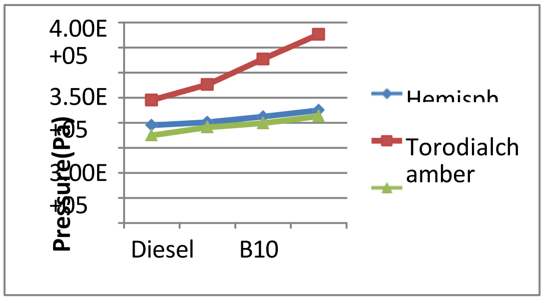
Table:5CFDanalysisresults

Shape of Geometry	Fluid and volume fraction (%)	Pressure (Pa)	Velocity (m/s)	Turbulence Intensity (%)	Molar concentration of N_2	Molar concentrationofCO_2
Hemispherical	**Diesel**	1.95e+05	4.16	9.81e+03	0.0542	1.85e-07
	B10	2.01e+05	4.72	9.99e+03	0.0492	1.95e-07
	B15	2.12e+05	5.12	1.13e+04	0.0421	2.01e-08
	B20	2.25e+05	5.45	1.56e+04	0.0391	2.05e-08
Torodial chamber	**Diesel**	2.45e+05	6.83	2.13e+04	0.0611	8.91e-05
	B10	2.76e+05	8.12	2.34e+04	0.0593	8.08e-05
	B15	3.27e+05	9.16	2.56e+04	0.0445	9.07e-05
	B20	3.76e+05	10.04	2.74e+04	0.0419	4.04e-06
Shallow depth chamber	**Diesel**	1.75e+05	4.23	1.12e+04	0.0552	2.95e-07
	B10	1.91e+05	4.84	1.34e+04	0.0498	5.95e-07
	B15	1.99e+05	5.25	1.67e+04	0.0412	8.45e-07
	B20	2.13e+05	5.84	1.94e+04	0.0396	9.13e-08

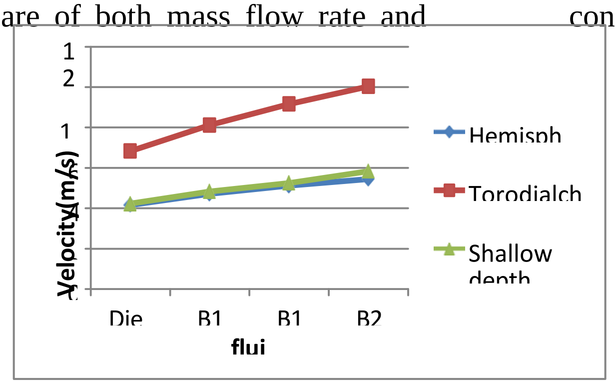
4.2 OBSERVATIONS

The following findings were drawn from the combined effects of computational fluid dynamics (CFD) studies of hemispherical, toroidal, and shallow depth piston bowl geometries.

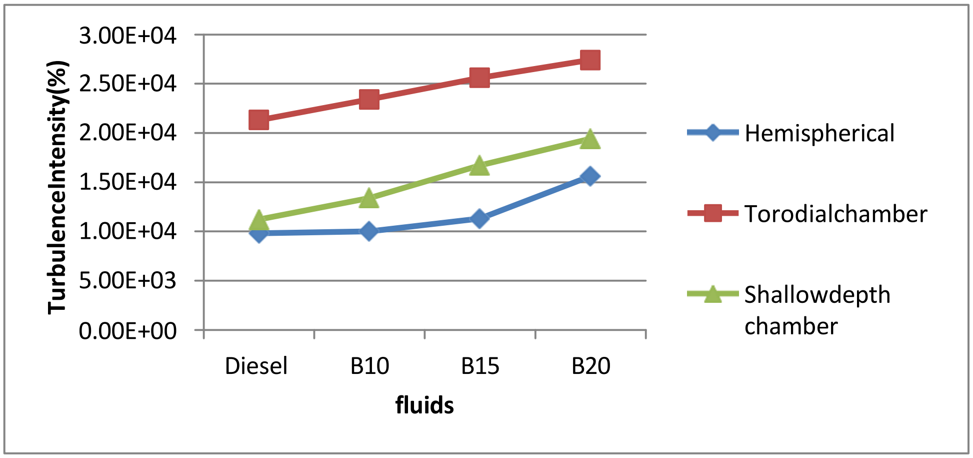
The results for the hemispherical piston bowl were retrieved by consulting figures 12 (a, b, c, d, and e).Figure 13's toroidal shape (a, b, c, d, and e) and Figure 14's shallow depth shape (a, b, c, d) additionally to e. Results from the investigation of the hemispherical piston showed that the dispersion of air molecules was asymmetrical with respect to both pressure and velocity. In contrast to the hemispherical bowl, the toroidal piston demonstrated a more consistent distribution of pressure, swirl, and air molecules, although the velocity of the air molecules was determined to be low. If the piston is located at a shallow depth, the air molecules within the cylinder will move at a faster velocity, the pressure distribution will be more even, and the swirl production will be better.



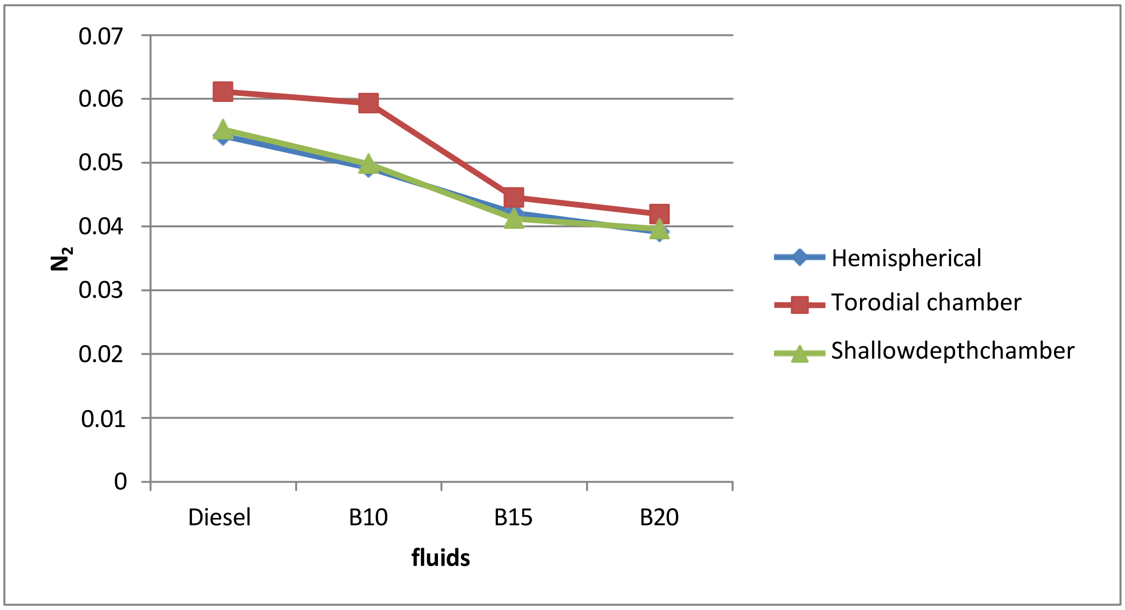
The above graph is plotted between Pressure and piston bowl geometries .The graph compares the pressure of various fuels (D100, B10, B15, and B20) used in the diesel engine. The pressure is an important parameter of an engine because it takes care of both mass flow rate and heating value of the fuel. The above graph shows that while increasing in the blend composition automaticallyit increasesthepressure.Theabove graphshowsthatbiodieselblendB20ishigher than the diesel (D100) fuel under loading condition.



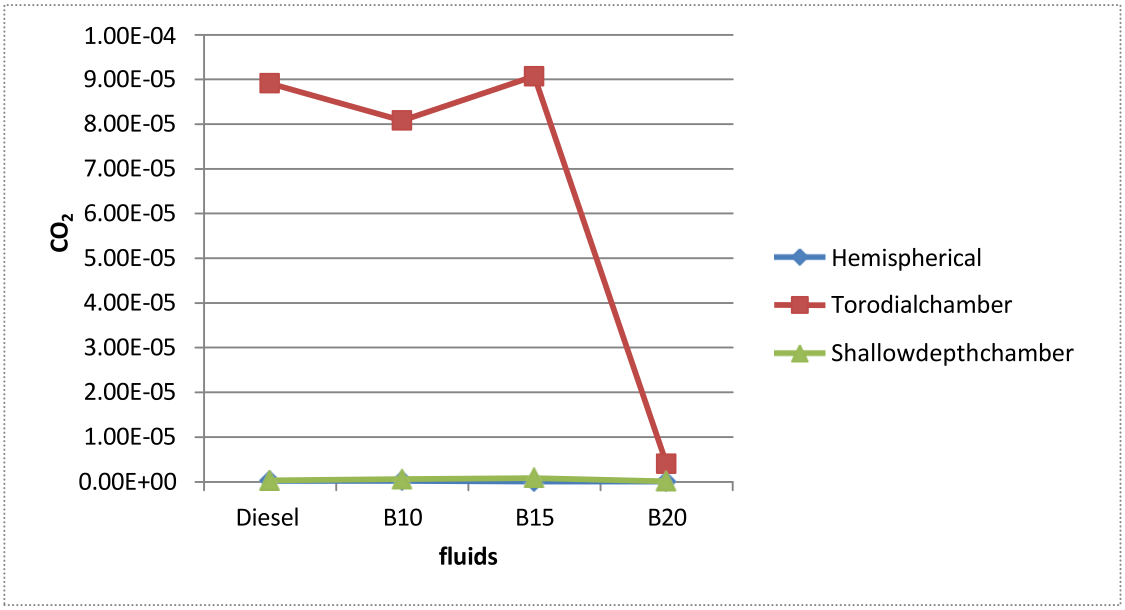
The above graph is plotted between Velocity and piston bowl geometries .The graph compares the velocity of various fuels (D100, B10, B15, and B20) used in the diesel engine. The Velocity is an important parameter of an engine because it takes care of both mass flow rate and heating valueofthefuel.Theabovegraphshowsthatwhileincreasingintheblendcompositionautomaticallyit increases thevelocity. The above graph showsthat biodiesel blendB20 is higher at torodial piston bowl than the diesel (D100) fuel under loading condition.



Piston bowl geometries and turbulence intensity are depicted in the above graph.This graph shows the relative turbulence levels of four different diesel engine fuels: D100, B10, B15, and B20. Because it controls the fuel's mass flow rate and heating value, turbulence intensity is a crucial engine characteristic. As can be seen from the graph above, the turbulence intensity rises in direct proportion to the blend composition. Compared to diesel fuel (D100) under loading conditions, biodiesel mix B20 is greater at the torodial piston bowl, as seen in the following graph.



The above graph is plotted between fluids and N_2The graph compares the N_2 emissions ofvarious fuels (D100, B10, B15, B20) used in the diesel engine. It shows that increasing in blend compositions automatically Decrease in NO_x emissions.



The above graph is plotted between fluids and CO_2 The graph compares the CO_2 emissions of various fuels (D100, B10, B15, B20) used in the diesel engine. It shows that increasing in blend compositions automatically Decrease in CO_2emissions.

Conclusion

The combination parameters of Karanja oil and Diesel, a base fluid, are computed. Karanja and Diesel are used in varying proportions by volume, with values ranging from 0.2% to 0.4%. Therefore, it was determined using CATIA 3D modelling and ANSYS CFD analysis that improving the swirl formation by changing the piston bowl shape leads to better combustion and higher power output. Diesel engines' turbulence levels while using four different fuels: D100, B10, B15, and B20. Because it controls the fuel's mass flow rate and heating value, turbulence intensity is a crucial engine characteristic. The turbulence intensity grows in direct proportion to the blend composition. Emissions of nitrogen gas and carbon dioxide from diesel engines run on different fuels. It demonstrates that a decrease in NO_x emissions occurs automatically when the blend compositions increase.

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