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Research on the Performance of Biodiesel using Diesel Engines with Different Combustion Chamber Shapes

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Abstract

The performance dynamics of diesel engines powered by biodiesel are examined in this study, with a focus on the impact of various combustion chamber configurations. Understanding how diverse combustion chamber designs impact engine performance, emissions profiles, and combustion efficiency under varied operating situations is the main goal. The study used a 25% blend of Corn Oil Methyl Ester (COME25) biodiesel to test two types of engines: a Toroidal Cavity Piston (TCP) engine and a regular Hemispherical Cavity Piston (HCP) engine. When compared to the COME25 HCP engine, the TCP engine exhibits a notable 2.14% gain in Brake Thermal Efficiency (BTE) at maximum power. This improvement is attributable to the TCP engine's capacity to produce more cylinder swirl and turbulence, which leads to more effective combustion. This efficiency improvement comes with trade-offs, too, since full-power operation results in a simultaneous 28% reduction in Carbon Monoxide (CO) and a 25% reduction in Hydrocarbon (HC) emissions, but a 14% rise in nitrous oxide (NOx) emissions. These results demonstrate the intricate relationship between emissions control and combustion chamber shape. Along with the TCP engine and COME25 blend, the study also examines changes in Compression Ratio (CR). It finds that optimising both CR and combustion chamber geometry can result in a 9.6% decrease in Brake-Specific Fuel Consumption (BSFC) and a 2.31% rise in BTE. This illustrates the possible advantages of optimising engine settings to increase performance. The study offers insightful information for optimising diesel engines using biodiesel mixes, presenting a viable path for raising combustion efficiency and lowering emissions.

Keywords: *Combustion Chamber, Corn Oil, Diesel Engine, Fossil Fuel*

1.0 Introduction

1.1 Origin of Study

Quest for sustainable and eco-friendly energy sources has been a central focus of global research and development efforts in recent decades. The automotive sector, which is primarily reliant on fossil fuels, contributes significantly to the creation of greenhouse gases and pollution of the air[1]. In this situation, biodiesel has emerged as a viable alternative to traditional diesel fuel since it is renewable and biodegradable[2]. Biodiesel is mainly composed of Fatty Acid Methyl Esters, (FAMEs), and produced from a variety of environmentally friendly ingredients such as

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vegetable oils and animal fats[3]. Its manufacturing and use have environmental benefits, such as reduced emissions of carbon and less dependence on limited fossil fuel resources[4].

However, the successful integration of biodiesel into diesel engines necessitates overcoming several technical challenges. These difficulties are mostly due to biodiesel's distinct chemical as well as physical features, which include increased viscosity, reduced energy content, and fluctuating cetane numbers when compared to standard diesel fuel. To unlock full prospective of biodiesel as a sustainable source of energy for the transportation sector, it is imperative to comprehensively investigate and optimize its combustion within diesel engines[5].

1.2 Significance of the Study

The significance of this study lies in its investigation of the fundamental parameters influencing diesel engine performance utilizing biodiesel, specifically focusing on the shape of the combustion chamber. Combustion chamber design plays a pivotal role in controlling combustion efficiency, emissions, and overall engine performance. By systematically analyzing the impact of various combustion chamber shapes on biodiesel combustion, this research aims to contribute valuable insights to both the scientific community and the automotive industry[6].

1.3 Environmental Impact

Biodiesel is regarded as a cleaner-burning fuel compared to conventional diesel, primarily due to its reduced carbon emissions[7]. Understanding how combustion chamber design affects emissions and combustion efficiency can aid in further reducing the environmental footprint of diesel engines.

1.4 Energy Sustainability

Due to rising energy needs and worries about the depletion of fossil fuel supplies, the study of biodiesel's combustion characteristics becomes paramount[8]. If biodiesel powered diesel engines can be optimized to match or exceed the performance of their fossil fuel counterparts, it would represent a significant step toward a more sustainable energy future.

1.5 Automotive Industry

The findings of this study can inform the design and development of diesel engines that are specifically tailored for biodiesel use[9]. Such engines could potentially offer a cost-effective and environmentally friendly alternative to consumers while providing the automotive industry with innovative solutions to meet emissions regulations.

1.6 Objective of the Study

The major goal of this study is to investigate the diesel engine utilizing biodiesel as a fuel, with a specific focus on the impact of various combustion chamber shapes. The study aims to achieve the following objectives:

1. Assess combustion efficiency by evaluating how different combustion chamber shapes influence combustion efficiency when biodiesel is used, including analysis of ignition delay, combustion duration, and overall combustion characteristics.
2. Examine emissions by investigating the emissions profile of biodiesel-powered diesel engines with different combustion chamber shapes, with a focus on CO, Nitrous Oxides (NOx), and Particulate Matter (PM) emissions.
3. Analyse engine performance by determining the overall engine performance in terms of BSFC and BTE for each combustion chamber configuration, and provide design insights by offering the optimal combustion chamber shape for biodiesel-powered diesel engines, aiming to enhance combustion efficiency and reduce emissions while maintaining or improving engine performance.

2.0 Review of Literature

2.1 Biodiesel Properties and Challenges

Biodiesel, a renewable alternative to petroleum-based diesel fuel, has gained substantial attention due to its potential environmental benefits. Biodiesels are typically made from Fatty Acid Methyl Esters (FAMEs) derived from various feed stocks, canola, soybean, pam oil[10]. This renewable nature makes biodiesel an attractive option for reducing emissions of greenhouse gases and fossil fuel reliance. However, biodiesel presents several unique challenges when used for diesel engines. Most important challenge is its higher viscosity compared to conventional diesel[11]. Viscosity of biodiesel can vary depending on the feed stock and production process, which can impact atomization and combustion processes of engine. Biodiesels larger viscosity can lead to incomplete combustion, increased fuel spray droplet size, and reduced atomization efficiency[12]. Another important consideration is the lower energy density. Biodiesel typically has a lower heating value, resulting in slightly reduced engine power and torque output. Additionally, cetane number of biodiesel, which indicates its ignition quality, can vary depending on the feedstock and production process[13]. Lower cetane numbers can lead to longer ignition delays, potentially affecting combustion efficiency.

2.2 Combustion Chamber Design

The combustion chamber shape is a critical component in diesel engine design, with a direct impact on combustion efficiency, emissions, and overall engine performance. Various factors, including swirl, turbulence, compression ratio, and injector spray patterns, are influenced by combustion chamber geometry. Researchers have recognized the importance of optimizing combustion chamber design to enhance diesel engine performance with conventional diesel fuel[14]. The role of combustion chamber geometry in controlling air-fuel mixing and combustion processes has been extensively studied. A well-designed combustion chamber can promote efficient air-fuel mixing, resulting in improved combustion efficiency and reduced emissions. In contrast, poorly designed combustion chambers can lead to incomplete combustion, increased emissions, and reduced engine efficiency.

2.3 Previous Research on Biodiesel Combustion

Several studies have examined combustion characteristics for biodiesel in diesel engines, recognizing the need for modifications to accommodate its unique properties. Combustion chamber geometry has been identified as a crucial factor affecting combustion efficiency and emissions in biodiesel-fuelled engines. Biodiesel combustion studies have shown that optimizing combustion chamber design can lead to improvements in combustion efficiency and emissions[15-17]. Modifying the geometry combustion chamber improves the outcome engine running on palm-based biodiesel. The optimized combustion chamber design resulted in reduced emission of particulate matter and NOx. In another study, scholars examined the combustion parameters of biodiesel for CI engines and noted that combustion chamber design played a significant role in regulating NOx emissions[18,19]. They highlighted the importance of considering combustion chamber geometry when optimizing biodiesel combustion.

3.0 Corn Oil Extraction and Biodiesel Preparation

Corn, a major grain crop worldwide, originated in Central and South America. Distribution is currently centred on countries between 30- and 50 degrees north latitude, including India, China, Mexico, the United States, Brazil, Romania and South Africa. To extract the most oil from the germ seed during solvent processing, the seed is ground mechanically after being wet-milled, when a seed's oil content is above 20%. Petroleum, which comprises up to 12%-15% of the caryopsis, is mostly linked through the scutellum of the seeds, which is another primary biochemical ingredient in corn grains. Regular maize typically has 4% lipid content, whereas HOC genotypes can have up to 8% oil content. Oil is recovered from germ by-products generated from dry milling processes. The oil is extracted physically and chemically using solvents from dry-milled germs having up to 50% oil. The resultant crude corn oil undergoes routine degumming and chemical refinement to eliminate colours, FFA, phospholipids, and small chemical components that provide off-flavours. While physical refining foregoes neutralization and uses harsher deodorization conditions, bleaching and deodorization are nevertheless carried out. Crucially, maize oil is often winterized to eliminate waxes that give maize a foggy look. Refined oils undergo hydrogenation, fractionation, and inter-esterification as alternate processes to alter their chemical and physical characteristics and hence change their useful characteristics. Corn oil has a moderate flavour and aroma, is yellow in colour, and has a high linoleic and oleic acid content. The extracted oil has exceptional oxidative stability. To transform maize oil from its extracted state into a consumable form, more processing is required[20]. The properties of the Biodiesel mixture are as follows: Specific gravity-0.88, Kinematic viscosity at 40°C-4.0 to 6.0, Cetane number- 47 to 65, Density, lb/gal at 15.5°C-7.3. The taste, fragrance, colour, and shelf life of edible oils is all enhanced by the refining procedures of neutralise, bleach, and deodorise. Phosphates, free acids, and antioxidants are only some of the impurities removed by these processes.

4.0 Experimental Test Procedure

An instrumented Diesel engine was used for the trials. Figures 1 depict the Diesel engine setup. The specifications of the engine are as- Make –Kirloskar Oil Engine, Bore x Stroke - 102x110 mm, Rated Output- 7.35/1500 kw/rpm, Compression ratio- 17:1.

All measurements were collected after the engine was running smoothly and steadily. All instruments were regularly calibrated, and before taking any measurements, the gas analyzers were switched on and given time to stabilize. The IP and injection time were held constant throughout all of the experiments at the permeability levels. The injection time was maintained across all studies. The ignition lag was determined by the duration of the dynamic injection. The engine's power is increased by 25% from idles to full load. At each load, data was collected on fuel flow rate, air flow rate, EGT, emission of nitrogen oxide, carbon monoxide, and hydrocarbon as well as smoke measurement. Using a data-gathering device and a computer, we were able to record the pressures and crank angles throughout the course of 50 cycles. The data was analysed to determine the typical pressure for crank angle changes.

4.1 Experimental Test using Different Blends of COME with TCP and HCP

Corn oil methyl ester was first tested in the basic engine. The experimental study began with diesel and COME mixes with HCP and then switched to B25, B50, and B100 COME-diesel combinations with Toroidal Cavity Piston (TCP). Temperature of Exhaust gas, NOx, HC and CO pollution levels, and the time it took to burn through 20cc of fuel, were all measured and recorded throughout the testing.

4.2 Test with COME25 with TCP and Different Compression Ratios

The emission, performance, and combustion behaviours of engines with compression ratios 17.5:1, 19:1, and 20:1 were investigated in the laboratory. Experiments were carried out at the recommended speed and with a typical injection of COME25.

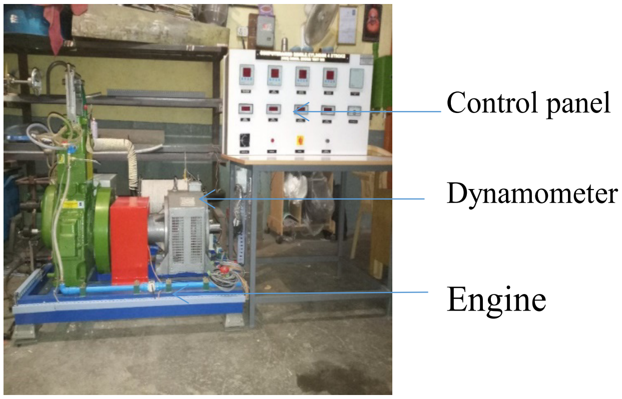

Figure 1. Diesel engine test rig.

5.0 Experimental Results

5.1 Experimental Test with Different Blends of COME with HCP and TCP

In this part, we address the combustion, performance and pollution studies of engines fuelled by COME mixes with hemispherical and toroidal hollow pistons.

5.1.1 Cylinder Pressure-Crank Angle Diagram

Figure 2 depicts Pressure Variation as a Function of Crank Position for different mixes. When compared to diesel with normal engines employing an HCP piston, COME25 and COME50 are demonstrated to have far lower peak pressures. Probably, an incorrect mixing of COME25 with air, as well as their high viscosity and weak heating value leads to lower pressure. Compared to HCP diesel mode, the pressure of the COME25 and COME50 TCP engines is higher. The higher cylinder pressure may be the result of more complete combustion brought on by enhanced airflow, which in turn improves air-fuel mixing. Due to more viscosity and decreased heating value, the pressure within the cylinder decreases as the mix percentage increases. COME25 and COME50 with

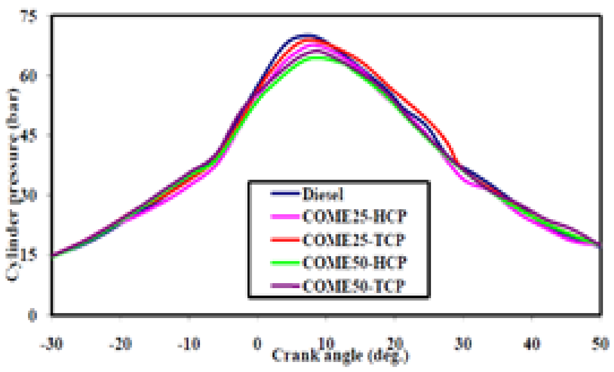

Figure 2. Cylinder pressure variance as a function of crank position.

an HCP combustion chamber produce cylinder pressures of 68.5 bar and 65.5 bar at full throttle, whereas TCP combustion chamber COME25, COME50, and HCP piston combustion chambers for diesel produce pressures of 69.3 bar, 67.5 bar, and 70 bar at full throttle, respectively.

5.1.2 Heat Release Rate

Figure 3 indicates Variation in heat emission rate with the crank position for various blends.

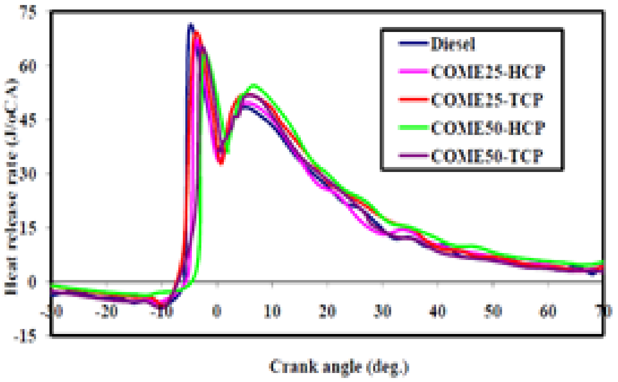

Figure 3. Heat emission rate variation with the crank position under full load.

The graph demonstrates how COME and its mixtures have later heat discharge curves in comparison with diesel at peak load. Because of short ignition delay and poor spray production of COME mixes, the HRR did not demonstrate a significant initial release of heat. COME25 with toroidal combustion chambers had a similar pattern of release of heat to the diesel engine. Low heating value addresses to fuel's greater viscosity and low volatility that also promote poor air-fuel mixing and evaporation. The highest HRR is to be 70J/^{0}CA for diesel, 65J/^{0}CA for COME25 and 63.4J/^{0}CA for COME50 in HCP operation, 68J/^{0}CA for COME25 in TCP operation, and 65J/^{0}CA for COME50 in TCP operating at peak load.

5.1.3 Temperature of Exhaust Gas

Figure 4 indicates a change in the temperature of exhaust gas with a crank angle for various blends. When operating in HCP or TCP, the EGT increases for diesel, biodiesel, and their mixture when the load is raised. More fuel is used with greater loads, resulting in a higher exhaust gas temperature for all fuels. TCP engine operating results have a considerable rise in exhaust gas temperature for COME25 and COME50 compared to HCP engine operation. Better airflow in TCP and greater oxygen levels in the biodiesel may be the cause for the increase in EGT. At full load, the EGT for the COME25 is 346^{0}C, for the COME50 it is 368^{0}C, and for the HCP it is 338^{0}C and 356^{0}C.

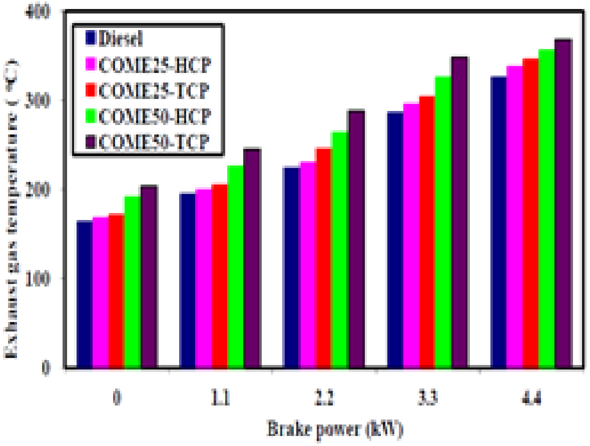

Figure4. Brake force versus exhaust gas temperature.

5.1.4 Emission of Carbon Monoxide (CO)

Figure 5 indicates the variation of CO emissions with Brake Power for various blends. For both combustion chambers' CO emissions are relatively constant throughout a wide range of diesel fuel loading. At full throttle, CO emissions from COME25 and COME50 were significantly less than the results of diesel fuel. At full throttle, the TCP engine had less emissions of carbon dioxide than the HCP engine

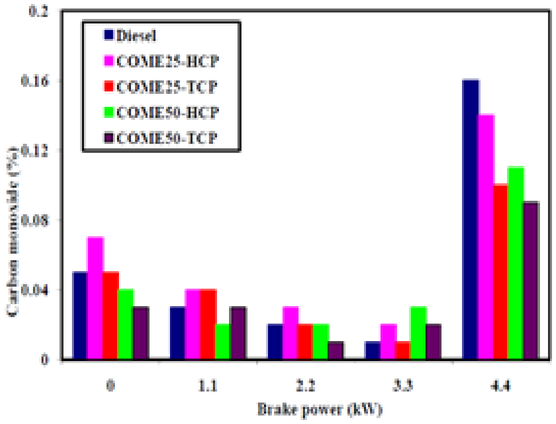

Figure 5. Comparison of carbon dioxide emissions with brake power

for both COME25 and COME50. Better combustion and lower emissions of carbon dioxide may be attributed to the improved air circulation during TCP engine operation and the use of oxygen in COME biodiesel. With TCP, CO emissions are reduced by 28% for COME25 and 36% for COME50 compared to the HCP engine. At full throttle, the TCP engine emits 0.07% Vol and 0.03% Vol of CO, whereas the HCP engine emits 0.1% Vol and 0.09% Vol of CO.

5.1.5 Nitrogen Oxide Emission

Figure 6 displays the variation in NOx emissions across all test fuels and both piston actions as a function of BP. When compared to the regular engine running on HCP, the TCP engine produced higher levels of NOx emissions for the COME25 and COME50. When compared to the HCP engine, NOx emissions for the COME25 and COME50 are 7.2% and 9%, respectively greater. A greater percentage of COME fuel combustion is completed TDC, and the delay time is shorter, which contributes to higher NOx emissions. At this stage, biodiesel fuels are likely to hit their maximum peak cycle temperatures. COME25 and COME50 with TCP engines emit 792 and 896 parts per million of nitrogen oxide, respectively, whereas the basic engine with HP at peak load emits 739 and 822 parts per million.

5.2 Experimental Test with COME25 with Toroidal Cavity Piston (TCP) and Different Compression Ratios

Diesel engine combustion, performance, and emission studies for COME25 blends with toroidal cavity pistons at varying compression ratios are shown and addressed.

5.2.1 Pressure Fluctuations in the Cylinder with Angle of Crank

Figure 7 indicates how pressure in the cylinder fluctuates with the angle of the crank for COME25 and diesel at various compression ratios.

At full throttle, CR17.5 with a basic engine (HCP) can produce a maximum pressure of 70 bar for diesel and 67.5

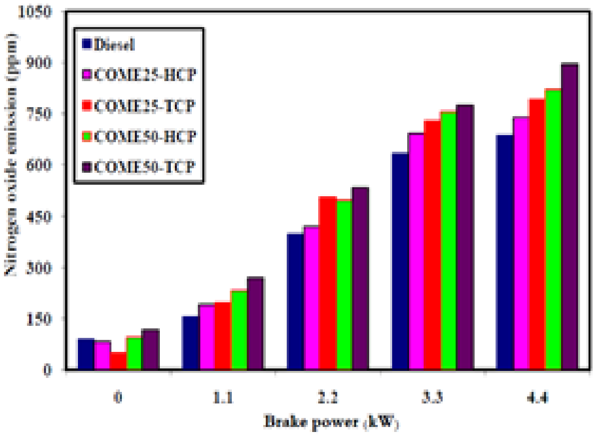

Figure 6. Comparison of brake performance to NOx emissions.

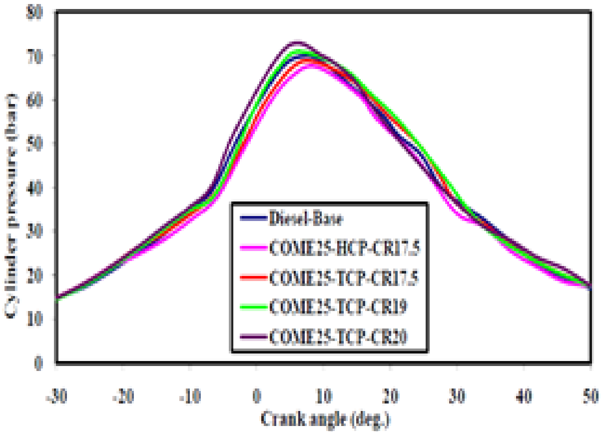

Figure 7. Pressure fluctuations in a cylinder with the angle of the crank.

bar for COME25. COME25's greater viscosity and lower heating value may both contribute to the drop in cylinder pressure. Increases in CRs also result in higher cylinder gas pressure in the TCP engine used by COME25. Cylinder pressures are 68.5bar, 71bar, and 72bar at full load for COME25 gasoline with a TCP engine at CR17.5, CR19, and CR20, whereas they are 67.5bar and 70bar for COME25 and diesel with CR17.5 with an HCP engine. Possible explanations for the rise in cylinder gas pressure at high CR include improved air-fuel mixture during the operation of the TCP engine, which results in a complete COME25 combustion at maximum load.

5.2.2 Heat Release Rate

Figure 8 depicts the variance in heat release rate for diesel and COME25 with a variation in the angle of the crank. Standard CR17.5 seems to provide HRR values of 70J/^{0}CA for diesel and 65.3J/^{0}CA for COME25. Increasing the CR raises its HRR. The pre-combustion phase releases more heat than the diffusion phase for the biodiesel mixture at greater CR. The HRR at full load for COME25 with CR17.5, CR19, and CR20 are 68J/^{o}CA, 72.4J/^{o}CA, and 73.5J/^{o}CA, respectively. The TCP engine's improved air and fuel mixing, lower ignition lag, and enhanced air pressure at high CR are all factors in its increased HRR.

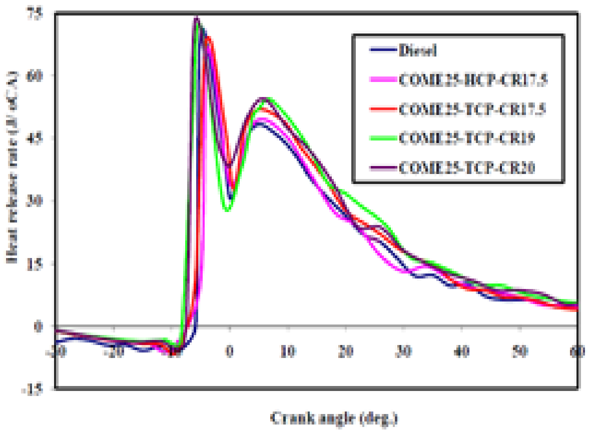

Figure 8. The heat release rate fluctuation with a variation of the angle of the crank.

5.2.3 Exhaust Gas Temperature (EGT)

Figure 9 indicates the relationship between Exhaust Gas Temperature variation and Brake Power. As the CRs increase for the test fuels, the EGT decreases steadily. When comparing diesel with another engine at maximum power, the TCP engine and CR20 produce an EGT 384^{0}C and which is higher. For this reason, greater CRs need a shift in the combustion process to an earlier cycle stroke. This causes a rise in EGT because more fuel energy is being effectively used for creating brake power. The EGT for both piston operations is increased for COME25 to boost the CR. When compared to other CRs with the TCP engine at full power, the EGT of the COME25 is higher at CR20. This is because of the correlation between improvements in CR and decreases in EGT causing waste energy. The maximum EGT temperatures for a COME25-powered TCP engine are 346^{0}C, 364^{0}C, and 384^{0}C, whereas the corresponding values for a diesel-powered, standard-CR17.5-powered HCP engine are 326^{0}C and 338^{0}C.

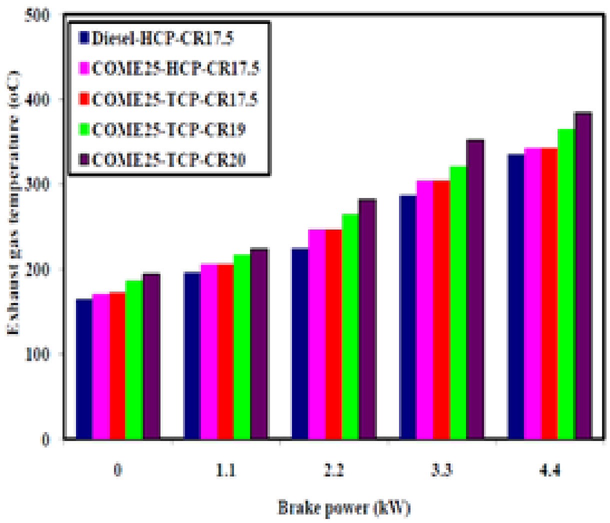

Figure 9. Exhaust gas temperature changes with crank angle.

5.2.4 Carbon Monoxide Emission

Figure 10 depicts CO emission fluctuation with BP for diesel and COME25 engines.

It has been shown that, for similar CRs, biodiesel blends emit less CO than diesel. This may be because the biodiesel combination has more oxygen than it needs, which improves the combustion. The CO emission for the COME25 with the TCP engine is 0.07% at rated power, which is a reduction of 50% in comparison to

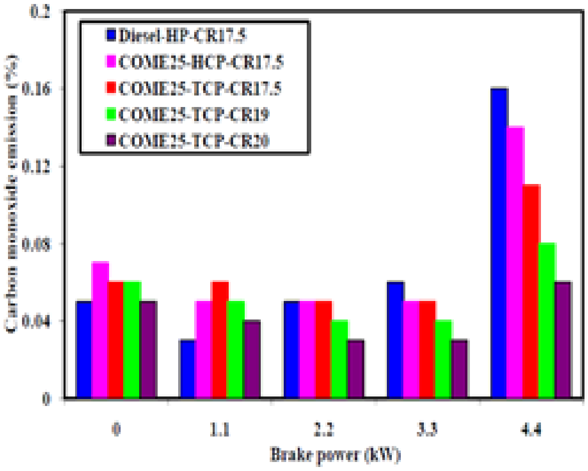

Figure 10. Carbon monoxide emission versus brake power.

the COME25 with the HCP engine at peak power. One possible explanation is that increasing the CRs increases the cylinder's air temperature, which in turn shortens the delay, promotes complete fuel combustion, and reduces emissions of carbon monoxide. Diesel and COME25 at regular CR17.5 and HCP engines produce 0.16 and 0.14 per cent CO emissions, respectively, at maximum power, whereas COME25 in the TCP combustion chamber emits 0.11%, 0.08%, and 0.07%.

5.2.5 Nitrogen Oxide Emission

NOx variation with BP for diesel and COME25 is shown in Figure 11 for both engines. With an increase in CRs, NOx emissions have steadily increased. NOx emission for COME25 at CR20 and the TCP engine is 908ppm, which is more than the case for diesel (686ppm) and COME25 (739ppm) while working at full power. Compared to diesel and COME25 at CR17.5 and the HCP engine at maximum power, is 32% and 23% higher, respectively. This is because elevated oxidising conditions during combustion, a higher CR and higher temperatures, tend to the formation of nitrogen oxides. When the compression ratio is raised, the ignition lag shortens, the peak pressure rises, the combustion temperature rises, and the NOx emissions rise. Excess oxygen in the biodiesel may enhance nitrogen oxidation at higher temperatures, leading to a surge in NOx production. Diesel and COME25 at typical CR17.5 and HCP engines produce 686ppm and 739ppm of NOx emissions at peak power.

5.3 Experimental Test with COME25 with Toroidal Cavity Piston (TCP) with Different Exhaust Gas Recirculation Rates

In this part, we analyse the combustion, performance, and emissions of a diesel engine operating on COME25 mixes with toroidal cavity pistons at varying exhaust gas recirculation rates.

5.3.1 Pressure Fluctuations in the Cylinder with Crank Angle

Figure 12 shows variations of in-cylinder gas pressure over a range of EGR rates and CA values for diesel and

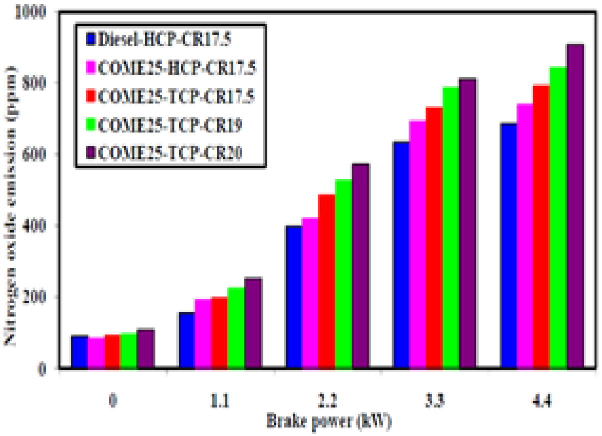

Figure 11. Nitrogen oxide emission versus brake power.

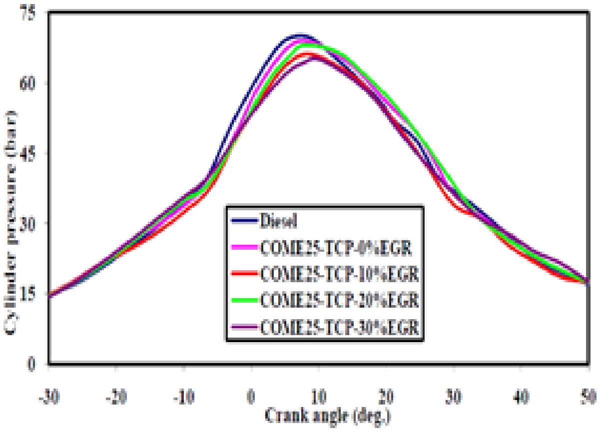

Figure 12. Pressure fluctuations in the cylinder with crank angle.

COME25 for both piston engines. Without Exhaust Gas Recirculation (EGR), the maximum cylinder gas pressure for diesel and COME25 TCP engines is 70bar, and 67.5bar. The low heating value and high viscosity of COME25 are factors for the reduction of cylinder gas pressure. In comparison to diesel and COME25 with TCP engines, the figure indicates that the in-cylinder pressure with COME25 increases with a higher EGR rate. There is a possibility that the toroidal hollow piston allows for greater combustion than the COME25 HCP engine at full throttle and is responsible for the increase in cylinder pressure. With a TCP engine with a COME25, the cylinder pressure at maximum power is 66bar with 10% EGR, 68bar with 20% EGR, and 65bar with 30% EGR. Cylinder pressure was increased by 20% with COME25 mixes in the TCP engine, compared to 10% and 30% with the TCP engine's EGR.

5.3.2 Rate of Heat Release

Figure 13 shows the variation in the rate of heat release over a range of EGR rates for diesel and COME25 engines. During peak load, the HRR measured at 70 J/°CA for diesel and 65.3J/°CA for COME25 with a TCP engine. The biodiesel mixture's high viscosity and heating value may be the cause for this issue. The TCP engine improves the HRR of the COME25 by increasing the turbulence of the air moving through the engine at various EGR settings. The HRR for COME25 at full blast is 65J/°CA for an EGR rate of 10%, 66.2J/°CA for 20%, and 63.5J/°CA for 30%. COME25 with TCP engine and 20% EGR generated the highest HRR compared to COME25 with HCP engine with 10% and 30% EGR.

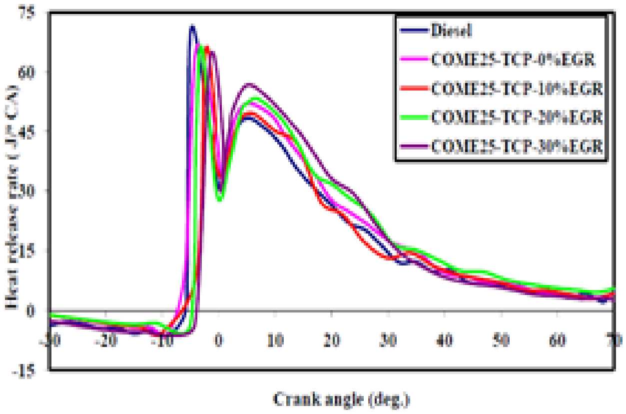

Figure 13. Heat release rate fluctuation with a variation of the angle of the crank.

5.3.3 Exhaust Gas Temperature

Figure 14 depicts the Exhaust gas Temperature fluctuation with BP for diesel and COME25 engines. When comparing the HCP and TCP versions of the COME25 engine, it is shown that the EGT is somewhat higher for the latter. Increased airflow during TCP engine running and the high concentration of oxygen molecules in biodiesel may be the reason for the EGT increase, which in turn improves combustion. At full power, the exhaust gas temperature for COME25 with TCP ranges from 350^{0}C to 362^{0}C, whereas it is 326^{0}C and 338^{0}C for diesel and COME25 with TCP.

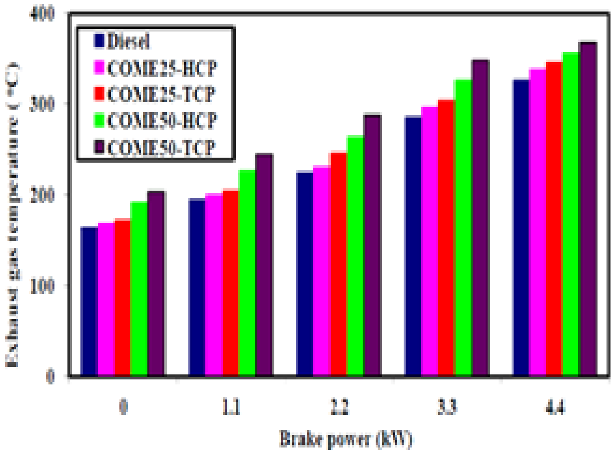

Figure 14. Exhaust gas temperature changes with crank angle.

5.3.4 Carbon Monoxide Emission

Figure 15 depicts the CO emission fluctuation with BP for diesel and COME25 engines. When the engine is run with EGR, the proportion of CO emissions is reduced for COME25 with TCP because the greater air movement provided by TCP leads to better burning and more oxygen molecules in the fuel. At full throttle, diesel and COME25 with HCP have CO emissions of 0.16 and 0.14 percent respectively, while COME25 with TCP at 10%, 20%, and 30% EGR rates has emissions of 0.13, 0.12, and 0.18 percent.

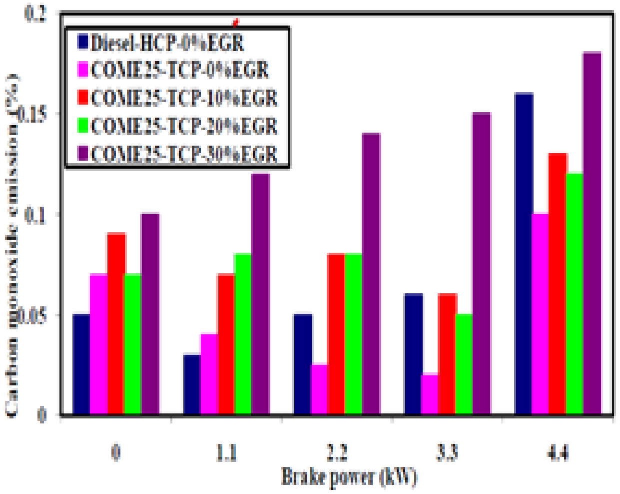

Figure 15. Carbon monoxide emission versus brake power.

5.3.5 Nitrogen Oxide Emission

NOx variation with BP for diesel and COME25 is shown in Figure 16. In most cases, EGR is used to regulate NOx emissions since it lowers the oxygen concentration and maximum temperature of a working fluid in a combustion chamber. There is evidence to suggest that as load raises, so do NOx emissions. When compared to an HCP engine, the NOx emission reductions for a COME25 with 10%, 20%, and 30% EGR rates at full power are 6%, 28%, and 37%, respectively. At HCP and COME25 without EGR, diesel's NOx emissions are 686 ppm and 792 ppm, respectively; at TCP and COME25 with 10%, 20%, and 30% EGR rates, diesel's NOx emissions are 694 ppm, 532 ppm, and 469 ppm, respectively.

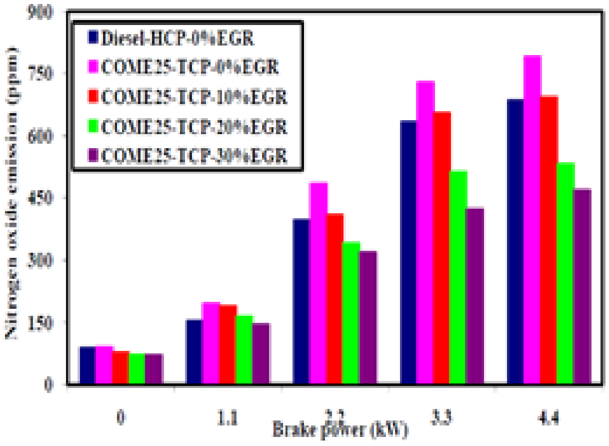

Figure 16. Nitrogen oxide emission versus brake power.

6.0 Discussion

The results of the experiments indicated that with full-throttle, the BTE of COME25 with TCP was 2.14% higher than that of COME25 with the normal HCP engine. CO and HC pollutants generated by COME25's TCP engine were lowered by 28% and 25%, respectively, while the NOx generation was raised by 14% at full power. Cylinder pressure and HRR for the COME50 with TCP engine are 1bar and 2.7J/^{0}CA higher than those of the regular HCP engine using a COME25 combination.

When it comes to emission, combustion, and performance of the engine, results of the experimental tests showed that the TCP engine with COME25 with an increase in compression ratios was better than the standard HCP engine due to improved swirl movement and turbulence within the cylinder. When compared to COME25 with a TCP engine with the conventional CR17.5 at peak power, the combined impact of TCP and CR20 raised BTE by 2.31% and decreased BSFC by 9.6%. When comparing COME25 at regular CR 17.5 to COME25 with TCP, the levels of HC and CO emissions reduced by 31%, and 50%, respectively, while NOx production increased by 14%. There was a 3.5 bar increase in cylinder pressure and a 5.5J/^{0}CA increase in HRR compared to regular CR17.5 at full load.

Results from experimental runs of the TCP engine with COME25 at 10%, 20%, and 30% EGR revealed that the improved feature worked as expected. The standard HCP engine's increased swirl movement and turbulence within the cylinder led to a significant reduction in NOx emissions; however, the BTE of COME25 with the TCP engine is only 29.12% with 20% EGR, and it's only 29.58% without EGR at peak load[7-10]. Improvements in CO and HC were seen for COME25 when EGR rates were raised throughout the test. At full throttle, the NOx emissions from a COME25 equipped with a TCP engine and 20% EGR were reduced by 33%[14-16]. The cylinder pressure and HRR for the COME25 with the TCP engine and the 20% EGR rate were significantly reduced by 1.5bar and 1.1J / ^{0} CA, respectively, at maximum load[17-20].

7.0 Conclusion

We conclude that the use of a toroidal cavity piston combustion chamber with an increased injection pressure of 240 bar and a compression ratio of CR20 improves the performance of diesel using a COME25 blend in comparison to a hemispherical cavity piston combustion chamber, except nitrogen oxide (NOx) emissions.

8.0 References

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