International Journal of Innovative Research in Engineering & Management (IJIREM)
ISSN: 2350-0557, Volume-6, Issue-6, November 2021
www.ijirem.org

Performance and Emission Evaluation of Varying Compression Ratio in A Diesel Engine Fueled with B20 Blend of Sea Mango Biodiesel

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ABSTRACT
For use in diesel cars, biodiesel is a renewable, clean-burning fuel manufactured from used cooking oil, animal fats, or recycled restaurant grease. Compared to petroleum diesel, biodiesel emits fewer harmful chemicals and greenhouse gases. A blend of B2 (2% biodiesel, 98% petroleum diesel), B5 (5% biodiesel, 95% petroleum diesel), B20 (20% biodiesel, 80% petroleum diesel), and B100 (pure biodiesel) can be utilized instead of using it in its purest form. VCR engine operating at different CRs of 16:1, 17:1, and 18:1 with B20 blend of sea mango biodiesel. The B20 blend's test findings were then contrasted with those of diesel, which was run at the recommended CR (17:1) ratio. The BTE of the B20 mix was nearly comparable to diesel at typical CR. Even though the BTE of the B20 blend was lower than diesel at CR 16:1 and 17:1, it increased by 5.12% at CR 18. Higher CRs led to improvements in the SFC and EGT.SFC and EGT values for the mix were discovered to be higher than those for diesel at CR 16:1 and 17:1. When compared to diesel, the blend's SFC and EGT were, however, reduced at CR 18:1 by 6.6% and 3.01%, respectively.

Keywords
Single Cylinder- 4SVCR Diesel Engine, Eddycurrent dy namometer, BTE, CR, SFC, and EGT

1. INTRODUCTION
Biodiesel Produced from Renewable Resources. This is arene an energy source, unlike other petroleum products that will vanish in years to come. Since it is made from animal and vegetable fat, it can be produced on demand and also causes less pollution than petroleum diesel. The Advantages of Biodiesel is this can be used in existing Diesel Engines without any modification, Less Greenhouse Gas Emissions, Cleaner Bio fuel Refineries, Better Fuel Economy, Positive Economic Impact, and More Health Benefits because of produce fewer to xicpollutants than other petroleum products. Jatropha biodiesel fuel was shown to have lower levels of HC, CO, CO2, and smoke in experiments conducted by Bhupendra Singh Chauhan et al. on the fuel. Jatropha biodiesel and its blend had greater NOx emissions than diesel. As far as decentralized energy production is concerned, the results of the studies imply that biodiesel made from non-edible oil like Jatropha might be a good replacement for diesel fuel in the near future [1]. In an experimental and comparative investigation, Hoang et al. used heated coconut oil (HCO) and fossil diesel fuel to power an 80-horsepower small marine diesel engine. It is measured how well engines work and how well they emit. Results indicate that when utilizing HCO instead of diesel fuel, thermal efficiency and NOx emission are lower while specific fuel consumption, CO, HC, and smoke emissions are greater. In addition, this study indicates that heated raw coconut oil heated to 100 oC is thought to be the most suitable fuel to produce engine performance and emission characteristics that are comparable to diesel fuel [2]. Manilkara zapota fruit and seed oil was used as the source of renewable biofuel in an experiment by Sathish Kumar et al., and the yield was 10.45% (v/w). The distilled sample included 4.9% water molecules and 95.09% pure bioethanol. For the production of ethyl ester, raw Manilkara zapota seed oil was mechanically extracted. For the highest yield of Manilkara zapota ethyl ester, variables such as the amount of KOH used, the temperature of the reaction, and the molar ratio of bioethanol to oil were examined. The increased ethanolysis process parameters were found to be a 70°C process temperature, 1.5% (w/w) KOH, and a 9:1 molar ratio of bioethanol to oil. The highest production of ethyl ester measured was 93.1% [3]. Raghuram Pradhan et.al.were studied Bael biodiesel, with diesel vehicles. Bael oil is produced from bael seeds, which are obtained from the fruits of the bael tree. Within that article, the performance, toxicity, and ignition properties of a diesel engine running on diesel, bael seed oil methyl ester (BSOME), and its blends (B20, B40, B60, B80, and B100) are discussed. Due to the increased acid quality of the oil, BSOME was constructed by mixing bael seed oil and methanol in acid as well as an alkali catalytic process. While BSOME as well as its blends have poorer brake thermal efficiency than diesel, they have smaller emissions, with the exception of NOx. According to this research, blend B20 (20% bael biodiesel + 80% diesel) can be used to partly replace diesel in conventional CI engines despite imposing some modifications [4].Uyumaz. An et. al. conducted extensive research on the combustion, performance, and emission properties of mustard oil biodiesel fuel blends. In order to achieve this, a single-cylinder DI diesel engine was operated in this investigation at varying engine loads of 3.75, 7.5, 11.25, and 15 Nm and full load conditions while using mustard oil biodiesel-diesel fuel mixes (M10, M20, and M30) and conventional diesel fuel (D100). At full load, it was observed that M10's indicated

thermal efficiency (ITE) decreased by 6.8% while M10's BSFC increased by 4.8%. Additionally, there were no significant differences in cylinder pressure between diesel fuel and mustard oil biodiesel-diesel fuel blends [5].

2. METHODOLOGY

2.1 Experimental setup

The experiments were performed using a single-cylinder, four-stroke VCR engine powered by a B20 blend of sea mango biodiesel. Table 2 lists the major features of the VCR engine.
The VCR engine is designed in such a way that the CR could be varied even without halting the engine. To measure the movement of the cylinder, a micrometre is attached to the cylinder. Two piezo-type sensors are installed on the fuel injector and cylinder head to direct the fuel line and combustion pressure. Two K-type thermocouples and four PT100-type thermocouples are installed throughout the setup to monitor the exhaust gas temperature. A differential pressure transducer is used to gauge the fuel. Rotameters were employed to keep track of the cooling water flow to the calorimeter, cylinder head, and engine block. The performance of the test rig is examined utilising all of the analogue data gathered from various places using the IC Engine soft v9.0 application. The AVL degas 444N gas analyser and the AVL 437 smoke metre were used to measure the levels of NOx, HC, CO, and smoke in the engine's exhaust. Table 2 displays the major characteristics of the VCR engine. The range, accuracy, and uncertainty of the instruments are shown in Table 3. Fig. 2.1 depicts the engine arrangement's schematic layout, and Fig. 2.2 shows a picture of the test apparatus.

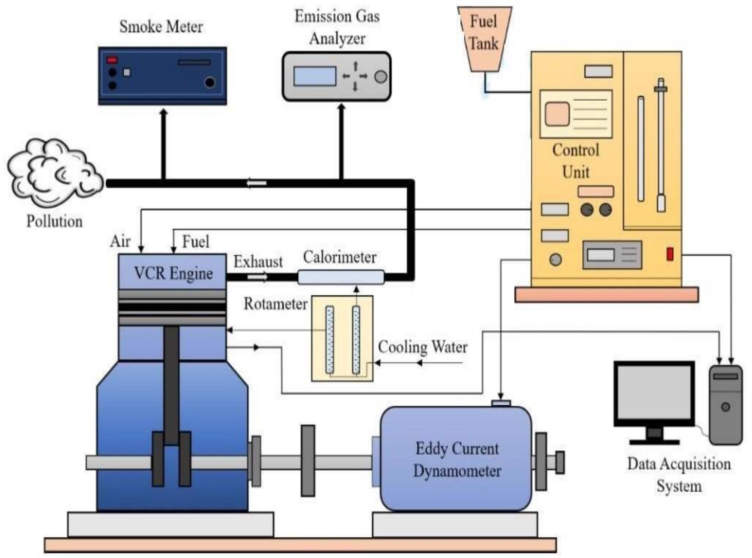

Figure 1: Schematic Representation of Engine Layout

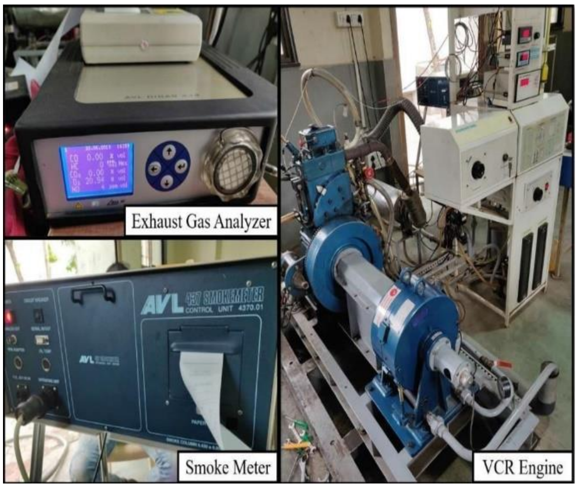

Figure 2: Photographic Image of the Testing Equipment

Table 1: The uncertainty percentage for various metrics

Parameters	Uncertainty%
Engineload±0.25	±0.25
BP±0.2	±0.2
BTE±0.75	±0.75
SFC±0.25	±0.25
EGT±0.6	±0.6
CO	±0.15
HC	±0.4
NO	±1.2
Smoke	±0.8
Cylinder pressure(Cp)	±0.25
Heat release rate(HRR)	±0.4

Table 2: Test Engine Specifications

Parameters	Specifications
General details	4-stroke,multifuel,VCRengine
Number of cylinders	1
Speed	1500rpm
Ignition	Compression ignition
Compression ratio	12:1–18:1
Rated power	3.5kW
Loading	Dynamometer for eddy currents
Bore	87.5mm
Stroke	10mm
Rotameter Calorimeter	25-250LPH
Temperature sensor	Type K, PT 100 the rmocouple

Transmitter for air flow	Pressure transmitter
Cooling	Water-cooled

2.2 Automobile Emission AVL Degas Analyser

Measurements of carbon monoxide (CO), carbon dioxide (CO2), fuel-dependent hydro carbons (HC), oxygen (O2), nitric oxide (NOx), and smoke are made using the AVL degas 444N gas analyser and the AVL 437 smoke metre. The AVL gas analyser is delivered fully assembled and prepared for usage in a protective case with all necessary accessories. Turn on the power switch, connect the hose and probe, and push the Zero button. When the Zero is complete, the analyser is ready to measure exhaust emissions gas. There are three power input options, which will recharge the internal batteries. Accessories include a stainless-steel probe assembly, an easy-storing sample line, and a built-in water trap and particulate filters to protect the internal infrared optics of the analysers. This valuable tool in the hands of your technicians will pay big dividends in allowing your business to tune and confirm a properly functioning engine.

Figure 3: AVL degas 444 Ngasanalyzer

Table 3: Specifications of the AVL digas 444 Ngasanalyzer and the AVL 437 Smoke Meter

Equipment	Measure Quantity	Measuring range	Accuracy	Uncertain ty
Digas 444N gas analyzer from AVL	CO	0-10%Vol	±0.03%vol	±0.15%
	O2	0-22%Vol	±5%vol	±0.5%
	CO2	0-20%Vol	±0.5%vol	±0.3%
	HC	0-20000ppm	±5ppm	±0.4%
	NOx	0-50000ppm	±10ppm	±1.2%
AVL437smokemete	Smoke	0-100%	±0.2%	±0.8%
AVL365Cangle	Crank angle	0-720^{0}CA	±1^{0}CA	±0.5%
AVLGH14Dpressur	Pressure	0-250bar	±0.3	0.25%
Tachometer	Engine speed	1-10,000rpm	±5rpm	±0.2%
Thermocouple	Exhaust gas temperature	0-1200^{0}C	±2^{0}C	±0.2%

2.3 Fuel Consumption

Pipettes and stop watches were used to do this. The pipette, which was used to gauge fuel use, is constructed of toughened glass. By timing how long it takes to fill up each loading and use a certain amount of diesel, the amount of fuel consumed was calculated. Fuel was transferred from the fuel tank to the engine when the volume was open. Fuel was pipette-fed into the engine when the valve was closed.

3. SPEED MEASUREMENT

A tachometer is a device that measures the rate of rotation of a shaft or disc, such as those found in motors or other machines. Although digital displays are becoming more prevalent, the device typically shows the revolutions per minute (RPM) on a calibrated analogue dial. The digital indicator on the dynamometer control controller offered information about engine speed.

4. MEASUREMENT OF TORQUE

The power absorbing (or power producing) components of the machine were mounted on bearings that were coaxial with the machine shaft, and the torque was measured by a smoke-type transducer acting tangentially at a known radius from the machine axis; the transducer was made up of a combination of a dead weight and a spring balance.

5. MEASUREMENT OF THE VISCOSITY

The apparatus was cleaned thoroughly. The ball valve was placed in position thus closing the orifice. The sample of esterified canola oil was poured into the cup up to the gauge point. The standard (50ml) round bottom lack was kept under the or if ice. The ball The valve was lifted, simultaneously starting the stopwatch and thus allowing the oil to pass through the orifice into the round-bottom flask of 50 mL at room temperature of 29 °C.

The observation was shown in tables of the next chapter. Then, heating of the oil was stopped and the oil was taken out from the cup. Then, the ball valve was lifted (by simultaneously starting the stopwatch) to collect 50 mL of oil, and then the time was tabulated. The experiment was repeated until the oil temperature was raised to 80 °C in steps of 10 °C. The time was noted from the stopwatch for 50 mL of oil collection. Then, the oil in the round-bottom flask was poured into the oil cup of the viscometer and started heating through an electrical heater so as to raise the temperature of the oil to 40 °C.

6. MEASUREMENT OF THE FLASH POINT AND FIRE POINT

The lowest temperature at which a volatile material's vapours will ignite in the presence of an ignition source is known as the flash point. Sometimes, the temperature—the temperature that triggers spontaneous ignition—is confused with the flash point. The lowest temperature at which the vapours continue to burn after the ignition source has been withdrawn is known as the fire point. It is higher than the flash point because there may not be enough vapour generated quickly enough to support combustion at the flash point. The ignition source temperature does not directly affect either the flash point or the fire point, but it is much higher than both of them.

The lowest temperature at which a fuel's vapour will continue to burn for at least five seconds after being ignited by a standard-sized open flame is known as the fuel's fire point. A substance will momentarily ignite at the flash point, a lower temperature, but it's possible that not enough vapour will be created to keep the fire going. Only material flash points are often listed in tables of material properties. Although it is generally accepted that the fire points will be approximately 10 °C higher than the flash points, this does not serve as a substitute for testing to determine whether the fire point is safety critical. Open cups were used to gauge the oil mixtures' flash and fore point. The fire point and the flash point were established.

7. RESULTS AND DISCUSSIONS

Performance, Emission and Combustion Curves

7.1 Load VS Brake Thermal Efficiency

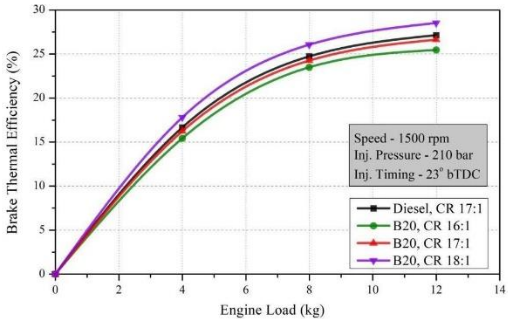

Figure 4: Brake Thermal Efficiency Vs Load at Different Compression Ratios

Brake thermal efficiency (BTE) makes predictions about the effectiveness of fuel energy conversion to workable energy. The effect of CRs on the BTE for the fuel samples is depicted in Fig. 5.1. There is a distinct rise in BTE as load increases due to lowered heat loss and increased power at higher loads. The findings show that at standard CR (17:1), the BTE of diesel and B20 blend were obtained as 27.13% and 26.62%, respectively, at full load, which are fairly close to one another. It is conceivable that the low energy content of the blend is responsible for its lower BTE. The increase in the compression ratio enhanced the engine's BTE. The BTE of B20 blend at full load was noted to be 25.45%, 26.62%, and 28.52% at CRs 16:1, 17:1, and 18:1, respectively. This rise in BTE may be partially related to greater compressed air temperatures, which facilitate blend combustion at higher CRs. The blend has a BTE of 28.52 percent at CR 18:1, 5.12 percent higher than diesel at regular CR.

7.2 Load VSB rake Specific Fuel Consumptions

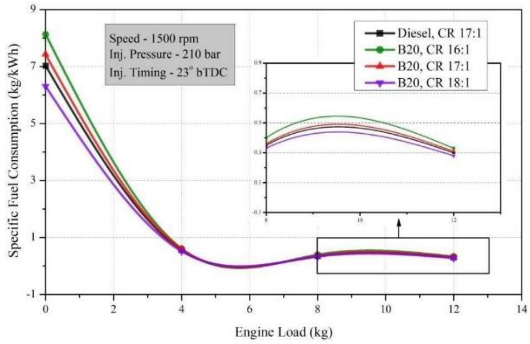

Figure 5: Specific fuel consumptions Vs load at different compression ratios

The amount of fuel required to generate one unit of braking power is known as the specific fuel consumption (SFC). Figure 4 depicts the variation in SFC for the fuel samples at various CRs. From no load to part load, the SFC dropped sharply, before progressively declining as load rose. This is because heat loss is reduced with larger loads.

At standard CR, the SFC readings for diesel and the B20 blend were reported to be 0.3 and 0.31 kg/kWh, respectively. The blend has a slightly greater SFC than diesel owing to its lower heating value. However, due to the calorific value of the B20 blend and diesel, they are very close to one another.

The SFC of the blend at full load and CRs 16:1, 17:1, and 18:1 was recorded to be 0.33 kg/kWh, 0.31 kg/kWh, and 0.28 kg/kWh, respectively. The SFC reduced with higher CRs. This tendency is logically explained by the fact that when CR climbs, the maximum cylinder pressure rises as a result of the fuel being delivered into a hotter combustion chamber, producing more effective power.

The blend's lowest SFC was measured at 0.28 kg/kWh at CR 18:1, a 6.6% improvement over diesel at standard CR.

Load vs. Exhaust Temperature

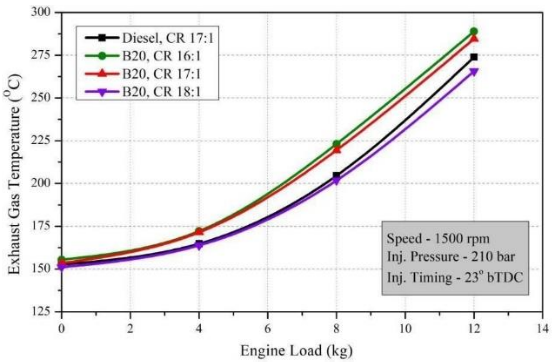

Figure 6: Exhaust gas temperature Vs load at different compression ratios

The measure of heat emitted by fuels during combustion can be referred to as exhaust gas temperature (EGT). Figure 5 depicts the variation in EGT for the fuel samples at different compression ratios (CRs). The EGT rises with engine load, owing to a greater combustion temperature which takes place within the cylinder at higher loads. The EGT for diesel and the B20 blend at the standard CR were 2730°C and 2840°C, respectively, at full load. Due to increased heat loss and decreased thermal efficiency, the biodiesel blend's exhaust gas temperature was higher than diesel. At full load, the EGT of the blend was noted to be 2880°C, 2840°C, and 2650°C at CRs of 16:1, 17:1, and 18:1, respectively. The drop in EGT at higher CRs may be due to increased expansion of burned gases and a larger quantity of work done by the burnt mixture. Increased air temperature, which aids in greater atomization of the fuel, results in incomplete combustion, which is also a reason for EGT reduction at higher CRs. At CR 18:1 and full load, the blend's EGT was noted to be 2650°C, which was 3% lower than diesel at standard CR.

7.3 Load VS CO Emissions

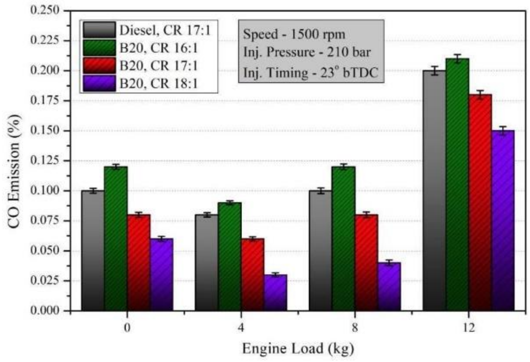

Figure 7: Coe missions Vs load at different compression ratios

Carbon monoxide (CO) is produced when fuel in an engine is not completely burned. Incomplete combustion takes place if there is not enough oxygen present to complete the combustion. Figure 7 shows the CO emissions of the fuel samples at various compression ratios (CRs). The CO emissions of the fuel samples decrease up to 60% load and subsequently increase. At low loads, the engine's gas temperature stays low, leading to incomplete combustion in the gas phase and very significant CO emissions. Due to the increased temperature of the gas within the cylinder, at higher loads, the CO oxidation rate rises, leading to reduced CO emissions. Under fully loaded conditions, the injected fuel is high and the fuel distribution becomes uneven. This leads to poor mixing and a high concentration of CO. At the standard CR, the emissions of CO for diesel and the B20 blend at full load were 0.2% and 0.18%, respectively. Due to the higher oxygen concentration in the biodiesel blend, it emits less CO than diesel. At full load, the CO emissions for the blend at CRs 16:1, 17:1, and 18:1 were 0.21 percent, 0.18 percent, and 0.15 percent, respectively. When the CR was increased, the blend's CO emissions decreased. This is because complete combustion can occur at higher CRs since there is more air and oxygen available inside the cylinder. The blend's CO emissions were lowest at CR 18:1, where they were 0.15 percent, or 25% less than those of the diesel at standard CR.

7.4 Load VSHC Emissions

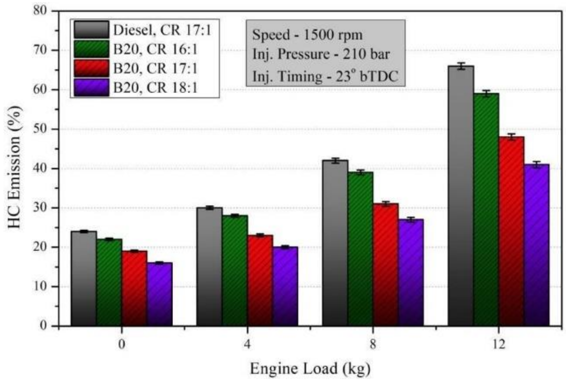

Figure 8: HC emissions Vs load at different compression ratios

Fuel entrapment in the combustion crevice, incomplete fuel evaporation, bulk quenching of the oxidation process at low temperatures, and locally lean or rich mixtures are all plausible causes of fuel's hydrocarbon (HC) emissions. Figure 5.5 depicts the HC emission at different CRs for the fuel samples. The graph demonstrated that as the load grew, HC emissions increased as well, owing to the existence of rich fuel blends and lower oxygen content for combustion at higher loads. At standard CR, the HC emission for diesel and the B20 blend were 66 ppm and 48 ppm, respectively, at full load. The hydrocarbons in the fuel interact with the oxygen in the blend to reduce its HC emission, making it less harmful than diesel. The HC of the mix was determined to be 59 ppm, 48 ppm, and 41 ppm, respectively, for CRs 16:1, 17:1, and 18. When the CR is raised, it has been observed that the HC emissions gradually decrease. Due to the rise in air intake temperature at the conclusion of the compression stroke, which improves the combustion temperature and results in better combustion, lower HC emissions are made possible at higher CRs. A minimum HC emission of 41 ppm is produced by the mix at CR 18:1, which is 38% less than the diesel's emission when run at standard CR and full load.

7.5 Load VS NO x Emissions

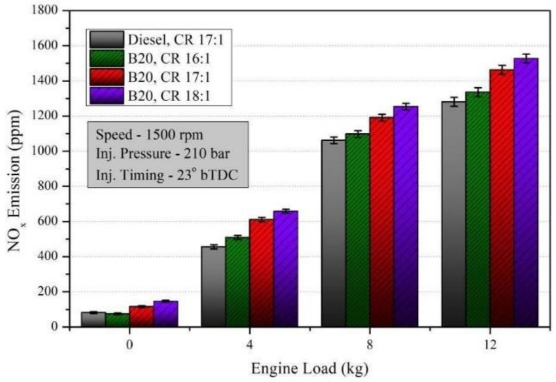

Figure 9: NO x emissions Vs load at different compression ratios

The three main variables affecting nitrogen oxide (NOx) emissions during premixed combustion are temperature, oxygen content, and reaction time. Figure 9 displays the NOx emissions of the fuel samples at various compression ratios (CRs). Due to the increase in combustion temperature brought on by high in-cylinder pressure at higher loads, the NOx emissions rose in relation to load.

At standard CR, the NOx emissions of diesel and the B20 blend were noted to be 1,281 ppm and 1,463 ppm, respectively, at full load. The blend's oxygen content raises the maximum gas temperature in the cylinder, which improves combustion and raises the NOx concentration as well. Along with the CR, the NOx increased as well. It was found that the blend's NOx emission values at full load for CRs 16:1, 17:1, and 18:1 were 1,336 ppm, 1,463 ppm, and 1,528 ppm, respectively.

Due to improved combustion and higher NOx emissions, higher CR causes the combustion chamber temperature to rise. The B20 blend had the lowest NOx reading at full load (1,336 ppm at CR 16:1) because it slows down the heat release from the pre-mixed fuel, which lowers the temperature of combustion. The blend at CR 18:1 had a 19.2% greater NOx emission than diesel at CR as-is. l

7.6 In-cylinder pressure Vs Crank angle

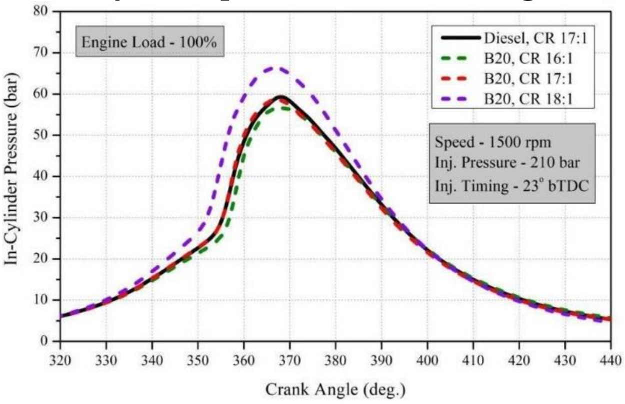

Figure 10: In-cylinder pressure Vs Crank angle at different compression ratios

Because combustion behaviour has a significant influence on an engine's characteristics, the in-cylinder pressure (Cp) vs. crank angle (CA) diagram is used to study combustion behaviour in engines. The variations in Cp for the B20 blend and diesel at various CRs in response to crank angle while the engine is operating at full load are shown in Fig.12. It is most likely that the mass of fuel burned during this time determines the maximum in-cylinder pressure that the fuel in CI engines reaches. The greatest Cp for diesel and the B20 blend were 59.35 bar at 3680 CA and 58.63 bar at 3670 CA, respectively, with full load and standard CR. Less fuel is built up during the premixed combustion phase because of the blend's enhanced density and viscosity.At CRs 16:1, 17:1, and 18:1, the blend's maximum Cp was calculated to be 56.59 bar at 3680 CA, 58.63 bar at 3670 CA, and 66.26 bar at 3670 CA, respectively. As the air temperature at the intake rises along with the CR, improving fuel atomization and hastening the combustion process, the cylinder pressure increased as the CR increased. When the blend was tested, its maximum cylinder pressure increased by 11.64% when compared to the diesel's at regular CR.

7.7 Heat release rate Vs Crank angle

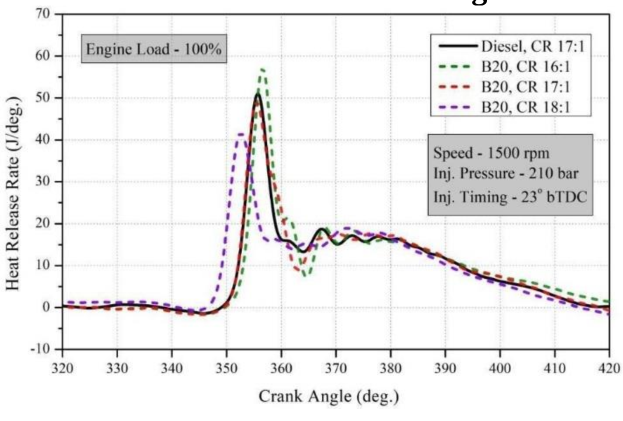

Figure 11: Heat release rate Vs Crank angle at different compression ratios

The heat release rate (HRR) is a useful way to explain how a diesel engine burns fuel. The HRR curves for diesel and B20 blend at various CRs are contrasted with one another at full load in Fig. 13. The maximum HRRs for B20 and diesel at standard CR were found to be 52.82 and 49.65 J/CA at full load, respectively. Due to its higher calorific value and longer ignition delay, which allows more fuel to collect in the combustion chamber, diesel has a higher HRR than the blend. The blend's HRR was 58.81, 49.65, and 42.36 J/CA at CRs 16:1, 17:1, and 18. The maximum HRR decreases as the engine compression ratio increases, as shown in Fig. 13, for example. This may be due to the fact that when the CR of the engine grows, the maximum in-cylinder temperature rises, increasing the rate of heat transfer inside the cylinder during combustion.

8. CONCLUSION

A VCR engine's characteristics were tested at varying CRs of 16:1, 17:1, and 18:1 while using a B20 blend of sea mango biodiesel. This investigation was conducted in two steps. Biodiesel preparation and property testing are part of the first stage. The engine testing and its characteristics when powered by a B20 blend of sea mango biodiesel at various CRs are covered in the second stage. The B20 blend's test findings were then contrasted with those of diesel, which was run at the recommended CR (17:1) ratio. The results of the experimental inquiry are as follows:

At standard CR, the brake thermal efficiency (BTE) of the B20 blend was almost identical to diesel. Though the BTE of the B20 blend was lower at CR 16:1 and 17:1 than diesel, at CR 18:1, the BTE of the blend improved by 5.12%. The specific fuel consumption (SFC) and exhaust gas temperature (EGT) improved with higher CRs.

At CR 16:1 and 17:1, the blend's SFC and EGT values were found to be greater than diesel. However, at CR 18:1, the SFC and EGT of the blend were reduced by 6.6% and 3.01%, respectively, when compared to diesel.

CO emissions of the B20 blend were higher than diesel at CR 16:1 but reduced when the CR rose to 17:1 and 18:1. At CR 18:1, the B20 blend resulted in 25% lower CO emissions than diesel. The HC emissions of the B20 blend were lower than diesel at all CRs. The B20 blend with CR 18:1 resulted in the lowest HC emissions, which was 38% lower than diesel.

Moreover, the NOx emission was higher than diesel for the B20 blend at all CRs. As the CRs lowered, the NOx emission of the blend reduced. Diesel had the lowest NOx emission of 1,281 ppm at standard CR. The lowest NOx level tested for the blend was 1,336 ppm at CR 16:1, which was still 4.29% higher than diesel. The blend produced 19.28% higher NOx emissions than diesel at CR 18:1.

At all CRs, the B20 blend had lower smoke opacity values than diesel. The opacity of the smoke decreased with higher CRs. The least smoke opacity was 34.72% lower than diesel, obtained by the B20 blend at CR 18:1.

Diesel and the blend's specific heat capacity (Cp) and heat release rate (HRR) were essentially the same at typical CR. As the CR increased, the Cp of the blend decreased, while the HRR of the blend increased.

The peak cylinder pressure increased as well.

The B20 blend had the least heat release rate (HRR) of 42.36 J/CA at CR 18:1. The B20 blend's maximum specific heat capacity (Cp) was calculated to be 66.26 bar at CR 18:1. While the CR increased, the HRR decreased. The blend with the lowest HRR at CR 18:1 was B20, at 42.36 J/CA.

According to the current research, sea mango biodiesel in the B20 blend could be a practical substitute for diesel fuel when used at a CR of 18:1, with just a slight increase in NOx emissions. Water emulsification techniques or exhaust gas recirculation techniques may be used to reduce the blend's enhanced NOx emissions. In addition, the research could be expanded to assess the effects of additives applied at various ratios by examining the engine characteristics of sea mango biodiesel blends.

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