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Investigation into the Impact of Ammonia Hydroxide on Performance and Emissions in Compression Ignition Engines Utilizing Diesel/Biodiesel Blends

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Abstract*- In recent times, there has been a surge in scientific endeavors aimed at combating global warming. Various methods have been employed to address this issue, including the substitution of fossil fuels with more environmentally sustainable alternatives and the combination of different fuel types. This can be achieved through the integration of innovative injection systems and the simultaneous combustion of alternative fuels alongside fossil fuels, or by modifying fuel injection systems such as in the PCCI, RCCI, or HCCI systems. In a particular research investigation, a blend of ammonia hydroxide and diesel, with volume percentages of 7.5% and 92.5% respectively, was utilized as green fuels. Various proportions of biodiesel were incorporated into the conventional injection system. Experiments were conducted on a four-stroke, single-cylinder, air-cooled diesel engine with fuel ratios of D80B20N7.5, D60B40N7.5, D40B60N7.5, D20B80N7.5, and pure diesel. The primary objective was to analyze the engine's brake thermal efficiency (BTE) and resulting emissions. Additionally, the study investigated changes in specific fuel consumption (BSFC) and compared the outcomes to those obtained using diesel alone. The study findings revealed that the inclusion of ammonia hydroxide in the blend of diesel and biodiesel in varying volumetric ratios led to an increase in brake thermal efficiency compared to using diesel alone. While the average brake thermal efficiency with pure diesel stood at 20.5%, the introduction of the diesel and biodiesel mixture in different proportions resulted in a decrease in average brake thermal efficiency. However, incorporating ammonia hydroxide at a volumetric percentage of 7.5% into the blend led to an increase in average brake thermal efficiency corresponding to the volumetric percentage employed. The highest brake thermal efficiency of 21.26% was achieved with the D80B20N7.5 mixture. As the percentage of biodiesel increased, there was a subsequent decrease in average brake thermal efficiency. Nevertheless, with the addition of the highest mixture percentage, D20B80N7.5, a brake thermal efficiency of 20.85% was recorded, surpassing the performance of diesel alone.

Keywords*- *Diesel engine; Ammonia Hydroxide; PCCI system; biodiesel; Average thermal efficiency.

I. INTRODUCTION

Sustainable development is a guiding principle that seeks to achieve human development objectives while also ensuring that natural resources and ecosystems can continue to support human needs. Example for sustainable development can be seen in action when community implements renewable energy sources, such as solar panels, to meet their electricity needs while reducing reliance on fossil fuels and minimizing harm to the environment[1-5].

In recent times, there has been a global focus on three major problems that affect the entire world: harmful exhaust emissions, global warming, and environmentally harmful industrial waste [6-11]. Scientists have dedicated significant resources to finding solutions for these issues. Examples for these issues were the three primary global concerns of noxious exhaust emissions, climate change, and environmentally detrimental industrial wastes have garnered widespread attention in recent years. Scientists have been working diligently to address these problems and develop effective solutions [10, 12-15]. One of the strategies that researchers have found to address global warming is to reduce emissions from internal combustion engines [16-20]. Internal combustion engines have witnessed many developments over the past few decades, and are still subject to ongoing research to reduce emissions, improve thermal efficiency, and reduce fuel consumption[21-24]. Scientists have used some strategies to put these ideas into practice, such as the use of green fuels [6, 17, 25-27]. We will discuss the addition of carbon-neutral fuels, using direct fuel injection technology[28-32]. We will examine the effect of adding different volumetric proportions of biodiesel fuel to a mixture of ammonia hydroxide and diesel fuel, using an atmospheric direct injection system using a single-cylinder, four-stroke compression engine, and air cooled[23, 27, 33-40]. The DEUTZ FL 511/W model was evaluated in terms of thermal efficiency, specific fuel consumption and environmental pollutants[22, 41-43].

Studies by Elkelawy and colleagues showed that using the mix previously described resulted in an approximately 23.5% increase in thermal efficiency [16]. But when diesel was the only fuel used, the thermal efficiency rose to 20.47%. There is a reduction in soot and nitrogen oxide emissions, exhaust temperature, and specific fuel consumption. As developments occurred, the choice was taken to upgrade the engine with a new injection system (PCCI), a cutting-edge low-temperature combustion (LTC) technology. By maintaining a low cylinder temperature, its main goal is to minimize exhaust emissions in the case of enhanced or unchanged efficiency[44]. As a result, there will be a decrease in the percentage of emissions of nitrogen oxide and soot generation[3, 44-48]. Since part of the fuel is utilized to create a homogenous combination of fuel and air, PCCI technology is regarded as an intermediate technology between HCCI and the old system; nevertheless, it is not as homogeneous as the mixture used in HCCI[49, 50]. In this study, we will take the direction of studying the effect of adding ammonia hydroxide to the diesel and biodiesel mixture [43, 51-53]. Adequate engine performance with blends of biodiesel/diesel is a well-known fact, as it enables an earlier ignition, a prolonged combustion duration, a lower ignition delay, and a lower HRR (heat release rate) [45, 47, 54-56]. Many countries have done numerous research on biodiesel employment over direct injection (DI) diesel engines, especially waste cooking oil biodiesel (WCOB) has accomplished a significant effect on diesel engines research due to its cost-effective nature and waste disposal minimization. Carbon deposits and extremely large viscosity are two of the most important problems affecting the use of pure WCOB[57-59]. Vegetable oils blended with conventional diesel would resolve the issues associated with diesel engine operating when using pure vegetable oils [30, 44, 60-64]. Vegetable oil readily dissolves in diesel fuel. For short term operation, a diesel engine could run correctly on a combination of diesel and biodiesel fuel without causing damage to engine components[56, 65]. Lower volume percentage blends of WCOB have superior combustion characteristics, lowering carbon monoxide (CO), hydrocarbon (HC), and soot emission levels, but they appear to encourage the production of NOx (Nitric oxide) Biodiesel is a possible mineral diesel substitute because to its greater energy density, Cetane value, and viscosity[66, 67].

As a result of the above, the experiment was conducted at a fixed speed of 1500 rpm for the diesel engine, as mentioned previously, under standard weather conditions [68-70]. As a result of the above, the experiment was conducted at a fixed speed of 1500 rpm for the diesel engine, as mentioned previously, under standard weather conditions. It was found that in the case of D80B20N7.5, the average thermal efficiency rises to 21.26%, and the average specific fuel consumption reaches 432.8 g/kWh, while in the case of D60B40N7.5, the average thermal efficiency rises to 21.14%, and the average specific fuel consumption becomes 435.77. Grams/km per hour. In the case of D20B80N7.5, the average thermal efficiency rises to 20.85%, and the average specific fuel consumption becomes 439.04 grams/kWh. Compared to the case of diesel only, the average thermal efficiency reached 20.5%, and the average specific fuel consumption reached 451.16 grams/kWh. Based on the previous results, combustion engines can operate stably and efficiently in the case of the previous system, which leads us to future studies in this field.

II. EXPERIMENTAL METHODOLOGY AND PROCEDURE:

A. *TEST RIG SETUP*:

A homogeneous mixture of diesel and biodiesel with adding ammonia hydroxide was injected into an internal combustion engine. This improved the combustion characteristics of pollutant emissions, thermal efficiency, and qualitative fuel consumption [48, 71-77]. Previously, the engine ran on diesel fuel and a conventional injection system using liquid ammonia hydroxide. For this experiment, a functioning internal combustion engine was utilised. The single-cylinder quadruple engine "Deutz F 511/W" is cooled with air as illustrated in figures 2 and 3, which represent an illustration of the engine and its contents, respectively. This engine works at a constant speed of about 1500 rpm, with a temperature of 90 ° C, direct pressure of 220 bar at 32 degrees below the dead top center of the cylinder, and a compression ratio of about 17. The technical properties of the engine are displayed in Table 1. To keep the engine at a constant speed of 1500 rpm with the change in the amount of fuel injected, an electronic console was added to control speed. The engine contains a fuel consumption system, which includes a tank in which diesel is placed in the event of operation and a gradual test in which the mixture or any other fuel used is placed, which will be injected into the engine according to the volumetric ratio -used engine. Using a dynamic scale of a vortex, the engine is loaded. The Dynamometer scale contains a simultaneous generator of 5 kW connected to the elbow column and the generator is connected to 6 lamps (for each cap power block 1 kW) and a variable voltage device to control the output energy as shown in Figure 1.

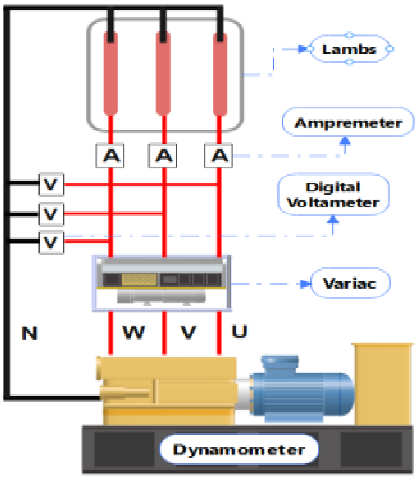

Figure 1. Load and dynamometer circuit schematic diagram.

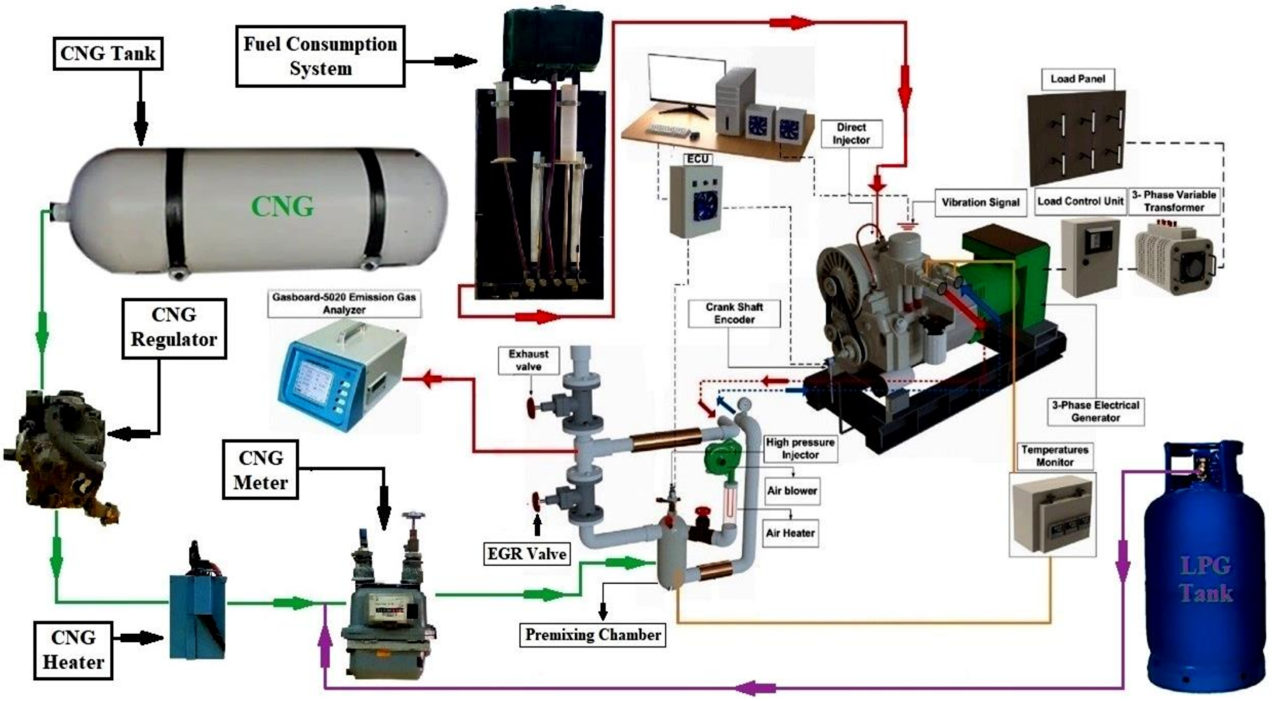

Figure 2. Schematic diagram of the PCCI engine setup with fuel vaporizer.

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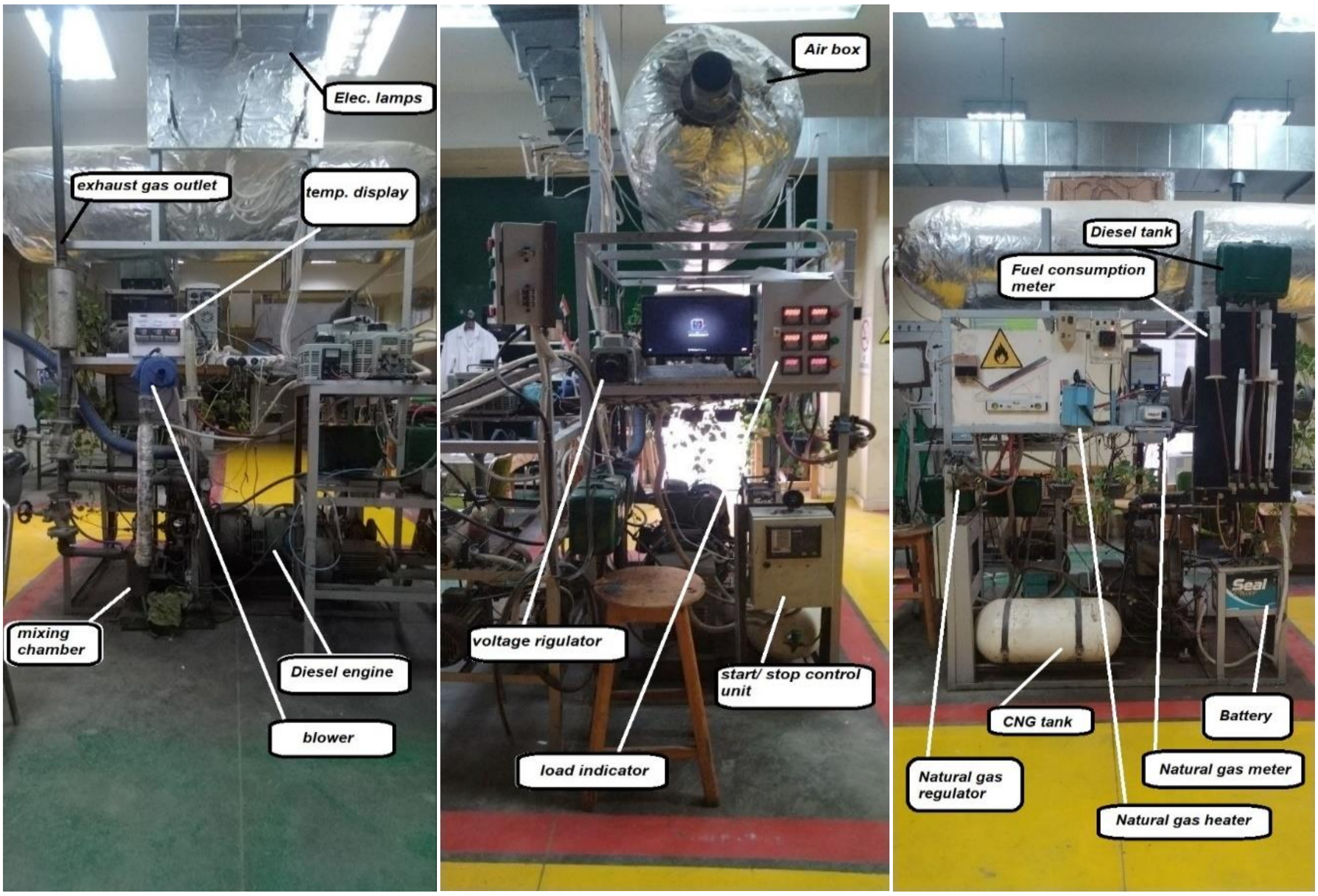

Figure 3. Actual image of the experimental setup of the engine with fuel vaporizer.

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Table 1. technical characteristics of the engine [78, 79]

Parameters	Dimensions	Parameters	Dimensions
No. of cylinder	Single	**Injection system**	Direct in injection
Engine version	DEUTZ FL500/W	Rated power	5KW at 1500rpm
Displacement	825 cm^3	**Compression ratio**	17
Bore	10cm	Inlet valve opening	32 CA BTDC
Cooling system	Air-cooled	**Inlet valve closing**	59 CA ABDC
Stroke	10.5cm	Exhaust valve opening	71 CA BBDC
Power cycle	Four strokes	**Exhaust valve closing**	32 CA BTDC

B. PRODUCTION METHODS OF BIODIESEL:

The biodiesel, which was tested, was produced from WCO via transesterification process. This chemical process was carried out using pure methanol (> 99 percent purity) and NaOH (sodium hydroxide). Biodiesel was produced from WCO with a high yield of 96% under optimal process conditions of 1:4 V/V% methanol to oil, 0.1 mass percent NaOH handling, 550 rpm stirring speed, 60-minute response duration, and 60 °C reaction temperature [50, 57, 78, 80-82]. The biodiesel manufacturing process was carried out using a test rig which was capable of producing a large amount of biodiesel with an elevated quality and high yield from a variety of feedstocks. The schematic representation for the biodiesel test bench is shown in Figure 4, while the actual image for the biodiesel test bench and produced WCO biodiesel is shown in Figure 5. The proposed system consists of four major stages [52, 83-88]: crude biodiesel production, glycerol separation, gathering, and biodiesel washing & drying (purification). The manufactured biodiesel complied with ASTM D6751, that had a large oxygen level, a golden yellow colour, and a 160 °C flash point. Additionally, the produced biodiesel has a lower heat and calorific value than traditional diesel owing to the presence of oxygen.

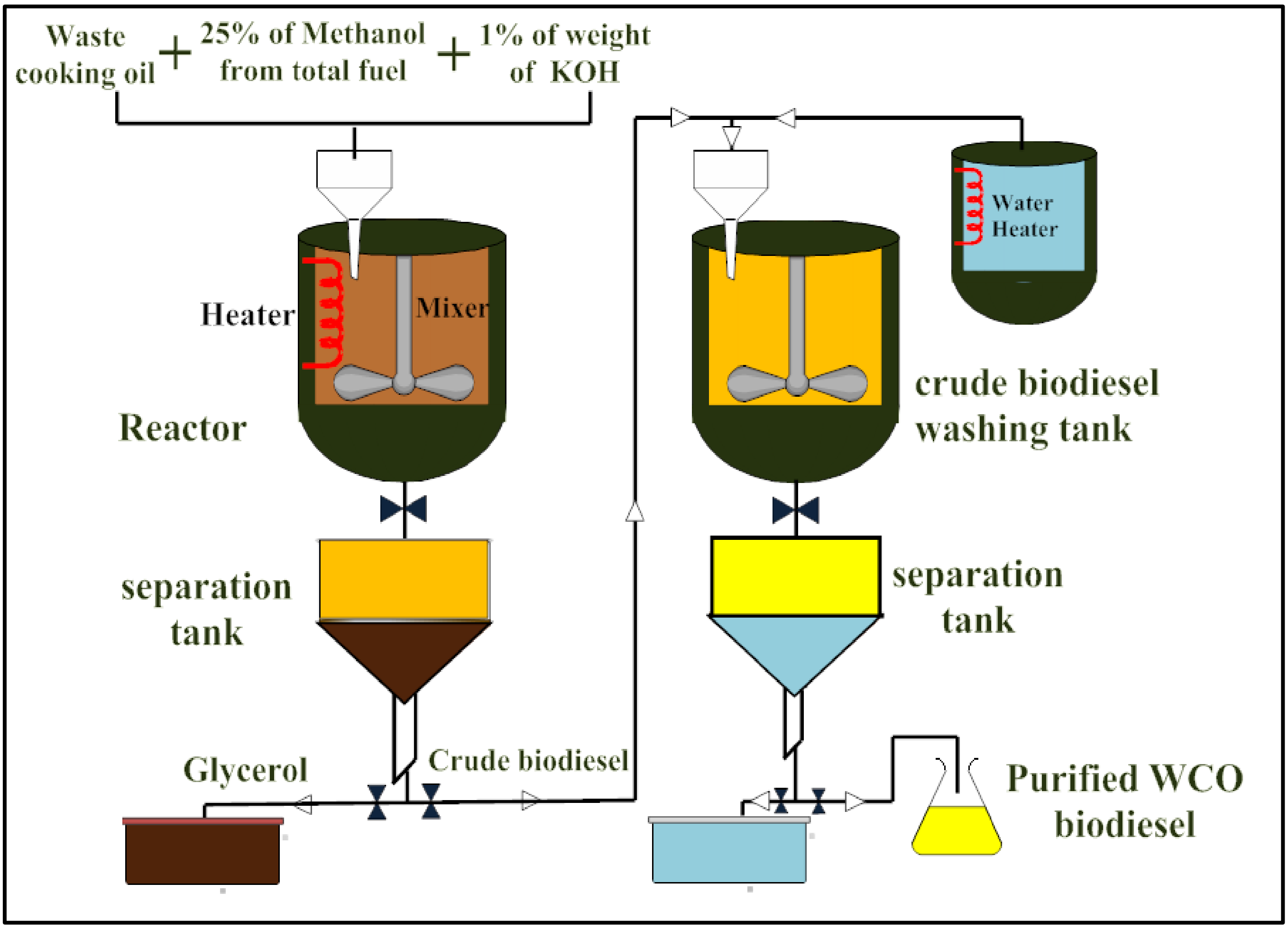

Figure 4. Schematic Representation For The Biodiesel Test Bench.

Complete Biodiesel production system

Biodiesel production Steps

Figure 5. the actual image for the biodiesel test bench and produced WCO biodiesel.

C. FUEL PREPARATION:

The WCO biodiesel was blended with conventional diesel with four volumetric proportions. The mixtures were thoroughly mixed with a magnetic stirring device for four consecutive hours at a mixing speed of nearly 1000 rpm @ room temperature before being placed within the fuel tank [89-95]. Four blends were created by combining diesel and WCO biodiesel in the following portions: D80B20 (20% WCO + 80% of diesel fuel), D60B40 (40% WCO + 60% of diesel fuel), D40B60 (60% WCO + 40% of diesel fuel), D20B80 (80% WCO + 20% of diesel fuel) [96-100]. After the process of preparing the diesel and biodiesel mixture, liquid ammonia hydroxide is added at a volumetric ratio of 7.5%. The mixture consists of diesel, biodiesel, and ammonia hydroxide with a volume ratio of 7.5% and a concentration of 33%. (NH3 -HOH). Place the mixture in a bowl below the mixer and stir for an hour at a speed of about 550 rpm to ensure that the fuel does not separate for a period of one hour for each mixture.

D. MEASUREMENT AND UNCERTAINTY (ERROR ANALYSIS):

The Following Table shows the Emission Analyzer and Sensors Used in the test Table2. In Figure 6 we find actual pictures of the measuring devices used to measure polluting emissions and soot resulting from the engine[101, 102].

Table 2. devices and sensors utilization

Device/sensor	Utilization
1st thermocouple	To measure air temperature
2nd thermocouple	To measure exhaust temperature
Speed sensor	To measure engine speed, attach to the engine's crankshaft.
DASHBOARD-5020 emission gas analyzer	Measure the values of [CO, O2, and CO2] in (% vol) and [HC, NOx] in (ppm).
Orifice system	Measure the volume of air flowing into the engine
GASBOARD-6010 opacity meter	Used to measure soot opacity

Figure 6. emission gas and opacity analyzers.

Because of the use of many devices, equipment, and optical measurement methods, each of them has an error rate that makes the results of the studied research need to be reviewed. Therefore, the total error rate resulting from the research must be studied by using Equation 1[103-105] .

$$\frac{\Delta w}{w}=\sqrt{\sum_{x=1}^{\infty}\left(\frac{\Delta x_n}{x_n}\right)^2}\ --------eq.1$$

Where; $\frac{\Delta w}{w}$ is a total uncertainty rate of the experimental results, Δx_n is an error of the equipment, $\frac{\Delta x_n}{x_n}$ is an uncertainty of each device used.

Measuring fuel consumption is one of the methods used to measure specific fuel consumption (SFC) [84, 106, 107], in which the measurement is done using a stopwatch and looking to determine the scale on the burette for its range. Where 10 cubic milliliters are measured during the time measured on the stopwatch, and we find the percentage of error in the measured volume $\Delta x=\pm 0.1cm$, $x=10cm$ the uncertainty value (accuracy) will be $\frac{\Delta x}{x}=\pm 0.01=\pm 1\%$

Table 3 shows the devices used, their range, and the measurement accuracy of each device.

Table 3. Device characteristics and accuracy

Instrument	Parameters	Range	Accuracy
GASBOARD-6010 opacity meter	Soot opacity	0-100%	+2%, -2%
Shaft encoder	Speed	0-720^{0}CA	+0.2%, -0.2%
K-thermocouple	Exhaust gas temp.	0-800 ^{0}C	+1%, -1%
GASBOARD-5020 emission gas analyzer	CO	0-20%	+0.06%, -0.06%
	HC	0-9999ppm	+0.12%, -0.12%
	CO2	0-20%	+0.4%, -0.4%
	NO	0-5000ppm	+0.5%, -0.5%
	O2	0-25%	+0.1%, -0.1%
Graduated cylinder/stop watch	Fuel flow meter	1-30 cm^3	+1%, -1%

From the above, the total uncertainty includes many factors in the experiment, as appeared in the accuracy of the devices used and the accuracy of the methods used[108, 109]. Thus, by applying Equation 1 to the coefficients, it becomes clear that the accuracy of the results in the experiment is as follows.

$$\frac{\Delta w}{w}=\sqrt{(1)^2+(2)^2+(0.2)^2+(1)^2+(0.06)^2+(0.12)^2+(0.4)^2+(0.5)^2+(0.1)^2+(1)^2}*\%$$

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$\frac{\Delta w}{w} = 2.735\%$, the total error value will be

$$\Delta w = \pm 0.02735$$

E. EXPERIMENTAL METHODOLOGY:

In this study, the experiment was conducted on a single-cylinder, four-stroke diesel engine operating at a constant speed of 1500 rpm under different load conditions [91, 92]. The experiments begin at no load and partial load and reach full load. The experiments were carried out using a mixture of traditional direct injection technology, and multi fuel was used, including diesel, ammonia hydroxide and biodiesel) [12, 16, 66, 110-113]. The effect of the combustion of the mixture on the combustion characteristics, engine performance, and the value of the resulting emissions was studied[90]. This mixture includes a volume percentage of ammonia hydroxide and diesel 7.5% - 92.5%, respectively, and compares it with its values for pure diesel in direct injection mode and the effect of adding biodiesel with different volume percentages (20% biodiesel, 40% biodiesel, 60% biodiesel, and 80% biodiesel) [114-119]. To study the effect of adding biodiesel to the diesel and ammonia hydroxide on engine performance and emissions [102, 104, 120, 121].

III. RESULTS AND DISCUSSION:

The use of a mixture (ammonia hydroxide - diesel) with the addition of biodiesel will improve the combustion characteristics, and thermal efficiency of the engine.

A. BRAKE THERMAL EFFICIENCY-BTE:

The Brake thermal efficiency is defined as the percentage of chemical energy produced by the fuel that is converted into usable work. we can evaluate its value from Equation 2,3.

$$BTE = \frac{power}{m^{\bullet} * Cv} * 100\% ------(eq.2) \qquad [122].$$

$$m^{\bullet} = \rho * V^{\bullet}_{ol} ----(eq.3)$$

where; $m^{\bullet}$ is defined as mass flow rate, Cv is defined as the calorific value of each fuel, ρ is defined as the density of each fuel, $V^{\bullet}_{ol}$ is defined as volume flow rate.

Figure 7 shows the difference in BTE for pure diesel and a mixture (diesel - ammonia hydroxide) with a volumetric ratio (7.5% - 92.5%) and another with the addition of biodiesel in volumetric quantities, respectively. It is clear from the figure that thermal efficiency increases with increasing load under all operating conditions due to decreased heat loss. The resulting energy increases because of the quality of combustion, and with the increase in the percentage of ammonia in the mixture, the thermal efficiency of the brakes increases. In case of adding biodiesel into pure diesel, thermal efficiency decreased, but adding ammonia hydroxide changed the values and lead thermal efficiency to increase.

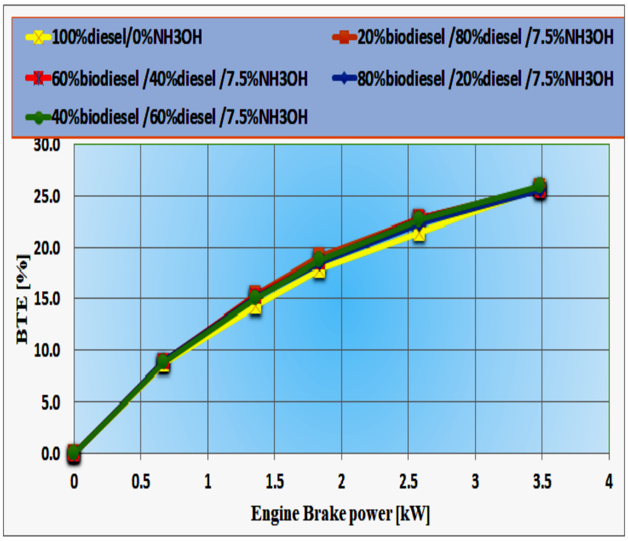

Figure 7. Brake Thermal Efficiency- BTE under Various Loads Conditions.

B. BRAKE SPECIFIC FUEL CONSUMPTION- BSFC:

Brake-specific fuel consumption, or BSFC, is the amount of fuel required to produce one unit of braking power and is determined by the calorific value of the fuel. Diesel and ammonia hydroxide mixtures have variable calorific values; hence they are not a reliable indicator of engine performance. Brake-specific energy consumption (BSEC) should be utilized as the benchmark when using a variety of fuels with different calorific values. By dividing the overall energy used by the braking force produced, the BSEC is determined. To get the BSEC value in MJ/kWh, use equation 4.[123]

$$BSEC = \frac{[(m^{\circ} * LHV)_{diesel} + (m^{\circ} * LHV)_{NH4OH} + (m^{\circ} * LHV)_{WCO}] * 3600}{power} ---eq.4$$

Where, BSEC in (MJ/kW.hr), m˚ in (kg/sec), LHV in (MJ/kg), and Power in (kW).

Figure 8 shows that in the case of pure diesel, the average fuel consumption was 451.16 [g/kWh]. By adding biodiesel at Volumatic percentage 20%, the average fuel consumption value decreased to 432.8 [g/kWh], and the average fuel consumption value in the case of biodiesel at a volume percentage 40% is reduced to 435.7 [g/kWh].in case of adding biodiesel at a volume percentage 80%, the average fuel consumption value was 439[g/kWh]. It is clear from the figure that at the same loads, the consumption rates in the presence of ammonia hydroxide with biodiesel are lower than in pure diesel.

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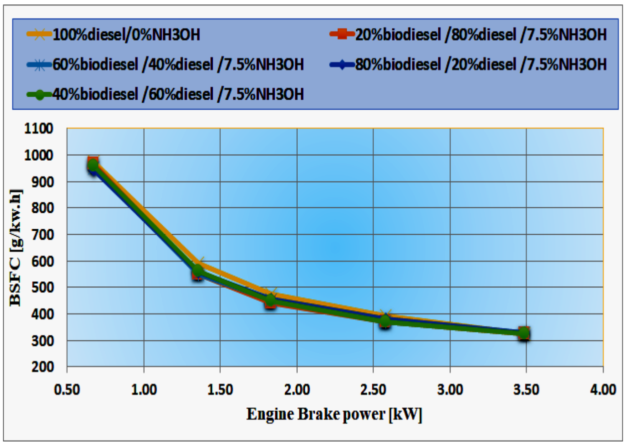


Figure 8. Brake-Specific Fuel Consumption Under Variation of Load Conditions.

C. EXHAUST GAS TEMPERATURE-EGT:

Since the temperature of the exhaust gases and the heat loss from them are directly related to the thermal efficiency of the engine, measuring the temperature of the exhaust gases is essential. Figure 9 shows an example of how exhaust temperatures fluctuate under different loads. The observed variation in results when adding ammonia hydroxide to diesel may be due to the proportion of water present in the mixture. However, it does not have any noticeable effect on the exhaust temperature because the presence of biodiesel in the mixture led to an increase in the exhaust temperature, which led to a convergence of results between the mixture of diesel, ammonia hydroxide, biodiesel, and diesel alone. The data clearly shows that although the average temperature rises to 204.3°C in the case of pure diesel. It decreases to 202.8 degrees Celsius when using the mixture D80B20N7.5. In the case of D60B40N7.5, the average exhaust temperature reaches 202.4 degrees Celsius, while in the case of D20B80N7.5, it reaches 202.5 degrees Celsius. From the previous results, it is clear that there is no clear change in exhaust temperatures, despite the clear change in specific fuel consumption and thermal efficiency, as a result of the presence of ammonia hydroxide.

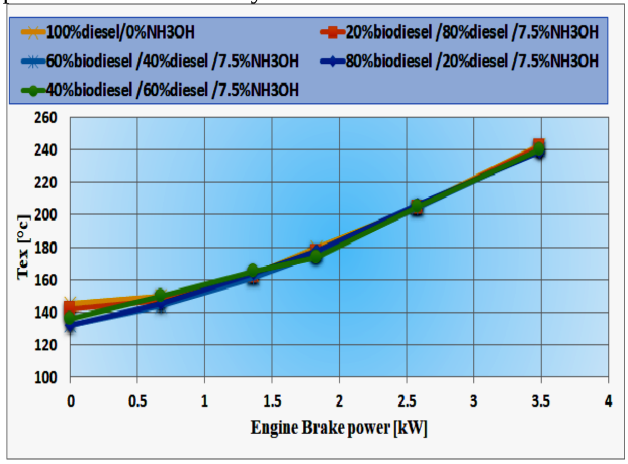


Figure 9. exhaust gas temperature under variation of load conditions.

D. OXIDES OF NITROGEN – NOX:

The primary variables affecting NOx emission are oxygen supply, increased combustion period, and combustion chamber temperature. Figure 10 shows that NOx emissions rise with load. This is due to an increase in the temperature of the combustion chamber, but in the case of the mixture, and as a result of the presence of water and nitrogen in the mixture, which works to reduce the temperature of the combustion chamber, the emission percentage of nitrogen oxides in the mixture is lower than that of diesel, while adding biodiesel to the mixture in gradual volumetric proportions. As a result of the availability of oxygen in the biodiesel, which leads to the creation of nitrogen oxides, it led to a reduction in the effect of ammonia hydroxide, which affected the mixture as a whole and led to an increase in the results of the emission of nitrogen oxides, but these results are still less than the results of diesel alone.

E. UNBURNED HYDROCARBONS-UHC:

Unburned hydrocarbons are produced due to liquid wall wetting, abnormally lean or rich mixtures, and incomplete combustion of fuel confined in crack volumes. Figure 11 shows the difference in engine HC emission values. In the case of pure diesel, it is clear that higher temperatures and the result of incomplete combustion within the engine cause higher levels of hydrocarbon emissions with increasing loads. Low engine temperatures and high hydrocarbon levels result from the addition of ammonia hydroxide and the effect of evaporated water. Adding biodiesel to the mixture of diesel and ammonia hydroxide, as a result of the presence of a high percentage of fat, led to an increase in the percentage of unburned hydrocarbons. For example, we find that the average value of unburned hydrocarbons in the case of diesel reaches 14 parts per million, in the case of the D80B20N7.5 mixture it reaches 25 parts per million, and in the case of the D60B40N7.5 mixture it reaches 33 parts per million, all the way to the D20B80N7.5 mixture, which recorded 30 parts. per million.

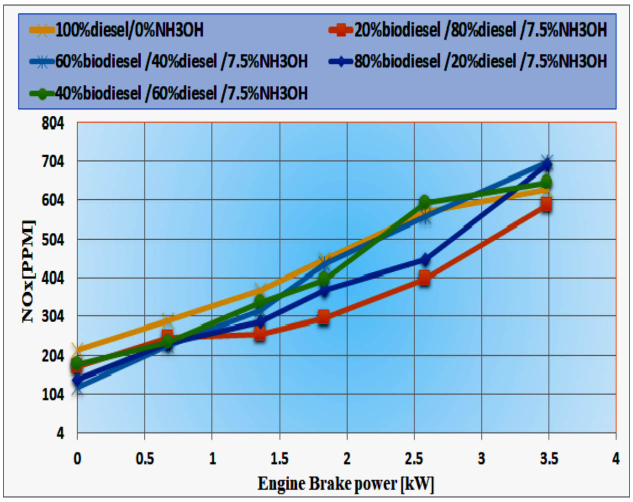


Figure 10. Oxides of Nitrogen under Variation of Loads Conditions.

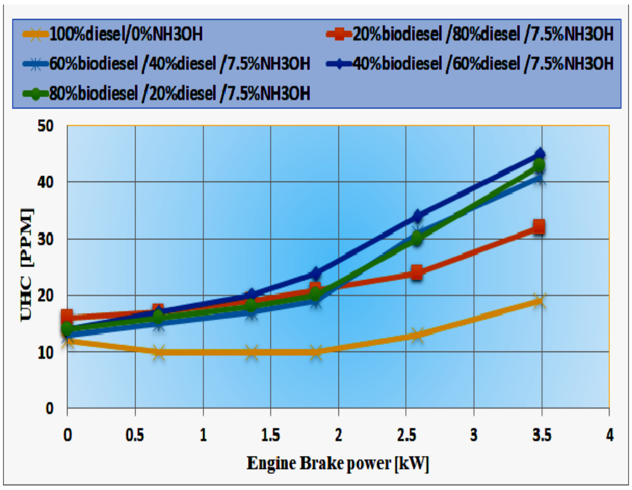


Figure 11. The variation of the unburned Hydrocarbon under various load conditions.

F. CARBON MONOXIDE-CO:

Carbon monoxide is one of the most dangerous engine emissions because it is a toxic and flammable gas. It is the product of incomplete combustion of carbon dioxide, and due to the low combustion temperature and low oxygen content, partial oxidation of carbon is generated, forming carbon monoxide. In Figure 12, the variation in carbon monoxide results for pure diesel fuel, a mixture of diesel, ammonia hydroxide, and biodiesel is shown. It was shown that as the loads increased in the experiment and due to the increase in combustion temperature, the emission of carbon monoxide decreased. If ammonia hydroxide is added as we explained previously and as is clear in the diagram, as the exhaust temperature decreases and partial oxidation of carbon dioxide occurs, carbon monoxide is generated.

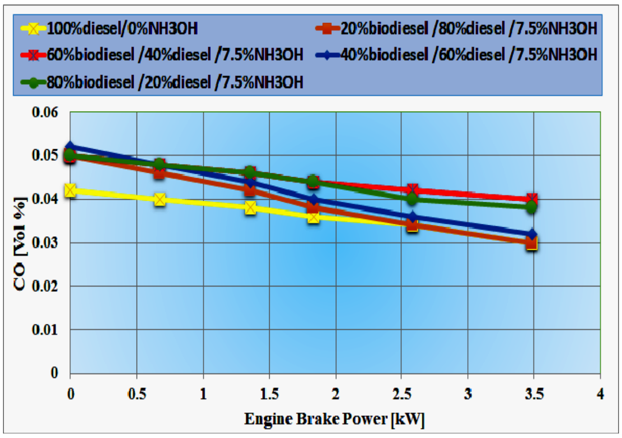


Figure 12. The variation of the Carbon monoxide under various load conditions.

We will find that by adding ammonia hydroxide, the emission will increase compared to diesel, and in the case of adding biodiesel to the mixture of diesel and ammonia hydroxide, the resulting deficiency in the mixture will be compensated by the availability of the percentage of oxygen required to complete the combustion process, which reduces the emission rate of carbon monoxide in the mixture of diesel, biodiesel, and ammonia hydroxide, and by increasing the percentage Biodiesel in the mixture reduces the emission of carbon monoxide.

G. AVERAGE WEIGHTED:

To determine the ideal mixture ratio that we may use going forward and incorporate in future research, the average findings will be explained below, along with comparisons between the outcomes of diesel combustion and those from combinations of ammonia hydroxide and diesel. The following demonstrations will calculate average values for the outcomes of our experiment using Equation 4.[124]

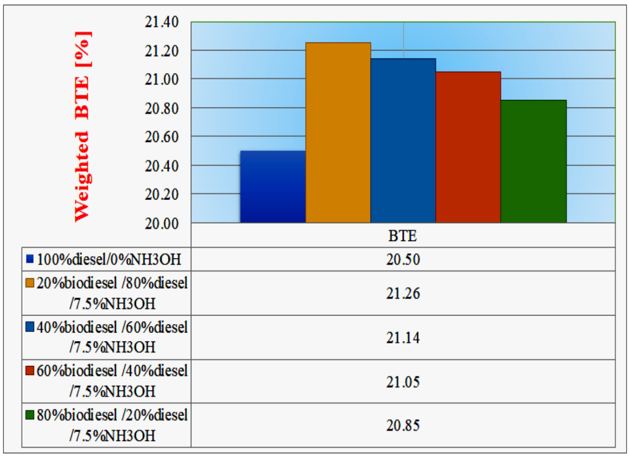
$$W = \frac{\sum_{i=1}^{n} \omega_i * X_i}{\sum_{i=1}^{n} \omega_i} ---------eq.4$$

Where, W Is the Weighted Average, n is no. of terms to be averaged, ω_i weights are applied to x values, and X_i data values are to be averaged.

1. WEIGHTED AVERAGE -BTE:

Figure 13 shows the average thermal efficiency values of the engine in the case of using pure diesel and a mixture of ammonia hydroxide + diesel with the addition of different volumetric percentages of biodiesel. It is clear from the curves that in the case of pure diesel, the average thermal efficiency recorded a value of 20.5%, while in the case of the mixture of diesel, biodiesel, and ammonia hydroxide D80B20N7.5, which is considered the highest efficiency recorded, it was 21.26%. As the percentage of biodiesel in the mixture increases, the efficiency decreases to reach the mixture D20B80N7.5. To record a value of 20.85%.

Compared to diesel, the increase in thermal efficiency was due to the presence of ammonia hydroxide in the mixtures.



	BTE
100%diesel/0%NH3OH	20.50
20%biodiesel /80%diesel /7.5%NH3OH	21.26
40%biodiesel /60%diesel /7.5%NH3OH	21.14
60%biodiesel /40%diesel /7.5%NH3OH	21.05
80%biodiesel /20%diesel /7.5%NH3OH	20.85

Figure 13. Weighted Average of BTE of the hydroxide ammonia variation.

2. WEIGHTED AVERAGE – BSFC:

Figure 14 shows the average values of the fuel consumption rate injected into the engine in the case of using pure diesel, and a mixture of ammonia hydroxide with diesel and biodiesel. From the results in the illustration, we find that the lowest value of the average fuel consumption rate was D80B20N7.5, recording 432.8 g/kw.h, and it begins to increase consumption by increasing the percentage of biodiesel in the mixture to record 439.04 g/kw.h in the case of the D20B80N7.5 mixture, while in the case of diesel it recorded 451.16 g/kw.h.

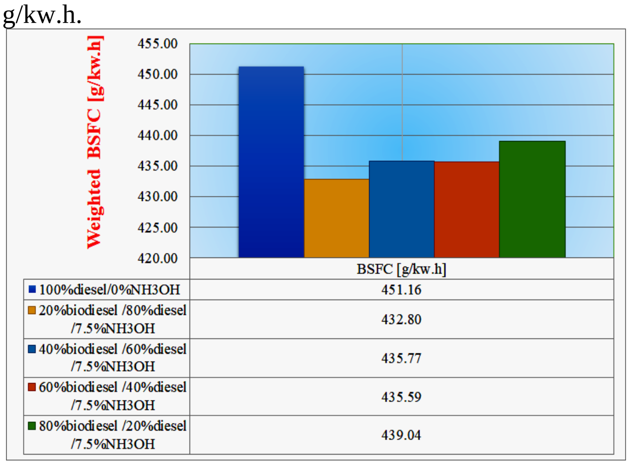


Figure 14. Weighted Average of BSFC of the Hydroxide Ammonia Variation.

IV. CONCLUSIONS:

Thermal efficiency, specific fuel consumption rate, and environmental pollutant emissions were studied in the case of using pure diesel fuel, and in the case of using a mixture of diesel, biodiesel, and ammonia hydroxide. The results showed that using ammonia hydroxide with biodiesel and diesel as a mixture improves performance of fire properties, emissions and thermal efficiency. The following results from the experiments will be summarized:

- In the case of a D80B20N7.5 mixture, the average BTE value increases by about 21.26%, and the average fuel consumption (BSFC) decreases by about 4.06% compared to diesel.
- NOx emissions values decrease due to the lower exhaust temperature when using diesel, biodiesel and ammonia hydroxide mixture.
- HC values increase if the mixture is used because of lower exhaust temperatures and incomplete combustion and increase at an average rate of about 33 ppm in the case of D80B20N7.5, while in the case of pure diesel, it is 14 ppm.
- Due to the presence of biodiesel as a result of the availability of a percentage of oxygen, which led to complete combustion and a decrease in the emission of carbon monoxide?

Finally, it is recommended to use a mixture of diesel, biodiesel, and ammonia hydroxide, which improves combustion properties and raises temperature. Engine efficiency.

V. FUTURE RESEARCH DIRECTION

Because the effect of ammonia-diesel hydroxide mixture addition and biodiesel addition on engine emission characteristics, performance and combustion characteristics has been discussed previously, future research on some interesting topics is recommended. The most important recommended topics are:

- The application of innovative technology for injection systems, including RCCI. Numerous studies and research have endorsed the usage of the technology due to its advantages in terms of combustion, emissions, and engine performance.
- Looking for other fuel sources that can be blended with diesel and ammonia hydroxide to create a homogenous mixture and assessing the impact of these additions on engine output, combustion characteristics, and fuel emissions.
- To achieve good control, dependability, and the potential to work in combustion, using an electric injector is preferable to its mechanical counterpart with fuel injection pressure because it allows it to control the amount of fuel that is sent directly to the injection in the cylinder to prevent knocking accidents in the engine.

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Conflicts of Interest:

The authors have no conflict of interest.

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