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INVESTIGATE THE IMPACT OF BIODIESEL FUEL BLENDS ON THE CHARACTERISTICS OF ENGINE AND RELEASES OF SINGLE-CYLINDER, FOUR STROKES

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ABSTRACT

In this article, an investigational analysis has been conducted to explore the effect of biodiesel fuel blends on characteristics of engine and releases (CO2, CO, HCl, and NOx) of single-cylinder, four strokes at the variable biodiesel concentration. The releases of gases and the engine's characteristics were measured at six blending biofuels and six-speed conditions and constant load. The blending proportions of biodiesel with diesel fuel-based by volume were at 0% pure diesel, 5%, 10%, 15%, 20%, and 25%. This investigation aims to assess the biodiesel fuel mixture's impact on the CI engine performance in terms of its Bsfc, Ƞbth, and engine release of CO2, CO, HCl, and NOx. The investigation revealed that biodiesel remarkably minimized the release of CO2, CO, HCl, and NOx. The influence of this fuel mixture was studied between 5% to25% biodiesel concentration, and the results of this investigation could aid in understanding the Impact of utilizing biodiesel as an energy source on engine releases and performances.

Keywords: *Pure diesel fuel; Biodiesel; Performance; and Release*

1. INTRODUCTION

The quest for alternative sources of energy (including alcohol and biodiesel) has piqued academics' attention in recent years due to their experimental work, owing to the continued depletion of fossil fuel supplies and the rising need for energy. In addition, global health experts have demonstrated that pollutants emitted from diesel engines negatively impact human, plant, and animal health and cause acid rains. Despite the availability of other alternative fuels, biodiesel has emerged as a promising candidate for further research because of its benefits, including its biodegradability, renewable nature, ease and flexibility in manufacturing processes, and lower releases compared to other traditional diesel. Since the good miscibility of biodiesel fuel with petroleum diesel, additives have been utilized with biodiesel to enhance the efficacy and characteristics of the engine Another important characteristic of biodiesel is that it contains a great percentage of oxygen, estimated at approximately 10 percent, which is not typically available in diesel fuel. Furthermore, they were indeed non-toxic and virtually sulfur-free.

Biodiesel's molecular structure is comparable to diesel fuel, but it includes more oxygen that helps decrease unburned smoke, CO, and HC releases in the exhaust. Nevertheless, a diesel engine running on biodiesel or a mix of biodiesel and other fuels emits more NOx than a diesel engine running on petroleum-based fuel (Karabektas, Ergen et al. 2008, Ozsezen, Canakci et al. 2008). Great-quality edible oils are one of the most utilized resources on a great industrial scale for producing biodiesel, despite the availability of a variety of feedstock materials for its production. The reason for this is said to be the supply chain's security and its reduced concentration of free fatty acids (FFA) (Lin, Cunshan et al. 2011, Avinash, Subramaniam et al. 2014). There have been several excellent debates regarding the long-term viability of the present feedstock supply series, strategy, particularly considering their possible negative impact on global food security. As a result, researchers have reported a growing number of investigations to evaluate the feasibility of various alternative feedstock sources. Researchers examined non-edible oil-bearing plants, including Castor beans, Soapnut, and Jatropha Curcas, and non-edible waste fat from animal carcasses and waste vegetable oils. In addition, sunflower, rapeseed, cottonseed, and soybean are common vegetable oils for biodiesel production (Chen, Chiang et al. 2013, Abdelfattah, Abu-Elyazeed et al. 2018, Ntaribi and Paul 2019). At an industrial scale, trans-esterification is among the most common chemical methods for converting pure oil/fat (triglyceride) to biodiesel (fatty acids methyl-ester; FAME) (Fukuda, Kondo et al. 2001). (ÇELİKTEN and ARSLAN 2008), conducted research to assess the utilization of biodiesels derived from oils of soybean and canola in a diesel engine. They found that the density of smoke has been substantially reduced, whereas NOx releases were significantly raised. (Yamik and İçıngür 2008), evaluated the release characteristics and performance of both the ethyl esters and sunflower oil methyl. They discovered that the methyl and ethyl ester of sunflower oil performed similarly to petroleum diesel fuel. (SUGÖZÜ, Cengiz et al. 2010), explored the release properties and biodiesel engine

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performance with direct injection, single-cylinder 4-stroke, naturally aspirated, and air-cooled at various engine speeds under full-load circumstances. The findings of biodiesel have indeed been compared with those of diesel fuel, which was utilized as a control. The engine's power and torque seem to have been lower in biodiesel, and the specific consumption of fuel has been greater, which may be ascribed to biodiesel's reduced calorific magnitude.

Transesterification has been utilized to make biodiesel from leftover cooking oil. Because it includes many triglycerides and several physical and chemical procedures to remove contaminants, waste vegetable oils are considered raw materials for biodiesel manufacturing (Primandari and Arafat 2021). (Can 2014), utilized two types of cooking oil wastes biodiesel (WCOB) and its mixtures with diesel. It seems to be detected that mixing waste vegetable oils biodiesel with diesel results in shorter ignition delay duration with greater combustion duration. There has been a reduction in HC, smoke, and CO, and a slight increase in NOx, CO2, and spent fuel for brakes. (Abed, El Morsi et al. 2018), explored a diesel engine's performance and exhaust pollutants by utilizing a waste vegetable oil mix with diesel fuel at various engine loads in an experimental setting. Diesel usage was lower than that of biodiesel blends in terms of specific fuel usage. Furthermore, CO2 levels increased whereas HC, smoke opacity, and CO releases decreased in waste vegetable-oil biodiesel mixes.

Many researchers have utilized various techniques such as adding chemical catalysts and nanoparticles/nanofluids into the base fuel to enhance the engine's performance and decrease harmful releases, as demonstrated below. (Yilmaz et al., 2014), explored the impacts of butanol–biodiesel mixtures on vehicle releases and performance parameters of a four-strokes, indirect diesel engine injection. They obtained that, a greater concentration of butanol in biodiesel leads to an increase in carbon monoxide and hydrocarbons releases and lower nitrogen oxides release than diesel, in addition, to an increase in fuel consumption, so it is preferable to use low concentrations of butanol. (Kumar, Dinesha et al. 2017), experimented to see how various volume proportions of Pongamia biodiesel mixtures of B20 with 1.0 percent ferrofluid as an additive impacted the Performance of a Kirloskar TV1 single-cylinder 4-stroke diesel engine at different loading whereas maintaining a constant speed of (1500) rpm. They found that adding Ferro fluid to gasoline had a positive impact, lowering BSFC by 8.0 percent compared with non-additive fuel. Compared to all other fuel mixtures, the nano-mixed biodiesel had the greatest efficacy and the lowest releases. (Zaharin, Abdullah et al. 2017), performed experimental research to evaluate the impacts of various alcohol additions in biodiesel-diesel fuel mixtures on diesel engine combustion behavior, performance, and exhaust release properties. Particularly compared to diesel fuel, the significant latent heat of alcohol vaporization and low cetane number produce a longer igniting delay, greater heat release rate, and lower pressure in the cylinder. Alcohol with low viscosity and density improves spray properties and speeds up the air-fuel mixing process. It has also been discovered that the availability of oxygen in alcohol fuels promotes a more efficient combustion process, resulting in greater thermal efficacy and lower carbon monoxide, hydrocarbon releases, and particulate matter. (Jiaqiang, Zhang et al. 2018), explored the Impact of Cerium oxide nanoparticles in diesel engines. They concluded that metal-based additives improved engine combustion parameters and decreased exhaust pollutants. (Reşitoğlu, Yaşar et al. 2018), explored the impacts of adding CuNO3 nano and butanol-diesel mixtures on the fuel characteristics (copper strip corrosion, Cetane number, heating magnitudes, density, and viscosity) and vehicle releases of a diesel engine in an experimental situation. CuNO3 nano additive has been demonstrated to improve diesel engines' fuel qualities, and vehicle releases characteristics when mixed with butanol-butanol mixtures. (Raju, Kishore et al. 2018, Shrivastava, Shrivastava et al. 2018), explored the Impact of combining Aluminum Oxide Al2O3 nanoparticles with Jatropha Oil Methyl Ester (JOME) on the Performance and releases of a diesel engine. The engine performance was lower compared with that of a diesel engine since the low calorific magnitude of Jatropha methyl ester oil. They concluded that utilizing nanoparticles with biodiesel and diesel results in a more efficient, cost-effective, and ecologically friendly engine. (Zurina, Adam et al. 2019), explored the impact of utilizing long-chain alcohols (pentanol and 2-ethyl 1-hexanol) on diesel engine vehicle releases. They discovered that utilizing alcohol fuels causes CO and hydrocarbon releases to rise (HC). Furthermore, there was a reduction in carbon dioxide (CO2) and nitrogen oxides (NOx). Furthermore, they discovered that 2-ethyl 1-hexanol is a superior additive to pentanol since it emits less NOx, HC, and CO. (Mohamed, Tan et al. 2020), explored the releases, Performance, and characteristics combustion of a biodiesel engine and its mixtures made from catalytic pyrolysis of waste vegetable oils in an experimental setting. The impacts of various catalyst types (sodium hydroxide vs. potassium hydroxide) have also been researched. They concluded that potassium hydroxide (KOH) seems to be less effective as a catalyst than sodium hydroxide (NaOH). The pyrolysis average temp for the NaOH catalyst has been considerably smaller, implying reduced total releases and energy consumption. (Jedsadaratanachai and Boonloi 2020), presented a numerical predictions on characteristic of heat transfer, flow topology and thermal performance assessment in a square channel. (Hamzah, Kareem et al. 2021), performed a numerical research to analyze the steady state heatlines visualization, fluid flow and heat transfer inside a square enclosure with a present of magnetic field. (Xiao, Feng et al. 2021), studied the supersonic condensation and influencing actors of natural gas with carbon dioxide. The impacts of different pressure, temperature and gas component proportion on droplet number, nucleation rate and humidity were examined. (Abdallah, Yasin et al. 2022), studied experimentally Heat Pipe Heat Exchanger to minimize the energy consumption in air-conditioning devices without changing the desired temperature level in the air-conditioned space.

In this investigation, the major aim is the alternative fuel for powering diesel engines and their impacts on the characteristics of engine η_{bth}, Bsfc, and releases CO2, CO, HCl, and NOx. This investigation intends to mixture biofuel with pure diesel at five various percentages (5+95, 10+90, 15 +85, 20+80, and 25+75) % of biodiesel, respectively. The engine performance and releases will also be described before and after the mixtures.

2. METHODOLOG

The tests conducted in this investigation have been performed in variable phases as follows:

1. Operating the engine with only pure diesel.
2. Operating the engine with various mixture proportions of biofuel and diesel, as earlier stated. Table 1 demonstrates the characteristics of diesel fuel and biodiesel.

- 5 percent biodiesel +95 percent Diesel.
- 10 percent biodiesel +90 percent Diesel.
- 15 percent biodiesel + 85 percent Diesel.
- 20 percent biodiesel + 80 percent Diesel.
- 25 percent biodiesel + 75 percent Diesel.

Table 1 The chemical and physical characteristics for various fuels (MOHAMMED, YASEEN et al. 2021)

Property	Pure Diesel	Biodiesel	(5Bio+95 Die) %	(10Bio+90 Die) %	(15Bio+85 Die) %	(20Bio+80 Die) %	(25Bio+75 Die) %
Flash point (C^0)	65	170	66	67	68	69	71
Pour point (C^0)	-18	-6	-16	-15	-14	-13	-12
Calorific value (kJ/kg)	44000	42300	43900	43800	43100	43200	42800
Density	0.819	0.882	0.818	0.829	0.830	0.832	0.835
Cetane number	54.4	47.1	52.8	51.9	50.3	48.9	47. 4
Viscosity mm/s^2	2.195	4.145	2.290	2.238	2.316	2.415	2.505
Specific gravity	0.8196	0.8827	0.8181	0.8296	0.8212	0.8336	0.8354
Diesel index	70.7	43.2	67.29	65.93	63.71	60.4	59.08
Refractive index	1.462	1.492	1.458	1.462	1.462	1.560	1.458

The experiments have been done to assess the influence of fuel types on the release and engine performance of 4- stroke diesel engines under variable speed direct injection, variable speed constant load; the experiments were carried out in the Power Mechanics Techniques Engineering Department, Lab I.C.E. Al-Musayib Technical College, Babylon. Iraq. The single-cylinder, air-cooled diesel engine (model: 114 MKII - TD) utilized in this investigation is demonstrated in Figure (1). The engine used in the experiment is a direct injection diesel engine supplied a bowl in the piston combustion chamber. Table 2. Offers the major properties of the engine utilized in this experiment, whereas Figure (1) demonstrates the test installation. Tests were performed utilizing six test fuels at varying engine loads; before introducing any new fuel into the engine, the engine is allowed to run for a specific period to ensure that the previous fuel has been completely combusted.

Table 2 Engine requirement utilized in the experiment

Item	Specification
Engine Manufacturer	114 MKII - TD
Engine kind	4-stroke, Compression ignition
Number of cylinders	Single cylinder
Bore *Stroke	6.8 cm *10.5 cm
Compression proportion	22.1
Cooling	Cooling of Air
Max power	2-7 KW
Swept Volume	0.000233 m^3

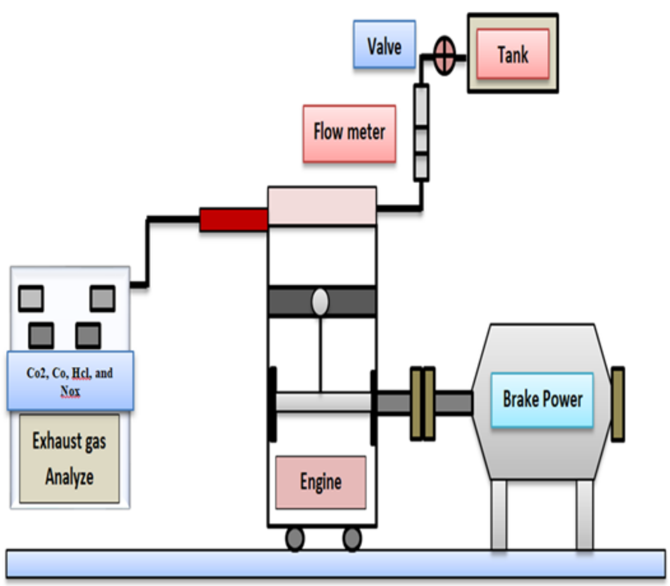

Fig. 1 Experimental setup of the rig.

2.1 The properties of Performance

The properties of the Performance of the experiment could be briefly demonstrated in Table 3.

Table 3 Assessing experimental indicators

Assessing Indicators	Formulas	Symbols	Description
Specific consumption of braking fuel	$\frac{\dot{m}f}{Wb}$	$\dot{m}f$ = Rate Fuel flow of the engine Wb =Braking Power	The quantity of fuel utilized by the engine in a certain period kg/kw.sec (Al-Gburi, Al-Abbas et al.)
Power of Braking	$\frac{2\pi \times N \times \tau}{60 \times 1000}$	N= Speed Number of engine cycles750-2000 (rpm) τ = torque N. m	the engine's power output (reported in kw) (Al-Gburi, Al-Abbas et al.)
Braking thermal efficacy	$\frac{Wb}{(LHV) \times \dot{m}f}$	LHV = lower Calorific magnitude	the proportion of energy in braking power to fuel power (Pulkrabek 2004)

During the experiments, glass cylinders have been utilized to mix the diesel and biodiesel at variable proportions as demonstrated in Figure (2). (A) contains the pure diesel, (B) contains the diesel-Biodiesel mixture at the proportion of (5Bi+95Di) %, (C) contains (10Bi+90Di) %, (D) (15Bi+85Di) %, (E)(20Bi+80Di) %,and (F) (25Bi+75Di)%.

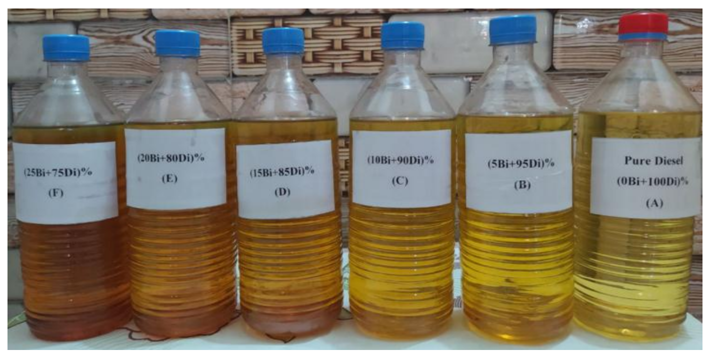

Fig. 2 Various glasses with various mixtures of percent.

3. RESULTS AND DISCUSSIONS

Biodiesel was used as an alternative fuel to explore the influence of biodiesel fuel blends on engine characteristics and releases of single-cylinder, four strokes at the variable biodiesel concentration, in terms of Bsfc, Ƞbth, and engine release CO_2, CO, HCl, and NOx.

3.1 The properties of the releases and Performance

Fig. 3 offers the brake specific fuel consumption of engine operating at different fuels mixtures, with respect to the engine speed. It can be summarized that the BSFC increases with the increase in the biodiesel mixing ratio. The BSFC of 25% biodiesel at 2000 rpm was slightly greater than that of pure diesel and those of other magnitudes of biodiesel concentrations. This increase can result in faster volatility of biodiesel, which improves the speed of mixing the fuel with air, thereby improving the combustion process. There were decreases in the Bsfc magnitudes as the engine's speed was enhanced from 750 to 2000 rpm, which concedes with (Carraretto, Macor et al. 2004).

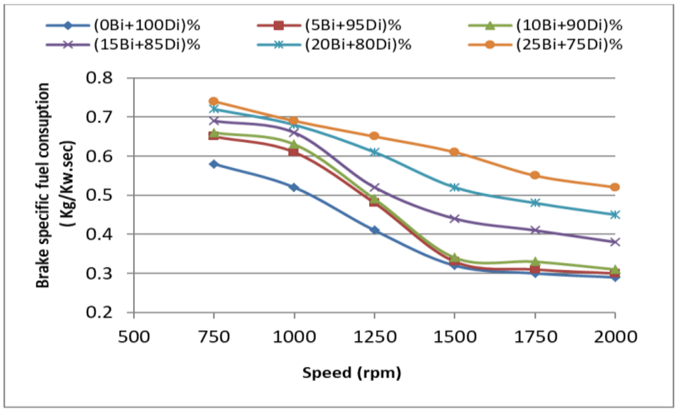

Fig. 3 The effects of biodiesel rate on BSFC at different speeds.

Fig.4 shows the impacts of the biodiesel fuel mixtures on thermal braking efficacy at different speeds. It could be detected that the thermal efficacy increased with increasing the biodiesel blending proportion. The greatest magnitude of the thermal efficacy observed at the speed of engine 2000 rpm for (25Bi+75Di) %. When the engine speed increases, the spray character is enhanced by the increase of cylinder temperature, then the cylinder combustion is improved. Thus, the thermal braking efficacy are improved.

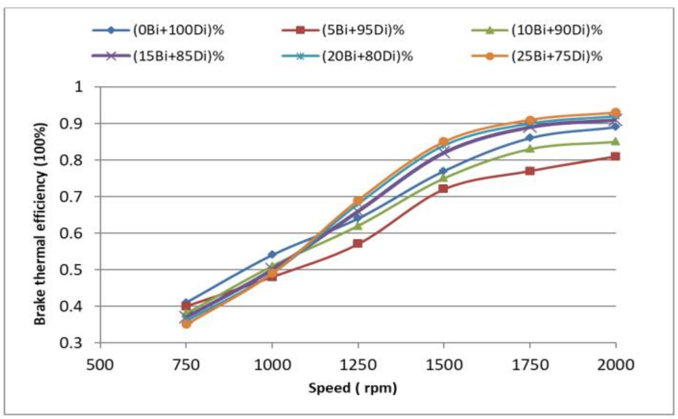

Fig. 4 The effects of biodiesel rate on Ƞbth at different speeds.

Fig. 5 shows the CO2 emissions with different biodiesel mixing ratios at different speeds. It could be detected that CO2 release was always low compared with the pure diesel fuel, the low release of CO2 on biodiesel fuel because of short hydrocarbons and its greater oxygen amount than the pure diesel fuel. The lowest CO2 release magnitude is 3.5%, obtained at a concentration of (25Bi+75Di) % at 2000 rpm.

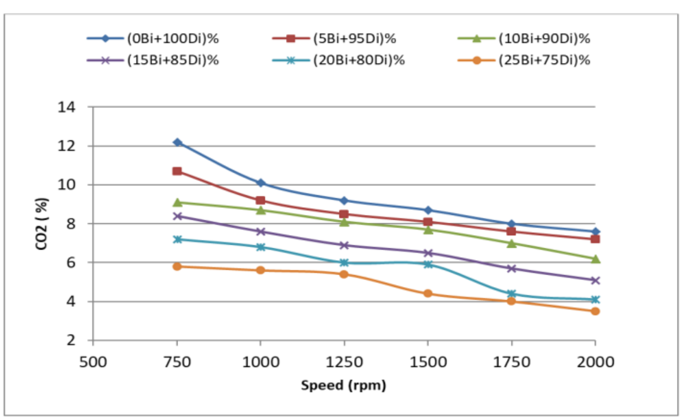

Fig. 5 Effects of different biodiesel rates on CO2 emissions at different speeds.

Carbon monoxide (CO) is a poisonous gas that is colorless and odorless. Incomplete hydrocarbon fuel combustion will lead to the formation of carbon monoxide. The Impact of biodiesel mixture proportion on the CO release is demonstrated in Fig 6. It can be found that with more fuel, more CO will be produced with the increase in speed. However, the greater the speed, the faster the oxidation rate of CO. In addition, the CO formation can be restrained, hence the CO emission can be decreased with the increased biodiesel mixing ratio. CO magnitude has been become 12.8%, at speed is 750 rpm at pure diesel fuel, and this magnitude decreased when increased the speed to 2000 rpm with increased biodiesel mixture fuel proportion to become 7.3%. The reason is that biodiesel contains large amounts of oxygen. This is due to the truth that the high viscosity of biodiesel is not beneficial to the oxidation of carbon monoxide.

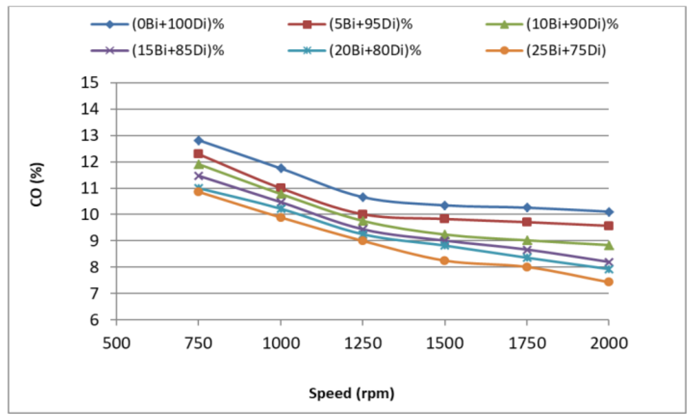

Fig. 6 Effects of different biodiesel rates on CO emissions at different speeds.

Fig. 7 offers that increasing the engine's speed from 750 - 2000 rpm leads to decreasing the Hcl release. The pure diesel and biodiesel mixture results were as follows: as engine speed increase from 750 to 2000 rpm, Hcl emission at pure diesel was 134 to 59 (ppm). At the same time, the Hcl emission of the biodiesel mixture reduces with the engine's increasing speed to 2000 rpm. Increasing the mixing proportion of biodiesel from 5% to 25% in diesel fuel leads to a decrease in Hcl to 102 ppm at the 2000 engine's speed. This result is due to the higher oxygen content in the biodiesel. Thus, the biodiesel-diesel fuel improves the combustion in the cylinder.

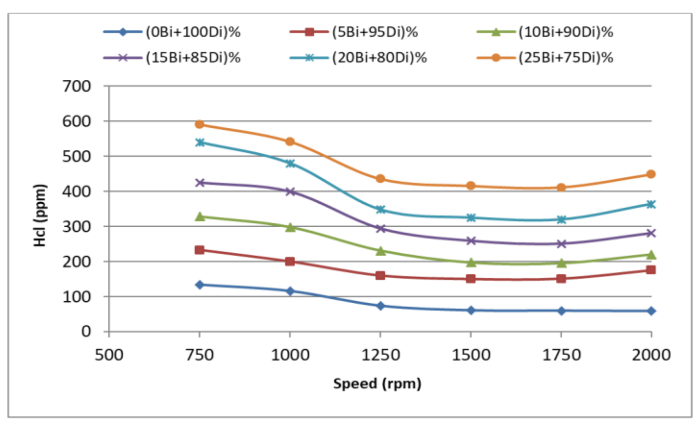

Fig. 7 Effects of different biodiesel rates on Hcl emissions at different speeds.

Fig. 8 demonstrates that the emission of NOx with different biodiesel mixing ratios at different speeds. It can be found that, as the biodiesel mixing ratios increased from (5% to 25%) at different speeds, the emission of NOx will increase. The high viscosity of biofuels leads to an increase in nitrogen oxide, which lead to reducing the efficacy of combustion, this is confirmed to some extent by (Gnanamoorthi and Devaradjane 2015).

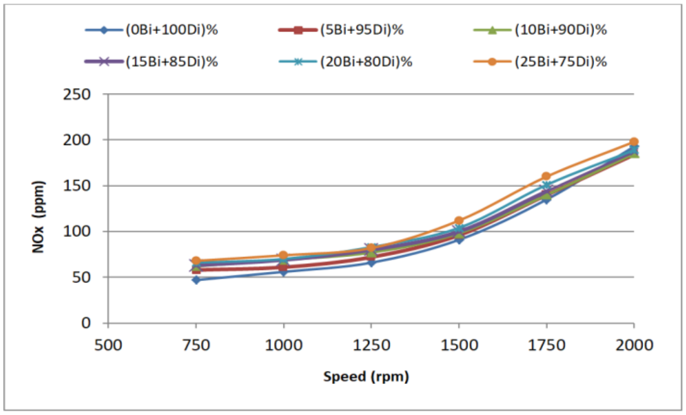

Fig. 8 Effects of different biodiesel rates on NOx emissions at different speeds.

4. CONCLUSIONS

This experimental investigation focused on the Impact of biodiesel addition on engine performance. The investigation observed better stability with biodiesel mixtures and suggested that it could be utilized without modification in diesel engines. The next facts could be drawn down:

1. The thermal efficacy increases with increasing biodiesel blending proportion, the greatest magnitude of thermal efficacy observed at a speed of the engine of 2000 rpm for (25Bi+75Di) %.
2. The consumption of braking fuel (Bsfc) was also detected to increase slightly.
3. The NOx release rises with increasing biofuel blend, but the release of CO2 and CO is reduced with increasing the biodiesel fuel proportion.

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