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EXPERIMENTAL STUDY FOR THE EFFECT OF DAMAGED VEGETABLE OIL BIOFUELS ON DIESEL ENGINE PERFORMANCE AND EXHAUST EMISSION

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Abstract

Biodiesel fuels are used as an alternative fuel in internal combustion engines. In this study, the damaged vegetable oil (the vegetable oil after using in cooking) was mixing with methanol to produce biodiesel fuels and tested in a single cylinder 4- stroke engine. Gases emission and engine performance were recorded at constant speed and five load conditions. This experimental study measured NOx, CO, CO_2 and O_2 at the different biodiesel concentration. The emissions of gases and the performance of engine measured at five blending biofuels and five load conditions and at constant speed. The blending ratios of biodiesel with diesel fuel based by volume were set at 0% (pure fuel), 5%, 10%, 20% and 30%, throughout this work denoted as 0S, 5S, 10S, 20S and 30S. The results show that, at higher content of biodiesel fuel, biodiesel exhibited better emission CO and CO_2, the reduction percent of these emission gases reach to 46% and 22% respectively. Also, the exhaust temperature gases reduction reach to 20%. Also, the obtained results found that the decrease values of break power and thermal efficiency. Furthermore, NOx increased when the content of biodiesel increases.

Keywords: Biodiesel, Diesel, Damaged vegetable oils, Engine, Exhaust emission.

1. Introduction

In the recent years, the increasing of air pollution is one of the most important problems of developed countries. The main source of this pollution is exhaust emissions from motor vehicles. The change of motor design is not sufficient to reduce this source, so that it is necessary to work on alternative fuel technologies [1-14]. Biodiesel fuel is an alternative to conventional fuel due to its desirable properties. The effects of biodiesel blends on the injection characteristics have been studied by many researchers [15, 16]. Biodiesel fuel is produced by using chemically reacting a vegetable oil or animal fats with an alcohol which include methanol or ethanol [17, 18]. The use of biofuel as an alternative fuel is a great attention in the present time [19-22].

The impact of biodiesel fuel on engine overall performance and emission characteristics of diesel engine have investigated and studied by Selvam and Vadivel [23]. The effect of pure biodiesel fuel and biodiesel combined with 10% methanol on engine performance investigated by Laforgia and Ardito [24]. The results reveal on reducing in smoke emitted from the solutions. Munack et al. [25] detailed an examination of the customary diesel fuel with the rapeseed oil methyl ester identified with fumes gas emanations and impacts of these outflows on human wellbeing and the earth. The general outcome indicated that a slight hindrance of biodiesel was found concerning NOx and ozone antecedents, however then again, a huge ash decrease was seen that is associated with a lower mutagenic strength of the particulate issue (PM). Carraretto et al. [26] examined various mixes of biodiesel fuel and unadulterated diesel fuel. The outcome demonstrated that decreasing in execution of the motor and expanding in utilization of the fuel. Likewise found that diminishing in CO discharges and expanding in outflow of NOx.

Zhu et al. [27] studied the impact of diesel fuel, biodiesel fuel and ethanol biodiesel fuel ignition in direct infusion motor. The outcomes show improving in execution of the motor when utilizing biodiesel fuel with 5% ethanol. Additionally, CO outflow expanding with increment of ethanol rate. The influence of compression ratio on the performance, combustion, and emission characteristics of a single cylinder 4-stroke direct injections naturally aspirated diesel engine powered by diesel-ethanol blends investigated by Gnanamoorthi and Devaradjane [28]. Pressure proportions, for example, 17.5:1, 18.5:1, and 19.5:1 was considered and differed by adjusting the elements of cylinder bowl by keeping the standard stroke volume. The outcome shows that the expansion in pressure proportion and ethanol mixed fuel improves ignition and improves the exhibition of motor. Additionally, there is a critical decline in HC, CO, and smoke discharges anyway there is an expansion in NOx.

Pidol et al. [29] introduced aftereffects of the investigation of the properties of ethanol mixed powers and assesses their conduct in regular diesel burning and propelled ignition, for example, low temperature ignition (LTC). The expansion of ethanol into diesel fuel influences some key properties, for example, the mix security, the cetane number or the blaze point, the fuel plan was along these lines improved.

Taghizadeh-Alisaraei et al. [30] study the effect of ethanol expansion to diesel fuel on motor execution and motor vibrations. The outcomes indicated that the torque and power increment all things considered by 3.8% at fuel mix with convergence of 6% ethanol as contrasted and those of unadulterated diesel fuel. Likewise, the root mean square and kurtosis of vibration on the motor square improve 4.75% and 7.75% as contrasted and unadulterated diesel, individually.

Fang et al. [31] examined the impact of ethanol on ignition and outflows in premixed LTC in a four chambers substantial Diesel motor. The biodiesel was utilized as an added substance to counteract the stratification of ethanol and diesel mixes. The premixed LTC is accomplished by the medium degree of fumes gas distribution and the drawn-out start delay. Contrasted and diesel fuel, ethanol-diesel-biodiesel mixes have lower NOx discharges because of lower ignition temperature, coming about because of the higher inactive warmth of vaporization.

Qi et al. [32] showed that lower emission NOx of the blended fuel in the case of low engine loads and when the engine load is high the higher emission. Also, at high engine loads the emission of gases are high.

Tutak et al. [33] investigated that the operation of test engine is stable when using diesel-ethanol fuel blend up to 30% of ethanol fuel.

Naima et al. [34] investigation the usability of waste polyethylene oil as an alternative fuel for diesel engines. The results showed that the total fuel consumption is lower and improved Brake Thermal Efficiency. Moreover, the exhaust gas temperature is lower.

Wahyu et al. [35] tested cassava bio gasoline on electronic fuel injection vehicles in urban traffic conditions with different engine loads. The results showed that fuel consumption varies with the conditions of with and without air-conditioner. Moreover, CO emissions are constant with variation of the proportion of cassava bio gasoline.

In the present work the damaged vegetable oil with methanol is used to produce biodiesel fuel and investigated the pure diesel fuel with four biodiesel ratios (5%, 10%, 20% and 30%) on the combustion performance and gases emission.

2. Production of Biofuel

The generation of biofuel from the damaged vegetable oil can be produce first by removing water from the damaged vegetable oil put it in a container and the temperature raise to 80 °C. A mount of sodium hydroxide (7.5 g) was used as catalyst mixed with amount of methanol alcohol (200 ml). Decant the mixture on the damaged vegetable oil at temperature 55 °C. For a period 30 min the composition mixing and for one hour leave it in the glass tube. Therefore, the glycerol begins depositing in the end of the tube and separate from methyl ester. Then remove the non-reactant methanol and the dissolved solids which locate at end of glass tube. Finally raise the temperature of the obtained fuel to approximate 100 °C to explosion the water from mixture, then biodiesel fuel is produced.

3.Measurement of fuel properties

The engine performance effected by the chemical and physical properties of the different fuels. These properties are density, calorific value , viscosity, chemical composition, flash point, and cetane number as listed in Table 1.

Table 1. The chemical and physical properties of the different fuels [36].

Property	Pure gas oil	Biodiesel	Blend 5% Bio+95% Die	Blend 10% Bio+90% Die	Blend 20% Bio+80% Die	Blend 30% Bio+70% Die
Flash point (ºC)	65	170	66	67	69	**71**
Pour point (ºC)	-18	-6	-16	-15	-14	**-12**
Could point (ºC)	-15	-3	-12	-12	-11	**-9**
Calorific value (MJ/kg)	44	42.3	43.9	43.8	43.2	**42.8**
Ash Content (% by weight)	0.01	Nil	0.009	0.009	0.007	**0.006**
Density 25 ºC	0.819	0.882	0.818	0.829	0.832	**0.835**
Viscosity mm^2/s	2.195	4.145	2.290	2.238	2.415	**2.505**
Cetane number	54.4	47.1	52.8	51.9	48.99	**47.04**
Refractive index	1.462	1.492	1.458	1.461	1.460	**1.458**
Aniline point (ºC)	77	66	77	76	72	**69**
Specific gravity	0.8196	0.8827	0.8181	0.8296	0.8336	**0.8354**
Diesel index	70.7	43.2	67.29	65.93	60.4	**59.08**

4. Experimental Procedure

In this study, performance of the engine and gases emission data were recorded in steady state operating conditions at five load conditions 0, 1, 2, 3 and 4 N.m at constant speed of 1500 rpm**.** The main engine parameters are presented in Table 2. The test stand is shown in Fig. 1. This engine is operating with constant rotational speed of 1500 rpm as shown in Fig. 2.

The experimental procedure consists of the following steps: -

Step-1: Before starting, it must be sure of stiffened of the connections. There should be guarantee that there is no any oil in the tank engine.

Step-2: The first type of biodiesel to be tested by a biodiesel about 1000 ml at the tank of the engine. For illustration to obtain the (5% Bio – 95% Di) blend. The mixing process is a volume mixing.

Step-3: The software program (SCADA TBMC-12) starts before starting the engine to certainty there is no flaw in the program.

Step-4: Start the engine and then keep the engine running for (5 min) for steady the combustion process. When observing that the sensors maintain their values stable, then record them by the software. Also, measure the brake power value (BP), and the values resulting from the combustion, when torque changes between (0 to 4 N.m)

Step-5: Stop the engine after the data record is finished.

Table 2. main engine specification.

Engine kind	4- stroke
Number of cylinders	**Single- cylinder**
Bore and stroke	**81mm@64mm**
Compression ratio	**20.5:1**
Cooling	**Air cooling**
Max – power	**11kw**
Swept volume	**0.0003296m^3**

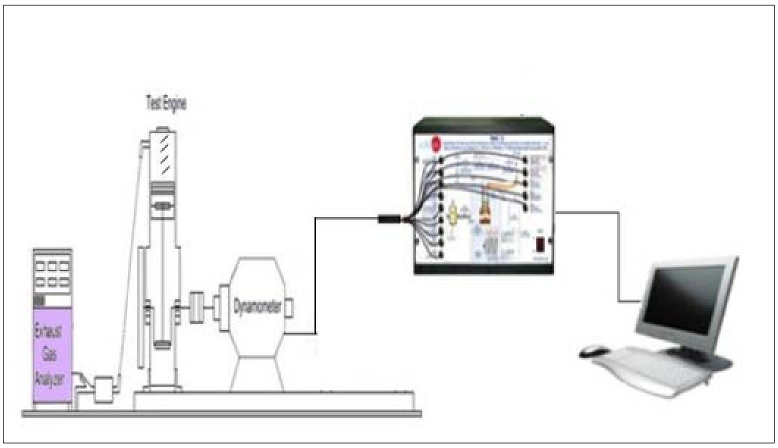

Fig. 1. The test stands.

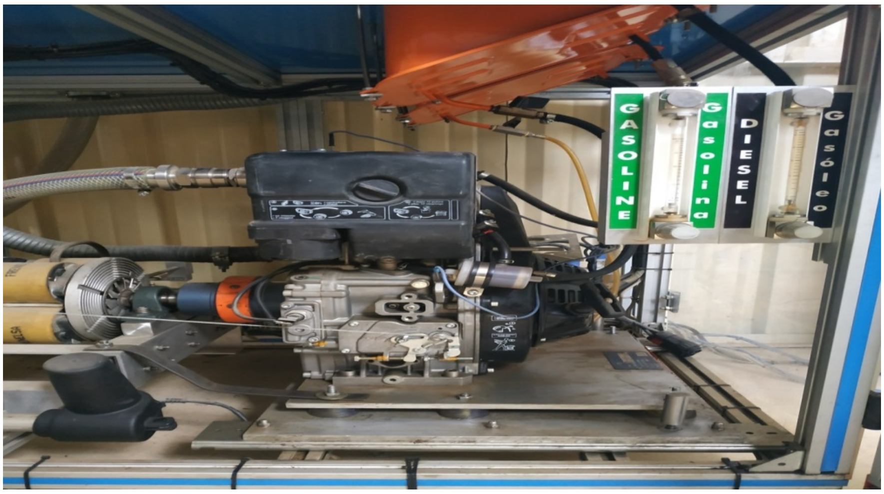

Fig. 2. The test engine.

5. Results and Discussion

The effects of the biodiesel blending ratio on the brake power is shown in Fig. 3. The fuels under studying are pure diesel fuel and four blends of biodiesel fuel. The blending ratios of biodiesel with diesel fuel based by volume were set at 0% (pure fuel), 5%, 10%, 20% and 30%, throughout this work denoted as 0S, 5S, 10S, 20S and 30S. It can be seen that as the blending ratio of the biodiesel increase the brake power will decrease. On the other hand, an increase of the torque lead to increase the brake power. Biodiesel produces about 2-5% less engine power in case of 5S and 8-40% in case of 30S due to its lower energy compared to diesel. Therefore, as shown the power output of the engine will be reduced with biodiesel. At low load, the break power is lower.

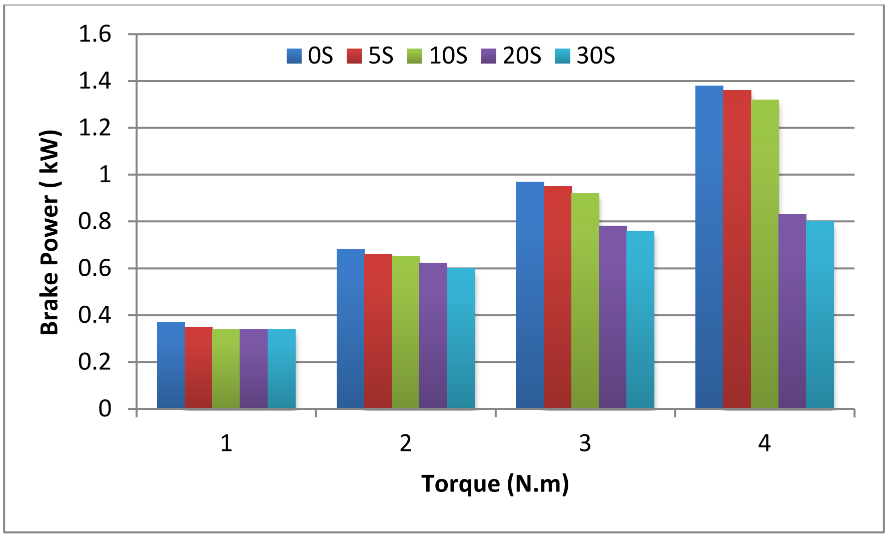

Fig. 3. The variation of the biodiesel blending ratio with brake power.

The brake specific fuel consumption of the engine operating on the different fuels is plotted in Fig. 4 for 1500 rpm. The result shows that there is an increase of the fuel consumption with the increase of blending ratio of biodiesel. Which concede with Carraretto et al. [26].

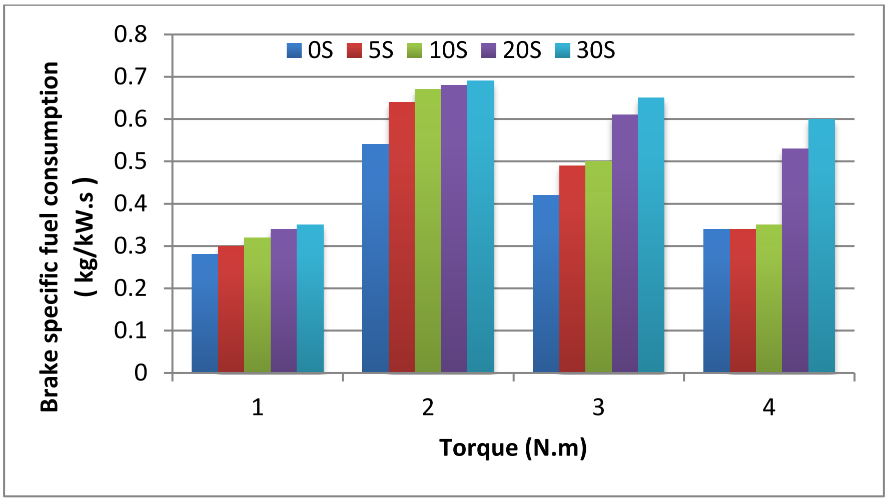

Fig. 4. The variation of the blending ratio of biodiesel with the brake specific fuel consumption.

Figure 5 presents the effects of the blending ratio of biodiesel fuel on the brake thermal efficiency. In all tests, the brake thermal efficiency was below the engine normal operation limit. The thermal efficiency decreases with the increase of the biodiesel blending ratio. Also, the thermal efficiency increases with the increasing torque.

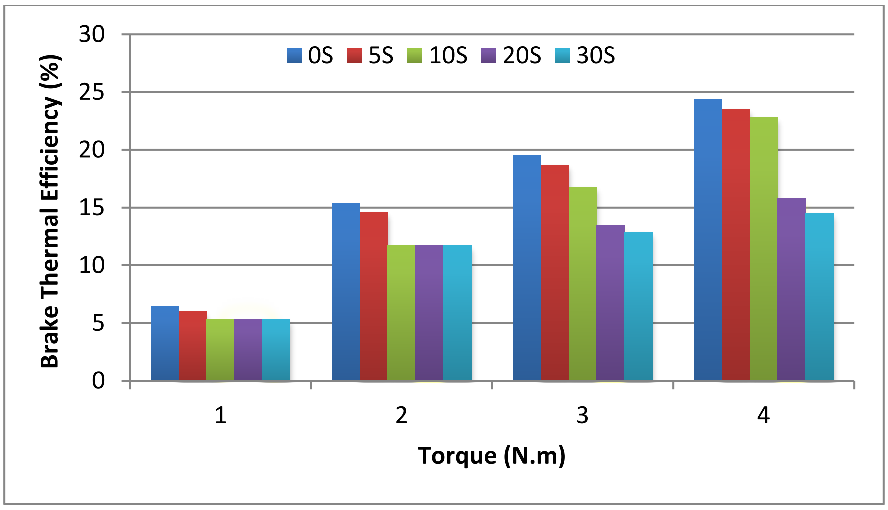

Fig. 5. The variation of the biodiesel blending ratio with the brake thermal efficiency.

The variation of exhaust gas temperature with the biodiesel blending ratio is shown in Fig. 6. It is unsurprising that the higher blend ratio of the biodiesel fuels, lead to lower temperature of the exhaust gas. When the load is low, the operating temperature is lower due to poor spray characteristics because of the higher viscosity of biodiesel fuels. The reduction percent of exhaust gas temperature varies from 3% for 5S to 20% for 30S.

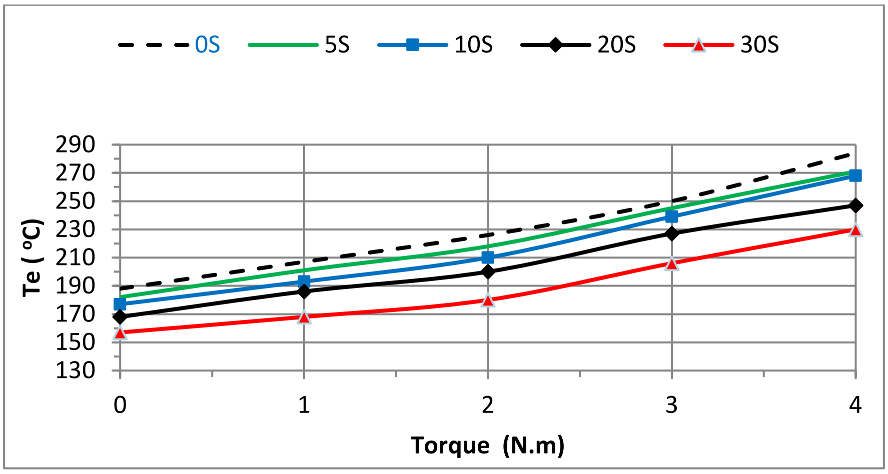

Fig. 6. Variation of exhaust gas temperature with the biodiesel blending ratio.

The effect of blend ratio of biodiesel on the reduction CO_2 emission is shown in Fig. 7. As shown in the figure the emission of CO_2 was always lower than for corresponding pure diesel fuel. As the ratio of the biodiesel blend is increased, the emissions of CO_2 decrease. The reduction percent varies from 8% for 5S to 46% for 30S. According to Ramadhas et al. [37], the low emission of CO_2 on biodiesel fuel because of short chain paraffin hydrocarbons and its higher oxygen content compared to pure diesel fuel.

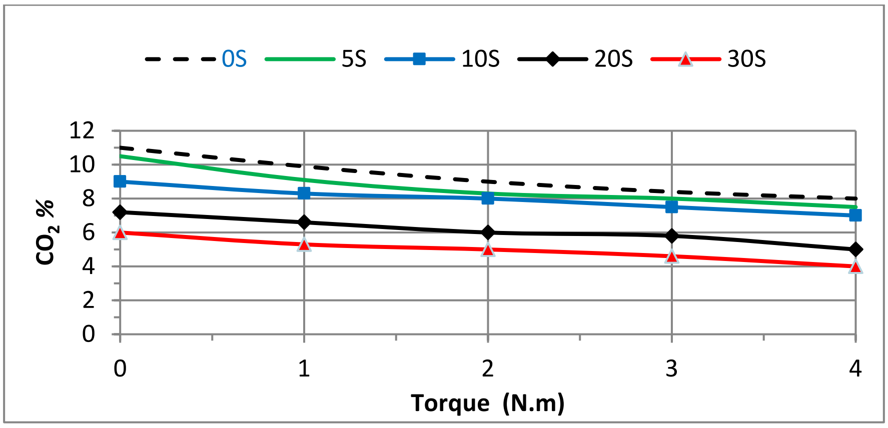

Fig. 7. The variation of the biodiesel blending ratio with CO_2 emission.

CO emissions is also reduced as shown in Fig. 8. The reduction increase with the increase the ratio of the biodiesel blend and the torque. The reduction percent varies from 6% for 5S to 22% for 30S at torque 4 N.m.

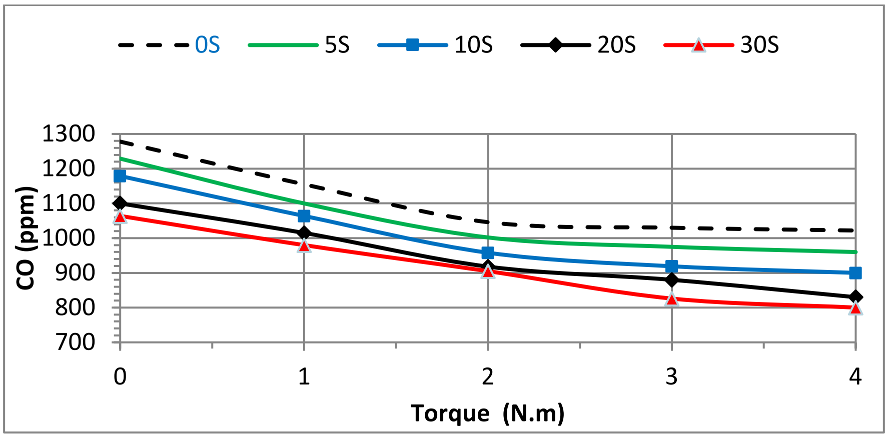

Fig. 8. The variation effects of the biodiesel blending ratio with CO emission.

Figure 9 shows the effect of biodiesel on the increasing of O_2 emission. In the case of low load (lower 1 N.m). As shown, there is small difference between O_2 emissions of biodiesel fuel as compared to diesel fuel. After this Torque, the emissions of O_2 are always higher than for corresponding commercial diesel operation. As the blend ratio of biodiesel fuel is increased the emissions of O_2 increased. The increasing percent reach to 7% for 30S.

Figure 10 shows that the emission of NOx. The difference in emissions of NOx for 5% blend compared with diesel are so small. For the other blends of biodiesel, the emission increased with increasing of the ratio of biodiesel blend, this is confirmed to some extent by Gnanamoorthi and Devaradjane [28]. The reason for increasing NOx because of the higher viscosity of the biofuels fuel cause to poor spray characteristics which lead to decreasing efficiency of combustion.

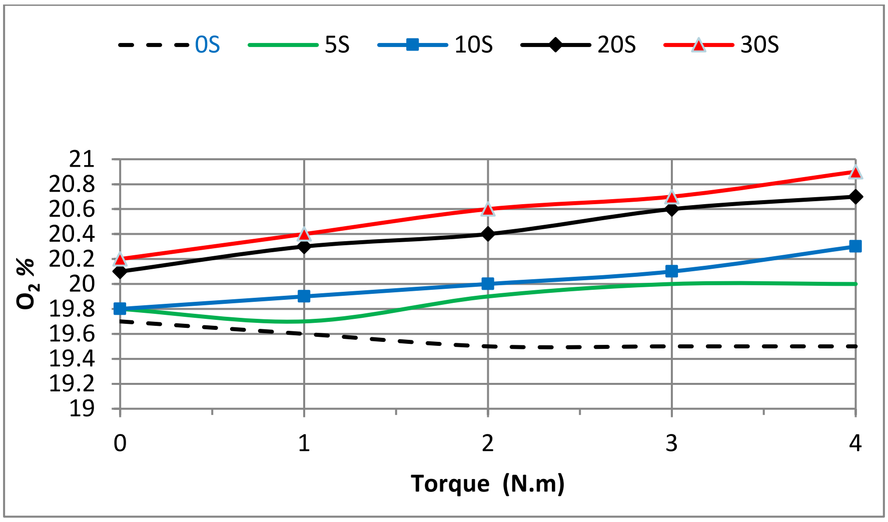

Fig. 9. The variation of the biodiesel blending ratio with O_2 emission.

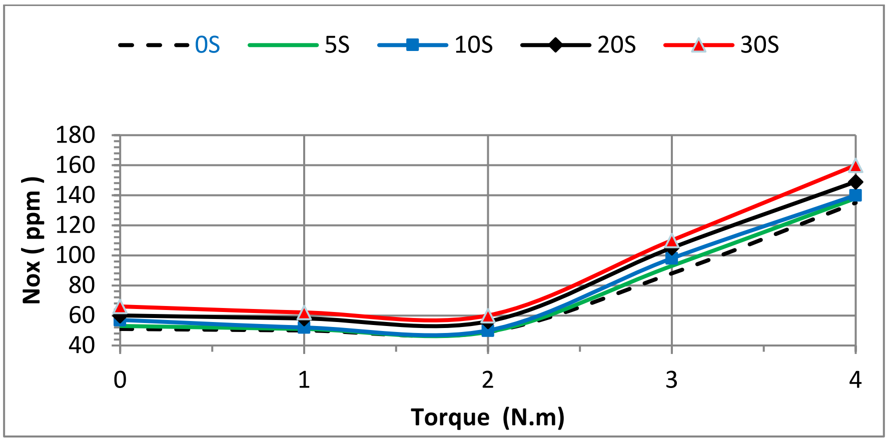

Fig. 10. Variation of the NOx emission with the biodiesel blending ratio.

6. Conclusions

In this study an experimental investigation on diesel engine has been carried out to obtain performance of the engine and emission of the gases by using pure diesel fuel and four blends of biodiesel. The following conclusions can be drawn:

- The emission of CO_2 and CO decreased with the increase in biodiesel fuel ratio.
- The reduction percent of gases emission reach to 46% and 22% respectively for 30S and torque 4 N.m. Moreover, exhaust gas temperature decreases to 20%.
- The thermal efficiency and break power decreases with the increase of the biodiesel blending ratio.
- The emission of NOx increasing with increase of biofuel blend.

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