A Simulation of Diesel Blended Kerosene on the Performance and Emissions in Diesel Engine

by Annisabhi FTI

A Simulation of Diesel Blended Kerosene on the Performance and Emissions in Diesel Engine

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Abstract. Diesel fuel is a hydrocarbon mixture that is less volatile as compared to gasoline and can release better energy during the combustion process. The use of diesel fuel can cause an increase in carbon dioxide, particulate matter (PM), as well as higher sulfur. Therefore, alternative additives must be added to diesel fuel to decrease some pollutants. Many researchers found that kerosene can be one of the solutions to reduce the emissions caused by diesel fuel. In this study, the simulation between diesel fuel and kerosene was used by Diesel RK. The blending of kerosene was 20% of the volume. The simulation was running for 2000, 2200, and 2400 rpm. The results show that blending 20% kerosene can reduce emissions such as PM up to 25.25% at 2200 rpm than diesel fuel and it can lower the NO_2 emission up to 48.31% than diesel fuel. Therefore, blending with kerosene can be an alternative to reduce the emissions from diesel fuel.

INTRODUCTION

The demand for diesel fuel for industry and automotive is increasing every year. The electrical company in Indonesia needs 2.6 million kiloliters of diesel fuel per year to run diesel engines in the power plants [1]. Moreover, the price of diesel fuel is not stable and can interfere with the industrial management in the company. The resources of diesel fuel are limited because it is non-renewable energy. Furthermore, the use of diesel fuel can increase the pollutants in the environment and can cause bad effects on human beings. The emissions that can be released using diesel fuel are high sulfur, high NOx, and high particulate matter (PM) [2]. To overcome these pollutants, it is necessary to blend another fuel into diesel fuel so emissions can be reduced and saved for the environment. Kerosene is one of the hydrocarbon fuels and it is from refined petroleum. Kerosene can be one of the choices to blend into diesel fuel so that emissions can be controlled and the price obtained from the diesel fuel mixture becomes cheaper.

Azeem et al [3] studied the experiment of blending kerosene in 10%, 20%, and 30%. Their results show that specific fuel consumption (SFC) decreased with an increased presentence of kerosene. Moreover, brake thermal efficiency and mechanical efficiency are increased by the percentage of kerosene. Obodeh and Isaac [4] investigated by blending kerosene into diesel fuel in 10%, 20%, 30%, and 40% percent of kerosene. They concluded that the use of 30% kerosene together with diesel fuel can save the fuel cost up to 10%. Anjum and Prakash [5] are studied by blending kerosene 5%, 10%, and 15% by volume and running in the diesel engine in different loads. The results are that brake thermal efficiency is higher than diesel fuel in various loads. Moreover, the fuel consumption in diesel fuel is higher than kerosene in different loads. Naseer [6] investigated the blending between diesel fuel and kerosene in the percentage of 10% and 20%. The study examined that using kerosene can be improved the specific fuel consumption, nevertheless, the emissions are increased by blending the kerosene. Bayindir, et al [7] investigated the blending between kerosene and biodiesel in diesel power generators. The results are that the combustion characteristics of kerosene blends are very similar to diesel fuel. The fuel consumption is slightly higher than diesel fuel, the hydrocarbon gas is increased, and NOx emission is drastically reduced for blending with kerosene.

This study investigates the simulation of diesel fuel and blending 20% of kerosene. The choice of 20% kerosene due to the higher caloric value in the fuel and to compare the diesel fuel in different engine rotations of 2000, 2200, and 2400 rpm respectively.

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MATERIALS AND METHODS

Materials

In this study, the fuel properties are important to consider. This fuel property shows the properties of fuels. In Table 1 fuel properties from diesel fuel are based on standard petroleum in Indonesia and 20% blending with kerosene (D80K20).

TABLE 1. Fuel Properties from Fuels

Properties	Units	Diesel Fuel (DF)	Diesel Fuel 80% + Kerosene 20% (D80K20)
LHV	MJ/kg	43.8	36.22
Density (323 K)	kg/cm^3	834	885
Viscosity (323 K)	PaS	0.00692	0.00463
Cetane Number	-	56	51.3
Surface Tension (323 K)	N/m	0.028	0.0433
Carbon Content	%	0.87	0.7731
Oxygen Content	%	0	0.1081
Hydrogen Content	%	0.126	0.1188

This simulation was determined by using the engine specification as seen in Table 2. In this simulation, the prediction of performance and emissions were calculated indifference engine speeds of 2000, 2200, and 2400 rpm.

TABLE 2. Engine Specification [8]

Type		Supercharged direct-injection 4 stroke
Bore x Stroke	[mm]	85 x 96.9
Displacement	[cm^3]	550
Compression ratio		16.3
Fuel injection system		Common rail
Number of holes		7
Injection Pressure	[bar]	1500
Engine speed	[rpm]	2000, 2200, 2400

Method Analysis

Diesel RK is a simulation platform that can calculate thermodynamics in a diesel engine. It can calculate the performance of DI and SI engines including in the pre-chamber by using diesel fuel, gasoline, natural gas, etc [9]. In this software emissions and knocking prediction, EGR analysis, optimization, dual-fuel engine mixture, spray analysis can also be calculated.

To calculate the simulations, first of all, create a new project in the software. Then, fill in the engine specifications and save the project. The engine setting from the operating system is important in calculating combustion in diesel-RK software. Afterward, check the correction of the nozzle configuration and the shape of the combustion chamber. Then, check the correctness of the injection chambers. After all the important data has been input, calculate all by clicking the run. Lastly, analyze all the parameters from the output data.

RESULT AND DISCUSSION

Sauter Mean Diameter Analysis

The Sauter Mean Diameter (SMD) or d32 is defined as the diameter of a sphere having the same ratio of volume to the surface area of small particles [10,11]. SMD can be determined for the atomization characteristics of the spray in the chamber. As can be seen in Fig. 1 the SMD D80K20 at 2200 rpm engine speed decreased to 3.72% and at 2400 rpm also experienced a decrease of 3.72% compared to the D100. This is because the greater the engine speed, the atomization of the fuel will be better and combustion will be better compared to low rpm.

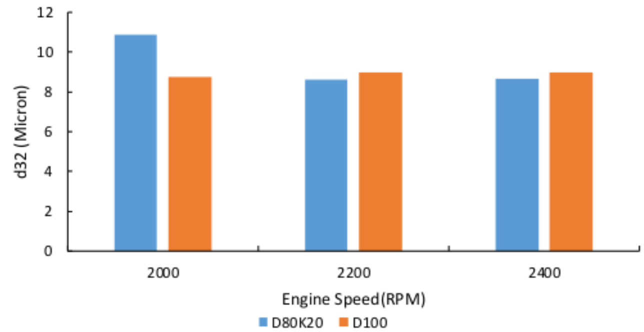

FIGURE 1. Sauter Mean Diameter in all fuels

Spray Penetration

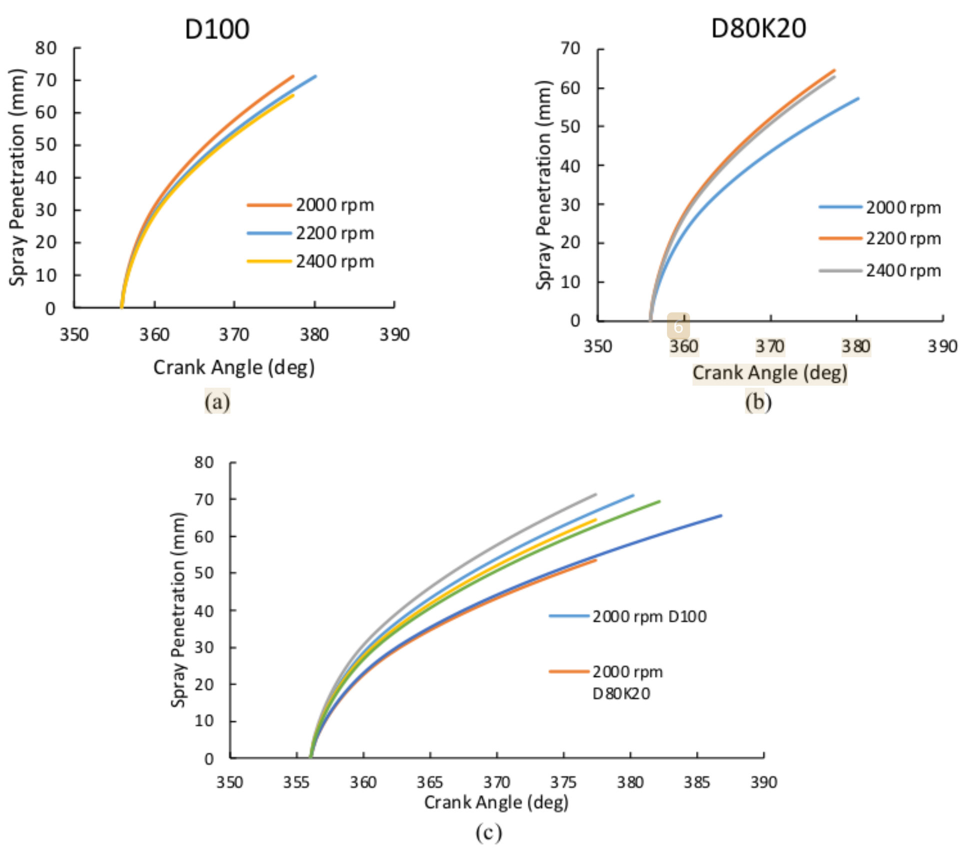

FIGURE 2. Spray penetration from all fuels

Figure 2 (a), (b) and (c) are spray penetration from all fuels. Figure 2 (a) is about the length of penetration spray-on D100 for various engine speeds. It can be noted that the greater the engine speed, the spray penetration is smaller, so that the atomization of the fuel can be improved, resulting in the combustion of fuel in the chamber will be easier [11]. This is because the greater the engine speed, the fuel will decrease in viscosity and density, making it easier for the fuel to be burned [12,13]. In Figure 2 (b) on D80K20 the spray penetration at 2000 rpm is lower than 2200 and 2400 rpm, it is possible that at 2000 rpm the fuel is better at burning fuel. At 2200 and 2400 rpm, the kerosene in the D80K20 content will heat up faster so that the cooling of the engine is reduced and causes the fuel to burn quickly and imperfectly. Figures 2 (c) show that the spray penetration length of the D80K20 at 2000 rpm is the shortest compared to all fuels. This is because D80K20 has a low boiling value compared to D100.

Cylinder Pressure

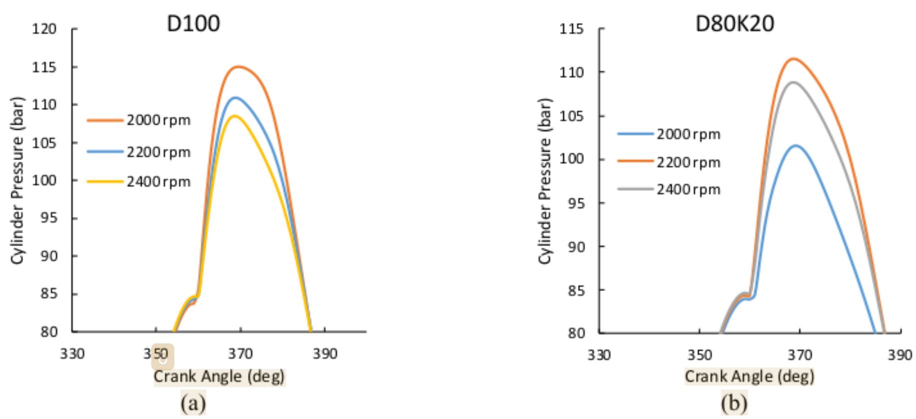

FIGURE 3. Cylinder pressure from all fuel

Figure 3 (a) is the cylinder pressure of D100 in the difference in engine speed. In figure shows that the higher the engine speed, the smaller the cylinder pressure. In the figure can be seen that cylinder pressure of 2000 rpm is on top of the 2200 and 2400 rpm lines. The higher the engine rotates, the lower the cylinder pressure. This indicates that when the rotary engine is high, the atomization is improved and the combustion will be better [14]. However, higher engine rotation at lower cylinder pressure will have high fuel efficiency. Figure 3 (b) illustrates the cylinder pressure for the D80K20. At engine rotation 2000 rpm, the cylinder pressure is the lowest than at 2200 and 2400 rpm. This result shows that at 2000 rpm engine rotation has improved combustion than 2200 and 2400 rpm.

Specific Fuel Consumption

Figure 4 is the fuel consumption from all fuels. It can be seen that the D80K20 at 2200 and 2400 rpm has lower fuel consumption compared to the D100. This is because, at high engine rotation, the cylinder temperature is also lower than at 2000 rpm. With a low cylinder temperature, fuel consumption will not be high. For D100, at a higher engine speed, the fuel consumption will also be high. This is due to the high-temperature cylinder; the engine will heat up quickly and will consume a lot of fuel as compared to low and medium rotations.

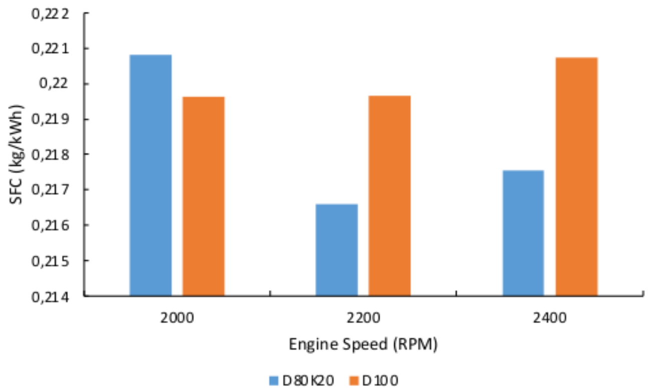

FIGURE 4. Specific Fuel Consumption in all fuels

Emissions

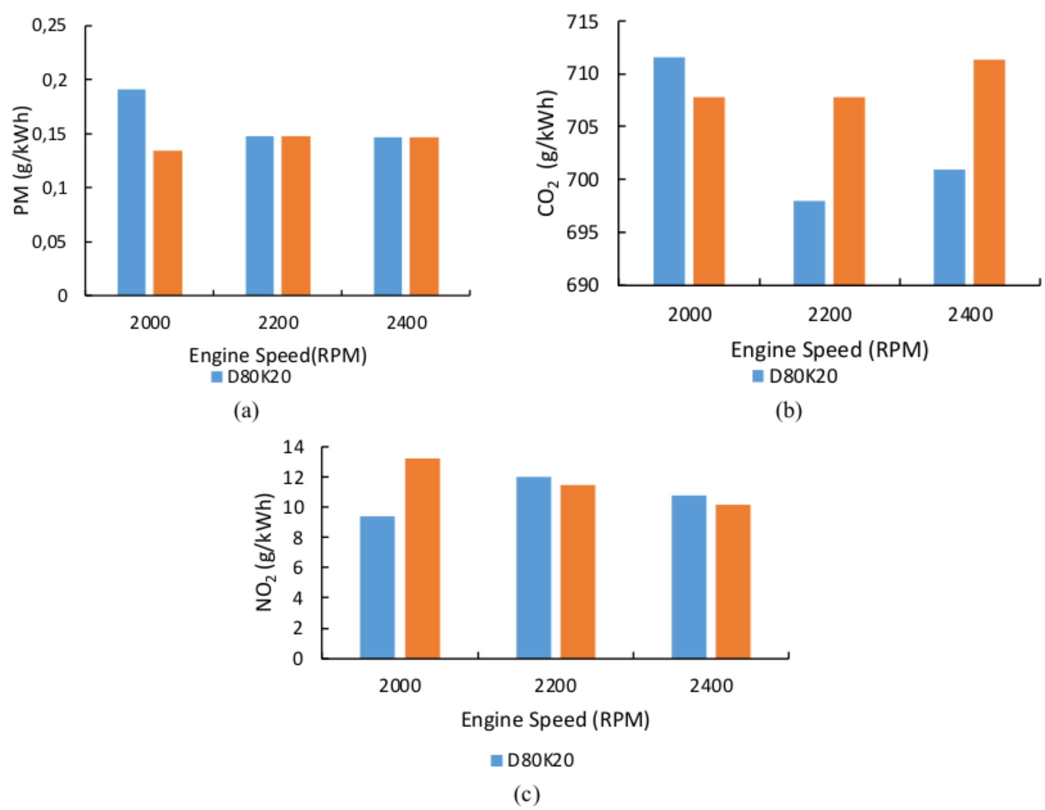

FIGURE 5. Emission from all fuels (a) particulate; (b) CO_2 Emission; (c) NO_2 Emission

The particulate emissions can be shown in Figure 5 (a). In this figure, at 2000 rpm engine speed, the particulate matter on the D80K20 is 29.62% higher than that of diesel fuel (D100). However, at 2200 rpm, the D80K20 will experience a decrease in particulate matter by 0.11% compared to the D100. Figure 5 (b) shows that CO_2 emission in D80K20 fuel will decrease at an engine speed of 2000 and 2400 rpm. At 2200 rpm, the use of the D80K20 will decrease to 13.91% in CO_2 emissions as compared to D100. As for the 2400 rpm, CO_2 emissions on the D80K20 will decrease by 14.55% compared to the D100. This is because the calorific value of the D80K20 is greater than that of the D100 resulting in better combustion efficiency and also having lower CO_2 emissions compared to the D100. Fig. 6 (c) shows the emission of NO_2. Figure 5 (c) shows that at 2000 rpm engine speed, NO_2 emissions from D80K20 will decrease by 29.10% compared to the D100. This shows that mixing kerosene in diesel will reduce NO_2 gas at engine speed around 2000 rpm, however, at 2200 and 2400 rpm engine speed will increase the NO_2 levels by about 4.57% and 5.64%, respectively. These results expand scientific knowledge regarding the use of diesel oil to keep pace with the expanding research on biodiesel development, with better results in improving properties and acceptance in diesel engines [15,16].

CONCLUSION

Blending 20% kerosene to diesel fuel will affect emissions and also the combustion process in diesel engines. CO2 emission for D80K20 at 2200rpm is decreased up to 14.55% compared to diesel fuel. Moreover, NO2 emission is decreased to 29.10% at 2000 rpm compared to diesel fuel. In addition, the effect on fuel combustion by adding kerosene, the penetration spray of D80K20 is the shortest compared to other fuels because it has a high distillation value, therefore, the atomization process can run very well and the combustion can be improved. For the pressure and temperature in the cylinder at a pressure of 2200 rpm, D80K20 has low temperature and high cylinder pressure which will result in high efficiency in the engine due to the temperature in the cylinder is not high, resulting in better efficiency in fuel consumption.

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