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EFFECTS OF USING JP8-DIESEL FUEL MIXTURES IN A PUMP INJECTOR ENGINE ON ENGINE EMISSIONS

Abstract:

JP-8 fuel used in the aviation industry, especially in military fields, is used as a common military fuel between NATO countries. As the basic substance of JP-8 fuel, kerosene flares at high temperatures directly increases aircraft safety and freezing point is around -49 °C, it is advantageous to use easily in fuel systems. In this study, the effects of jp-8 and diesel fuel mixtures on engine emissions were investigated experimentally. A 3-cylinder, four-stroke, turbocharged diesel engine with pump injector fuel system was used for this purpose. 5% JP8 was added to diesel fuel. It was used as a fuel in the engine and the obtained values were analyzed according to the diesel fuel.

Keywords:

JP8, Engine Emissions, Diesel Fuel

JEL Classification: Q40

1. Indroduction

Due to the high thermal efficiency, high power density, and capability to operate on conventional as well as alternative and renewable fuels, compression ignition (CI) engines are used in many applications, including heavy duty vehicles and passenger cars. However, due to the variations in the properties of these different fuels, new control strategies and experimentation are required for CI engines to operate optimally on each specific fuel (Asokan, Senthur Prabu et al. 2019).

Aviation fuel technology; oil refineries, engine and aircraft manufacturers and the airline industry. The most basic ideas of the use of aviation fuels in military vehicles were created after World War II to facilitate the logistics of the supply chain (Fernandes, Fuschetto et al. 2007). In 1988, NATO countries introduced a single aircraft for use in military aircraft and all land vehicles and equipment have reached a common decision on the use of fuel (Lee, Lee et al. 2015). This idea was called the “single fuel concept ve and the aviation fuel JP-8 fuel (also called F34) was chosen as the uniform fuel to be used in military aviation and military road transport (Lee, Oh et al. 2012). The main reason for this practice is to prevent high logistics expenditures in times of war and to ensure that fuel control is performed more effectively by NATO (Ning, Duan et al. 2019).

Although JP-8 was initially considered as an aviation fuel, its field of use was extended to land vehicles equipped with diesel engines. However, before deciding on such a study, some preliminary studies have been carried out in order to identify the problems that may arise in practice with the use of avionics-based fuels in diesel engine vehicles of NATO member countries (vehicles such as tanks, carriers etc.) (Sogut, Seçgin et al. 2019).

There are two important parameters that limit the use of the JP-8 in an internal combustion engine. One of them is that the cetane number is lower than diesel fuel. This may increase the ignition delay time and cause the combustion to become worse than expected and even increase the diesel knocking. The second is that the lubrication of JP-8 is lower than that of diesel fuel. This may be due to the fact that diesel with a higher boiling temperature range than kerosene contains a higher proportion of natural lubricants. As it is known, the lubrication of parts such as high pressure pump and injector in the diesel injection fuel system is carried out by diesel fuel. Using low-lubricating JP-8 can increase pump and injector needle wear and cause system failure (Sundararaj, Kumar et al. 2019, Wei, Liu et al. 2019)

2. Material and Method

Fuel mixtures were prepared from reference diesel fuel and JP-8 fuel. This mixture was prepared by adding 5% by volume JP-8 to diesel fuel. The various properties of JP-8 fuel are shown in Table 1. The prepared new fuels were allowed to mix homogeneously and allowed to stand at room temperature for 24 hours and no phase separation and precipitation was observed. Before all the tests, the fuel system of the engine was cleaned from the previous fuel with the new fuel to be tested and the test started.

Table 1. Specifications od test fuels

Fuel	Diesel fuel	JP-8	Method
Density (g/cm^3, 15^{o}C)	0,8372	0,7950	ASTM D 1298
Viscosity (cSt)	2,8(40^{o}C)	3,87(40^{o}C)	ASTM D 445
Cold Filter Plugging Point (^{o}C)	-5	-48,5	ASTM D 2386
Flash Point (^{o}C)	73	41	ASTM D 93
Lower Calorific Value(kcal/kg)	10450	10200	ASTM D 2015
Cetane number	54	45	ASTM D 976

In the study, a test apparatus which consisted of a diesel engine and a hydraulic dynamometer device was constructed in order to compare diesel fuel and JP8 diesel fuel. A Volkswagen-brand three cylinder, four-cycle, water cooled diesel engine with a pump injector fuel system was used in the experiments. The technical characteristics of the engine are given in Table 2. A hydraulic dynamometer with a break power of 100 kW was used in the experiments.

Table 2. The technical characteristics of the diesel engine used in the study

Type of engine	4 stroke
Engine volume	1422 cc
Number of cylinders	3
Diameter of cylinder	79.50 mm
Stroke length	95.50 mm
Maximum power	52 kW @ 4000 rpm
Maximum Torque	155 Nm @ 1600 rpm
Compression ratio	19.5:1
Fuel system	Pump injector
Fuel Type	Diesel

The characteristics of the engine dynamometer used in the experiments are given in Table 3.

Table 3. The characteristics of engine dynamometers

Model	BT-190 FR
Capacity	100 kW
Maximum rotation	6000 rpm
Maksimum torque	750 Nm

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The technical information on the exhaust emission device used in the experiments is given in Table 4.

Table 4. The technical characteristics of the exhaust emission device used in the study

Measurement Ranges	Unit	Value
CO	%	0-9.99
CO_2	%	0.19.99
HC	ppm	0-2500
λ	%	0-1.99
O_2	%	0-20.8
NOx	ppm	0-2000
Operation temperature	°C	5-40
Supply voltages	V	12

The test setup is shown in Figure 1.

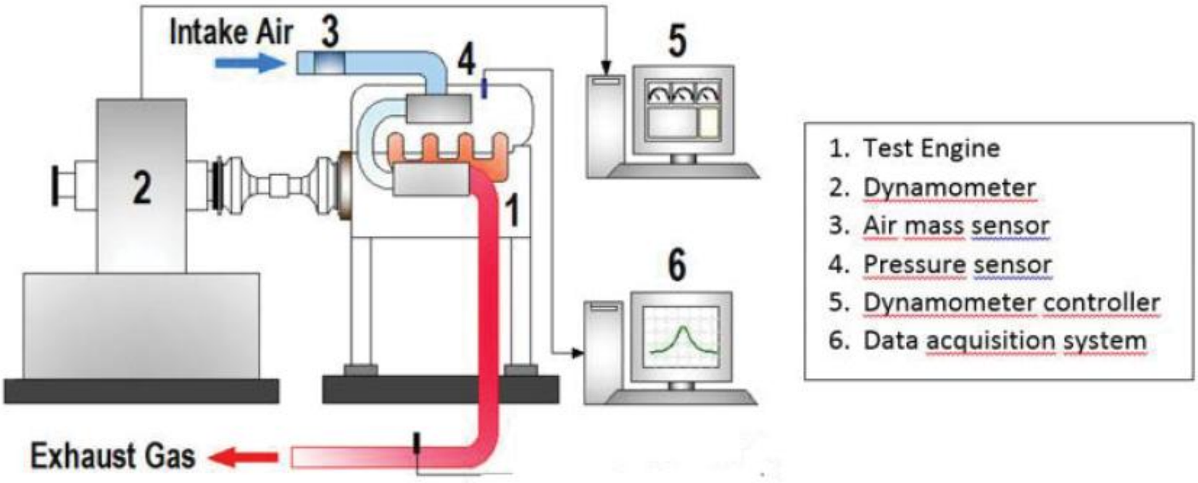

Figure 1. Engine test equipment

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3. Results

The changes observed in the carbon monoxide (CO) values of the diesel fuel and JP8 fuel blends used in the diesel engine depending on engine speed are presented in Fig. 2. An decrease was observed in CO values depending on the increase of engine speed.

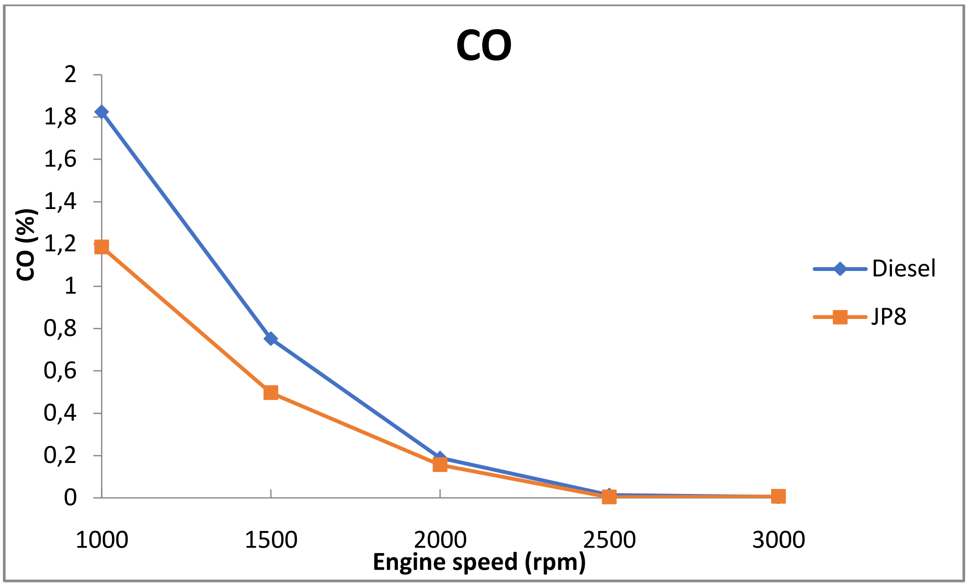

Figure 2. CO values

The changes observed in CO_2 values depending on engine speed are presented in Fig. 3. The highest value was obtained with JP8 fuel when the engine was operated. At the same engine speed, the CO_2 value of diesel fuel was found to be 10% lower compared to that of JP8 fuel.

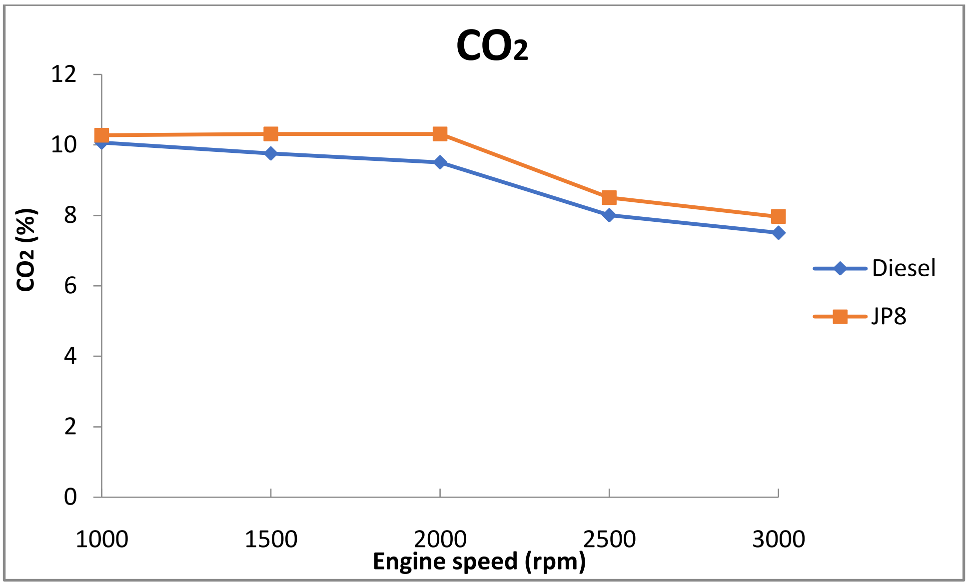

Figure 3. CO_2 values

The changes observed in HC values depending on engine speed are presented in Fig. 4. When the figure is examined, it can be seen that the lowest values were obtained with JP8 fuel and diesel fuel produced the highest values at all engine speeds.

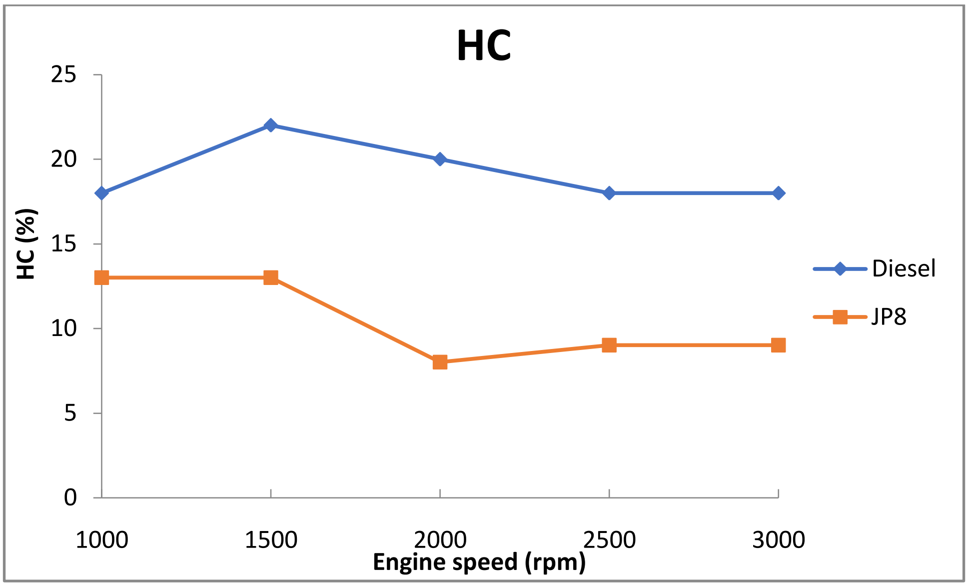

Figure 4. HC values

The changes that occurred in the NOx content of the exhaust gases depending on engine speed are given in Fig. 5. When the engine speed was 1000 rpm, the lowest NOx was obtained with JP8 fuel and the highest NOx value was observed in the exhaust gas produced using diesel fuel.

The amount of NOx in the exhaust gas increased as the engine speed was increased. At 3000 rpm, the highest NOx value was observed in the exhaust gas produced using diesel fuel.

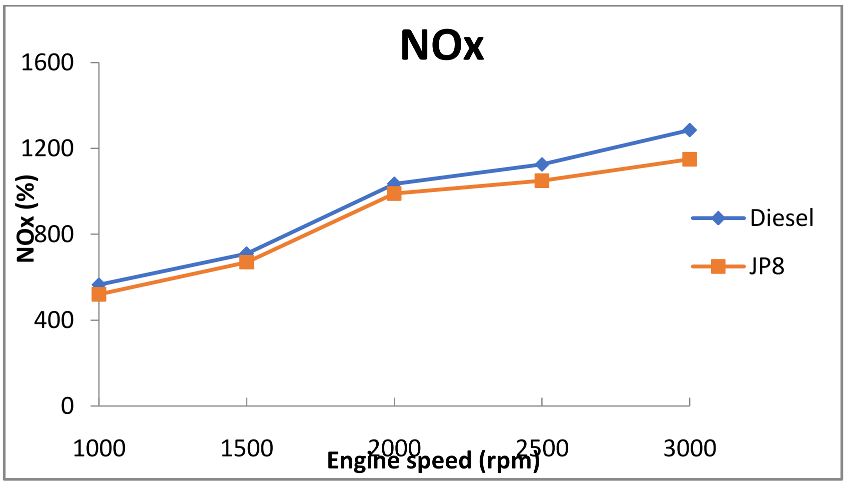

Figure 5. NO_x values

4. Conclusion

As a result; NOx values decreased and CO_2 increased in diesel and JP-8 blend fuels compared to reference diesel fuel. When all these parameters are evaluated together, it is preferable that the mixture performance of the used fuels will improve and the freezing point and cold filter clogging point of the mixture fuels will be improved when 5% JP-8 + 95% diesel fuel v mixtures are used in cold climatic conditions.

Acknowledgement

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