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EFFECT OF JP-8 AND ANIMAL FAT METHYL ESTER BLENDS ON DIESEL ENGINE EXHAUST EMISSIONS

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Diesel engines are internal combustion engines that are fulfilling important functions and powered by fossil origin diesel and biodiesel. Since fossil-based fuels have finite reserve, and they are quickly consumed today and will be exhausted in the near future, and combustion of the fuel releasing significantly pollution components into the atmosphere have accelerated scientific studies on alternative fuels.

In this study, animal fat methyl ester (AFME) and JP-8 fuel were blended and the exhaust emissions were investigated. Experiments held in a single cylinder, air cooled, direct injection diesel engine. With the test depending on the engine speed increases, exhaust emissions have been determined and the results obtained are compared with the values of diesel fuel. Accordingly, JP-8 and biodiesel fuel blends were determined at lower CO and HC emissions compared to D2 fuel. It has been concluded that test fuel can be used in diesel engines with success without any modifications on engine construction.

Keywords: Diesel engine, JP-8, animal fat methyl ester, Exhaust Emissions

1. INTRODUCTION

As a result of world population growth, technological and economic development, the role of the internal combustion engine is increasing day by day in people's daily life. These are used in transport, industry, security and agriculture applications. The conventional energy source of internal combustion engine today is still petroleum derivatives, which are fossil fuels. The life of world's oil remained at around 40 years. Day by day number of motor vehicles are increasing and fuel reserves are declining in parallel [1, 2 and 3]. Researches in recent years have been focused on alternative bio fuels, electric vehicles, hybrid vehicles and hydrogen [4, 5]. Biodiesel, despite some differences in recent years, has established itself as a partial substitute for diesel fuel in existing diesel engines [4]. Measures have been taken for environmental pollution by emissions due to more widespread use of diesel engines, and alternative fuels that are being developed release less exhaust emissions to the atmosphere compared to diesel fuel [6]. While declines are experienced in the value of torque and power of Biodiesel fuel against diesel fuel in performance testing, brake specific fuel consumption in parallel increase in value. This can be explained, as the calorific value of biodiesel being low compared to diesel fuel, and kinematic viscosity and density being higher [7]. The development of engine technologies and reduce the exhaust emissions of diesel engines is also important. Sulfur content in diesel fuel which was 5000 ppm in the 1990s, was obliged to decrease due to the US Environmental Protection Agency (EPA) and the European Union Euro norms. In the near future these values are intended to be reduced to 10 ppm with the advanced technology used in oil refinery.

Kerosene is a combustible hydrocarbon liquid fuel. It is generally used, in heating, lighting and aviation field. Flash point is 40 °C. With this feature, the main reason for using it as "Aircraft Fuel", is its low risk of immediate fire start in any accident/decimation. Since the freezing point of the kerosene fuel is -47 °C to -49 °C, it reaches the engine easily without motor fuel freezing. Kerosene is also known in the aviation field as the "JET-A1" fuel. Today, other types of kerosene fuel used in jet engine aircraft are classified as "JET-A, JET-B, JP-4, JP-5, JP-7 and JP-8" [8, 9]

Biodiesel produced from waste vegetable oil or animal fat, may have a higher viscosity compared to those produced from crude vegetable oils [10]. The main problems in the use of vegetable oil in diesel engines are high smoke density and low efficiency [11].

Compared to the reference fuel sample, its expressed that biodiesel mixture addition causes an increase in the value of NOx, but when JP-5 is used volumetric up to 40% that NOx emissions is reduced. As expected, it is stated that by the addition of biodiesel, particulate matter (PM) emissions are significantly reduced, and JP-5 initially reduced PM emissions, but when JP-5 is used more than 60% by volume, PM emissions are increased, but in contrast PM emissions are still lower than D2 fuel [9].

Researcher stated that, in his work with a variety of fuel mixtures comprising diesel oil, JP-4, JP-8, and methyl ester in a diesel engine, depending on the mixture ratio of relative to the reference fuel diesel oil, while 50% JP-8 + 50% of the methyl ester mixture decrease the engine power to 2.4%, but usage of 50% JP-4 + 50% methyl ester cause 31.2% of decline in engine power. In the same working conditions, in terms of emissions, depending on the content of the mixture, a large extent of decline is experienced in smoke and NOx emissions compared to diesel fuel in reference. Accordingly, argued that diesel engines can also work with JP-4 and JP-8 that are cheaper than methyl ester which is produced from sunflower. Sunflower methyl esters have considerable advantages in terms of environmental protection. In recent, in many countries, considerable interest has been focused on vegetable oils as starting material for biodiesel production [12, 13].

2. MATERIALS and METHODS

The experiments were being carried out at the Engine Test Laboratory Department of Mechanical Engineering Faculty of Engineering at the University of Batman. Schematic diagram of experimental setup is seen in Fig. 1. Tests were carried out using a direct injection, 4-cylinder, 4-strokes, and water-cooled NWK22 diesel engine generator. Specifications of the test bed and test fuels are shown in Table 1, and Table 2 respectively. The CAPELEC CAP 3200 exhaust gas analyzer was used to measure the emissions of test fuels.

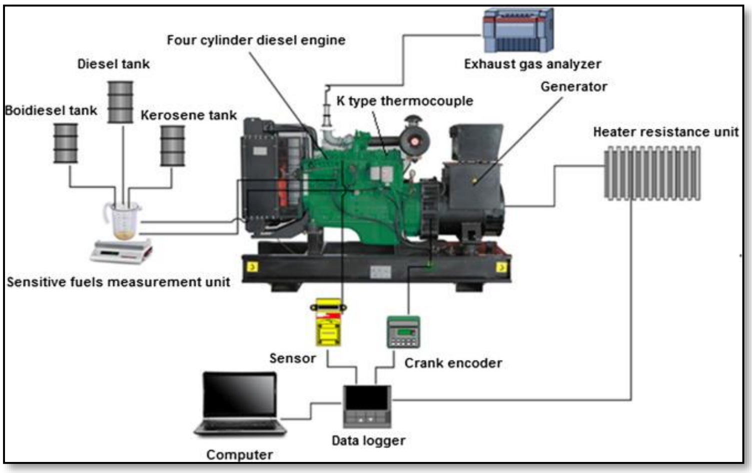

Fig. 1. Schematic Diagram of Experimental Setup

Table 1. Specifications of the Diesel Engine.

Manufacturer	NWK22
Power output @ 1500 rpm	18 kW
Engine cooling system	Water cooling
Intake system	Naturally aspirates
Engine model	4DW81-23D
Bore x stroke (mm)	85 × 100
Displacement (cm^3)	2400
Number of cylinder	4
Combustion system	Direct injection
Compression ratio	17:1
Number of injector nozzle	4

Table 2. The Specifications of Test Fuels

Properties	Units	D2	AFME	JP-8
Density @15°C	(kg/m^3)	820	869	820
Kinematic viscosity @ 40 °C	(mm^2 /s)	3.2	4.6	3.86
Cetane number	-	49	52	45
Sulfur content	(mg/kg)	<0.05	<0.01	<0.05
Low Heating Value	(kJ/kg)	42900	38100	42100
Flash point	ºC	55	128	41
Stoichiometric AFR	air/fuel ratio	15	13.07	15

Diesel fuel, waste animal fat methyl ester and JP-8 aircraft fuel blends are used in the experimental work. Engine tests were performed first with diesel fuel. Then 10%, 25%, 50% waste animal fat methyl ester was added into JP-8 fuel respectively. Before starting, the test engine settings were adjusted to manufacturer company's values, engine lubrication oil was changed and new oil was put and by running the engine the temperature has been brought to a steady state temperature. First the experiments were made when the engine is at full load and different speeds, and then at fixed speed varying loads. Tests were made with a single-cylinder, four-stroke diesel engine at full load different engine speeds with D2, JP-8, and a mixture of fuel derived from waste animal fat methyl ester. Volumetrically 100% D2, 90% JP-8+10% (AFME10), 75% JP-8+ 25% (AFME25), 50% JP-8+50% (AFME50) was used as test fuel. In the experiments, the exhaust emissions are determined and the obtained results were compared with diesel fuel values.

2.1. Exhaust Emissions

Combustion can be defined as the fuel's and air's oxygen's chemical reactions at high speed with a heat effect. These reactions result in light and heat outcome. At each combustion carbon dioxide (CO_2) and water vapor (H_2O) are revealed as product. Water vapor is not harmful, but CO_2 has an impact on the global climate change through the greenhouse gas effect. Unburned hydrocarbons (UHC) and carbon monoxide (CO) are revealed as a product of incomplete combustion. In addition, NOx, and SOx components are also released into the atmosphere through factory chimneys, fuels used for heating and exhausts of internal combustion engines.

2.1.1. Carbon Monoxide (CO)

By adding AFME to JP-8 fuel in CO emissions have decreased according to D2 fuel value. Because of oxygen in the presence of AFME, when AFME rate in the mixture increases, CO decline is accelerated. Another reason for the reduction of CO emissions is the increase in engine speed. As the engine speed increases, the mixture is partially impoverished and combustion quality is improved. As a result of these situations CO shows a decline, and CO_2 shows increase. CO Emissions Variations by Engine Speed are given in Fig. 2

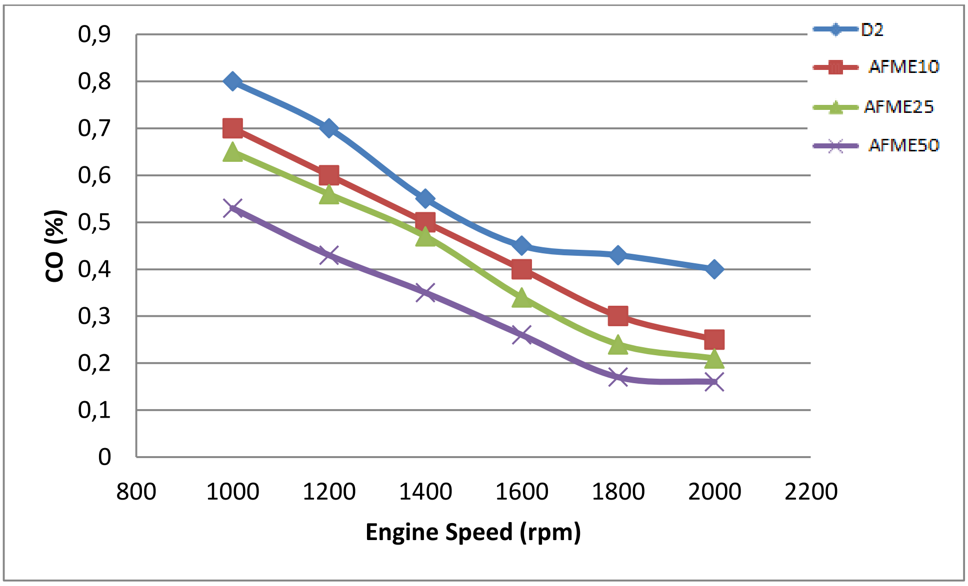

Figure 2. CO Emission Results at Different Engine Speed

2.1.2. Unburned Hydrocarbons (UHC)

The finding of unburned hydrocarbons in the exhaust emissions of internal combustion engines is an indication of no complete combustion of the fuel. Engine speed increase - hydrocarbon change provided by test fuel is given in Figure 3. Decline in the hydrocarbon value of all test fuel were observed, depending on the engine speed increase. Theoretically HC is mainly caused by misfire in a locally rich region or locally lean region.

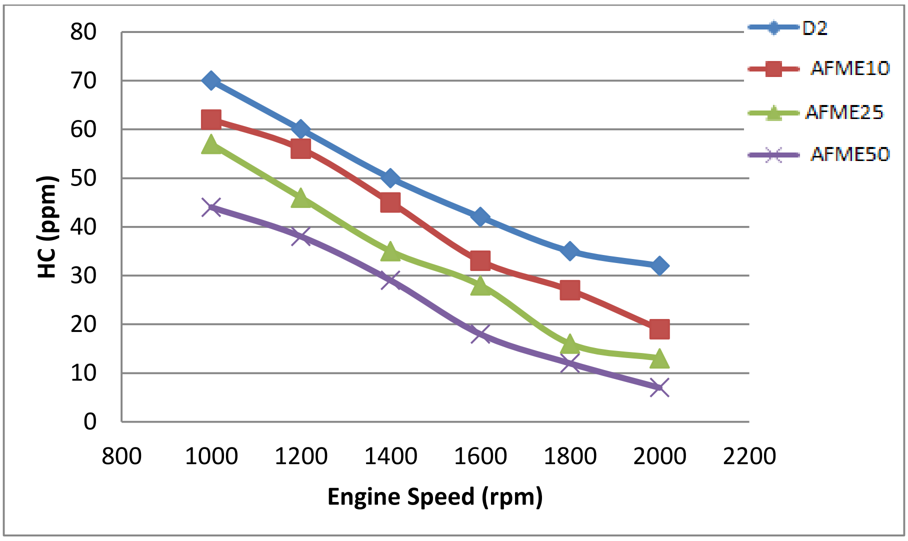

Figure 3. UHC Emission Results at Different Engine Speed.

2.1.3. Emissions of Nitrogen Oxides (NOx)

Effect of AFME addition to JP-8 fuel on NOx emissions is seen to show an increase with engine speed. It is understood with this increase that, the combustion is improved when the engine speed increases up to a certain value, and the temperature inside the cylinder is over 1800 °K. NOx value of diesel fuel is higher than the value of all the mixture fuels.

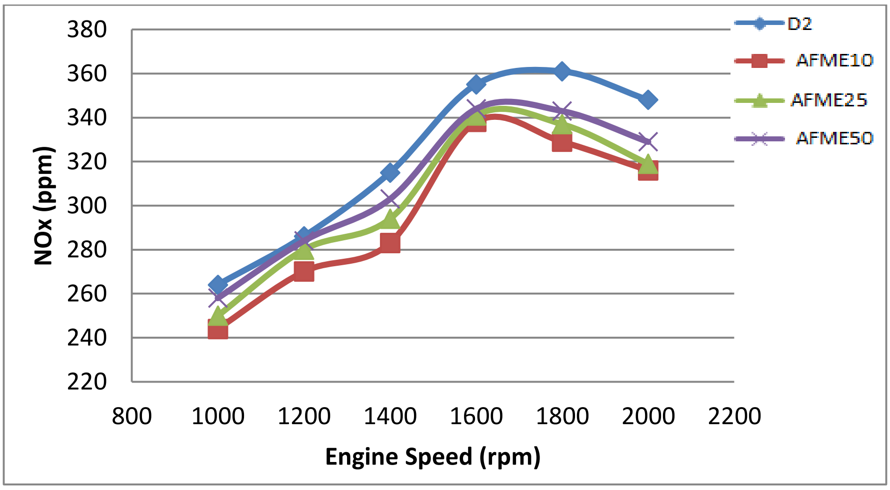

Figure 4. NOx Emission Results at Different Engine Speed

In this case, as the cetane number of JP-8 fuel is low, the combustion is relatively lower than D2 fuel value, NOx value approaches to the value of D2 fuel with the usage of AFME50 as a mixture. This case can be explained as the cetane number of the methyl ester being higher than the cetane number of D2 fuel. Engine speed increase and NOx change obtained through test fuels is given in Figure 4.

3. CONCLUSION

The amount of CO showed a decrease with engine speed increase and the ratio of AFME increase in JP-8. CO emissions were found to decrease as the amount of oxygen within the body of the fuel mixture increases because the ratio of AFME in the mixture increases.

The main reason for the formation of hydrocarbons is because the combustion cannot be completed as a result of insufficient oxygen or temperature. This situation; can be explained by the slowdown of the oxidation reaction as the result of the fuel-air mixture in some of the cylinder to be at very rich or very poor rate. In addition, the amount of HC emission varies depending on injected fuel quantity during ignition delay, the character of the mixture with air in this process, and the conditions inside the cylinder. The emergence of low hydrocarbon value of the mixture fuels compared to D2 value is an important value in terms of environmental pollution and fuel consumption.

One of the initiatives undertaken in recent years is to reduce the NOx from diesel engine emissions. In this study, significant reductions of NOx value was found using JP-8 and waste animal fat methyl ester. This can be explained with the cetane number of the JP-8 fuel being lower than the cetane number of D2 fuel and its negative interference with the quality of combustion. This is a desirable case. Another indication of the increase in the engine combustion efficiency is the increase of NOx emissions. However, the release of NOx in to the atmosphere and the stroke of it to the earth as nitric acid by forming a compound with humid in the air is an undesirable case.

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