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Araştırma / Research

PROPANIN DİZEL YAKITIYLA KULLANIMI: DİZEL MOTOR YAKIT TÜKETİMİ İLE EGZOZ EMİSYONLARI ÜZERİNDEKİ ETKİLERİ

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ÖZ

Bu deneysel çalışmada propan-dizel yakıt karışımlarının direk enjeksiyonlu tek silindirli dizel motorda kullanımının yakıt tüketimi ve egzoz emisyonları üzerindeki etkisi araştırılmıştır. Hacimsel olarak %3 propan-%97 dizel ve %6 propan-%94 dizel içeren karışımlar test yakıtı olarak kullanılmıştır. Test yakıtlarına ait yakıt özellikleri dizel yakıt özelliklerine göre farklılık göstermiştir. Dizel yakıtıyla kıyaslandığında, viskozite, ısıl değer, parlama noktası ve setan değerlerinde düşük oranda azalma olmuştur. Motor testleri tam yük şartlarında gerçekleştirilmiştir. Karışımların özgül yakıt tüketimi değerlerinde düşme eğilimi gözlemlenmiştir. Genel olarak, karışım yakıtlara ait egzoz emisyonu değerlerinde iyileşmeler sağlanmıştır. CO ve Partikül madde emisyon değerlerinde sırasıyla % 25.37 ve %12.08'lere ulaşan azalmalar elde edilmiştir. NO_x emisyonu değerlerinde kayda değer bir değişim gözlemlenmemiştir.

Anahtar kelimeler: Yanma, Alkoller, Dizel motor, Egzoz emisyonları

USE OF PROPANOL WITH DIESEL: EFFECTS ON FUEL CONSUMPTION AND EXHAUST EMISSIONS OF DIESEL ENGINE

ABSTRACT

In this experimental study, the influences of propanol and diesel mixtures on direct injection single cylinder diesel engine fuel consumption and exhaust emissions were investigated. Volumetrically, 3% propanol - 97% diesel and 6% propanol - 94% diesel blends were used as test fuels. Fuel properties of the test fuels were analyzed and found different from those of diesel fuel. In comparison with diesel, viscosity, heating value, flash point, density and Cetane number decreased slightly. The engine tests were carried out at full load condition of the test engine. Specific fuel consumption values of the blend fuels showed decreasing trend. In general, exhaust emission values of the blends improved. CO and particulate emission values decreased up to 25.37% and up to 12.08%, respectively. NO_x emission values with the blend fuels did not change, considerably.

Keywords: Combustion, Alcohols, Diesel engine, Exhaust emissions

1. INTRODUCTION

Environmental pollution in the world has been increasing depending on industrialization and modernization. Important part of environmental pollution in the cities caused from usage of petroleum based fuel in the internal

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combustion engines. Use of renewable alternative fuels such as biodiesel and alcohols in internal combustion engines has been very important and studied by scientists for many years [1-2]. Evaluation of alcohol as alternative fuel decreased air pollution and dependence on petroleum based fuel. Alcohols can be produced domestically from biomass crop such as wood, wheat, sugar cane and grass [3-5].

Recently, use of alcohols as alternative fuels for diesel engines is one of the most popular topics. Particulate matter (PM), hydrocarbon (HC) and carbon monoxide (CO) values can be decreased with addition of alcohols into diesel fuel at low ratio. In terms of diesel engines, important advantages of alcohol are lower viscosity and higher oxygen content. Oxygen atoms in the molecular structure of alcohols improve combustion efficiency and emission characteristics of diesel engines [3]. Important disadvantages are lower Cetane number and lower heating values [6-8].

Different alcohols have been performed in internal combustion engines by researchers. Suhaimi and et al. [9] tested 2 ethyl 1 hexanol in diesel engine. They added 5%, 10%, and 20% of 2 ethyl 1 hexanol into diesel fuel. They found that the blend with 5% of 2 ethyl 1 hexanol has the preeminent properties among other blends in terms of viscosity, calorific value and density. Also Break Thermal Efficiency had increased by 91.72% and Break Specific Fuel Consumption had decreased by 45.22% with the use of %5 of 2 ethyl 1 hexanol. The effects of propanol and pentanol on engine performance and emission were investigated by Yilmaz et al. [10]. They found alcohols led to increase in CO and HC emissions while NO_x emissions decreased by propanol. Jamrozik et al. [11] added the methanol, ethanol, 2- propanol and 1-butanol to diesel fuel to see their effects on combustion process, performance and emissions of diesel engine. Mean indicated pressure, thermal efficiency and stability of engine were improved with the addition of alcohols. CO emission decreased while NO_x emissions increased. The combustion, performance and emission characteristics of a diesel engine were examined using butanol, ethanol and methanol with the 10% volumetric ratio by Emiroğlu and Şen [12]. The results showed ignition delay of the alcohol blends is longer than diesel while their peak cylinder pressures are higher. Also, alcohol addition caused a slight increase in NO_x emissions while CO and Smoke emissions decreased.

In this study, Effects of propanol-diesel blends on diesel engine fuel consumption and exhaust emissions were studied. Propanol at low ratios added into diesel fuel. The blend fuels were tested at full load condition of a single cylinder direct injection single diesel engine. The results of engine tests were analyzed and compared.

2. MATERIAL AND METHOD

Mixtures of propanol (isopropyl alcohol) and diesel fuel on volume basis were used as test fuels. Purity of propanol (C_3H_7OH) was 99.8%. The mixture ratios of the test fuels were 3% propanol - 97% diesel and 6% propanol - 94% diesel. The test fuels were abbreviated according to dose ratio and symbol of alcohol (P) as ‘‘P3” and “P6”. Diesel fuel was referred to as ‘‘D”. Mixture of propanol and diesel were mixed in a magnetic stirrer for 30 minutes to obtain homogeneous mixtures.

The fuel properties were determined in Petroleum Research and Automotive Engineering Laboratories of the Department of Automotive Engineering at Cukurova University. Density, Cetane number, Lower heating value, Kinematic viscosity, copper strip corrosion and flash point of test fuels were determined respectively using A KYOTO DA-130 Portable Digital Density Tester, ZX-440 Analyzer, IKA WERKE Bomb Calorimeter, K 40091 Cinematic Viscosity Meter, Copper Strip Corrosion Tester and TANAKA Flash Point Tester.

Engine tests were run on a single cylinder, four stroke, air-cooled direct injection compression ignition engine. Technical specifications of the engine were given in Table 1. The test engine was connected with a hydraulic dynamometer. The technical specifications of the hydraulic dynamometer were given in Table 2. The test carried out at full load condition. Before each tests, the engine was warmed up with diesel fuel. The test fuels were tested 3 times and mean of the results were calculated.

Smoke emission (opacity of the exhaust gasses) was measured with CAP 3200. Measurement capacity of the test device is 0–10 m^{-1}. Testo 350-S gas analyzer was used for measurement of CO and NO_x emission values. Measurement capacities of the device for CO and NO_x are 0–10,000 ppm and 0–3,000 ppm, respectively.

Table 1. Specification of the test engine

Manufacturer/type	Antor Diesel 4 LD 640
Cylinders number	1
Swept volume	638 cc
Bore	95 mm
Stroke	90 mm
Compression ratio	17:1

Maximum power	13 HP
Maximum brake torque	43 Nm at 1800 rpm
Injection type	Direct injection

Table 2. Technical specifications of the hydraulic dynamometer

Items	Specification
Maximum torque	1000 Nm
Maximum speed	7500 rpm
Capacity of load cell	2500 N
Length of torque rod	350 mm
Trunk diameter	350 mm
Totally weight	110 kgf

3. RESULTS AND DISCUSSION

3.1 Test Fuels

Fuel properties of test fuel were given in Table 3. The fuel properties of the blend fuels changed depending on addition of propanol content. Viscosity, heating value, flash point values, density and Cetane number slightly decreased. Density, viscosity and copper strip corrosion values of the blend fuels meet the EN 590 standards. The maximum change in properties of test fuels was realized with P6 in flash point. The flash point of P6 was decreased to 47 ºC (lower 9,5 ºC than diesel's). Because of the lower flash point of alcohols, flash points of P3 and P6 were decreased compared to diesel fuel [13].

Table 3. Physical and chemical properties of test fuels

Properties	**EN590**	**D**	**P**	**P3**	**P6**
Density, kg/m^3	820−845	830	786	828	825
Cetane Number	Min 51	56,415	-	53,257	50,897
Lower heating value, MJ/kg	-	44,149	33,600	43,982	43,969
Kinematic viscosity, mm^2/s, 40ºC	2,0−4,5	3,30	1,77	3,28	3,26
Copper strip corrosion (3 h, 50 ºC)	1	1	1	1	1
Flash point °C	Min 55	56.5	13	55	47

3.2 Specific Fuel Consumption

Specific fuel consumption (SFC) values are shown in Figure 1. In general, SFC values of blends increased slightly. The reduction may be due to the low heating value and low Cetane number of blend fuels. The lowest SFC values were measure at 2400 rpm for D, at 2200 rpm for P3 and at 2800 rpm for P3. The maximum increasing ratio of SFC for P3 and P6 were 3.03% at 1200 rpm and 3.68% at 2600 rpm, respectively. SFC values of P6 were generally higher than those of P3. Same results were obtained by Alptekin [14].

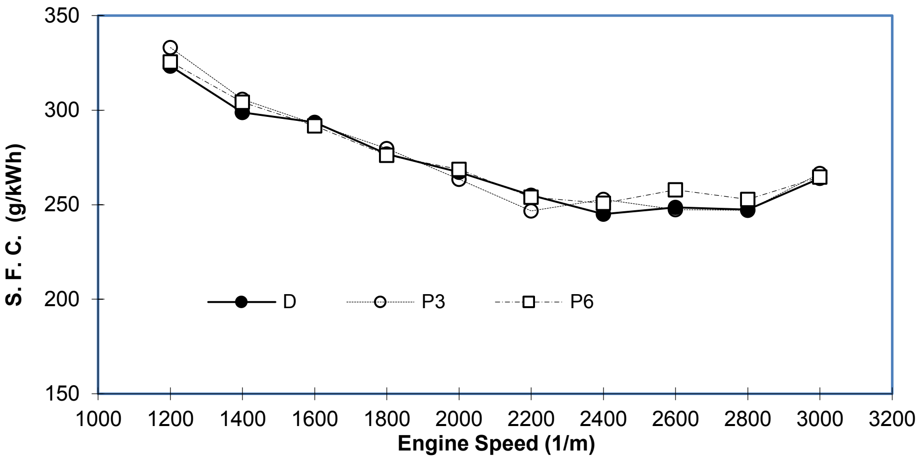

Figure 1. Variation of SFC values at full load condition.

3.3 Exhaust Emissions

Variations of CO emissions were shown in Figure 2. Addition of propanol into diesel fuel reduced CO emission values. The maximum reduction ratios for P3 and P6 were 15.62% at 2200 rpm and 25.37% at 2600 rpm, respectively. Mean reduction ratios for P3 and P6 were 8.33% and 11.57%, respectively. CO emission values of the blend fuels did not reduce between 2400 and 3000 rpm. The use of propanol allows a higher relative concentration of oxygen to exist in the combustion gases and this achieves a greater conversion of CO than for diesel fuel. The reduction in CO emissions with the use of alcohols in diesel engines was obtained by other researchers [12,13]

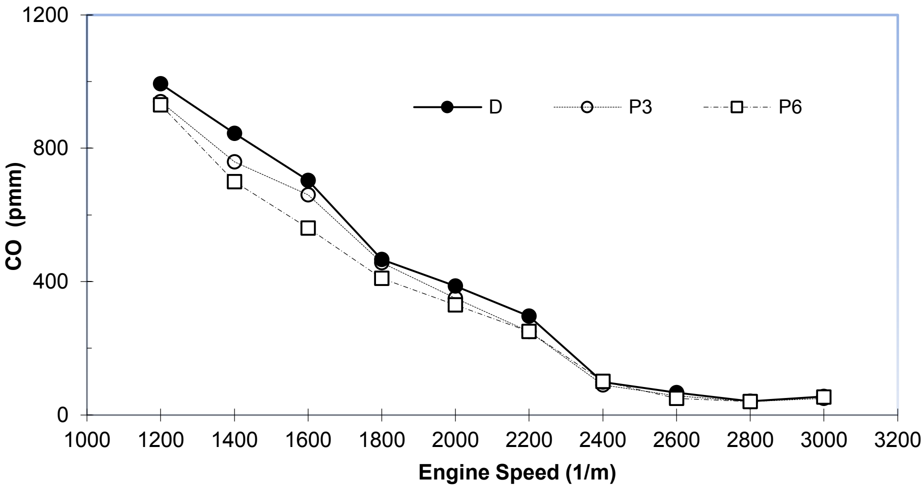

Figure 2. Variation of CO emissions at full load condition.

NO_x emission values of the test fuels were given in Figure 3. In comparison with diesel fuel, NO_x emission values of blend fuels did not change significantly. Lower NO_x emission values were measured with P6 between 1200 and 1800 rpm. The maximum reduction ratio was obtained as 8.05% with P6 at 1600 rpm. The maximum increasing ratio was 12.71% with P3 at 2200 rpm. Compared with diesel fuel, average NO_x emission values of P3 increased slightly as 2.61%, however those of P6 decreased as 0.82%. The same trend for NO_x emissions with the use of alcohols was shown in other studies [7, 9, 10].

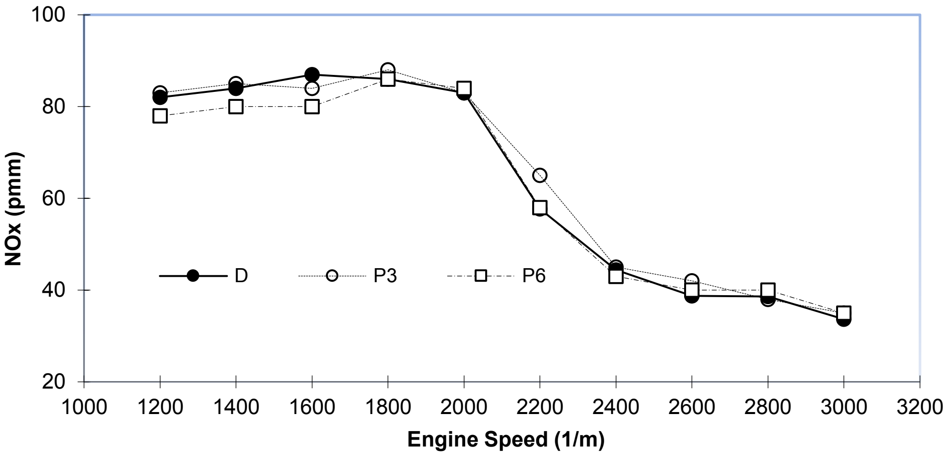

Figure 3. Variation of NO_x emissions at full load condition.

The changes of smoke emissions were shown in Figure 4. Smoke emission tests were carried out by measuring opacity of the exhaust gases. Smoke emission values of P3 reduced at all engine speeds compared with diesel fuel. Reduction ratio of smoke emission with P3 ranged from 0.97 to 12.08%. At low engine speeds, smoke emission values of P6 showed decreasing trend, however at high engine speeds, higher smoke emission values were measured with P6. For all test fuels, the minimum smoke opacity values were obtained at 2400 rpm. The use of alcohols in diesel engines is an affective technique to reduce Smoke emissions [8].

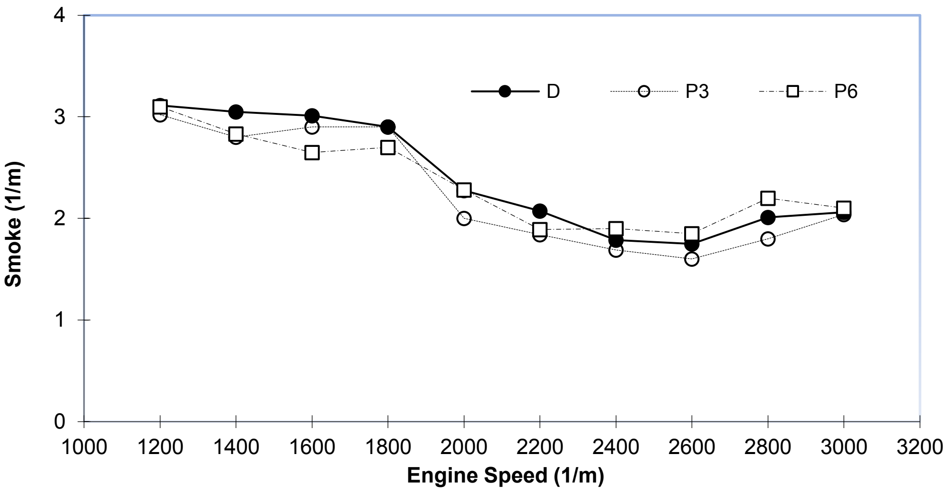

Figure 4. Variation of smoke emissions at full load condition

4. CONCLUSION

Viscosity, heating value, flash point values, density and Cetane number of the blend fuels decreased depending on addition of propanol content. SFC values of blend fuels decreased slightly due to the low heating value and low Cetane number of blend fuels. Addition of propanol into diesel fuel reduced CO up to 25.37%. These results are probably due to oxygen content of the blend fuel. NO_x emission values of blend fuels did not change significantly. The maximum reduction in NO_x emission was obtained as 8.05% with P6 at 1600 rpm. For all test fuels, the minimum smoke opacity values were obtained at 2400 rpm. Smoke emission values of P3 reduced at all engine speeds. However, smoke emission values of P6 showed decreasing trend at low engine speeds. The reduction in smoke emissions reached up to 12.08%. Consequently, the use of propanol as an oxygenated additive in diesel engines improved the emissions characteristics with the catalytic effect on combustion.

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