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Research Article

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Performance and Emission Studies of Compression Ignition Engine Fuelled with Diesel and Ethanol Blends

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Abstract One of the disadvantages of compression ignition engines is the smoke emission problem. A method of adding ethanol to a method of reducing such an exhaust gas can be considered. However, the diesel fuel and ethanol have a phase separation phenomenon. In this study, the problem of phase separation was solved by adding unleaded gasoline to prevent phase separation. The author found the most optimal mixture of diesel and ethanol. In addition, engine load test was carried out by mixing diesel fuel and ethanol in a compression ignition engine. Mixing ethanol rather than pure diesel fuel could have a significant effect on reducing smoke emission, although the torque and power could be slightly lower.

Keywords Dompression Ignition Engine, Diesel, Ethanol, Unleaded Gasoline, Torque, Bake Horse Power, Smoke Emission

Introduction

The issue of depletion of fossil fuels is not a problem yesterday, fossil fuels are not endless. However, fossil fuels continue to be found in places where we do not expect them. A more serious problem than exhaustion of fossil fuels is that the emissions from fossil fuels are further deteriorating the quality of life. Research has been actively conducted to solve the problem of air pollution emitted from automobiles. Several researchers are finding alternative fuels that can replace fossil fuels. Alternative fuels include hydrogen, natural gas, hybrid vehicles, fuel cells, and so on. Alcohol fuels, which can replace fossil fuels, can play an important role in the category of biofuels [1-2].

Methanol and ethanol can be produced from sugarcane, fermentation materials, starch materials, biomass, natural gas, etc., and they are also renewable fuels. This is a fuel that does not pose a problem of exhaustion of fossil fuels. In addition, it can be used as a fuel that can be excluded from the fossil fuel category in economic terms. It is considered that one of the ways to solve the exhaustion of fossil fuels is to be able to obtain methanol and ethanol, which are alcohol fuels, from biomass and renewable fuels, renewable energy materials these days. It is true that in the past, oil shocks have led to alcohol research in the area of alternative energy. Alcohol fuels are also in the spotlight recently. Already the use of alcohol in gasoline engines has been a lot of research and is not that difficult [3-4].

It is easy to mix methanol or ethanol with the spark ignition engine. So in the United States, gasoline and about 10% alcohol are mixed. The fuel that mixes gasoline fuel and alcohol fuel is called gasohol. In this case, the exhaust gas can be reduced. However, it can be difficult to start cold in cold areas, so it is mainly used in hot areas. However, using alcohol fuels in compression ignition engines is not easy task. The compression ignition engine adopts a method in which ignition is performed by increasing the temperature and pressure of air by high compression and injecting diesel with low ignition point in such an environment. Diesel fuels to be used in compression ignition engines should use fuel that is around 50 cetane number. However, the cetane number of methanol and ethanol is less than 10. Because of the low cetane number, operation in a compression ignition engine is almost impossible, and alcohol has a lower viscosity than light oil, resulting in a problem of lubrication of the fuel injection pump [5].

However, many researchers are working hard to overcome difficulties and to use methanol or ethanol fuel for compression ignition engines. In particular, if alcohol fuels can solve the particulate matter in diesel automobiles, it is a worthwhile study. When ethanol or methanol is added to diesel fuel, phase separation occurs. Also, the viscosity of the fuel is lowered. Ethanol and an anti-segregation agent are added to the diesel fuel, thereby significantly reducing the exhaust gas generated from the diesel engine [6].

In this study, a diesel engine for compression ignition engine was used. The diesel engine was mixed with diesel fuel and ethanol and the engine load test was carried out by adding a phase separation inhibitor. This study suggests that the mixture of ethanol rather than pure diesel fuel may decrease the torque and the output slightly, but it can be expected to have a great effect in terms of exhaust gas. In addition, this study will show how the optimum alcohol mixing ratio is achieved.

Experimental Apparatus and Method, and Characteristics of Fuel Used

Table 1 shows the engine specifications used in this study. The engine used in this study was a four-cycle single cylinder diesel engine. The cooling method is water-cooled. The compression ratio is a compact engine designed with a high compression ratio of 21.

Fig. 1 shows a schematic diagram of the experimental apparatus. A DC dynamometer capable of motoring was used to control and measure the engine load applied to the engine. A thermocouple was inserted to measure the required temperature of the intake pipe, cooling water, and engine oil.

In order to obtain the indicated diagram, a pressure sensor was used for pressure measurement. The crank angle was measured using an encoder. The pressure values obtained were averaged over 100 cycles. The pressure sensor was inserted into the combustion chamber head through holes, and pressure, pressure rise rate, pressure-volume curve, heat release rate, and mass burned rate in combustion chamber were obtained. The engine speed was performed at 800 rpm, 1000 rpm, 1200 rpm, 1400 rpm, 1600 rpm, 1800 rpm, and 2000 rpm, and the injection timing was constantly performed at 16°BTDC (before top dead center).Also, the smoke was measured to investigate the influence on the exhaust gas.

Table 2 shows the basic characteristics of diesel fuel and ethanol. It can be seen that ethanol has a structure close to water. The fuel was used by mixing ethanol with diesel. However, when the ethanol and diesel are mixed with each other due to the specific gravity difference, phase separation occurs. Therefore, unleaded gasoline is used as the phase separation preventing agent.

In Fig. 2, when 1% of ethanol is added, 0.05% of unleaded gasoline does not cause phase separation, and 98.95% of diesel fuel is used. When 2% ethanol was added, unleaded gasoline was 0.07% and diesel fuel was 97.93%. When 3% ethanol was added, unleaded gasoline was 0.10% and diesel fuel was 96.9%. When 4% ethanol was added, the addition of unleaded gasoline and diesel fuel were 0.14% and 95.86%, respectively. In addition, when 5% ethanol was added, unleaded gasoline was 0.30% and diesel fuel was 94.7%.

Table 1: Engine specifications.

Items	Specifications
Cooling system	Water-Cooled
Displacement	632 cc
Bore × stoke	92 × 95 mm
Compression ratio	21.0
Combustion Chamber	Pre-combustion chamber
Fuel injection pump	Bosch A-type
Injection nozzle	Pintle type
Nozzle opening pressure	127.7 bar

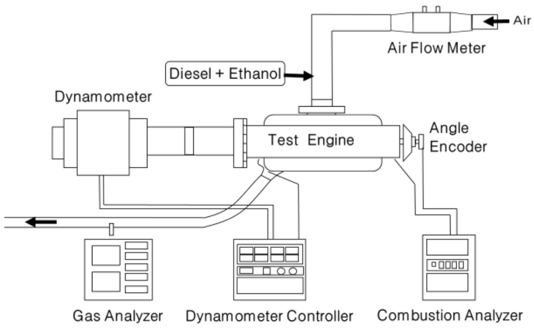

Figure 1: The schematic diagram of the experimental set-up.

Table 2: Properties of diesel and ethanol

Items	Diesel	Ethanol
Formula	$C_{16}H_{34}$	C_2H_5OH
Specific gravity	0.82-0.85	0.79
Lower heating value (MJ/kg)	42.6	26.8
Cetane number	45-63	9
Boiling point (℃)	210-325	78.4
Viscosity (cSt) at 25℃	2.79	1.1
Latent heat ofevaporation (MJ/kg)	312	865
Theoretical air-fuel ratio	14.6	9.0

Fig. 3 is a graph showing the air fuel ratio when the ethanol vol% is increased. Theoretical air-fuel ratios are 14.6 for diesel fuel and 9.0 for ethanol as shown in Table 2. Although the fuel consumption rate will increase due to low lower heating value of ethanol and low air-fuel ratio, it would not be a problem economically if a small amount of ethanol is mixed.

Fig. 4 shows the lower heating value when ethanol was added in vol%. As shown in Table 2, the lower heating value of diesel fuel is 46.6MJ/kg and the lower heating value of ethanol is 26.8MJ/kg, which is lower than that of ethanol fuel. The viscosity of alcohol fuel is significantly lower than that of diesel fuel. The cetane number of the diesel fuel has a large value of 45-63, while ethanol is only about 9. One of the biggest problems of using alcohol fuel, methanol or ethanol fuel for compression ignition engines, is that it has low viscosity and low cetane number. This low viscosity is also considered to be a negative factor in lubrication and injection pressure. The latent heat of vaporization has a vaporization latency of about 2.7 times that of diesel 312MJ/kg, and that of ethanol is 865MJ/kg, so mixing diesel fuel with ethanol is considered to be a positive factor for reducing the smoke.

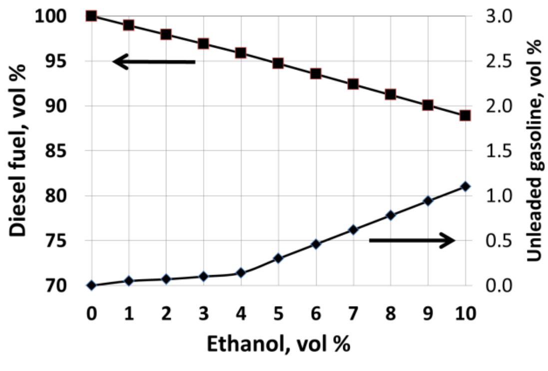

Figure 2: Blending rate of soluble additive and diesel fuel vs. ethanol rate.

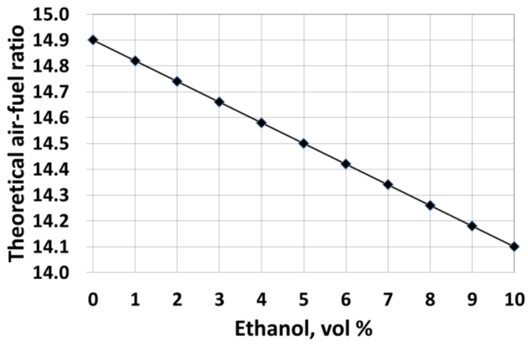

Figure 3: Comparison of theoretical air-fuel ratio vs. ethanol blending.

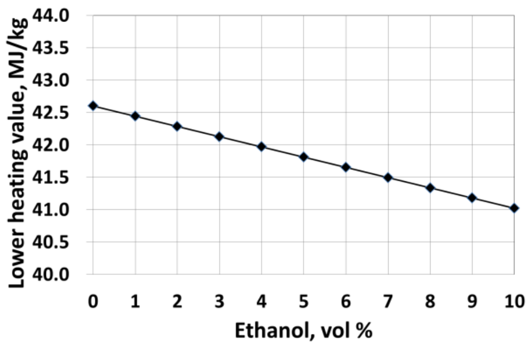

Figure 4: Comparison of lower heating value vs. ethanol blending rate.

Results and discussion

Fig. 5 is the experimental result showing the torque for the engine speed change. It can be seen that the magnitude of the torque depends on the magnitude of the low calorific value as shown in Table 2 and Fig.4. That is, 100% of the diesel fuel has the largest value with respect to the engine speed change, and the torque value of the diesel is the largest. As the mixing ratio such as EB03(Ethanol 3%) EB05(Ethanol 5%), it shows torque reduction as increasing the mixing ratio from 3% to 5%.In this study, experiments were carried out in EB03 (Ethanol 3%) and EB05 (Ethanol 5%), which are practical and stable areas.

Fig. 6 shows the results of BHP (Brake horse power, kW) for the engine speed. Engine power is affected by torque and engine speed, but the effect of engine speed is much greater than torque. Although there is a slight difference, 100% of the diesel fuel shows the largest output value with respect to the change in the engine speed, and the power is slightly reduced as the content of ethanol increases.

Fig. 7 is the experimental result showing the smoke of the engine speed change. The compression ignition engine is in a state where the air excess ratio is not homogeneous or smoke is generated when the fuel injected from the injection pump is not uniformly mixed with air. Even if air is left due to such uneven combustion, smoke is generated. In particular, the supplied fuel, diesel, produces dehydrogenation in the presence of hot oxygen depletion, resulting in smoke when liberated carbon is released.

Smoke collectively refers to gas or liquid fine particles and gases that are discharged into the air during the process of oxidation or pyrolysis of a substance. Smoke is a particle usually contained in the gas that is formed during the combustion process, and it is composed of solid, gas, and volatile vapor. Particulate matter refers to graphite. In the past, it was expressed as concentration of emitted gas or transmittance of light, but recently it is regulated as weight. As shown in Fig. 5, as the engine speed increases, torque increases, indicating that the smoke concentration increases. In addition, the latent heat of vaporization of ethanol is 2.7 times higher than that of diesel, so that hydrogen atoms in the fuel molecules weaken the binding force with oxygen, and the amount of unburned carbon decreases as the mixing ratio of ethanol increases. Because of this, ethanol plays an important role in reducing smoke.

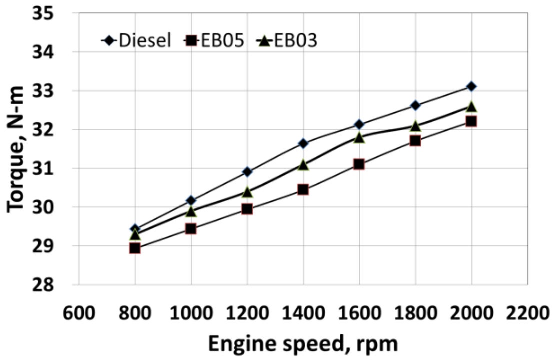

Figure 5: Torque vs. engine speed.

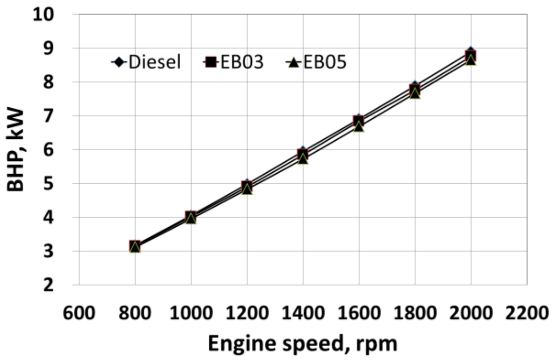

Figure 6: Brake horse power vs. engine speed.

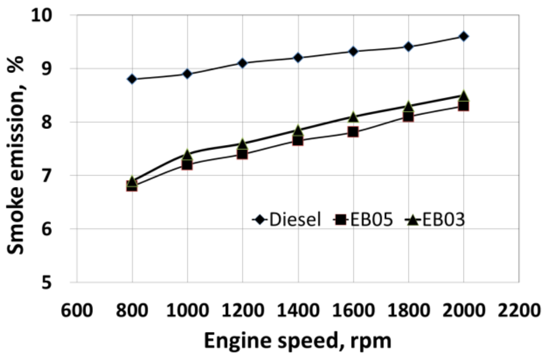

Figure 7:Smoke emission vs. engine speed.

Conclusions

Experiments were conducted by mixing ethanol with diesel fuel. The results are as follows:

The pure diesel fuel has a relatively large output value with respect to the engine speed variation. However, as the content of ethanol increased, the output decreased.

As the latent heat of vaporization of ethanol is 2.7 times higher than that of diesel fuel, it is believed that as the ratio of ethanol increases, the amount of unburned carbon decreases and the smoke is reduced as compared with the operation of pure diesel fuel.

Adding 3% ethanol and 5% ethanol to the diesel fuel did not affect the output significantly, but the smoke emission could be reduced significantly. Considering the reduction of viscosity and cetane number, it was found that 3% of ethanol was the optimum addition rate.

References

[1]. Chum, H. L., Overend R. P., Biomass and renewable fuels, Fuel Processing Technology, Vol.71, pp. 187–195, 2001.

[2]. Deep, A., Potential utilization of the blend of orange peel oil methyl ester and isopropyl alcohol in CI Engine, SAE Paper 2014-01-2778, 2014.

[3]. Deep, A., Kumar, N., Kumar, M., Singh, A., Gupta, D. and Patel S., Performance and emission studies of diesel engine fuelled with orange peel oil and n-butanol alcohol blends, SAE Paper 2015-26-0049, 2015.

[4]. Singh, A. K., Mishra, C., Vibhanshu, V and Kumar, N., Performance evaluation and emission studies of a single cylinder diesel engine fuelled isopropyl alcohol and diesel, SAE Paper 2013-01-1132, 2013.

[5]. Bromberg, L. and Cohn, D., Alcohol fueled heavy duty vehicles using clean, high efficiency engines, SAE Paper 2010-01-2199.

[6]. Michikawauchi, R., Tanno, S., Ito, Y. and Kanda, M, Combustion improvement of diesel engine by alcohol addition - investigation of port injection method and blended fuel method, SAE Paper 2011-01-0336, 2011.