Available online www.jsaer.com

Journal of Scientific and Engineering Research, 2018, 5(8):139-144

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

A Study on the Reduction of Exhaust Gas by the Methanol Mixing Method of Compression Ignition Engine

Sung Bin Han

Department of Mechanical & Automotive Engineering, In duk University, 12 Choansan-ro, Nowon-gu, Seoul, 01878, Republic of Korea

Abstract Regulations on exhaust gas are getting bigger and bigger. Especially, exhaust gas problems of automobile engines using fossil fuels are inevitable. A study on exhaust gas reduction related to smoke emission, which is one of the most important problems in diesel engines, was conducted. Unlike gasoline engines, diesel engines cannot mix with alcohol fuels. In this study, the cause of smoke emission in diesel engines is identified. Fumigation method is adopted to double fuel supply instead of conventional blending method.

In this study, diesel fuel is supplied to existing diesel engine and methanol fuel is supplied by fumigation method. The methanol feed rate was varied stepwise. Experimental parameters are the air-fuel ratio and the engine speed, and the optimum ratio to reduce the smoke emission according to experimental variables is found through experiments. The optimal experimental results were obtained by using CVMP (Cyclic Variation of Maximum Pressure) as a method to support this.

Keywords Compression Ignition Engine, Diesel, Methanol, Smoke Emission

Introduction

Regulation of automobile exhaust gas is increasing all over the world. Unlike a gasoline engine, the combustion of a diesel engine is fueled in a self-ignition combustion in the combustion chamber at a high pressure due to the high compression ratio and the temperature of the air in the combustion chamber increases. Also, exhaust gas from a diesel engine, which is a compression ignition engine, is mostly combusted in a state where it is not sufficiently mixed in a combustion process. Research on the reduction of exhaust gas, which is an unnecessary combustion product of a diesel engine, is under way due to strengthened regulations on environmental pollution. In the past, diesel engines were considered to be relatively green vehicles, compared to gasoline engines [1-3]. Many studies have been conducted to reduce exhaust gas by mixing alternative fuels with gasoline or diesel fuel, which are petroleum-based fuels. In particular, you can consider using biomass as an automotive fuel. Unlike other renewable energies, biomass is called biofuel, which can be converted directly into liquid for application in transport [4, 5].

Ethanol is primarily used as a fuel additive to reduce emissions of carbon monoxide and smoke in vehicles, and a flexible-fuel vehicle operating with a mixture of gasoline and 85% ethanol is on the market [6,7]. In addition, vegetable oil-rich crops such as oil palm, bean, algae, and jatropha are also used as fuel. These oils, when heated, are low in viscosity and can either be directly burned in the diesel engine or chemically processed to produce a fuel such as bio-diesel (ether). Bio-diesel consists of cooking oil, animal fat, or used cooking oil and methanol. Methanol can be used as an additive in vehicle exhaust emission reductions, or as a renewable alternative fuel for diesel engines. Other bio-diesel fuels include methanol and modified gasoline, and wood and its by-products can also be converted to wood gas, methanol, or ethanol fuel. Methanol, also called wood alcohol, is currently produced from natural gas and can also be produced from biomass. It is also possible to produce cellulose ethanol as part of an inedible crop, but there are still many problems to be solved from an economic point of view [8-10].

Gasoline engines can be easily mixed with methanol or ethanol fuel. However, diesel engines can not be mixed with alcohol fuels unless they are a special method. The diesel engine is the best way to adopt a fumigation method that duplicates the fuel supply because the phases are very separated by the conventional blending method [11,12].

In this study, we focus on one of smoke emission among many emissions of diesel engines. In order to supply diesel fuel to existing diesel engines and to mix them, fumigation method fuel is supplied. The methanol feed rate was changed stepwise to stabilize combustion and reduce smoke. The experimental variables were air-fuel ratio and engine speed. Depending on the experimental conditions, it will be possible to find the optimum rate and combustion stability for reducing smoke emissions. The stability of combustion was obtained by using CVMP (Cyclic Variation of Maximum Pressure) to obtain optimum experimental results. Through this study, it will contribute to the development of stable diesel engine by using dual fuel for diesel engine.

Experimental Apparatus and Method

In order to carry out this study, the experimental setup as shown in Fig. 1 was constructed. In order to measure the instantaneous pressure in the combustion chamber, a pressure transducer is mounted on the upper end of the injection nozzle, and the pressure transducer is inserted into the cylinder head. The signal from the pressure transducer is input to the combustion analyzing device via the charge amplifier, to the pressure within. In order to supply methanol to the intake tract, a dual device capable of changing the methanol supply amount was constructed.

The engine used is a water-cooled direct injection type diesel engine and the main specifications are shown in Table 1. The combustion chamber is direct injection type and the combustion chamber shape is toroidal type. The compression ratio was 19.

Fig. 1 is a schematic diagram of the experimental apparatus. The experimental single cylinder engine was directly connected to the direct current dynamometer to measure the power, and the temperature and pressure of the intake and exhaust system and each required part were measured. In order to measure the correct air fuel ratio, the amount of air and the amount of fuel on the intake side were accurately measured. Also, in order to adjust the air fuel ratio to the desired air fuel ratio, the intake air amount was measured by the orifice flow meter, and the fuel ratio was measured by measuring the fuel consumption by installing the fuel flow meter. The desired methanol-diesel mixing ratio was obtained by controlling the needle valve of carburetor supplying methanol fuel.

The cooling water outlet temperature was kept constant at 80 °C.

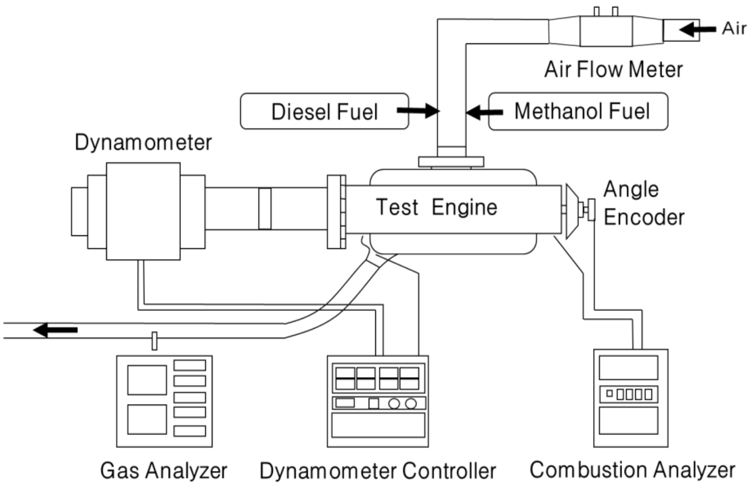

Figure 1: Schematic diagram of experimental apparatus

Table 1: Specifications of engine used

Items	Specifications
Engine type	Direct injection diesel
Displacement	632 cc
Compression ratio	19.0
Cylinder number	Single
Combustion chamber	Toroidal chamber
Injection nozzle	Pintle type

In addition, the injection amount of diesel fuel was adjusted by rack adjuster to control the lift of the flange and barrel in the injection pump. By varying the supply amount of the desired diesel fuel using the rack adjuster, the mixture ratio of desired methanol and diesel amount was obtained there was.

In order to manually control the injection timing of the diesel engine, the injection timing control device was changed to change the injection timing. At the injection timing, the optimum injection timing was selected and the diesel fuel was injected at the time when the optimum torque could be obtained. The engine speed was maintained at a constant dynamometer load, and the injection timing for each rotation speed was set to optimum injection timing and the rack position of the injection pump was adjusted. The engine speed was increased stepwise from 800 rpm to 200 rpm, and then to 2000 rpm.

The amount of methanol supplied was calculated as the volume ratio of methanol and diesel supplied to the engine. If the amount of methanol introduced during the engine operation increases, the fluctuation of the cycle may become worse due to unstable combustion, or even misfire may occur. Knocking is also detected by the knocking sensor, but when the cycle fluctuation is severe, it is considered to be in an inoperable region and the operation is stopped.

Results and Discussion

Fig. 2 shows experimental results at engine speed of 1400 rpm, which represents the best torque of the test engine. The injection timing of the diesel fuel in the compression ignition engine was performed at 15BTDC (before top dead center). The amount of methanol was changed stepwise to 0% (Diesel 100%), 10%, 20%, 30%, 40%, 50, and 60% through Carburetor. The injection timing of the fuel supply was performed in an optimal state. As shown in the figure, the smoke emission is reduced by increasing the amount of methanol in each organ.

Generally, it is known that the generation of smoke is first formed after the pyrolysis reaction of the hydrocarbon fuel occurs.

Therefore, the emission of smoke is caused by the pyrolysis which occurs in an atmosphere with insufficient air, and this pyrolysis decomposes the hydrocarbon fuel to form the nucleus of the smoke, and the unoxidized is discharged into the smoke.

In general, the fuel in the rich core region of the diesel engine is not sufficiently mixed with air, and generates heat by pyrolysis of the fuel. Pyrolysis of these fuels is also the main cause of smoke generation.

Fig. 3 is an experiment similar to Fig. 2, but the experimental results were obtained at engine speed of 1400 rpm and diesel fuel injection timing at 20 BTDC.

The injection timing of diesel fuel in a compression ignition engine was performed at 20BTDC (before top dead center) instead of 15BTDC. The amount of methanol was changed stepwise to 0% (Diesel 100%), 10%, 20%, 30%, 40%, 50, and 60% through Carburetor. The injection timing of the fuel supply was performed in an optimal state.

Experimental results show that cycle fluctuation occurs with increasing amount of methanol because methanol fuel with low viscosity flows into the combustion chamber as the amount of methanol is increased and the temperature of the combustion chamber is lowered due to the latent heat of vaporization of methanol. It is also believed that misfire occurs in the combustion chamber because the injected diesel does not absorb the heat required for methanol evaporation.

This misfiring appears as cycle variation of the maximum pressure value in the combustion chamber.

Fig. 4 shows the experimental results showing the cycle variation of the maximum pressure value for the increase of the amount of methanol.

Experimental results show that cycle fluctuation tends to increase with increasing methanol amount. Similar results were obtained in Fig.2 and Fig.3. In addition, the amount of smoke is reduced due to the increase of methanol. However, since there is a limit of unstable combustion, the experiment was stopped when CVMP (Cyclic Variation of Maximum Pressure) was over 3.5% there was.

CVMP is a value calculated by the following equation.

$$CVMP = \frac{Standard\ deviation\ of\ maximum\ pressure}{Mean\ value\ of\ maximum\ pressure} \text{x } 100, \%$$

Fig. 4, it is possible to operate at all air-fuel ratios from 20% to 30% of the amount of methanol. However, at air-fuel ratios 12, 15 and 18, the operation is stable even at 20% to 30% of methanol, but the air-fuel ratio is slightly unstable at 18, respectively.

In this situation, the operation is good at 20% to 30% of methanol. Especially, in methanol 20%, stable operating condition is observed even at the lean burn region, air-fuel ratio 21. Furthermore, at air-fuel ratio 21, the amount of smoke is drastically reduced.

Fig. 5 shows the experimental results except methanol 50% and 60%, which can not be operated within the operating range. Fig. 5 shows the variation of the engine speed from 800rpm to 2000rpm and the methanol content was changed stepwise to 0% (Diesel 100%), 10%, 20%, 30% and 40%. The injection timing of the fuel supply was performed in an optimal state.

As the rpm increases, the amount of fuel is increased, so the smoke will increase. Of course, the amount of smoke is drastically reduced as the methanol content increases. In particular, the calorific value of diesel fuel is almost twice that of methanol, so it is predicted that the power will be twice as large. Also, as the methanol content increased, the smoke emission gradually decreased. However, there is a positive aspect that the smoke decreases sharply as the methanol content increases, rather than the negative aspect that the output decreases with increasing methanol. It has been found that mixing methanol with a diesel engine, which is a compression ignition engine, can drastically reduce smoke.

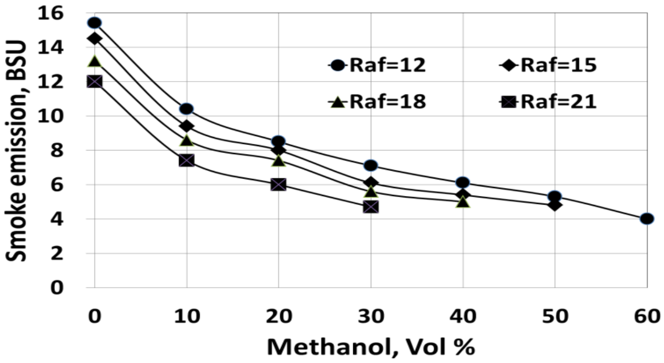

Figure 2: The smoke emission for the amount of methanol at injection timing 15BTDC

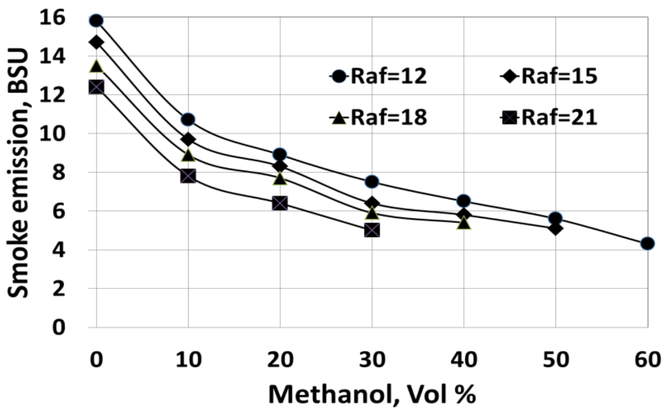

Figure 3: The smoke emission for the amount of methanol at injection timing 20BTDC

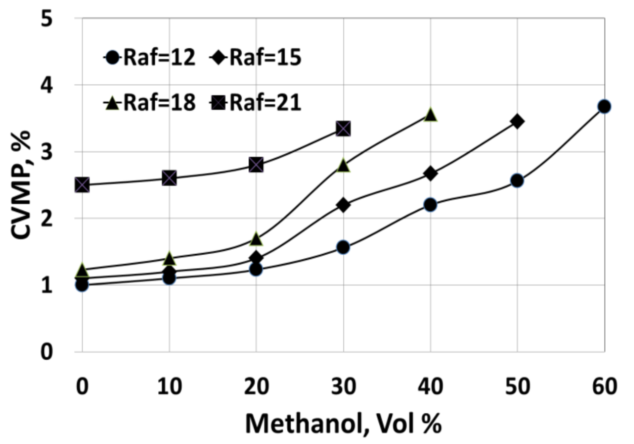

Figure 4: Cyclic Variation of Maximum Pressure versus amount of methanol

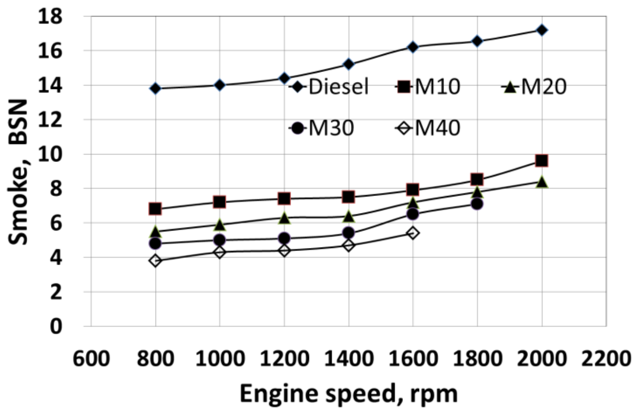

Figure 5: Smoke emission versus engine speed at the changes of methanol amount

Conclusions

Experimental results of fumigation of methanol to reduce smoke in diesel engine which is representative engine of compression ignition engine are as follows.

(1) As the methanol content was increased, it was found that the smoke emission was drastically reduced as compared with the diesel engine regardless of the injection timing and the air fuel ratio.

(2) As the amount of methanol is increased, the cycle fluctuation occurs because the temperature of the combustion chamber is lowered due to the latent heat of vaporization of methanol as the amount of methanol is increased, and the injected diesel does not absorb the heat required for vaporizing the methanol It is considered that misfire occurs in the combustion chamber.

(3) As the methanol mixture increases, cycle fluctuations tend to increase. Also, due to the increase in methanol, the amount of smoke is reduced, but the CVMP (Cyclic Variation of Maximum Pressure) increases because of unstable combustion.

(4) The operation is good from 20% to 30% of methanol. Especially, in methanol 20%, stable operating condition is observed even at the lean burn region, air-fuel ratio 21. Furthermore, at air-fuel ratio 21, the amount of smoke is drastically reduced.

(5) As the rpm increases, the amount of smoke increases because of the increase of the fuel supply. As the methanol content increases, the smoke emission decreases sharply. However, there was a positive aspect that the smoke decreased sharply as the methanol content increased, rather than the negative side where the output decreased as the methanol increased.

References

[1]. Hiroyasu, H., Arai, M., and Nakanishi, K., 1980, Soot Formation and Oxidation in Diesel Engines, SAE Paper NO.800252.

[2]. Murayama, T., Miyamoto, N., and Yamada, T., 1982, A Method to Improve the Solubility and Combustion Characteristics of Alcohol - Diesel Fuel Blends, SAE Paper NO. 82113.

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

[4]. C. Mishra, P. Mishra, B. Kar, and N. Katiyar, Performance, emission and combustion characteristics of an agricultural diesel engine studies of diesel engine fuelled with blends of calophyllum vegetable oil and isopropyl alcohol, SAE Paper 2015-26-0055, 2015.

[5]. I. Gravalos, D. Moshou, T. Gialamas, P. Xyradakis, D. Kateris, and Z. Tsiropoulos, Performance and emission characteristics of spark ignition engine fuelled with ethanol and methanol gasoline blended fuels, www.intechopen.com, 2011.

[6]. S. Chockalingam, and S. Ganapathy, Performance and emission analysis of a single cylinder constant speed diesel engine fueled with diesel-methanol-isopropyl alcohol blends, SAE paper 2012-01-1683, 2012.

[7]. S. Yousufuddina, M. Masoodb, Effect of ignition timing and compression ratio on the performance of a hydrogen–ethanol fueled engine, International Journal of Hydrogen Energy, 34, 6945-6950, 2009.

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

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

[10]. M.B. Celik, Experimental determination of suitable ethanol–gasoline blend rate at high compression ratio for gasoline engine, Applied Thermal Engineering, 28, 396–404, 2008.

[11]. S. Prasad, A. Singh, and H.C. Joshi, Ethanol as an alternative fuel from agricultural, industrial and urban residues, Resources Conservation and Recycling, 50, 1–39, 2007.

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