Effect of Blend of Diesel with Bioethanol and Biodiesel on the Emissions of CRDi Diesel Engine

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ABSTRACT: Biofuel is considered one of the most promising alternative fuels to petrol fuels (biodiesel, bioethanol). The objective of the work is to study the characteristics of the distribution of particle size, the reaction characteristics of nanoparticles on the catalyst and the characteristics of exhaust emissions when the diesel engine is operating on biofuel-blended diesel fuels using a common rail direct injection (CRDI). In this analysis, an ECE (Economic Commission Europe) R49 test and a European Stationary Cycle (ESC) test examined the engine output, emission characteristics and particle size distribution of a CRDI diesel engine that was fitted with a warm-up catalytic converter (WCC) or catalyzed particulate filter (CPF). Under a biofuel-blended diesel fuel, the engine output was close to that under D100 fuel, and the high fuel consumption was due to the decreased calorific value resulting from biofuel mixing. The use of a biodiesel-diesel blend fuel decreased the overall emissions of hydrocarbons (THC) and carbon monoxide (CO) but increased emissions of nitrogen oxide (NOx) due to the increased fuel oxygen content.

KEYWORDS: Diesel engine, Biodiesel, Bioethanol, Particulate matter, Catalysed particulate filter (CPF), Particle size distribution

INTRODUCTION

As diesel engines have a higher thermal efficiency than petrol engines, they have the benefit of minimizing global warming and reducing the use of fossil fuels. However, because of the relatively low air utilization rate, they emit more diesel PM (particulate matter) than gasoline engines. A very powerful way to minimize CO (carbon monoxide) and THC (total hydrocarbon) emissions and the SOF (soluble organic fraction) of PM emissions has been the after-treatment of the diesel engine exhaust. Recently, petroleum prices have fluctuated widely and the level of interest in biodiesel, natural gas, ethanol, dimethyl ether (DME), hydrogen, etc. as alternatives to fossil fuels has been increased by the stringent regulation of pollutant emissions [1]. As a potential substitute fuel, biodiesel fuel, which is applicable to diesel without engine modification, has been actively researched. Biodiesel comes from a number of sources, including soybean oil, jatropha oil, vegetable oil, rapeseed oil, etc., palm oil, sunflower oil, animal fat and cooking waste, the oils.

Bioethanol is a gasoline substitute fuel with its high octane number, which is made of different types of biomass such as maize, sugar cane, sugar beet, cassava, red seaweed, etc. Blending biodiesel and bioethanol with diesel greatly decreases particulate matter emissions because oxygen is found in the blended biofuel [2]. Currently, particulate matter is regulated in terms of grams per kilometer or grams per kilowatt-hour, but PM legislation based on numbers is being considered for implementation in the near future. The smaller the particle released, the more dangerous it is to the human body because particles with a diameter of less than 100 nm (ultrafine particles) have a higher surface area per particle unit mass; thus, the smaller particles will more easily penetrate the respiratory organs. Based on the use of biodiesel and bioethanol-diesel blends, the weight reduction of PM is known. There is, however, a shortage of research concerning biodiesel. In terms of particle size distribution and numerical concentration, bioethanol-diesel blends with PM emission characteristics. The goal of this experimental study is to analyze the characteristics of the distribution of exhaust emissions and particle size and the amount of PM concentration from a CRDI diesel engine through the ECE R49 and ESC tests and the use of blends of biodiesel and bioethanol-diesel [3].

Using the bioethanol-diesel mix, the emission of smoke was decreased by 50 percent. The efficiencies of emission conversion under biofuel-blended diesel fuels in the WCC and CPF were similar to those under D100 fuel. The use of biofuel-blended diesel fuel decreased the overall amount of particles released from the vehicle, but when compared to the use of D100, the use of biodiesel-diesel blends resulted in more particulate emissions lower than 50 nm. Compared to the use of BD20 fuel, the use of mixed biodiesel and bioethanol fuel (BD15E5) was much more effective in reducing the number of particles and the mass of particles.

EXPERIMENTAL APPARATUS

A diagram of the central experimental system used to research the engine performance, emission characteristics, and particle size distribution of a biofuel-blended diesel fuel CRDI diesel engine is shown in figure 1. A warm-up catalytic converter (WCC) or catalyzed particulate filter (CPF) was used to meet with the EURO 4 diesel emission regulations in the after-treatment system of each test cycle. In the rear part of the exhaust manifold, catalysts were installed. For fast activation, the exhaust pipe leading to the after-treatment was completely insulated. The WCC was 76 mm in diameter and was 0.51 L in volume. A honeycomb-type monolithic substrate coated with g-Al2O3 and 3.18 g/L platinum with a cell density of 600 cpsiwa (Pt). A Company CPF is the front consists of a diesel oxidation catalyst (DOC) and the rear of the catalytic system has a CPF [4]. To calculate power output, an eddy-current dynamometer (Fuchino, ESF-600) capable of adsorbing 440 kW was used [5]. The CO, THC, and NOx concentrations were determined by an exhaust gas analyzer (Horiba, MEXA-9100DEGR). The amount of smoke emitted was determined by a Bosch-type smoke meter (World Env., ATF-2000). The Table 1 indicates the test engine specifications.

At the inlet and outlet of the after-treatment device, both the particle size distribution and emission characteristics were measured; a scanning mobility particle sizer (SMPS) (Model 3080, TSI. Inc) was used for the former [6]. Due to the exhaust steam, exhaust gas was diluted in an ejector-type dilutor Concentration of large particle numbers. A portion of the exhaust gas and filtered ambient air were mixed in the 1:132 ratio in this study via a dilutor method developed by the authors. The dilution air was preheated to approximately 150℃ - 5℃ by the first dilutor in order to prevent the volatile elements from being nucleated and condensed [7-9]. Compressed air was filtered and kept at the ambient temperature for the second dilution. The distribution of particle size was determined by the SMPS over a range of diameters from 10 nm through to 385 nm, and the concentration of particle mass was estimated from the Distribution of calculated dimension, assuming a particle density of 1.2 g/cm3.

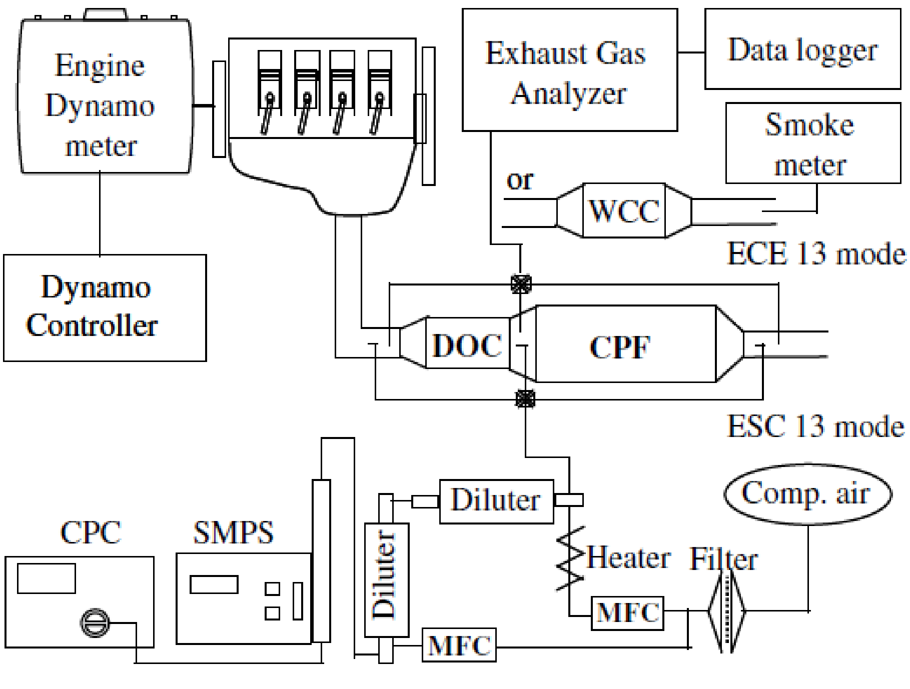

Figure 1: Experimental setup

Table 1: Test Engine specifications

Items	Specifications
Engine Type	CRDI 4 Cylinder
Bore × Stroke (mm)	91 × 96
Displacement (cc)	2497
Compression ratio	17.1
Max. Power (PS@rpm)	145@3800
Max. Torque (N m@rpm)	324@2000
Aspiration	T/C & after cooler

RESULTS & DISCUSSION

The ECE R49 test cycle consists of 25%, 50 percent, 75 percent and 100 percent engine loads at 2100 and 3800 rpm, displaying the maximum torque, maximum output and idling modes of the engine (750 rpm; modes 1, 7, and 13). With the exception of low-load driving conditions (modes 2 and 12), the fuel consumption range in each mode was 220-400 kg/kWh. The bioethanol-diesel blends' fuel consumption rate increased by 6.5 percent compared to that of D100, while the biodiesel-diesel blends' fuel consumption rate increased by 1-2 percent. This is due to the varying calorific values resulting from the oxygen content differentials in the fuels. The engine's full output is under biofuel-blended diesel fuel, the torque and power output were the same or only slightly lower than under the D100.

CONCLUSION

Under the ECE R49 and ESC test cycles and the use of biodiesel and bioethanol blended diesel fuels, the properties of exhaust emissions and particle size distributions of PM from a CRDI diesel engine have been examined. The study findings are that in biofuel-blended diesel fuels, the engine output was similar to that of D100 fuel; the slightly higher fuel consumption was due to the lower calorific value centered on the biofuel mixture. The use of biodiesel-diesel blends decreased emissions of THC and CO but increased emissions of NOx, as the fuel's oxygen content increased. The use of bioethanol-diesel blends decreased smoke emissions by 50 percent. The conversion efficiencies of THC and CO emissions from biofuel-mixed diesel fuels in the WCC and CPF were very close to those of the D100 fuel. The total number of particles emitted from the engine has been reduced by the use of biofuel-blended diesel fuels. However, the use of biodiesel-diesel blends has caused the emission of more particles smaller than 50 nm, which are toxic to the human body, relative to the use of D100. Compared with the use of BD20 fuel, the use of mixed biodiesel and bioethanol (BD15E5) fuel was much more effective in reducing the number of particles and particulate mass.

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