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Effects of SCR System on Nox Reduction in Heavy Duty Diesel Engine Fuelled with Diesel and Alcohol Blends

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Abstract

The aim of this experimental work was to explore the effects of SCR System on NOx reduction in heavy duty diesel engine fuelled with diesel and alcohol blends. The experimental tests were performed in a 6-cylinder, turbocharged heavy duty diesel engine at full load. In the experimental tests diesel, ethanol, methanol and butanol were used as fuel. The alcohol fuel blends were prepared by mixing low sulphur diesel at volumetric rates of between 5 to 15%. The test results showed that SCR system reduce the NOx emissions 42.6% for diesel fuel. The maximum NOx reduction (43.43%) was achieved with 15% methanol–85% diesel fuel (D85M15) blend.

Keywords: NOx emission; Alcohol; Heavy duty diesel engine

Introduction

Diesel engine is one of the crucial reason of air pollution such as nitrogen oxides (NOx), hydrocarbons (HC), carbon monoxide (CO), Carbon dioxide (CO_2), Smoke opacity, etc [1]. The extinction of petroleum fuels has led researchers to find alternative fuels [2-4]. For enhance the quality of the performance and combustion various fuel additives are recently used in the automotive sector [5]. The most investigated additives are oxygenated fuel additives in diesel engines [6]. Alcohols like as methanol, ethanol, proponal and butanol are preferred as fuels because they can be generated by fermentation of sugar from vegetable materials, like as corn, algae, sugar cane and other plant materials compraising cellulose [7,8]. Alcohol fuels have many advantages such as decrease particulate matter (PM), nitrogen oxides (NOx) and carbon monoxide (CO) exhaust emissions due to the additional oxygen in fuel [2]. There are various studies about the impacts of ethanol, methanol and butanol on diesel engine combustion and emissions [6-14].

Liotta and Montalvio [15] investigated the impacts of oxygenated fuels on exhaust emissions on heavy duty engines and they found glycol ethers additions have more effect for reducing PM, CO and NOx emissions.

Ajav et al. [16] explored the impacts of ethanol diesel fuel blends (E5, E10, E15 and E20) on diesel engine emissions and they reported that obtained fuel blends were reduced CO and NOx emissions in a diesel engine operated at a constant speed.

Chao et al. [17] researched the impacts of fuel additives containing methanol (MCA) on the regulated emissions of heavy duty diesel engine. The neat diesel fuel blended with methanol levels 5, 8, 10 and 15% by volume respectively. And the results noted that the addition of MCA decreased exhaust emissions, such as NOx, PM, and PAHs diesel engine emissions.

Li et al. [18] explored the impacts of ethanol–diesel fuel blends (5, 10, 15 and 20%) in a single-cylinder diesel engine and the results showed that ethanol-diesel fuel blends were reduced CO, NOx and smoke opacity exhaust emissions with regard to diesel fuel.

Rakopoulos et al. [19] researched the performance and emission values of ethanol-diesel fuel blends (5% and 10% (by vol.)) on a six-cylinder, turbocharged heavy duty diesel engine. They measured exhaust gas emissions of haevy duty diesel engine and they reported that the ethanol-diesel fuel blends were decreased the smoke density, NOx and CO emissions with regard to neat diesel fuel.

Zhang et al. [20] measured the emission change with using diesel oxidation catalyst system on diesel engine. They blended diesel fuel with fumigation methanol. They performed the experiments on a 4-cylinder direct-injection diesel engine with 1800 rev/min speed at different five engine loads. They observed that fuel blends decreased nitrogen oxides (NOx), smoke opacity and the particulate mass concentration decreased.

Ozsezen et al. [21] explored the combustion and exhaust emission values of isobutanol-diesel fuel blends on a heavy duty diesel engine. They blended iso-butanol addition into diesel fuel with ratios 5%, 10% and 15% by volume and they tested fuel blends at the speed of 1400 rpm at 150, 300 and 450 Nm loads. The results showed that when iso-butanol-diesel fuel blends were used the NOx emissions decreased compared to diesel fuel.

In this study, the effects of ethanol, methanol and butanol diesel fuel blends on NOx emissions of a 6-cylinder, turbocharged heavy duty diesel engine with and without SCR system was investigated. Ethanol, metanol and butanol were blended with neat diesel fuel at volumetric rates between 5 and 15%.

Material and Method

The experimental tests were performed on a six cylinder, four-stroke, air-cooled turbocharger diesel engine. The technical specifications and schematic diagram of test unit are shown in Table 1 and Figure 1 respectively. A hydraulic dynamometer was used to determine the torque. Technical specifications of dynamometer are given

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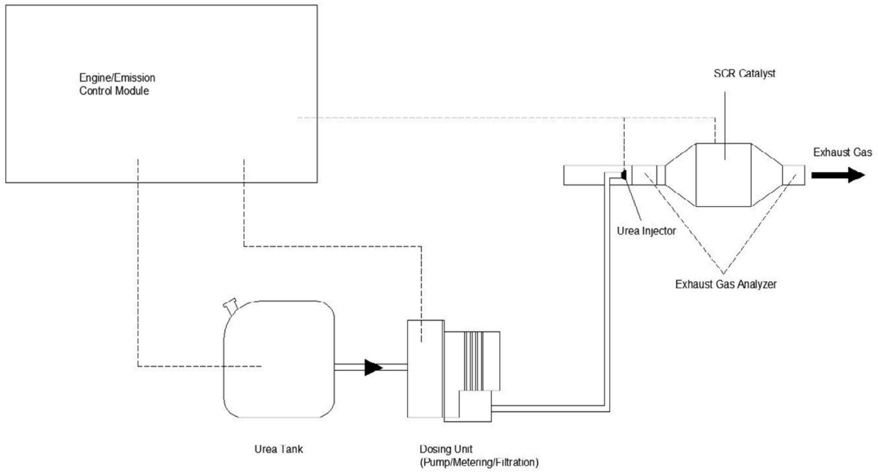

Figure 1: Schematic diagram of test unit.

Brand	Cummins
Model	ISBE4+250B
Type	Electronic control system
Cylinder	6
Bore/Stroke	107/124 mm
Compression Ratio	17.3
Weight	485 kg
After treatment	SCR
Peak Torque/Speed (r/min)	1200-1800
Rated Speed	2500 rpm
Displacement	6700cc
Power	184 kW@2500 rpm
Torque	1020Nm @1500 rpm
Oil Cooler	Turbocharger and after cooled

Table 1: Technical specifications of engine.

Torque range	250-2200 Nm
Speed range	0-4500 rpm
Body weight	45 kgf
Coupling length	400-750 mm
Torque arm length	350mm

Table 2: Tecnical specifications of dynamometer.

FTIR Spectrometer Data	
Sampling rate	1 scans per second (1 Hz)
Data rate	All measured gas components at 1 Hz
Spectral resolution	0.5 cm^{-1}
Measurement cell	Gas cell heated to 191°C (375.8 °F)
Response time	t_{10} to t_{90} within 1 s (fast response version within 300 ms)
Sample flow rate	10 l/min per stream (20 l/min for fast response version)
Detector cooling	Liquid nitrogen, 50 ml/h
Zero/purge gas	Nitrogen/synthetic air, 0.6-1.5 l/min
Compressed air	5-6 bar rel. max. 100 l/min per FTIR stream

Table 3: FTIR Technical specifications.

Fuel Properties	Diesel	Ethanol	Methanol	Butanol
Density (kg/lt)	0.833	0.788	0.793	0.810
Cetane Number	61	~8	3.8	~25
Viscosity (cSt)	2.7	1.078	0.5445	3.6
Calorific value (kj/kg)	45,100	26,900	20,100	33,100
Boiling Point	180-360	78	64	118
Stoichiometric air fuel ratio	15	8.9	6.7	11.2

Table 4: Fuel properties of diesel, methanol, ethanol and butanol.

in Table 2. AVL SESAM i60 Fourier Transform Infrared Spectroscopy (FTIR) device was used measuring of exhaust emissions. FTIR device technical characteristics are presented in Table 3. In the after treatment process, selective catalytic reduction, which involves the spraying of urea in the tail pipe, was incorporated to mitigate NO_X. The engine is equipped with SCR aftertreatment system (Figure 2). shows schematic diagram of SCR system unit.

In the experiments, diesel, methanol, ethanol and butanol were used as fuel. The fuel blends were prepared by mixing euro diesel at volumetric rates of 5, 10 and 15%. Methanol-diesel blends specified as D95M5, D90M10 and D85M15. Ethanol-diesel blends specified as D95E5, D90E10 and D85E15. Butanol-diesel blends specified as D95B5, D90B10 and D85B15. Before start to test, engine was runned during 15 min using diesel fuel to reach operating temperature. The fuel blends were tested between 1400 rpm to 2400 rpm with interval of 200 rpm in full load conditions. The fuel propertis of diesel fuel, ethanol, methanol and butanol are reported in Table 4.

Result and Dıscussıon

The NOx emission mostly regards to nitrogen monoxide NO and nitrogen dioxide NO_2 [22]. NO is usually the most abundant NOx and compose more than 70–90% of total NOx in diesel engine exhaust [23]. Alcohol fuel blends were used for further NOx emission study in a diesel engine fitted with SCR system. The variations of nitrogen oxides (NOx) emissions of test fuels with engine speed are demonstrated in the Figures 3-5. Figure 3 shows the NOx emission values of methanol fuel blends with and without SCR system. After applying SCR system, the NOx emission is substantially reduced by 43.12%, 43.3 and 43.43% than D95M5, D90M10 and D85M15 respectively.

Figure 4 shows the NOx emission values of ethanol fuel blends with and without SCR system. After applying SCR system, the NOx emission is substantially reduced by 42.9%, 43.01% and 43.14% than D95E5, D90E10 and D85E15 respectively.

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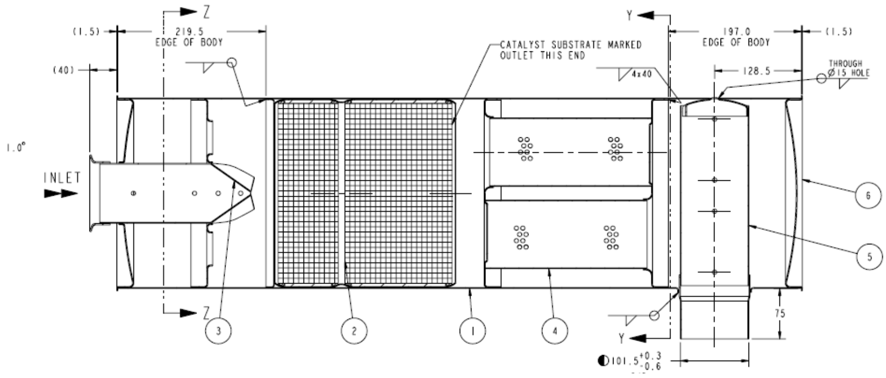

Figure 2: Schematic diagram of the SCR.

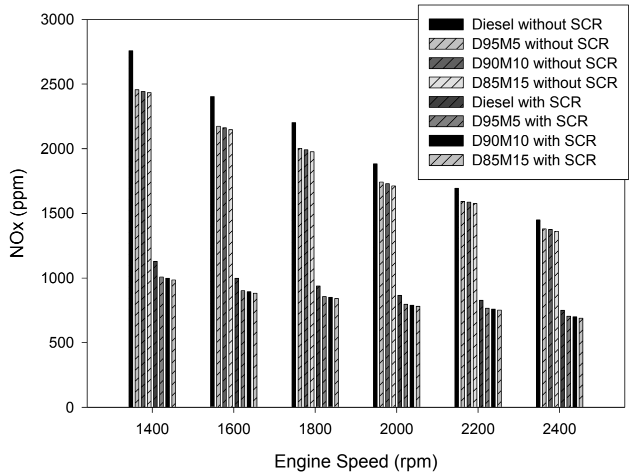

Figure 3: Investigation NOx emission of methanol blends.

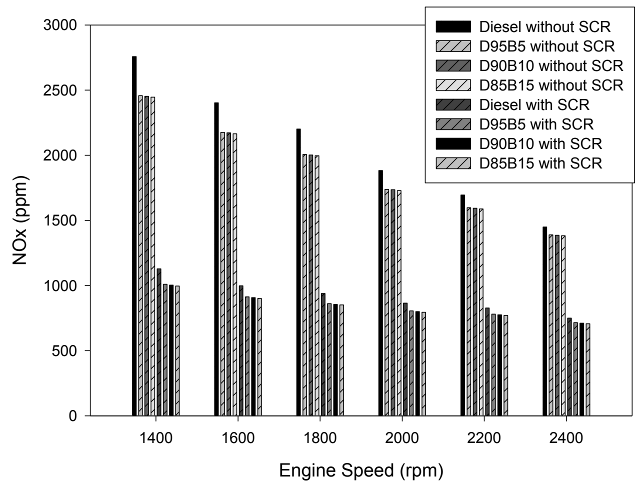

Figure 5: Investigation NOx emission of butanol blends.

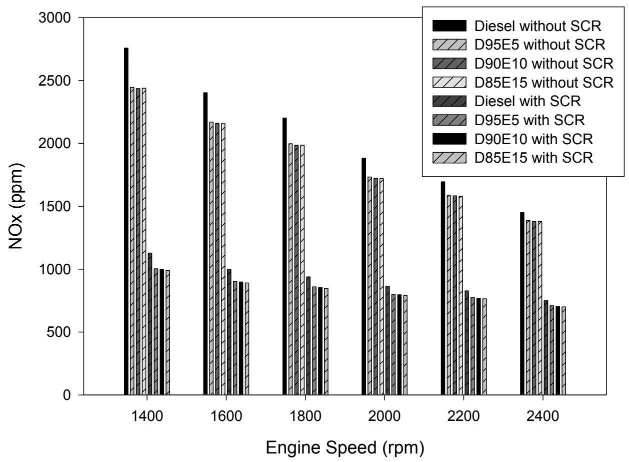

Figure 4: Investigation NOx emission of ethanol blends.

Figure 5 shows the NOx emission values of butanol fuel blends with and without SCR system. After applying SCR system, the NOx emission is substantially reduced by 42.7%, 42.8% and 42.94% than D95B5, D90B10 and D85B15 respectively.

Conclusion

In this work, the NOx emission values of ethanol, methanol and butanol additives on a 6-cylinder, turbocharged heavy duty diesel engine with and without SCR system was investigated. The main findigs from this study is aligned below:

After applying SCR system for D85M15, D85E15 and D85B15 fuel blends, the NOx emission is substantially reduced by 46.45%, 45.9% and 45.5% than diesel respectively.

Addition of ethanol, methanol and butanol decrease the NOx emissions with regard to neat diesel. The reason of the reduction may be owing to the increasing oxygen content and lower cetane number of alcohol additives. Lower cetane number of ethanol, methanol and butanol blends precipitates to longer ignition delay, and leading possibly to higher combustion temperature during the premixed combustion mode [3,9].

Acknowledgement

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References

1. Zhang ZH, Cheung CS, Chan TL, Yao CD (2010) Experimental investigation of

regulated and unregulated emissions from a diesel engine fueled with Euro V diesel fuel and fumigation methanol. Atmospheric Enviroment 44: 1054-1061.

2. Tosun E, Yilmaz AC, Ozcanli M, Aydin K (2014) Determination of effects of various alcohol additions into peanut methyl ester on performance and emission characteristics of a compression ignition engine. Fuel 126: 38-43.
3. Tuccar G, Ozgur T, Aydın K (2014) Effect of diesel–microalgae biodiesel–butanol blends on performance and emissions of diesel engine. Fuel 132: 47-52.
4. Balki MK, Sayin C, Canakci M (2014) The effect of different alcohol fuels on the performance, emission and combustion characteristics of a gasoline engine. Fuel 115: 901-906.
5. Paul A, Bose PK, Panua RS, Debroy D (2015) Study of performance and emission characteristics of a single cylinder CI engine using diethyl ether and ethanol blends. Journal of the Energy Institute 88: 1-10.
6. Ulrich A, Wichser A (2003) Analysis of additive metals in fuel and emission aerosols of diesel vehicles with and without particle traps. Analytical and Bioanalytical Chemistry 377: 71-81.
7. Rakopoulos DC, Rakopoulos CD, Hountalas DT, Kakaras EC, Giakoum EG, et al. (2010) Investigation of the performance and emissions of bus engine operating on butanol/diesel fuel blends. Fuel 89: 2781-2790.
8. Chen Z, Liu J, Han Z, Du B, Liu Y, et al. (2013) Study on performance and emissions of a passenger-car diesel engine fueled with butanol-diesel blends. Fuel 55: 638-646.
9. Doğan O (2011) The influence of n-butanol/diesel fuel blends utilization on a small diesel engine performance and emissions. Fuel 90: 2467-2472.
10. Lapuerta M, Armas O, Herreros JM (2008) Emissions from a diesel–bioethanol blend in an automotive diesel engine. Fuel 87: 25-31.
11. Hansen AC, Zhang Q, Lyne PWL (2005) Ethanol–diesel fuel blends; a review. Bioresour Technol 96: 277-85.
12. Can O, Celikten I, Usta N (2004) Effects of ethanol addition on performance and emissions of a turbocharged indirect injection diesel engine running at different injection pressures. Energy Convers Manage 5: 29-40.
13. Can O, Celikten I, Usta N (2005) Effects of ethanol blended diesel fuel on exhaust emissions from a diesel engine. Pamukkale Univ J Eng Sci 11: 219-224.
14. Bilgin A, Durgun O, Sahin Z (2002) The effect of diesel–ethanol blends on diesel engine performance. Energy Sources 24: 431-440.
15. Liotta FJ, Montalvio DM (1993) The effect of oxygenated fuels on emissions from a modern heavy-duty diesel engine. SAE technical paper no. 932734.
16. Ajav EA, Singh B, Bhattacharya TK (1999) Experimental study of some performance parameters of a constant speed stationary diesel engine using ethanol diesel blends as fuel. Biomass and Bioenergy 17: 357-365.
17. Chao MR, Lin TC, Chao HR, Chang FH, Chen CB (2001) Effects of methanol-containing additive on emission characteristics from a heavy-duty diesel engine. Science of the Total Environment 279: 167-179.
18. Li D, Zhen H, Xincai L, Wu-Gao Z, Jian-Gyang Y (2005) Physicochemical properties of ethanol–diesel blend fuel and its effect on performance and emissions of diesel engines. Renewable Energy 30: 967-976.
19. Rakopoulos DC, Rakopoulos CD, Kakaras EC, Giakoumis EG (2008) Effects of ethanol–diesel fuel blends on the performance and exhaust emissions of heavy duty DI diesel engine. Energy Conversion and Management 49: 3155-3162.
20. Zhang ZH, Cheung CS, Chan TL, Yao CD (2009) Emission reduction from diesel engine using fumigation methanol and diesel oxidation catalyst. Science of the Total Environment 407: 4497-4505.
21. Ozsezen A, Turkcan A, Sayın C, Çanakçı M (2011) Comprasion of performance and combustion parameters on heavy duty diesel engine fueled with isobutanol/diesel fuel blends. Energy Exploration and Exploiation 29: 525-541.
22. Skalska K, Miller JS, Ledakowicz S (2010) Trends in NOx abatement: A review. Science of the Total Environment 408: 3976-3989.
23. Patil KR, Thipse SS (2015) Experimental investigation of CI engine combustion, performance and emissions in DEE–kerosene–diesel blends of high DEE concentration, Energy Conversion and Management 89: 396-408.