International Journal of Applied Engineering Research ISSN 0973-4562 Volume 15, Number 7 (2020) pp. 716-720

Emission Reduction of Diesel Engine by Using DPF, DOC and Injecting Hydrazine Hydrate in Exhaust Pipe

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Abstract

An experiment was conducted with four stroke single-cylinder, water cooled compression ignition engine having a cylinder bore of 80mm, stroke of 100mm, compression ratio of 16:1, and developing 3.68 kW at 1500 rev/min. Test runs were done on this engine by injecting diesel as fuel at injection timings of at 23˚ BTDC and injection pressure of 230 bar. Main focus of this research is to investigate the emission level by having DPF, DOC and injecting hydrazine hydrate at exhaust. In the experiments each type of emissions and control systems is comprehensively examined. CO emission has increased with DPF and reduced with DOC. But HC emissions reduced by adopting DPF and DOC. The combination of DPF, DOC & H_6N_2O reduces up to 50% of NOx emissions. Overall comparison of all the results, it can be concluded that the least emission level was observed when engine is operated at 4 kg load and having DPF, DOC and also H_6N_2O. At this condition, the emissions values are CO 11%, CO_2 26%, HC 20450 ppm, NO_x 55 mg/Nm^3

Keywords: Diesel Engine, Hydrazine Hydrate, Diesel particulate filters, Diesel oxidation catalyst.

1. INTRUDUCTION

Diesel engine is an internal combustion engine, uses the heat of compression to initiate ignition to burn fuel, which is injected into the combustion chamber of engine. In today's context, diesel engine has become an important power source in farming activities in rural areas where electrical energy is unavailable. Also, the market share of diesel car has increased in many countries because of its higher thermal efficiency. This trend is expected to be continued in the future. However, the problem with diesel engine is its higher emissions. Among the main pollutants PM, NO_x, CO, HC, CO_2, SO_x, aldehydes most harmful pollutants of diesel engine are NO_x and PM

In order to cope with the strict emission standard, green engine which reduces exhaust emission should be developed. This is supported by the statement "Research makes diesel engine greener". Implementation of after-treatment systems induce significant gain in emissions reduction were tried. For many years, diesel engine manufacturers have been working extensively to develop after treatment technologies that are capable of significantly reducing the emission levels of each of the primary pollutants which are a risk to the environment and public wellbeing. Diesel particulate filters (DPF) and Diesel oxidation catalyst(DOC) are devices that physically capture diesel particulates in the exhaust pipe to prevent their release to the atmosphere. Some of diesel filter materials which have been developed show quite impressive filtration efficiencies.

1.1 REVIEW OF LITERATURE

J.E. Parks *et. al.* builded a 2 chamber catalyst in a device as after treatment system for diesel exhaust. NOx conversion efficiencies were more than 90% over a broad range of temperatures and NOx values. The system had a NOx catalyst (SCONOx™) for the removal of CO, HC and NOx from the exhaust stream and a SO_2 catalyst (SCOSOX ™) for the purpose of protection from sulphur poisoning of the NOx catalyst. Both catalysts used were of "trap" type for the diesel engine exhaust. Hartmut Luders *et al.* in their paper titled "Diesel Exhaust Treatment- New Approaches to Ultra Low Emission Diesel Vehicles", mentioned that currently, all over the globe, development of combustion engine is influenced by two concerns. First is the increasing concern for global warming, and second is the concern over PM and NO_x, each of which will affect the human health because of the toxicity.

Louis Cédric A *et al.* investigated the Ultrafine particle, black carbon and NOx emissions from Diesel and gasoline passenger cars and influences of aftertreatment device at different driving conditions viz; the cold start, urban, rural and motorway conditions on emissions. Additive DPF vehicles emit two times more NO_2 for urban conditions (175 mg/km), comparing to Diesel catalysed DPF (80 mg/km). No significant differences have been observed between additive and catalysed DPF for CO_2 and NOx emissions.

Yu Quan-shuna *et al*. studied the improvement of particulate and gaseous pollutants before and after DPF transformation, the comparison test was carried out on 20 diesel vehicles. The installation of DPF had a great effect on concentration of NO_2, the average have dropped to 0.43775 times of the original; concentration of NOx unchanged.

2. EXPERIMENTAL SETUP

Experiments were conducted on a four stroke single-cylinder, water cooled compression ignition engine. The photograph of diesel engine set up and arrangement of DPF, DOC & Injecting Hydrazine Hydrate are shown in figure 1 and 2 respectively. The specifications of the engine are shown in the table 1. The measuring of fuel consumption (for diesel), speed, emissions has been recorded manually. All tests are conducted at different loads viz, no load, 4kg and 8 kg load. The engine speed is maintained constant at 1380 rpm. After every load the engine is allowed to attain steady state for duration of about 15 minutes. The specification of DPF and DOC has been shown in table 2 and 3 respectively. The properties of hydrazine hydrate have been shown in table 4.

Fig 1. Photograph of Diesel engine used for experimentation

Fig 2. Photograph of DPF, DOC & Injecting Hydrazine Hydrate at exhaust pipe

Table 1. Specifications of Diesel Engine

Type of ignition	CI
No. of Cylinders	1
Rated Power	3.68 KW
Rated speed	1500 rpm
Bore x Stroke	80*110 mm
Compression ratio	16

Table 2: Specifications of Diesel Particulate Filter

DPF core	150×150mm
Volume	2 liter
Cell density	100cpsi
Material	Cordierite
Chemical Composition	Al_2O_3 35.2±1.5%, SiO_2 50.9±1.5%, MgO 13.9±1.5%
Compressive Strength	≥10Mpa
Porosity	≥45%
Maximum Use Temperature	≥1200℃
The average of pore diameter	7-10μm
DPF core	150×150mm
Can thickness	1.2mm
Total length	400mm
PGM	15g/ft3 Pt/Pd=3/1

Table 3: Specifications of Diesel Oxidation Catalyst

Cell density	400cpsi
Material	Cordierite
Total length	320mm
Volume	2 liter

Table 4: Properties of Hydrazine Hydrate

Appearance	Colorless Liquid
Density	1.02 g/cm^3
Boling Point	114 ºC
Freezing Point	-62 ºC
Viscosity	1.10 cp
Specific Gravity	1.021

3. RESULTS AND DISCUSSIONS

Fig.1 shows the CO emission engine at three loads when the engine is having DPF, DOC and injecting Hydrazine Hydrate. The CO emission has increased with using DPF by 15%. However, CO emission decreased with DOC as it oxidises by 45%. Hence, utilizing only DPF is not advisable and combination of both DPF and DOC is essential. The CO emission was found to be increased by 15% with DPF alone; by 8.5% with DOC alone & by 10% with DOC & DPF together. Further increased by 1% was observed when H_6N_2O was injected.

Fig.2 shows the HC emission measured from the engine when it is adopted with DPF, DOC and injecting Hydrazine Hydrate. Reduction of HC emissions is achieved by adopting DPF and DOC. Having DPF, HC emission were reduced from 23000 ppm to 20000 ppm. With DOC alone, emission was reduced from 23000 ppm to 22000 ppm. Having both DPF & DOC, HC emission was reduced from 23000 ppm to 19000 ppm.

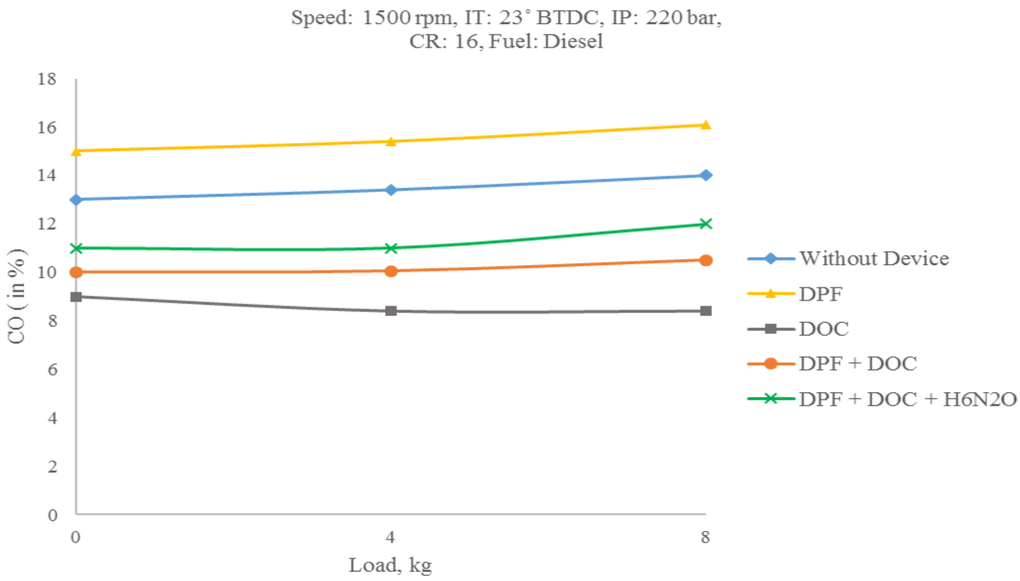

Fig1. CO emission at three loads when the engine is having DPF, DOC and injecting Hydrazine Hydrate.

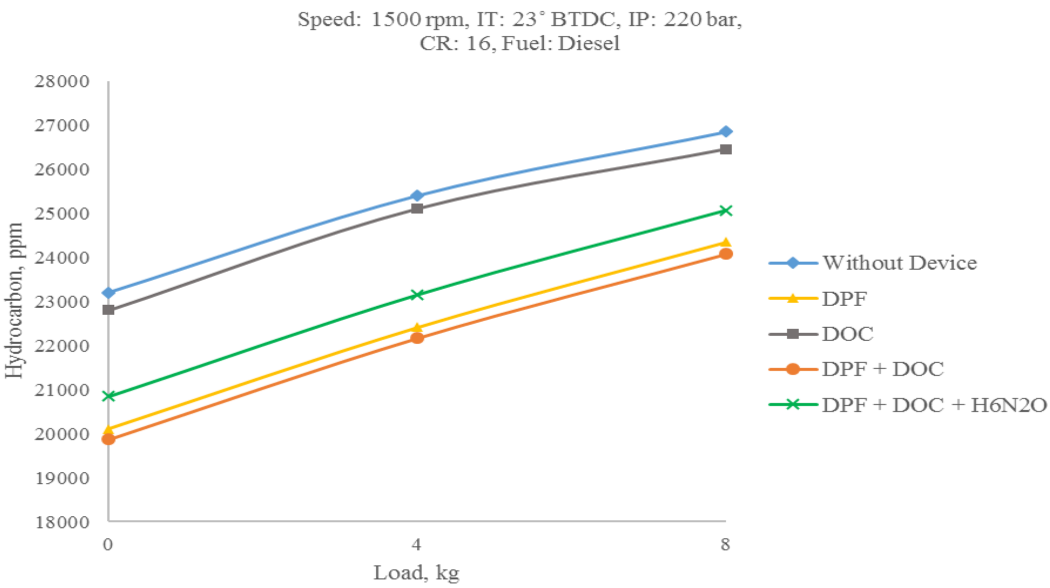

Fig 2. The HC emission of engine when it is adopted with DPF, DOC and injecting Hydrazine Hydrate.

Fig.3 shows CO_2 gas comes out of the engine at three loads. When engine is added with DPF & DOC, increase in CO emission was observed and this resulted in decrease in CO_2.

Fig.4 shows NO_x emission level reduces slightly at all the loads when the engine is having DPF. It is observed that, adopting DPF, NO_x emission is reduced by nearly 10% (from 104 to 93.6 mg/Nm_3); adopting DOC, NO_x emission is reduced by 6% (from 104 to 97.4 mg/Nm3). With DPF & DOC it reduces by 16% (from 104 to 72 mg/Nm3). The combination of DPF, DOC & H_6N_2O reduces up to 50% (from 104 to 55 mg/Nm3).

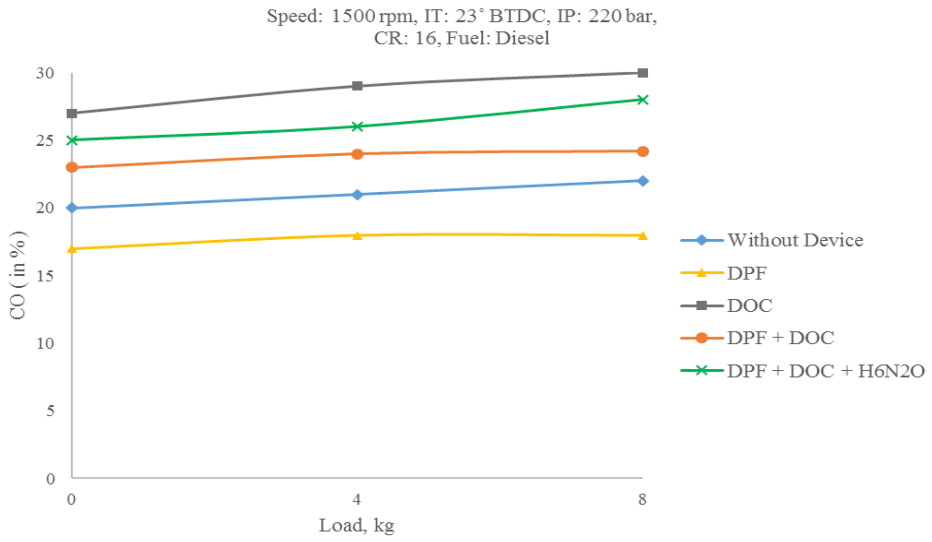

Fig 3. CO_2 emission of the engine at three loads.

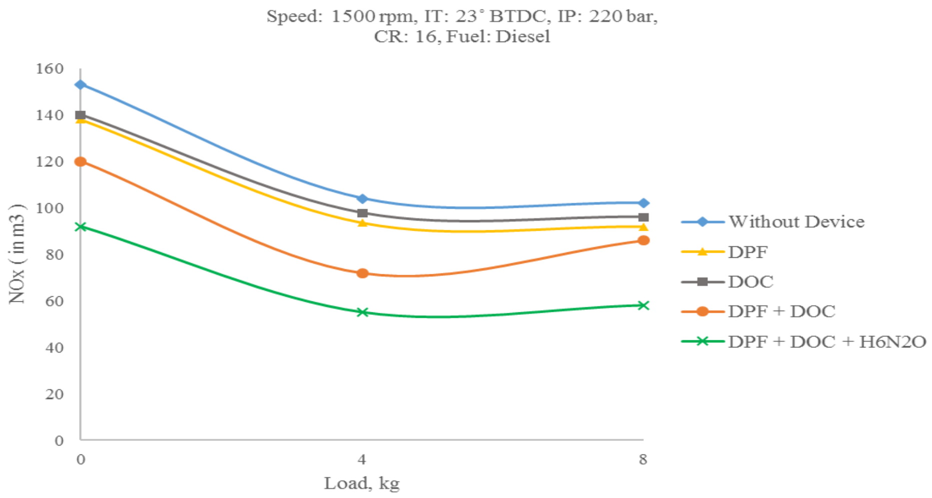

Fig 4. Reduction of NO_x emission level at all the loads.

4. CONCLUSIONS

At 4 kg load, the combination of DPF, DOC & H_6N_2O reduces NO_x up to 50% (from 104 to 55 mg/Nm^3). Overall comparison of all the results, it can be concluded that the least emission level was observed when engine is operated at 4 kg load and having DPF, DOC and also H_6N_2O. At this condition, the values are CO 11%, CO_2 26%, HC 20450 ppm, NOx 55 mg/Nm^3 When the load is increased fuel consumption is more which leads to high combustion and emissions.

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