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NO_X EMISSION CONTROL AND ANALYSIS OF C.I ENGINE EXHAUST USING WATER SPRAY AND SILICA GEL TREATMENT

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ABSTRACT

The Internal Combustion engines play major role in all modes of transportation and electricity generation. The main drawbacks of these I.C Engines are their hazardous emissions causing environmental pollution. The diesel engine emissions are considerably high compared to the petrol engines. The main pollutants contributed by diesel engines are Carbon monoxide (CO), Oxides of Nitrogen (NO_x), Unburned Hydrocarbons (HC) and other particulate emissions. Among these emissions, NO_x is considered more dangerous so it should be reduced. Hence the emission control became the biggest challenge for automobile companies. So, the only way to reduce emission is by finding various methods used to control it. The main objective of this paper is to address the reduction in NO_x emission by spraying pressurized water droplets in the exhaust gas flow and making the treated gas to pass through the Silica Gel layer for further NO_x reduction. This method is considered as simple and cost effective method compared to other emission control methods. The method showed considerable reduction in the exhaust emission of the C.I Engine.

Key Words: NO_X Emission control, Exhaust setup, Water spray, Silica gel, Emission test.

INTRODUCTION

Environment is our surrounding where all the living species live their life. Various manmade activities like transportation and electricity generation using diesel engines affect the nature of the environment and releasing hazardous gases like Carbon monoxide, Oxides of Nitrogen, Unburned Hydrocarbons and other particulate emissions [1].The major problems created by NO_x emission include acid rain when NOx reacts with water bearing clouds and lung problems when the gas is inhaled [2]. Although future transportation will be based on

electric vehicles and hybrid vehicles, the major amount of electricity for those vehicles are being produced from fossil fuels. Hence the pollution is inevitable and inorder to control the emissions, certain pollution control norms are developed by world countries. Bharat Stage Emission Standards (BSES)are developed by the Indian Government based on Euro Norms to control the vehicular emissions [3]. The emission norms for stationary diesel generators are created by Ministry of Environment and Forests, Government of India. According to Bharat Stage IV (BS IV), the Nitrogen oxide emission limit for diesel vehicles should be between 0.08 g/km to 0.11 g/km [3]. In order to meet the emission standards proposed by the governments, various methods like Exhaust Gas Recirculation (EGR) that reduce NOx upto 30%[1] [10] and Selective Catalytic Reduction (SCR) that reduce NOx upto 70% to 90%[8] [9]are adopted by automobile companies. These two methods serve their best to reduce NO_X but both of the methods have their own disadvantages [1]. So, many researches are being carried to overcome those disadvantages and to control NO_x emission in less expensive way.

Silica gel is a non-toxic odourless chemically inert material mainly made up of amorphous Silicon dioxide (SiO_2). The microstructure of the silica gel is composed of tiny microscopic pores [4]. These pores have the ability to trap water molecules as it is used as desiccant in various industries. Also, it has been proved that silica gel can absorb nitrogen compounds, sulphur compounds and CO_2 readily [11]. So, silica gel can be used as the emission absorption material.

METHODOLOGY

EXPERIMENTAL SETUP

The main components of the setup consist of a silica gel layer having around 800 m^2/g of specific surface area, a water pump with the discharge rate of 1.5 L/min and a water sprayer. The outer body of the setup is built with mild steel as it has high strength and can be expected to be readily weldable and have reasonable coldbending properties [5]. The experimental setup is illustrated in the figure below.

The water sprayer is fitted inside the cylindrical column in a way that the spraying diameter of water should cover the entire column diameter. Then the water sprayer is connected to the water pump through a pipe. The silica gel layer is made with the L/D ratio of 0.63 inorder to minimize the backpressure [4] and is placed above the water sprayer as it should not be exposed to spraying water.

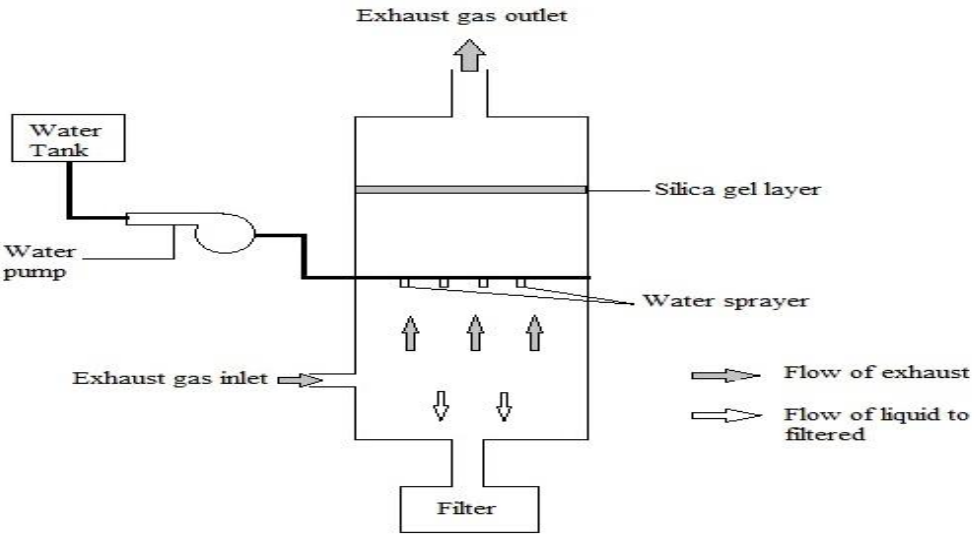

Fig. 1 Experimental setup

WORKING

In the diesel engine combustion chamber, nitrogen (N_2) and oxygen (O_2) reacts at high temperature (about 1483 K) to form nitrous oxide (NO) and nitrogen dioxide (NO_2) [6].

$$N_2(g) + O_2(g) \rightarrow 2NO(g) \text{ at } 1483 \text{ K}$$

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

The C.I engine exhaust containing carbon monoxide (CO), hydrocarbons (HC), oxides of nitrogen (NO_x) and particulate matter is passed through the gas inlet of the setup. Simultaneously, the water pump is switched ON to spray the pressurised water droplets into the gas flow. At this time, the oxides of nitrogen mainly nitrous oxide (NO) and nitrogen dioxide (NO_2) combine with water molecules (H_2O) as they have higher tendency towards hydrogen bonding and forms nitrous acid (HNO_2) and nitric acid (HNO_3) [7] [13].

$$2NO_2(g) + H_2O(l) \rightarrow HNO_3(aq) + HNO_2$$

$$2NO(g) + H_2O(l) \rightarrow 2HNO_2$$

In the above reactions, complete conversion of NO_x to the nitric acid is impossible. So, the water treated exhaust gas is then passed through the silica gel (SiO_2) layer. The silica gel containing number of microscopic pores readily absorbs the nitrogen compounds in the exhaust gas [4] [11]. This process further reduces the amount of oxides of nitrogen emission into the environment.

EMISSION TEST

The exhaust gas from the engine treated with water and silica gel is tested using a 5-Gas Analyser to determine the reduction capacity of the setup. Before the conduction of the test, the 5-Gas Analyser is properly calibrated and the diesel engine is checked for any operating problems. The engine selected for this experiment is a 4-stroke diesel engine with the following specifications.

Table 1. Engine specifications

ENGINE DETAILS	DESCRIPTION
Type of engine	Diesel engine
Type of stroke	4 Stroke
No. of cylinders	4 Cylinder
Cylinder capacity	1489 cc
Power	37 BHP

TESTING PROCEDURE

1. During the test, a set of readings are taken from the 5-Gas Analyser at different speed conditions of the engine without fixing the setup.

Table 2. Test results without the setup

Speed Variations (rpm)	**Engine Emissions**		
	NOx (ppm)	**CO (%)**	**HC (ppm)**
1500	439	2.5	1400
2500	527	2.6	1456
3500	649	2.65	1462

2. Then, at the same speed conditions, another set of readings from the 5-Gas Analyser are taken by fixing the setup.

Table 3. Test results with the setup

Speed Variations (rpm)	Engine Emissions		
	NO_X (ppm)	CO (%)	HC (ppm)
1500	432	2.4	1404
2500	522	2.56	1453
3500	648	2.6	1461

RESULTS AND DISCUSSION

The comparison between the exhaust emission without the NOx reduction setup and emission with the setup is performed using the graph below.

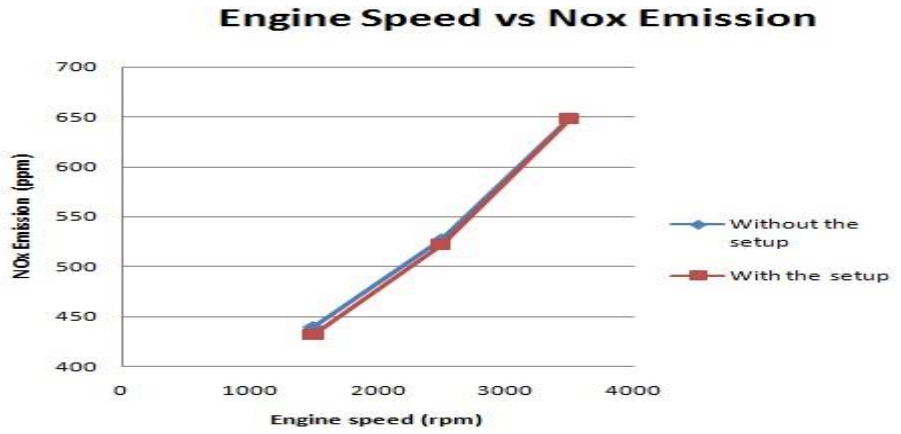

Fig.2. Comparison of NOx emission with and without the setup

Initially, at the low speed conditions, the amount of NOx from the engine is less due to minimum engine temperature. When the speed of the engine is raised, the NOx emission is increased. The fig.2 shows the reduction of Nitrogen Oxides at different engine speeds.

The performance of the NOx reduction setup can be determined by using the Fig.2. From the fig.2, we can observe the reduction of NOx using the setup varies with the engine speed. At minimum speed of the engine, the velocity of the flow of exhaust is also minimum. So, the exhaust has enough time to react with the water droplets to get reduced to nitric acid. Hence, more reduction of NO_X can be achieved in low speed conditions. The NOx reduction setup is also contributed in reducing the other harmful emissions like Carbon monoxide and Hydrocarbons.

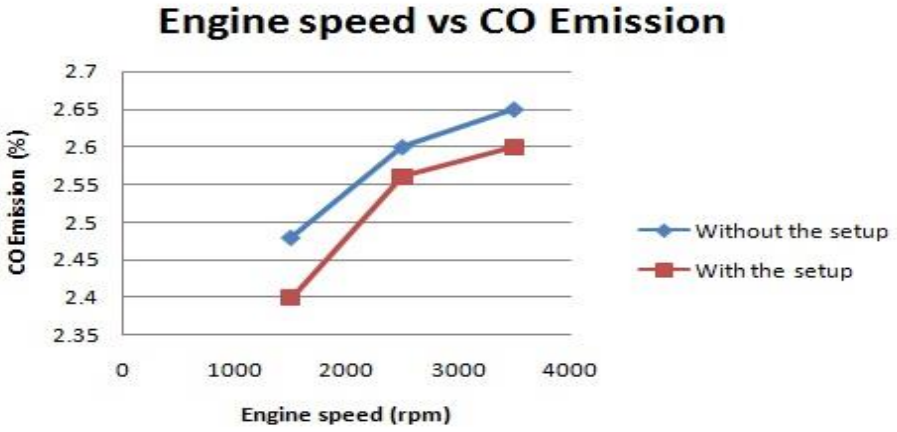

Fig.3. Comparison of CO emission with and without the setup

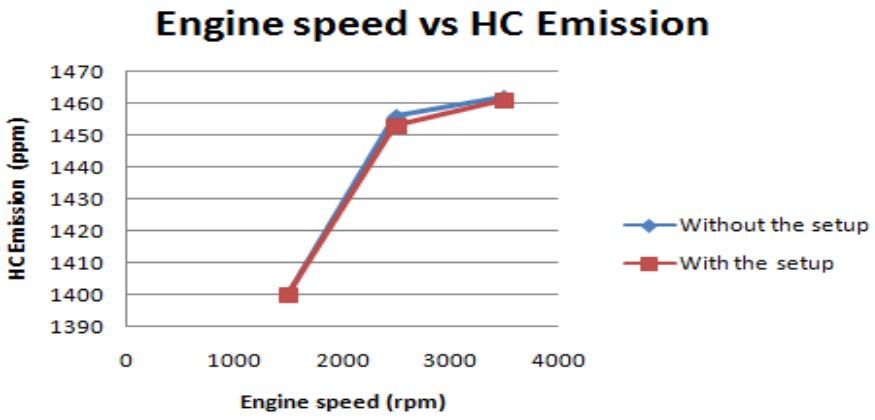

Fig.4. Comparison of HC emission with and without the setup

CONCLUSION

The results of the gas analysis have shown that the considerable reduction in the diesel engine exhaust can be achieved by the reduction setup. This setup is suitable for low and medium speed engines. In order to achieve high reduction rate, the water spray type can be changed to give tiny droplets for complete chemical reaction.

REFERENCES

I. Ali Azom, ShoukatAli,AdnanIqal .Emission From Diesel engine and Exhaust After Treatment Technologies 4th International Conference on Energy, Environment and Sustainable development 2016 (EESD 2016).
II. www.epa.gov/no_2-pollution / basic-information -about -no_2#effects
III. Pankaj Sharma, Mohit Yadav, Deepak Yadav, Devendra Vahist . A Comparative Study and Analysis of emission Norms Adopted by developed and Developing Nations. IJETSR-ISSN 2394-3386 volume 5 , Issue 1, January 2018.
IV. Vishwajit Patil Dr.L.G.Navale, Dr.M.Talib. Effect of Silica Gel based Diesel Particulate Filter on a C.I. engine .ICAAMM-2016.
V. Rakesh Kumar Sathish Kumar . Study of Mechanical Properties In Mild Steel Using Metal Inert Gas Welding. IJRET- eISSN:2319-1163|pISSN:2321-7308.
VI. Gurumoorthy S Hebbar. NO_x From Diesel Engine Emission and Control Strategies. ISSN 2278-0149 vol.3, No.4, October 2014.
VII. en.m.wikipedia.org/wiki/NO_x
VIII. R.Praveen, S.Natarajan. Experimental Study Of Selective Catalytic Reduction System On C.I Engine Fuelled with Diesel – Ethanol Blend for NO_x Reduction with Injection of Urea Solution. IJET-ISSN:0975-4024 vol 6 No 2 -2014
IX. Kirtan Aryal, Bishal Sapkota, Chiran Adikabi. Vehicular Emission control Techniques.ISSN:2321-9009, vol-4, Iss-2 Dec-2016.
X. Badamasi Maiwada, Nura Muaz, Gali Haruna Musa. Diesel Engine Modification Techniques to Minimize its Exhaust Emission (Theoretical Survey) IRD India.
XI. Divyansh Dixit, Vidyadhar Biswal, Vaibhav Singhi, Rohit Goyal, Deepak Kumar, Azroddin Ansari. Formation of Silica Gel And Gas Pollutant Adsorption. IRJET Vol.04 Issue:08 Aug-2017.