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CONTROLLING OF EXHAUST GAS EMISSIONS OF DIESEL ENGINE USING EXHAUST GAS RECIRCULATION

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ABSTRACT

Diesel engines are widely used in variety if vehicles due to its fuel efficiency and low cost compared to petrol engines. Even though it produces low carbon monoxide and hydrocarbon emission than the gasoline engines, the major particulate matter and nitrogen oxides are present in its exhaust emissions. The project deals with the control of toxic gases responsible for air pollution in normal diesel engine. The project aims to reduce some of the major toxic gases such as carbon monoxide (CO) and nitrogen oxides (NOx) in diesel engine. Potassium and Urea are treated with water in a specific proportion and it is made to react with the exhaust gases coming from the diesel engines to reduce the major toxic gases thereby reducing the pollution. The experimental work was carried in Kirloskar diesel engine and the result shows that nitrogen oxides, carbon monoxide and hydrocarbon were reduced.

Keywords: Emissions, CO, NO

1. INTRODUCTION

The diesel engine is a major candidate of the future. Before that happens, however, further progress in diesel emission control is needed. Potassium and Urea are used here which is an after treatment process in which it is not used as an additive thereby mixing with the fuel but the reaction is made to occur only at end. Therefore the engine properties would not affect much. As Potassium hydroxide attains the property of absorbing the carbon molecules, carbon monoxide is much reduced. Urea evolves ammonia which helps in reducing the nitrogen oxides thereby converting them to nitrogen molecules. The types of pollutants are Carbon Monoxide, Nitrogen oxide, Photochemical smog, Unburned Hydrocarbon and Particulate matter. Carbon monoxide is an extremely hazardous gas with no odor, color, or taste. Carbon monoxide can be formed from incomplete burning of gasoline, wood, kerosene or other fuels. Carbon monoxide is the most common cause of fatal poisonings. It's strongly recommended that all homes be equipped with a carbon monoxide (CO) detector. Nitrogen oxides (NOx), a mixture of nitric oxide (NO) and nitrogen dioxide (NO2), are produced from natural sources, motor vehicles and other fuel combustion processes. Nitric oxide is colourless and odourless and is oxidised in the atmosphere to form nitrogen dioxide. Nitrogen dioxide is an odourous, brown, acidic, highly-corrosive gas that can affect our health and environment. Nitrogen oxides are critical components of photochemical smog - nitrogen dioxide produces the yellowish-brown colour of the smog. The formation mechanisms of unburned hydrocarbons (HC) in low NOx, homogeneous-type diesel combustion have been investigated in both standard and optical access single-cylinder engines operating under low load (2 and 4 bar IMEP) conditions. In the standard engine, parameters such as injection timing, intake temperature and global equivalence ratio were varied in order to analyze the role of bulk quenching on HC emissions formation.

2. MATERIALS & METHODS

The some of the CI engine emission control technologies:

- Exhaust gas re-circulation
- Turbocharging

- Electronic fuel injection system
- Catalytic exhaust gas after treatment

Exhaust gas re-circulation (EGR) is a nitrogen oxide (NOx) emissions reduction technique used in most petrol/gasoline and diesel engines. EGR works by re-circulating a portion of an engine's exhaust gas back to the engine cylinders. In a gasoline engine, this inert exhaust displaces the amount of combustible matter in the cylinder. This means the heat of combustion is less, and the combustion generates the same pressure against the piston at a lower temperature. In a diesel engine, the exhaust gas replaces some of the excess oxygen in the pre-combustion mixture. Because NOx formation progresses much faster at high temperatures, EGR reduces the amount of NOx the combustion generates. NOx forms primarily when a mixture of nitrogen and oxygen is subjected to high temperature. In modern diesel engines, the EGR gas is cooled through a heat exchanger to allow the introduction of a greater mass of re-circulated gas. Unlike SI engines, diesels are not limited by the need for a contiguous flame front; furthermore, since diesels always operate with excess air, they benefit from EGR rates as high as 50% (at idle, where there is otherwise a very large amount of excess air) in controlling NOx emissions.

3. PROPERTIES

3..1 PROPERTIES OF POTASSIUM

It is a soft, low-melting solid Together with nitrogen and phosphorous, potassium is one of the essential macro minerals for plant survival. Potassium reacts violently with water, producing hydrogen. The reaction is notably more violent than that of lithium or sodium with water, and is sufficiently exothermic that the evolved hydrogen gas ignites.

$$2\ K(s) + 2\ H_2O(l) \rightarrow H_2(g) + 2\ KOH(aq)$$

Potassium hydroxide reacts strongly with carbon dioxide to produce potassium carbonate, and is used to remove traces of CO_2 from air. Potassium compounds generally have excellent water solubility, due to the high hydration energy of the K^+ ion.

3.2 PROPERTIES OF UREA

Urea or carbamide is an organic compound with the chemical formula $(NH_2)_2CO$. Being solid, colorless, odorless (although the ammonia which it gives off in the presence of water has a strong odor), neither acidic nor alkaline, highly soluble in water, and relatively non-toxic. Urea is widely used in fertilizers as a convenient source of nitrogen. Urea's high aqueous solubility reflects its ability to engage in extensive hydrogen bonding with water. Selective Catalytic Reduction (SCR) is a method of converting harmful diesel oxides of nitrogen (NOx) emissions, by catalytic reaction, into benign nitrogen gas and water. SCR can deliver near-zero emissions of NOx, an acid rain and smog-causing pollutant and greenhouse gas, in diesel engines. The selective catalytic reduction of nitrogen oxides (NOx) using urea or ammonia as reducing agents is being applied in diesel engines. In this process, at first urea is sprayed in the exhaust gas emitted by the diesel engines. The hydrolysis of urea is done to produce ammonia and carbon dioxide. Then the ammonia reacts with the nitrogen oxides present in the exhaust to convert it in to nitrogen. The basic chemical reactions in the urea – SCR process are as follows:

Urea Hydrolysis:

$$(NH_2)2CO + H_2O \quad CO_2 + 2NH_3$$

Nitrogen Oxides Conversion:

$$4NO + 4NH_3 + O_2 \quad 4N_2 + 6H_2O$$

$$6NO_2 + 8NH_3 \rightarrow 7N_2 + 12H_2O$$

Urea concentrations of 30 to 40 in water solution are usually employed, although higher concentrations of urea would help in reducing the weight. The NOx diesel engines consist of around 10% NO_2. Based on the stoichiometric considerations for 90% conversion of nitrogen oxides (NOx), the NH_3-NOx molar ratio of about 0.9 is required. The emissions are analyzed by the Exhaust Gas Analyzer. The modification made in the selective catalytic reduction is that instead of the spraying mechanism followed and shown in Fig 1, the exhaust outlet is connected to the inlet of the tank without any leakage and it is immersed in the Urea and water mixture to ensure complete reaction.

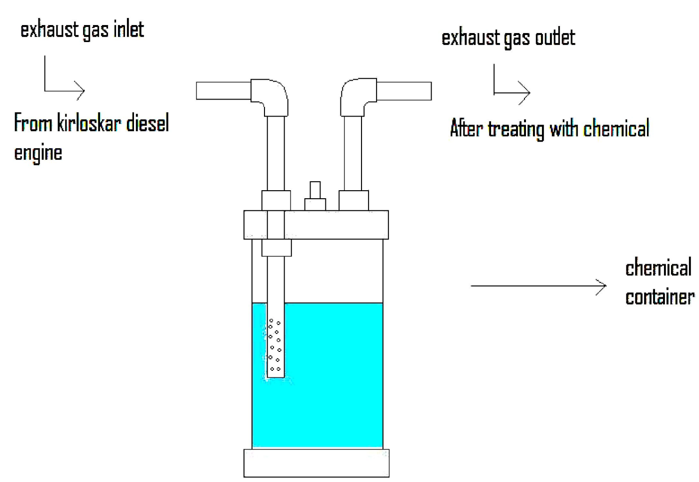

Fig.1 Schematic representation of the tank

During the functioning of the diesel engine, the concentration of the nitrogen oxides in the exhaust gases varies all the time requiring continuous urea injection therefore instead of spraying, urea is mixed with water in a proportion of 30% to 40% of urea per liter of water. And it is kept in a separate tank in which the exhaust from the diesel engine made to react with water through a pipe immersed in it. So that the exhaust gases comes out in the form of bubbles by passing through the urea solution. The excess urea injection rate would result in emission of unreacted ammonia in the exhaust which is called as the ‘ammonia slip’. Therefore this immersive method may reduce such a problem as reaction progresses based on the amount of exhaust coming from the engine. When urea is mixed with water, the temperature automatically goes down which reduces the temperature of he exhaust gases coming from the engine.

Refilling of the solution or is done from the inlet pipe provided at eh top of the tank and removal of the solution can be done by the provision at the bottom of the tank. Results have shown reduction in carbon monoxide (CO) and hydrocarbon (HC) . Another test have been performed with replacement of potassium in the place of Urea with the same working conditions and a comparison have been made which shows reduction in carbon monoxide and nitrogen oxides. The reaction performed here is,

$$2KOH + 2CO + 0.5\ O_2 \quad 2\ K_2CO_3 + H_2O$$

4. EXPERIMENTAL SETUP & PROCEDURE

The engine is run with various load conditions the time taken, 10cc fuel consumption and exhaust gas emissions are measured. The engine set up is shown in Fig 2 which consists of electrical loading set up

Fig 2 Experimental set up

Run 1- Readings Taken without treatment

S.No	Load	Speed	Exhaust Temp	CO	O_2	CO_2	NO_X	HC
	kw	rpm	(°C)	%	%	%	ppm	ppm
1	0	1580	52	0.91	16.94	2.92	699	7
2	0.6	1525	55	0.103	15.82	3.42	1121	9
3	1.2	1516	60	0.114	14.67	4.27	2086	14
4	1.8	1507	66	0.135	12.92	5.38	3048	22
5	2.4	1493	72	0.150	12.04	6.41	4163	24
6	3.0	1479	82	0.168	9.95	7.61	4904	39

RUN2-Readings Taken when exhaust gas treated with Urea

S.No	Load	Exhaust Temp	CO	O_2	CO_2	NO_X	HC
	kw	(deg Celsius)	%	%	%	Ppm	Ppm
1	0	37	0.032	16.48	2.52	0556	5
2	0.6	37	0.058	15.32	3.54	0957	7
3	1.2	37	0.082	14.26	4.52	1937	13
4	1.8	38	0.089	12.38	5.33	2542	17

RUN3-Readings Taken when exhaust gas treated with potassium hydroxide

S.No	Load	Exhaust Temp	CO	O_2	CO_2	NO_X	HC
	Kw	(deg celsius)	%	%	%	Ppm	ppm
1	0	36	0.085	16.65	2.67	439	17
2	0.6	36	0.099	15.45	3.54	714	21
3	1.2	36	0.078	14.07	4.41	1472	28
4	1.8	36	0.093	11.78	5.49	2475	29
5	2.4	36	0.109	10.5	6.82	3365	35

Comparison of Run 1, 2 and 3 table

S.No	Load	CO present in RUN1	CO present in RUN2	Comparison of CO Emission reduction	NOX present in RUN1	NOX present in RUN3	Comparison of NOX Emission reduction	HC present in RUN1	HC present in RUN2	Comparison of HC Emission reduction	CO present in RUN1	CO present in RUN3	Comparison of CO Emission reduction
	kw	%	%	%	PPM	PPM	%	PPM	PPM	%	%	%	%
1	0	0.91	0.032	96.40	699	439	37.1	7	5	28.57	0.91	0.085	90.6
2	0.6	0.103	0.058	43.60	1121	714	36.3	9	7	22.22	0.103	0.099	3.8
3	1.2	0.114	0.082	28.07	2086	1472	29.4	14	13	7.14	0.114	0.078	31.57
4	1.8	0.135	0.089	34.07	3048	2475	18.7	22	17	22.7	0.135	0.093	31.1
5	2.4	0.150	0.118	21.30	4163	3365	19.1	24	21	12.5	0.150	0.109	27.3
6	3.0	0.168	0.152	9.52				39	29	25.64			

5. RESULTS & DISCUSSION

The experiment has been conducted at various load conditions (Run1,2 and 3) and the emission parameters carbon monoxide, hydrocarbon and nitric oxide is noted using gas analyzer. The result reveals that by using potassium and urea the exhaust gas is found as decreased. Higher decrement in CO emission is obtained for no load conditions. Also for all load conditions the CO emission is found decreases with after treatment. Greater reduction in NO emission is found with potassium after treatment as compared to others. Compared with standard readings the HC emission is found decreased more while using urea. Overall the usage of urea and KOH results as reduction in emission using after treatment method.

6. CONCLUSION

In this investigation it is analyzed that carbon monoxide and nitrogen oxides are controlled by urea and potassium solutions in the diesel engine and the following conclusions have arrived: Comparing with normal emission in the diesel engine, nitrogen oxides level is being reduced by potassium. Comparing with normal emission in the diesel engine, hydro carbon level is being reduced by urea. Carbon monoxide level is reduced by urea and potassium hydroxide.

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