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Emission Control by Catalytic Converter in Diesel Engine by using Alternative Fuel with Injecting Urea Solution

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ABSTRACT

A catalytic converter is an emission control device that converts toxic gases and pollutants in exhaust gas to less toxic pollutants by catalyzing a redox reaction. Catalytic converters are used with internal combustion engines fueled by diesel. catalytic converters are most commonly applied to exhaust system in automobile. Now a days exhaust emission control from internal combustion engine have become one of the most important challenges.

There are various techniques existing for CO, HC, and NOx control but each technique has its own advantage and disadvantages. Technologies available for CO, HC and NOx reductions either increase other polluting gas emission or increase fuel consumption. Oxides of nitrogen (NOx) are one of the major hazardous pollutant that come out of diesel engines.

In this proposal work is planned to study experimentally maximum reduction of emissions (HC, CO and NOx) by varying concentration of blended fuel (Neem & Methanol oil with Diesel)with urea solution with catalytic converter. An aqueous solution of urea was directly injected in catalytic converter for reducing NOx emission in single cylinder light duty stationery DI Diesel Engine.

A concentration of urea solution 32.5% by weight as per ISO 22241 with constant flow rates and tested with catalytic converter which control by products of ammonia and vapor.

Test were conducted in a single cylinder direct injection diesel engine. The engine is to be operated using diesel, ester of vegetable oil like neem and eucalyptus oils. In all the above cases emission characteristics are to be analysis

INTRODUCTION

A catalytic converter is an equipment used to reduce the harmful emissions from an internal combustion engine. These converters fitted in the exhaust of engine ducts of fossil fueled vehicles convert harmful gases into less harmful or neutral gases. They convert almost all the carbon monoxide, and nitrogen oxides and hydrocarbons into carbon dioxide or nitrogen and water. Since it was invented more than 96% of cars today come with these converters pre-installed.

Not only automobiles they are also used in various other aspects where internal combustion takes place and fuel burns. The major role of these converters is to give these toxic gases an environment wherein they undergo chemical reaction to become less toxic. These are precisely placed between engine manifold and exhaust tailpipe to receive the gases from the engine.

Catalytic converter could be only device that converts harmful gases because of engine exhaust into eco-friendly gases. During this report, we've tried to bring into focus importance of reducing pollution and why converter is important inautomobile. Wehave a tendency to conjointly bring advance technology recognized currently daily reducing pollution. By best effort, we have a tendency to try and focus necessity of subject. We have a tendency to hope our report is one step ahead along this direction.

Although chemical action converters are most ordinarily applied to exhaust systems in vehicles, they're additionally used on electrical generators, forklifts, mining instrumentation, trucks, buses, locomotives and motorcycles. They're additionally used on some wood stoves to manage emissions. This can be typically in response to government regulation, either through direct environmental regulation or through health and safety laws.

Carbon dioxide causes environmental issues associated with warming. The past century has been a dramatic increase within the atmosphericallyconcentration of heat-trapping gasses, because of act. If this trend continues, scientists project that the earth's average surface temperature can increase between 2.5 ºF and 10.4 ºF by the year 2100. One among these necessary heat-trapping gasses is CO_2. Carbon monoxide gas (CO) is taken into account as poisonous waste material, whose effective reduction are often achieved by victimization convertor

SCR could be a method for reducing the concentration of Roman deity from the combustion exhaust that involves the injection of solution of organic compound within the tail pipe of a four stroke, constant speed DI ICE. Ammonia has been dominated out as a reluctant, due toxicity and handling problems. Thus organic compound has been hand-picked for chemical agent of selection for many applications, hold on board in associate degree solution. To beat the difficulties related to pure ammonia, organic compound is chosen. Organic compound are often hydrolysed and rotten to come up with ammonia. Associate degree injectedof organic compound solution is made into pure ammonia and vapour, then pure ammonia reacts with oxides of chemical element and reduced into eco-friendly chemical element and vapour.

2. DEVELOPMENT METHODOLOGY

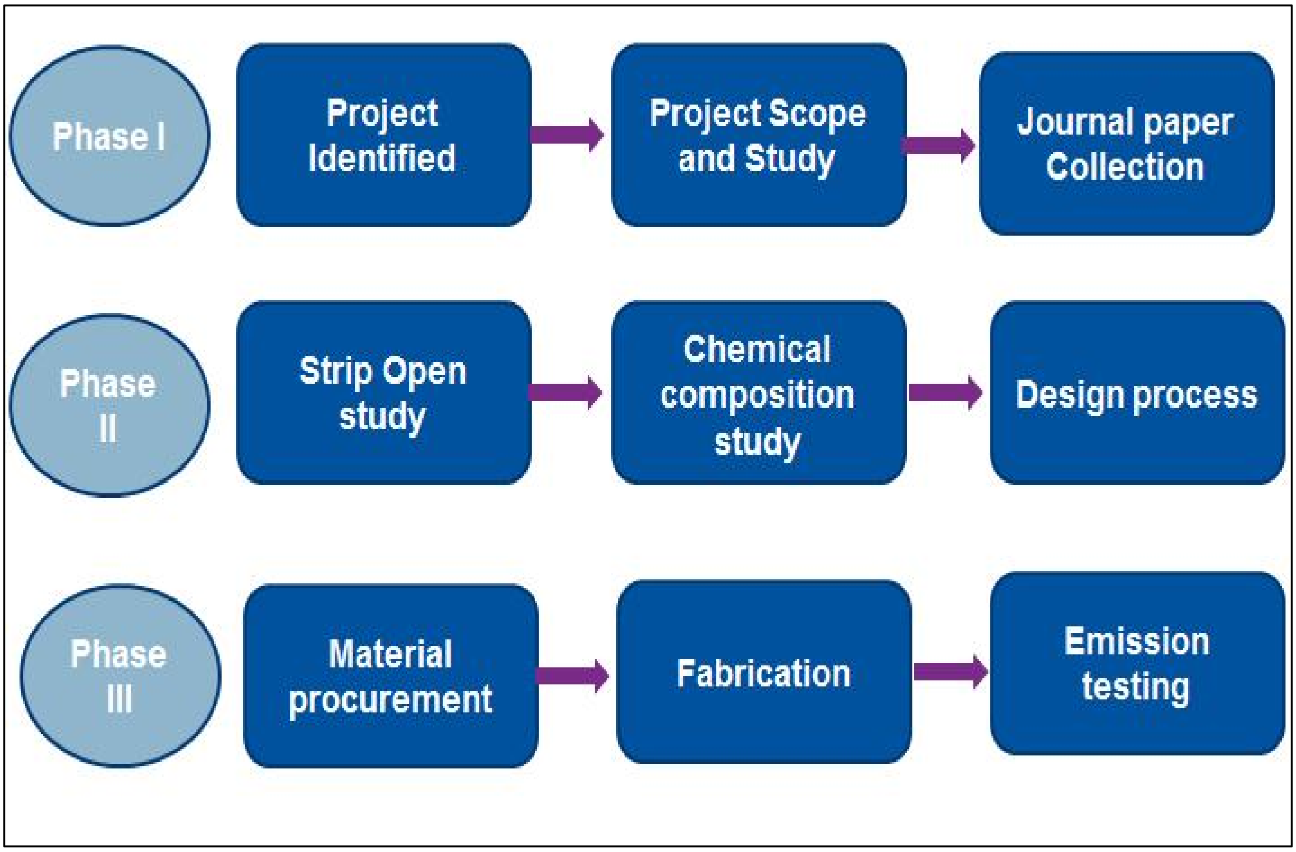

Fig 1 : Process Chart

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2.1 Schematic of UREA Injection System

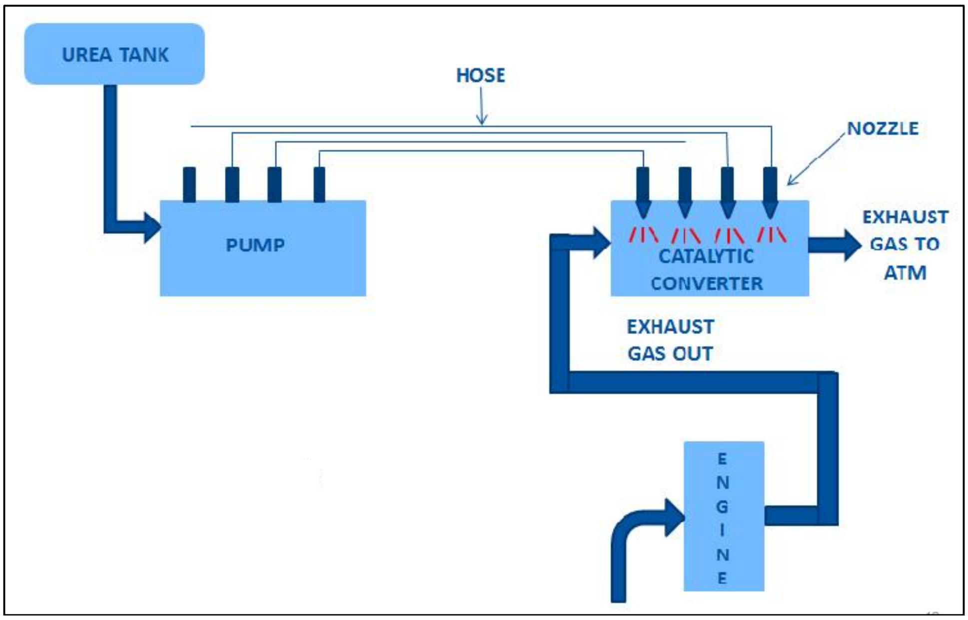

Figure.2:Schematic of UREA Injection System

2.1 Urea solution

Diesel exhaust fluid (DEF) is an aqueous urea solution made with 32.5% urea and 67.5% deionized water. It is standardized as AUS 32 (aqueous urea solution) in ISO 22241. DEF is used as a consumable in selective catalytic reduction (SCR) in order to lower NOx concentration in the exhaust emissions from diesel engines. Urea solution injected constantly 1lit per hour at 2 bar pressure.

Diesel engines are run with a lean burn air-to-fuel ratio (over stoichiometric ratio), to make sure the complete combustion of soot and to forestall the exhaust of unburnt fuel. The surplus of air essentially results in generation of mono-nitrogen oxides (NOx) that are harmful pollutants, from the gas within the air. Selective chemical process reduction is employed to cut back the quantity of NOx released into the atmosphere.

Diesel exhaust fluid (DEF) from a separate tank is injected into the exhaust pipeline, wherever the binary compound organic compound vaporizes and decomposes to form ammonia and carbon oxide. Within the SCR catalyst, the NOx are catalytically reduced by the ammonia (NH_3) into water (H_2O) and nitrogen (N_2), which are both harmless; and these are then released through the exhaust.

SCR systems are sensitive to potential chemical impurities in the urea solution, therefore the solvent is demineralized water.

DEF is a 32.5% solution of urea, $(NH_2)_2CO$. When it is injected into the hot exhaust gas stream, the water evaporates and the urea thermally decomposes to form ammonia and isocyanic acid:

$(NH_2)_2CO \rightarrow NH_3 + HNCO$

The Isocyanic acid hydrolyses to carbon dioxide and ammonia:

$HNCO + H2O \rightarrow CO_2 + NH_3$

Overall, this is

$(NH_2)_2CO + H_2O \rightarrow 2\ NH_3 + CO_2$

From this point, ammonia, in the presence of oxygen and a catalyst, will reduce nitrogen oxides

$2\ NO + 2\ NH_3 + 1/2\ O_2 \rightarrow 2\ N_2 + 3\ H_2O$ and

$3\ NO_2 + 4\ NH_3 \rightarrow 3\ 1/2\ N_2 + 6\ H_2O$

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The overall reduction of NOx by urea is:

$2\,(NH_2)_2CO + 4\,NO + O_2 \rightarrow 4\,N_2 + 4\,H_2O + 2\,CO_2$ and

$2\,(NH_2)_2CO + 3\,NO_2 \rightarrow 3\,1/2\,N_2 + 4\,H_2O + 2\,CO_2$

Table 1: Properties of Aqueous Urea Solutions

SI.no	TERMS	VALUE
1	Chemical Formula	$(NH_2)_2CO.7H_2O$
2	Molecular Weight (g/mol)	60.06
3	Concentration (%)	32.5
4	Density (15 ° C) (kg/lt)	1.085
5	Appearance	Clear Transparent
6	Smell	Odourless
7	Acidity (PH)	9-11
8	Freezing Point(° C)	-11
9	Self-Ignition Temperature (° C)	630

2.2 Nozzle (0.5 mm diameter)

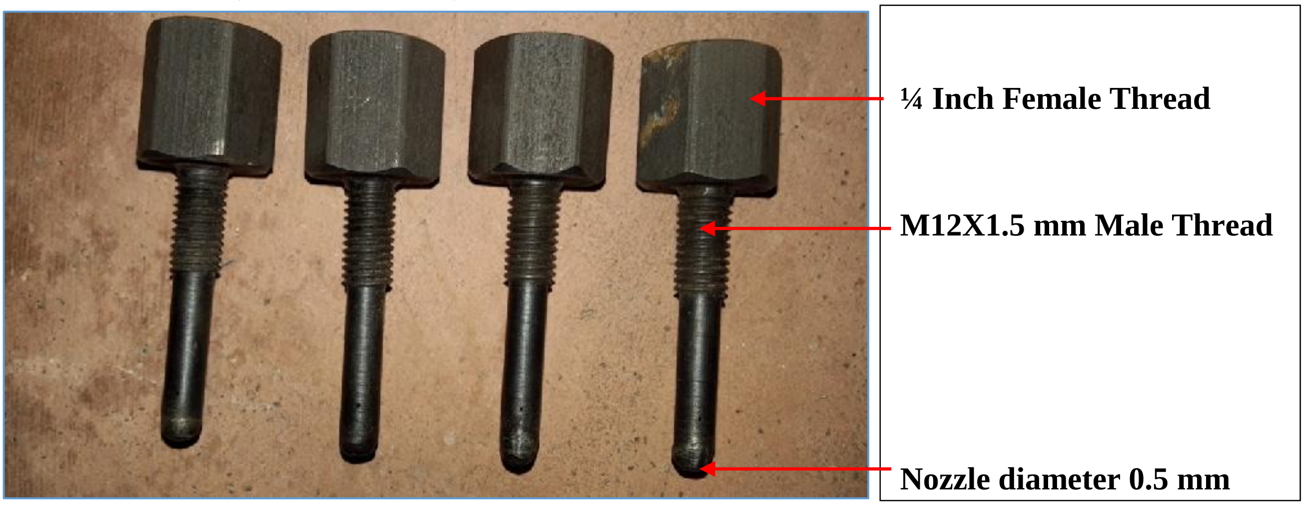

Figure.3: Nozzle

2.3 Pump

Specification: **Stroke: 0-100 mm**

Pulse: 0 to 100

Voltage: 230 V

Figure.4: Dosing Injection pump

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Specification:

Make: Festo

Range: 0 to 16 bar

Medium: Water

Figure.5: Fitting and Pressure gauge

2.4 Blended fuel ratio detail

Table 2: Blended fuel ratio details

BLEND NAME	DIESEL (%)	METHANOL (%)	NEEM (%)
B5	85%	5 %	10 %
B10	75%	5 %	20 %
B15	65%	5 %	30 %
B20	55%	5 %	40 %
B25	45%	5 %	50 %

3. EMISSION TEST AND RESULT

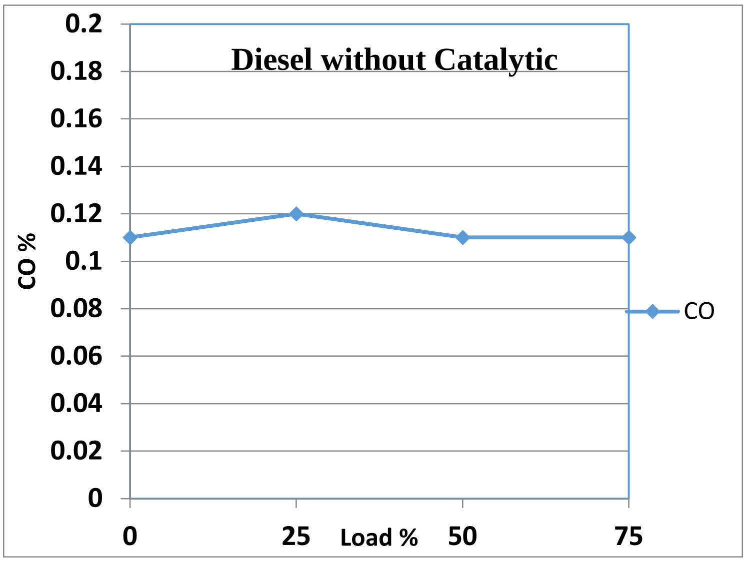

Figure 6: Test Graph- CO emission -Diesel without Catalytic converter

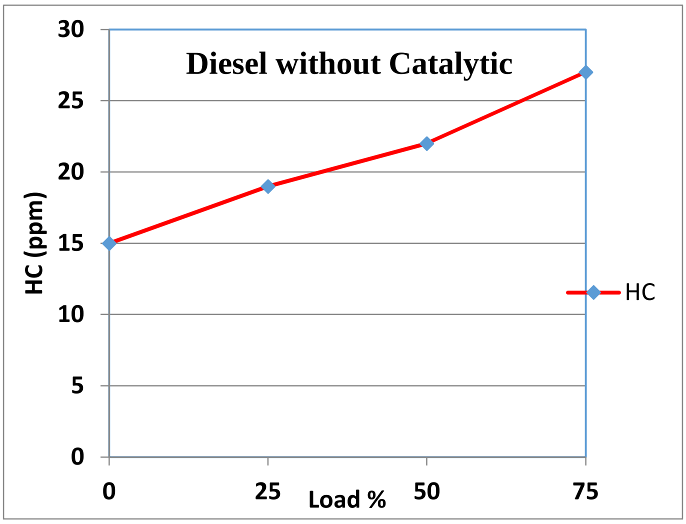

Figure.7: Test Graph- HC emission -Diesel without Catalytic converter

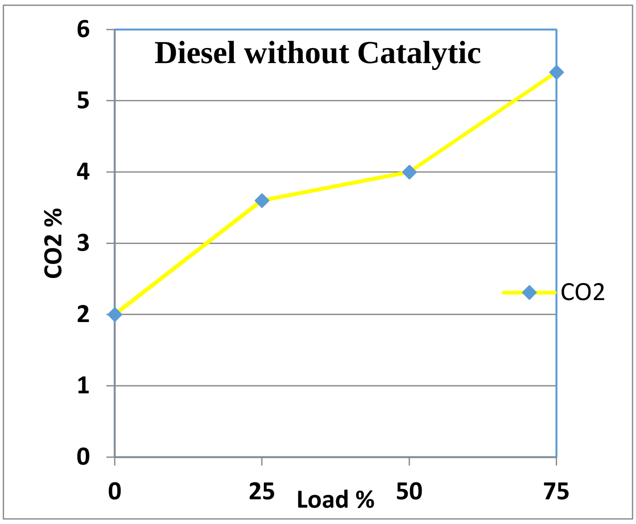

Figure.8: Test Graph - CO_2 emission -Diesel without Catalytic converter

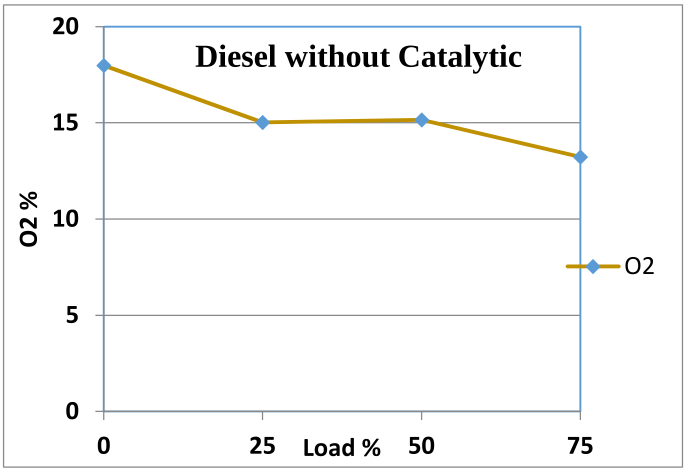

Figure.9: Test Graph - O_2 emission -Diesel without Catalytic converter

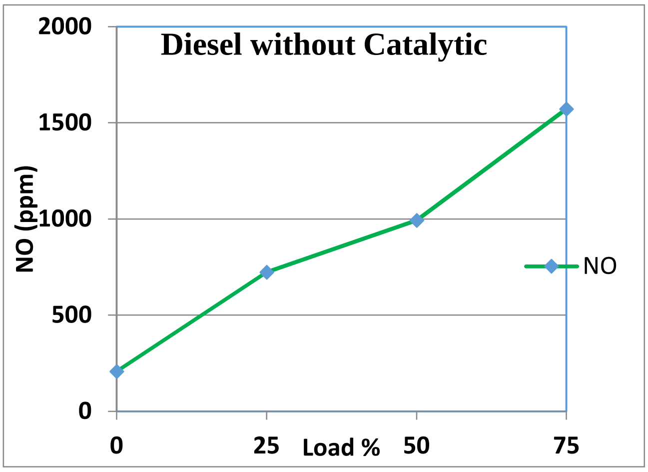

Figure.10: Test Graph - NOx emission -Diesel without Catalytic converter

3.1 Carbon monoxide (CO) Emission

Carbon monoxide (CO) is a very important emission occurring in associate engine. CO emissions happen thanks to the unfinished combustion of the fuel, principally thanks to lack of atomic number 8 atoms for effective combustion to occur. Another excuse for CO emissions is that the lack of your time for effective combustion to occur. The variation in CO emission for diesel, neat biodiesel and therefore the numerous blends at numerous different the engine are shown in figure. It is seen that there's a major reduction within the CO emissions whereas mistreatment biodiesel blends with convertor organic compound injection system in

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comparison to diesel while not convertor. The rationale for the reduced CO emissions is that the simpler and complete combustion happening thanks to the redoubled variety of atomic number 8 atoms within the biodiesel. The supply of enough atomic number 8 atoms causes most of the CO to be modify and regenerate to carbonic acid gas however the whole conversion of CO to carbonic acid gas is rarely doable.

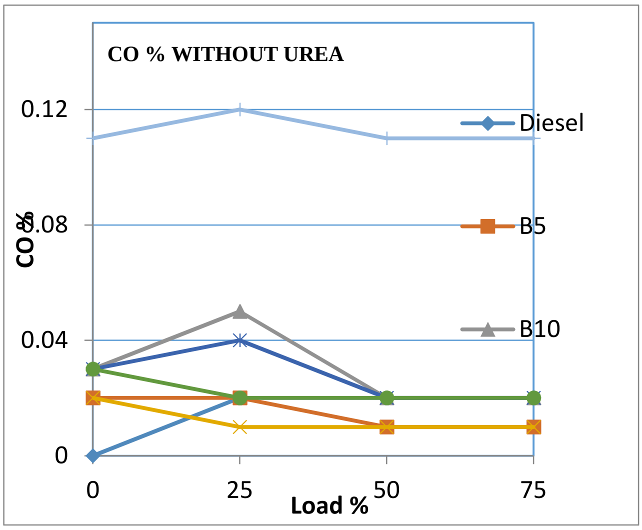

Figure.11: Test Graph – CO Emission without Urea solution

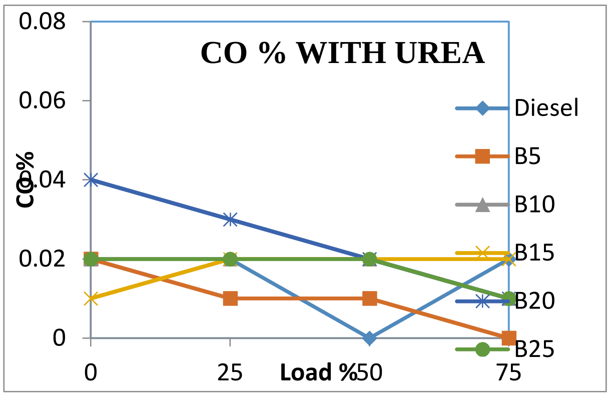

Figure.12: Test Graph – CO Emission with Urea solution

- In figure 11 with catalytic converter, The CO (%) Emission is reduced from 0.11 to 0.02 % compared with without catalytic converter by using diesel fuel.

- In figure 12, Blended fuel B10 and B25: Catalytic converter with urea solution, The CO (%) Emission is reduced from 0.05 to 0.02 % compared with without urea solution.

- In figure 12, Blended fuel B15 and B20: Catalytic converter with urea solution, significant change in CO (%) Emission compared with without urea solution.

3.2 Hydrocarbons (HC) emission

Hydrocarbons (HC) are another prominent parameter within the emission characteristics of an internal-combustion engine. Like CO emissions, HC emission happens once the fuel molecules fail to burn utterly within the engine. The variations in HC emission for fuel, pure biodiesel, and also the numerous blends at variable hundreds on the engine. The figure shows 26 and 27 that the HC emissions of biodiesel blends are abundant below those of fuel. It may also be seen that rock bottom HC emissions were recorded by B5 & B25 mix. Because the biodiesel content within the fuel mix will increase, the HC emissions decrease. The reduction in HC emissions whereas exploitation biodiesel because the fuel will be attributed to the economical and additional complete combustion going down because of the presence of bigger range of element atoms within the biodiesel fuel blends.

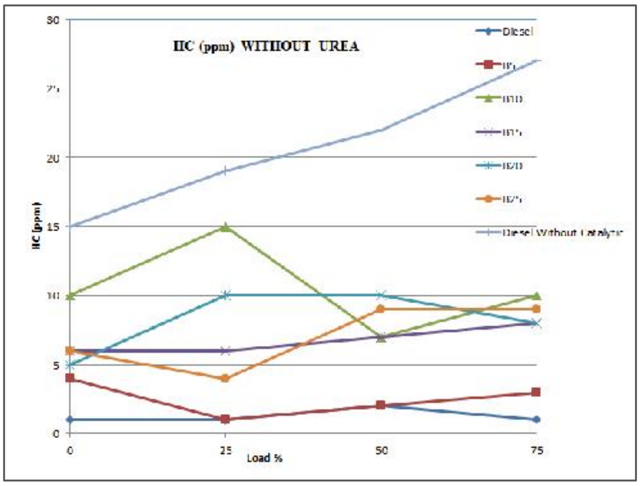

Figure.13: Test Graph – HC (ppm) Emission without Urea solution

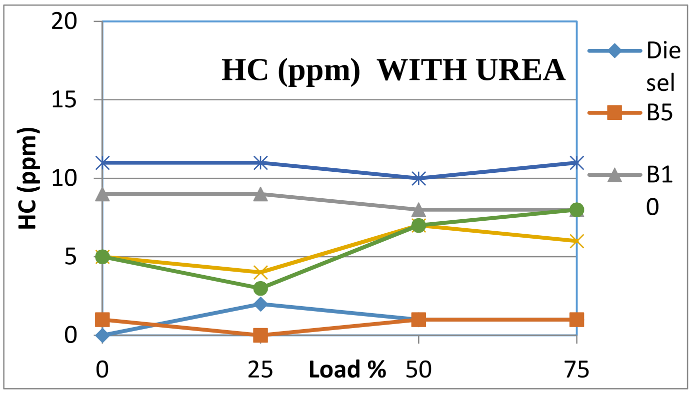

Figure.14: Test Graph – HC (ppm) Emission with Urea solution

- With catalytic converter, The HC (ppm) Emission is reduced from 27 to 2 ppm compared to without catalytic converter by using diesel fuel.
- In figure 13 and 14, it can be seen that there is a significant reduction in HC emissions while using biodiesel blends (B5, B10, B15 and B25) with catalytic converter urea injection system when compared to diesel without catalytic converter.

3.3 Carbon di oxide (CO_2) emission

Carbon dioxide enters the atmosphere through burning fossil fuels (coal, gas, and oil), solid waste, trees and wood product, and conjointly as results of bound chemical reactions (e.g., manufacture of cement). CO2 is removed from the atmosphere (or "sequestered") once it's absorbed by plants as a part of the biological carbon dioxide cycle.

Most of the greenhouse emission came out from diesel motor.

It may be seen that there's a major reduction within the greenhouse emission emissions whereas mistreatment of biodiesel blends with convertor carbide injection system when put next to diesel without catalytic convertor.

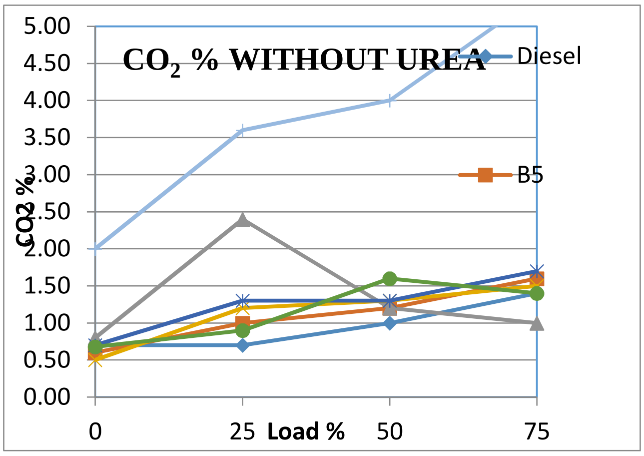

Figure.15: Test Graph – CO_2 (%) Emission without Urea solution

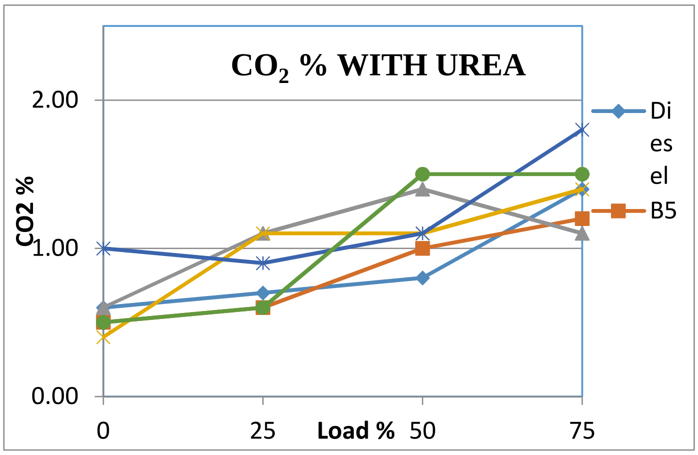

Figure.16: Test Graph – CO2 (%) Emission with Urea solution

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With catalytic converter, The CO_2 (%) Emission is reduced from 5.4 to 1.4 (%) compared to without catalytic converter by using diesel fuel

In figure 16, it can be seen that there is a significant reduction in the CO2 emissions while using biodiesel blends (B5, B10, B15, B20 and B25) with catalytic converter urea injection system when compared to without urea solution.

3.4 Oxygen (O2) emission

The O2 sensing element is mounted within the manifold to watch what proportion unburned O is within the exhaust because the exhaust exits the engine. Watching O_2 levels within the exhaust could be a method of gauging the fuel mixture. It tells the pc if the fuel mixture is burning wealthy (less oxygen) or lean (more oxygen).

It is seen that there's a major maintenance within the O_2 emissions whereas exploitation biodiesel blends with convertor organic compound injection system compared to diesel without catalytic convertor.

The variation of oxygen emissions with variation in load for different blends of biodiesel Shown below

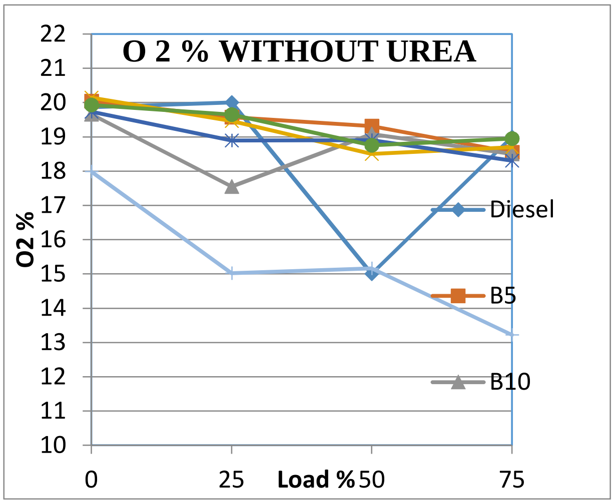

Figure.17: Test Graph – O2 (%) Emission without Urea solution

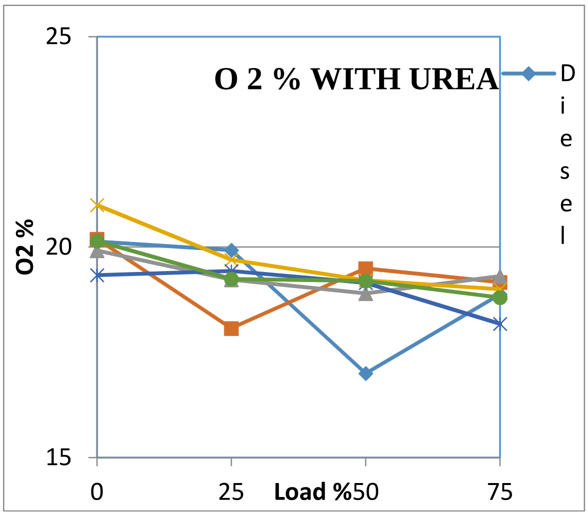

Figure.18: Test Graph – O2 (%) Emission with Urea solution

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In figure 18 it can be seen that there is a significant maintenance in O_2 emissions while using biodiesel blends (B5, B10, B15, B20 and B25)with catalytic converter urea injection system when compared to diesel without catalytic converter.

3.5 NOx emission

The variations of NOx emissions for diesel and biodiesel blends for various engine loads are shown in the figure. NOx emission from an engine increases with increase in power output of the engine. The NOx emission from an engine depends upon the maximum combustion temperature and the availability of oxygen. When the combustion temperature inside the engine exceeds a particular limit, atomic nitrogen combines with free oxygen to form oxides of nitrogen (NOx). Since the combustion temperature is higher and the oxygen concentration is greater for biodiesel, it can be seen that the NOx emissions of biodiesel and its blends are higher than those of diesel at all loads on the engine.

It can be seen that there is a drastic reduction in the NOx emissions while using biodiesel blends with catalytic converter urea injection system when compared to diesel without catalytic converter

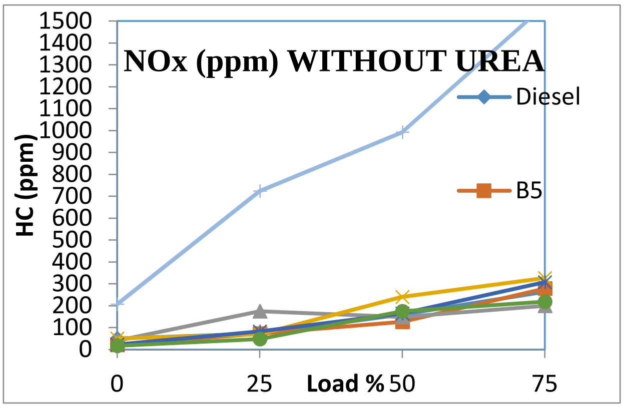

Figure.19: Test Graph – NOx (ppm) Emission without Urea solution

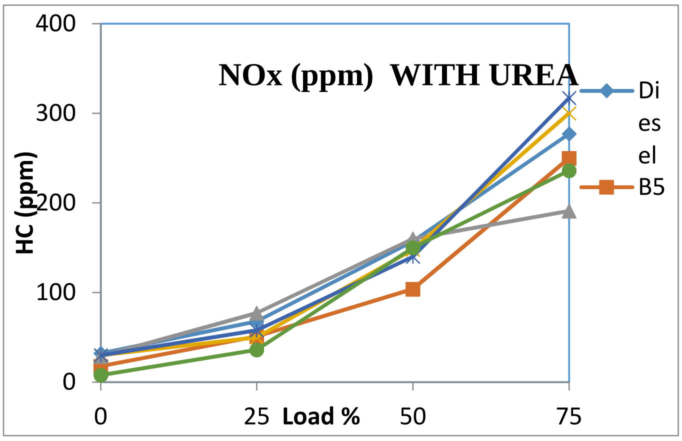

Figure.20: Test Graph – NOx (ppm) Emission with Urea solution

In figure 20 it can be seen that there is a drastic reduction in the NOx emissions while using biodiesel blends (B5, B10, B15, B20 and B25) with catalytic converter urea injection system compared to diesel without catalytic converter.

4. SMOKE DENSITY

Smoke Density (also referred to as “Light Extinction Coefficient” and “Light Absorption Coefficient”). A fundamental means that of quantifying the effect of a smoke plume of smoke containing gas sample to obscure light-weight. By convention, smoke density is expressed on a per meter basis.The smoke density could be a function of the amount of smoke particles per unit gas volume, the scale distribution of the smoke particles, and also the light absorption and scattering properties of the particles. Within the absence of blue or white smoke, the scale distribution and also the light absorption/scattering properties square measure similar for all diesel exhaust gas samples and also the smoke density is primarily a function of the smoke particle density.

4.1 Diesel without Catalytic converter

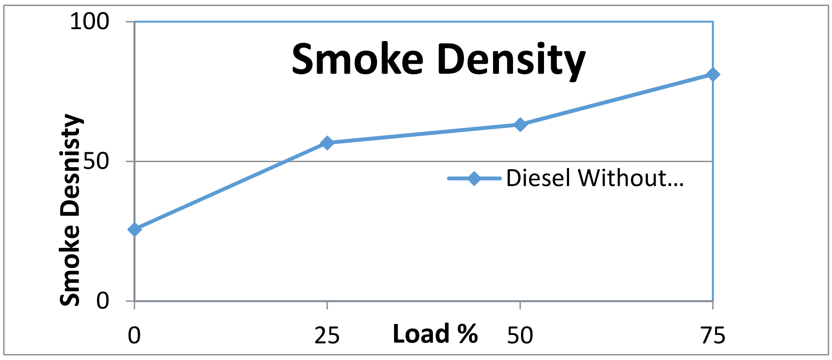

Figure.21: Test Graph-Smoke Density without catalytic

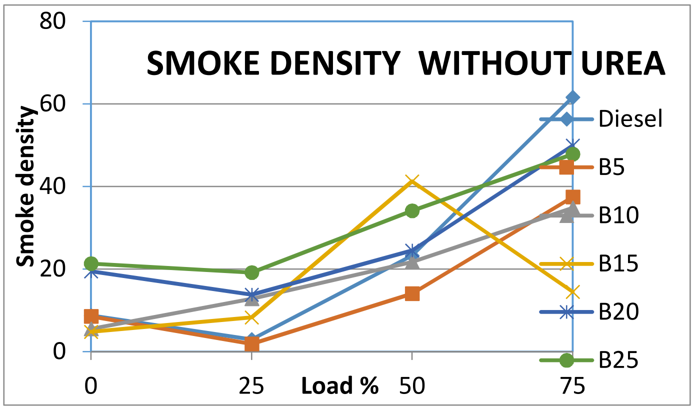

Figure.22: Test Graph-Smoke Density with urea

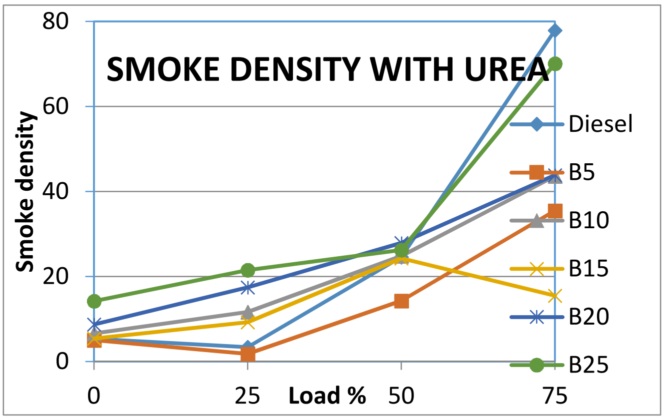

Figure.23: Test Graph-Smoke Density with urea

In figure 23, it can be seen that there is a significant reduction in the Smoke density emissions while using biodiesel blends (B5, B10, B15, B20 and B25) with catalytic converter urea injection system when compared to diesel without catalytic converter.

5. RESULT AND DISCUSSION

- CO emission is reduced, compared to without catalytic converter.
- HC emission is reduced, compared to without catalytic converter.
- CO2 emission is reduced, compared to without catalytic converter.
- NOx emission is reduced, compared to without catalytic converter.
- O2 emission is reduced, compared to without catalytic converter.
- Drastic reduction in NOx emissions while using biodiesel blends with catalytic converter urea injection system when compared to diesel without catalytic converter.
- Significant reduction in HC emissions while using biodiesel blends with catalytic converter urea injection system when compared to diesel without catalytic converter.
- Significant reduction in CO emissions while using biodiesel blends with catalytic converter urea injection system when compared to diesel without catalytic converter.

The properties of biodiesel and their blends are compared with those of ASTM biodiesel standards. Most of the fuel properties of Neem and the blends are comparable to those of diesel.

The results show that there is drastic and consistent reduction in NOx emission using bio-diesel blends with catalytic convertor using Urea solution injection.

6. CONCLUSION

An experimental investigation was conducted in Emission HC, CO,NOx of Neem oil and its fuel blends with diesel in a direct-injection single-cylinder diesel engine and the results obtained suggest the following conclusions:

- Drastic reduction in NOx emissions while using biodiesel blends with catalytic converter urea injection system when compared to diesel without catalytic converter.
- Significant reduction in HC emissions while using biodiesel blends with catalytic converter urea injection system when compared to diesel without catalytic converter.
- Significant reduction in CO emissions while using biodiesel blends with catalytic converter urea injection system when compared to diesel without catalytic converter.
- With catalytic converter, CO (%) emission is reduced 0.11 to 0.02 % compared to without ence catalytic converter by using diesel fuel.
- Blended fuel B10 and B25: Catalytic converter with urea solution, CO (%) emission is reduced 0.05 to 0.02 % compared to without urea solution.
- Blended fuel B15 and B20: Catalytic converter with urea solution, significant change in CO (%) emission compared to without urea solution.
- With catalytic converter, HC (ppm) emission is reduced 27 to 2 ppm compared to without catalytic converter by using diesel fuel.
- There is a significant reduction in HC emissions while using biodiesel blends (B5, B10, and B15and B25) with catalytic converter urea injection system when compared to diesel without catalytic converter.
- With catalytic converter, CO_2 (%) emission is reduced from 5.4 to 1.4 (%) compared to without catalytic converter by using diesel fuel
- There is a significant reduction in the CO_2 emissions while using biodiesel blends (B5, B10, B15, B20 and B25) with catalytic converter urea injection system when compared to without urea solution.
- Significant maintenance in O_2 emissions while using biodiesel blends (B5, B10, B15, B20 and B25) with catalytic converter urea injection system when compared to diesel without catalytic converter.
- Significant reduction in the Smoke density emissions while using biodiesel blends (B5, B10, B15, B20 and B25) with catalytic converter urea injection system when compared to diesel without catalytic converter.

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