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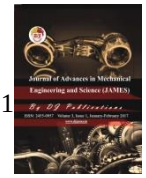

RESEARCH ARTICLE

Emission Control in Catalytic Converter by using Natural Liquid

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ABSTRACT

This project is focussed on lowering the emission of toxic gases such as Hydrocarbons (HC), Carbon monoxide (CO) and Nitrous oxide (NO_X) from the IC engines of automotive vehicles released as a result of combustion of the fuel thereby reducing the environment pollution. The discharge of toxic substances during the combustion in the automotive vehicles can be reduced by noble metal based catalytic converters which convert toxic CO and HC gases to CO_2 and H_2O respectively. In order to overcome the issues related to the use of noble metals, a novel method utilizing the natural liquids for minimizing the emission level is suggested. The pH values of natural fluids such as water, banana tree extract, cow urine and aloe vera were tested and then injected into silencer as separate liquid. Finally it is suggested to use the mixture of cow urine and banana tree extract to produce a significant reduction in emission of all the exhaust gases.

Keywords: Toxic gases, IC engines, Catalytic converters, Natural liquids, Silencer.

1. INTRODUCTION

In Internal combustion (IC) engine, the emission of toxic gases like HC, CO and NO_X occurs due to restricted combustion process by engine's cycle. The discharge level of these toxic gases are more at idle and deceleration state where less amount of air is taken by the engine for combustion. The main reasons for the formation of these gases are,

- Less oxygen intake during high air to fuel mixture.
- High temperature causing nitrogen to react with oxygen.
- Presence of lean mixtures, porous deposits and oil absorption.

These gases mainly affect the environment causing greenhouse effect, acid rain, global warming, etc. Numerous substitutes like pre-treatment of fuel, usage of renewable resources, adding additives to fuel, etc. have been developed to minimize the emission level of the engine. Of all the techniques developed so far, catalytic converter can be suggested to be the best way to control the emission level.

[1] deliberated the simulation of catalytic converters to reduce the emission of NO_X, CO and HC. In order to minimize the cost, copper powder and nickel was used as a catalyst which proved to be effective. [2, 3] analysed the exhaust emission of diesel engine concerning oxides of nitrogen and particulate matter. Although the emission of NO_X can be controlled by reducing the combustion temperature, the level of discharge of particulate matter increases making it inefficient. [4] examined high efficient catalytic converters of square and hexagonal shaped honeycomb structures. Among the two shapes, hexagonal shaped honeycomb provided low power loss.

[5] demonstrated the performance of catco which operates using titanium dioxide and cobalt oxide instead of palladium/ platinum in view of reducing the process cost. From the investigation, it was found out that the emission of NO_X, CO and HC were reduced by 24%, 41% and 40% respectively when compared with the conventional converters. [5] explained the characteristics of copper based catalytic converter for a volume

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of 1.54 m^3 in wire mesh technique and four stoke engine. It is proved that the amount of HC and CO level was reduced to 38% and 33% by using this technique. [7] elaborated a low cost catalytic converter using cerium oxide, zirconium dioxide, silver nitrate and copper substrate with a small underlying substance.

[8] discussed the latest trends in exhaust catalyst and also proposed an innovative method for separating the metal ions by solution combustion technique. [9, 10] announced the future emission legislation for light weight vehicles. It is recommended to use diesel oxidation catalyst and cooled exhaust gas recirculation for reduced emission of HC, CO and particulate matter and NO_X respectively. [11] revealed the deposition of phosphorous in accordance to the decline in the performance of the catalyst over a period of time. This paper also described a model that combined both poisoning and sintering techniques of ageing, which was later transformed into fluid dynamic model. By using this model, it is easy to predict deactivation as a function of length and time.

[12] conducted research to estimate the significance of copper catalyst covered with manganese to minimize the expense of catalytic converter. Owing to the applications of manganese coated copper catalyst there was a considerable reduction in the emission of carbon monoxide but emissions of other gases could not be controlled by this technique. [13] focused on the usage of blending low viscous pine oil with diesel in order to reduce the discharge of toxic gases. The experiment concluded that the discharge gases such as smoke, carbon monoxide, hydrocarbons and oxides of nitrogen were minimized by 70.1%, 67.5%, 58.6% and 15.2%. [14] explained the process of reusing the carbon Nano particles of particulate matter to increase the efficiency of reduction reaction.

[15] suggested the use of electro-chemical catalytic cell to reduce the discharge of NO_X in lean burn engines. The rate of reduction can be improved by increasing the content of water and carbon dioxide and relatively zero discharge of NO_X can be obtained by this method. [16] elucidated the significance of honeycomb structure for lean burn NO_X discharge control. This technique directly converts oxides of nitrogen into nitrogen and oxygen by decomposition resulting in reduced exhaust emission without heat treatment. [17] revealed a new technique to blend diesel and waste cooking oil to reduce the discharge of NO_X gas thereby minimizing the marine pollution. The developed blend exhibits quite high cylinder pressure but the ignition of the fuel gets decreased owing to the blended fuel. [18] presented a survey to highlight the influence of alcohol, natural gas, bio-diesel and dimethyl ether on combustion properties and discharge substance of diesel engine. The review suggests that alternative fuel can lead to a better emission control.

This paper focuses on using natural liquids such as water, banana tree extract, cow urine and aloe vera for silencer to minimize the emission of toxic gases during combustion.

2. METHODOLOGY

2.1. Working of catalytic converter

The most efficient after treatment of exhaust emission can be done by catalytic converter. Generally catalytic converter consists of two types of catalysts viz reduction catalyst and oxidation catalyst. Both the catalyst contains ceramic structure coated with a noble metal catalyst of platinum/ rhodium/ palladium. The reduction catalyst utilizes platinum and rhodium to minimize the discharge of NO_X whereas the oxidation catalyst uses platinum and palladium. The schematic diagram of catalytic converter is represented in figure 1.

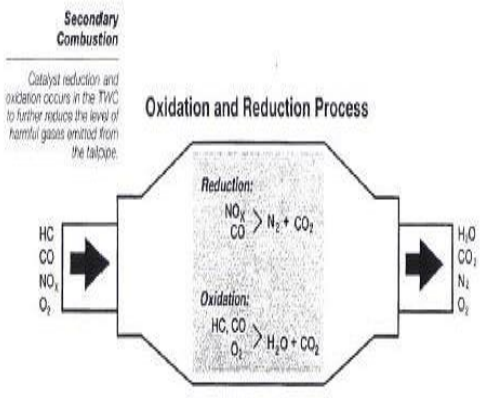

Figure 1.Catalytic converter

During the reduction catalyst process, molecules of NO react with the catalyst, which separate the nitrogen atom from the molecule and freeze the oxygen atom in O_2 form. The separated nitrogen atoms bind with each other and also with the catalyst thereby giving rise to

N_2. The equation representing the reduction reaction is given in (2.1).

$$2NO \rightarrow N_2 + O_2 \text{ or } 2NO_2 \rightarrow N_2 + 2O_2 \quad (2.1)$$

In the course of oxidation, emission of HC and CO is minimized by oxidizing them. The catalyst used for oxidation enhances the reaction of CO and HC with exhaust oxygen. The oxidation reaction is represented in equation (2.2) as,

$$2CO + O_2 \rightarrow 2CO_2 \quad (2.2)$$

Typically there are two types of design pattern for catalytic converters viz honeycomb structure and ceramic bead structure. Of the two, the most common type of structure for car is the honeycomb structure.

2.1.1. Problems encountered with noble metal catalytic converters

Basically catalytic converters use noble metals to advance oxidation process. But there are several issues connected with noble catalytic converters as mentioned below.

- Due to extreme heat, the minor particles attached on the converter may melt/ break thereby causing the termination of exhaust emission due to dislocation.
- Converters do not have the ability to halt the reaction during necessary conditions.
- It is difficult to clean the traces of HC and CO inside the converter.
- Owing to the liquefaction of contaminants, the surface area of the converter gets reduced.
- The engine performance gets affected due to clogged or choked converter.

2.2. Overall sketch of the system

Figure 2 highlights the sketch of the system. The engine setup is connected to the catalytic converter which in turn is connected with the manufactured silencer. The silencer has a diameter of 30 cm and a height of 120 cm. The manufactured silencer consists of buffle plates, inner piper of diameter 38 cm and length 120 cm and an exhaust pipe of diameter 38 cm and length 180 cm.

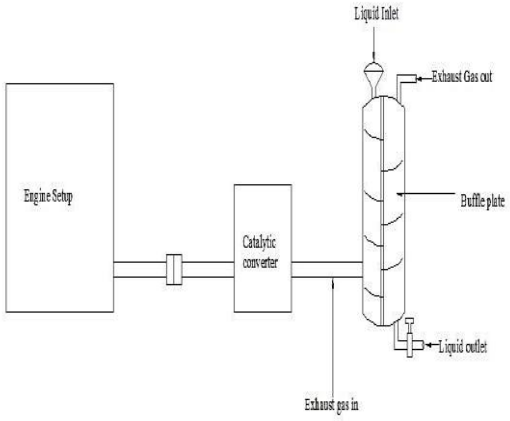

Figure 2.Design of the system

2.3. Necessary materials

- G1 sheet of thickness 8 ft x 4 ft x 1mm
- G.I pipe inner 120 cm length and 3.8 cm diameter
- G.I pipe outer 180 cm length and 3.8 cm diameter
- Welding rod 1 pocket
- Cutting wheel 15 numbers
- Flange 6 numbers

With the help of these materials, the designed system was manufactured and then investigated to figure out the liquid with lowest emission level.

3. EXPERIMENTAL ANALYSIS

A four stroke, dual cylinder diesel engine with hydraulic loading was chosen with the specifications mentioned in table 1. A four stroke engine has numerous advantages such as

- At low speed, four stroke engine exhibits more torque than two stroke engine.
- Fuel consumption is low.
- Reduced pollution level.
- Elimination of excess oil to the fuel.
- More consistency.

In order to evaluate the emission level of different liquids, first the pH values of the liquids were determined and then infused into the liquid inlet of the system. Table 2 highlights the pH values of the experimented liquids. Among the analysed liquids, aloe vera is found to be more acidic and cow urine is determined to be more alkaline.

Knowledge about chemical composition of the liquids is an essential one. Analysis has been carried to estimate the chemical composition of cow's urine and

banana tree extract which is showcased in table 3 and table 4.

Table 1.Specifications of diesel engine

Parameter	Specification
Manufacturer	HTC
Diesel engine model	VC 14
Cylinder	2 inline
Bore	0.0875 m
Stroke	0.110 m
Speed	1500 rpm
BHP	10(twin cylinder) 7.5 kW
Compression ratio	17:1
Fuel	High speed diesel
Specific gravity	0.833
Calorific value	45000 KJ/KG
Torque arm length	0.2 m

Table 2.pH values

Liquid	pH value
Cow urine	8
Water	7
Banana tree extract	5.7
Aloe Vera	5.3

Table 3.Composition of cow urine

Experiment	Result	Normal range
Random blood sugar	15	80-140 mg%
Blood urea	75	15-40 mg%
Serum creatinine	2.5	0.5-1.4 mg%
Serum calcium	3.9	8.1-10.5 mg%
Sodium	245	135-155 mmol/l
Potassium	10.5	3.5-5.5 mmol/l
Chloride	124	98-109 mmol/l
Cholesterol	15	15-200 mg/dl
Triglycerides	23	up to 160 mg/dl
SGOT	13	up to 42 IU/L
SGPT	10	up to 49 IU/L
Alkaline	21	64-706 IU/L

Analysis highlights that cow urine is rich in urea, serum creatinine, sodium and potassium.

From the table we can infer that banana tree extract contains more sugar than the normal range and very low quantity of serum calcium, sodium, potassium and chloride. Comparatively banana tree extract have high level of triglycerides, Serum Glutamic Oxaloaacetic Transaminase (SGOT), Serum Glutamic Pyruvic Transaminase (SGPT) than cow urine.

Table 4.Composition of banana tree extract

Experiment	Result	Normal range
Random blood sugar	180	80-140 mg%
Blood urea	21	15-40 mg%
Serum creatinine	0.8	0.5-1.4 mg%
Serum calcium	2.1	8.1-10.5 mg%
Sodium	24	135-155 mmol/l
Potassium	1.1	3.5-5.5 mmol/l
Chloride	14	98-109 mmol/l
Cholesterol	21	15-200 mg/dl
Triglycerides	48	up to 160 mg/dl
SGOT	18	up to 42 IU/L
SGPT	21	up to 49 IU/L
Alkaline	37	64-706 IU/L

3.1. Experimental description

The experimental ring consists of a four stroke, dual cylinder diesel engine which is connected to a hydraulic dynamometer. The experimental setup consists of diesel engine arranged with all its accessories, a burette stand to measure the level of fuel, three way stop cock and stop watch. The experimental setup is displayed in figure 3.

Figure 3.Experimental setup

At first, the engine is started after closing the inlet valve. When the shaft rotates, the inlet valve opens thereby allowing water to enter into the dynamometer which in turn causes braking effect on the engine. More fuel is injected to the engine to enhance the speed to the required value. High inflow rate may cause high loading to the dynamometer as it is very sensitive to flow rate. So dynamometer should be handled with much care.

The water to be drained from the dynamometer flows out at the bottom valve. The outlet valve should not be closed at any circumstances. During operation, the dynamometer consumes the engine power output and transforms the power output to heat with the help of water brake.

When the flue gas passes through the silencer, the tested liquids were dropped in to the liquid inlet valve. The injected liquid combines with the flue gas hence discharging gases. A gas analyser rod is inserted to take emission measurements. The procedure is repeated for all the tested liquids and the emission results were distinguished.

When water is made to flow through the silencer, it reacts with carbon monoxide thereby releasing carbon dioxide and hydrogen gas which is given by the chemical equation (3.1).

$$CO + H_2O \rightarrow CO_2 + H_2 \qquad (3.1)$$

Similarly, when cow urine is injected in to the silencer, it responds to carbon monoxide, nitrogen oxide and oxygen by releasing carbon dioxide, nitrogen and water.

The chemical equation involved during the reaction is shown in (3.2).

$$CO(NH_2)_2 + CO + 2NO + O_2 \rightarrow 2CO_2 + 2N_2 + 2H_2O \qquad (3.2)$$

Thus water and cow urine reacts with flue gases present inside the silencer and converts them into non-toxic gases and substance like carbon dioxide, nitrogen and water resulting in controlled emission of exhaust gases.

4. RESULTS & DISCUSSION

At first diesel engine is energized by exterior force and water is made to flow through the dynamometer to create a braking effect. After the duration of 10 minutes, the surrounding exhaust gas is taken into account by gas analyser which is displayed in figure 4.

The exhaust gas is allowed to flow through the manufactured silencer where water is used as liquid. After 10 minutes of operation, exhaust gas reading is taken which is shown in figure 5. The exhaust contained 6.18% of CO, 298 ppm of HC, 7.11% of CO_2 and 345 ppm of NO_X.

Figure 4.Exhaust gas result after 10 minutes of engine operation

Figure 5.Exhaust gas result after 10 minutes of engine operation with water as liquid

Table 5.Comparison of exhaust gas report of all the liquids

Liquids	**CO %**	**HC ppm**	**CO_2 %**	**NO_X ppm**
Normal Load	6.11	299	6.9	373
Water	6.18	298	7.11	345
Banana tree extract	6.2	298	7.19	329
Cow urine	5.91	300	6.62	344
Aloe Vera	6	299	6.79	330
Cow urine & aloe vera	6.04	297	7.06	334
Cow urine & banana tree extract	5.74	299	6.29	332

Similar procedure is followed for banana tree extract, aloe vera and cow urine, mixture of cow urine & aloe vera and mixture of cow urine & banana tree extract and reports

were generated. The comparison of exhaust gas report for all the liquids were made and displayed in table 5 and distinction of different liquids based on their reduction percentage is exhibited in table 6.

Table 6.Reduction of emission in percentage

Liquids	CO (%)	NO_X (%)	CO_2 (%)
Water	1.14↑	7.5↓	3 ↑
Banana tree extract	1.47↑	11.79↓	1.5↑
Cow urine	3.27↓	7.7↓	4.05↓
Aloe Vera	1.8↓	11.52↓	1.6↓
Cow urine & aloe vera	1.14↓	10.45↓	2.31↑
Cow urine & banana tree extract	6.02↓	10.99↓	8.8↓

Figure 6 highlights the comparison of various liquids with respect to carbon monoxide emission. From the figure we can interpret that CO emission is very high for banana tree extract and is low for mixture of cow urine and banana tree extract.

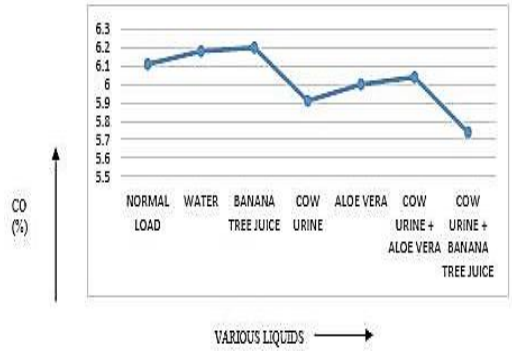

Figure 6.Comparison of CO level

The emission of hydrocarbon for various liquids was distinguished in figure 7. It can be clearly noted that the emission level is at the peak for cow urine and low for cow urine and aloe vera mixture.

Like this, comparisons were performed on different liquids based on their carbon dioxide and NO_X emission as in figure and figure 8. Figure 9 exposes that emission of CO_2 is reduced in large amount for mixture of cow urine and banana tree extract whereas CO_2 emission is high for banana tree extract alone. From the figure we can desist that normal load of diesel engine has high level emission of NO_X.

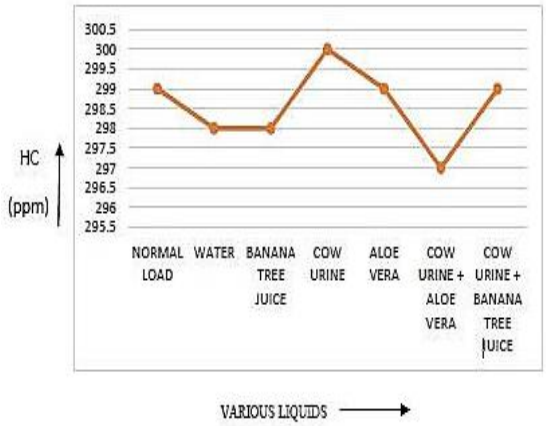

Figure 7.Comparison of HC level of different liquids

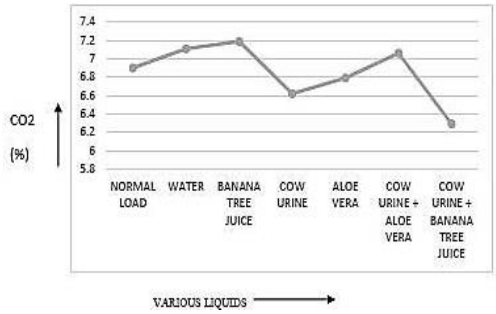

Figure 8.Measurement of CO_2 emission of different liquids

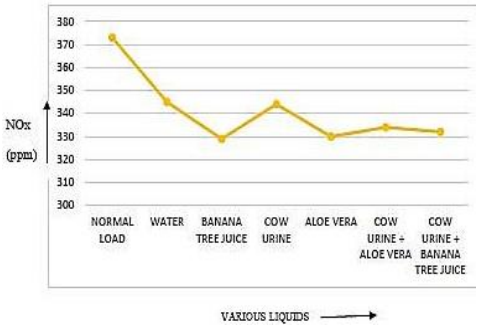

Figure 9.Distinction of various liquids based on NO_X discharge

5. CONCLUSION

The experimental analysis highlighted that the amount of NO_X discharge can be reduced by using either water or banana tree extract as a liquid in silencer. But the emission of carbon monoxide and carbon dioxide increased. Similarly, when aloe vera and cow urine were sprayed as separate liquid, all the flue gas emissions was reduced. Also, mixture of cow urine and aloe vera gave a good decline in carbon monoxide and oxide of nitrogen emission. At last, it can be concluded that the combination of cow urine and banana tree extract give a significant minimization of all the exhaust gases.

6. FUTURE SCOPE

Future work can be carried out to minimize the size of the manufactured silencer depending upon the vehicle requirements. Also a liquid injector can be inserted at the top of the silencer so that liquid can be refilled easily in accordance with consumption. It can also be implemented in industries involving anchored engines. Thus the emission level in automotive vehicles can be easily reduced to a great extent by this simple technique.

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