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Emission reduction in automobile engine exhaust using bio catalytic converter: An Experimental Study

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Abstract: *Automobile vehicle engine exhaust after treatment design has become very important because exhaust emissions standards are ever increasing. Catalytic converter is a main apparatus for eliminating the pollutants in engine exhaust. There are challenging problems to the emission control designers especially demanding different standards in exhaust gas conditions. In order to adopt stringent emission regulations, engine requires more vigorous and durable catalysts as well as optimized exhaust system design. To achieve the emission levels well below the standard regulations a specially designed bio catalytic converter is incorporated with the existing three way catalytic converter. Algae are used in specially designed bio catalytic converter. Experimental investigations were carried out with specially designed bio catalytic converter and found reduced emission levels in comparison with three way catalytic converter.*

Keywords: *Automobile vehicle, Catalytic converter, Exhaust gas emission, Algae, Pollutants.*

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I. Introduction

Increased use of cars in some major cities had resulted in serious concerns about urban air quality caused by engine exhaust gas emissions themselves, and by the more harmful species derived from them via photochemical reactions. The three main exhaust gas pollutants are hydrocarbons, carbon monoxide and nitrogen oxides. Controlling the emission from internal combustion engine can be accomplished by designing the composition of the fuel and during post combustion treatment of exhaust gases. The better combustion can be occurs with improved engine design combustion technology for combustion of fuels and introduction of other fuels which controls the generated emission in internal combustion engines. Engine modifications alone were not sufficient to control them, and catalytic systems were introduced to do this. This catalytic chemistry involves activation of small pollutant molecules that is achieved particularly effectively over platinum group metal catalysts. Catalytic emissions control was introduced first in the form platinum based oxidation catalysts that lowered hydrocarbon and carbon monoxide emissions. The engine out exhaust emission can be controlled by different catalyst converters [1]. The most wide spread type make use of a ceramic honeycomb structure held in a metal case in the exhaust stream [2, 3].

The present day monolithic three way emission control catalytic converter use combined platinum and rhodium as precious metal components. The precious metal replaced with palladium by Harkonen et al. [4]. Some problems were reported when palladium is incorporated with platinum and rhodium. When palladium is incorporated in platinum-rhodium catalyst, palladium can form alloy with rhodium in which palladium is enriched at the alloy surface, thereby hold back the full development of the cabalistic activity of rhodium [5, 6]. Recent trends in improvement of the catalyst relevant properties of the fuel available in U.S. and Europe, along with wide applications of advanced engine management systems with a capability for much tighter A/F control close to stoichiometric relive the above mentioned constrains to the use of Tri-metal catalysts[4, 7]. Reduction of nitrogen oxides to nitrogen was initially done over very precise platinum/rhodium catalysts and tri-metal catalysts prior to oxidation and subsequently conversion of all three pollutants over a single three way catalyst to harmless products up to certain extent. Important role of catalyst technologies in meeting the stringent vehicle emission standards demanding the further designing of engine exhaust after treatment system.

The present study makes modest attempt to decrease engine exhaust emission by incorporating the bio catalytic converter with three way catalytic converter. Algae were used in bio catalytic converter instead of using it as alternate fuel in spark and combustion ignition engines. Algae have a great potential source of bio fuels and also have unique importance to reduce gaseous emissions, greenhouse gases, climatic changes, global warming receding of glaciers, rising sea levels and loss of biodiversity.

II. Working Principle Of Catalytic Converters

The main function of three-way catalytic converter is to control the harmful hydrocarbons and carbon monoxide that are emitted from the internal combustion engine. The reduction and oxidation catalysts are typically contained in a common housing; however, in some instances, they may be housed separately. A three way catalytic converter has three simultaneous tasks:

1. Reduction of nitrogen oxides to nitrogen and oxygen: $2NO_x \rightarrow xO_2 + N_2$
2. Oxidation of carbon monoxide to carbon dioxide: $2CO + O_2 \rightarrow 2CO_2$
3. Oxidation of un-burnt hydrocarbons (HC) to carbon dioxide and water: $C_xH_{2x+2} + [(3x+1)/2]O_2 \rightarrow xCO_2 + (x+1)H_2O$.

In order to adopt increasing stringent pollution emission standards in the future evolution of vehicles, there is a need to modify the design and optimization of engine exhaust after treatment system.

III. Design Of Exhaust After Treatment System

The bio catalytic converter which consists of three algae chambers is incorporated with the existing three way catalytic converters emission pipe for reducing the exhaust emission. The emission reduction pipe consists of a three way catalytic converter followed by chambers of algae known as bio catalytic converter. The main focus in the design of emission reduction pipe is to expand the gases that are coming out of catalytic converter before entering into the bio catalytic converter. This is to reduce the temperature of the gases that are entering the bio catalytic converter because the bio catalytic converter is sensitive to temperatures and works effectively below 35 degrees. The design of three algae chambers connected with the common rail which is used to connect inlet and outlet of the exhaust system (1.inlet of the exhaust, 2.exhast to the atmosphere and 3.common rail which is connecting the three algae chambers) of the vehicle is as shown in Fig.3.1. The three way catalytic converter and the three algae chambers connected with exhaust come out from the common rail as shown in Fig.3.2 (1.engine exhaust, 2.three way catalytic converter 3.algae chambers and 4.algae which is stored in chambers).

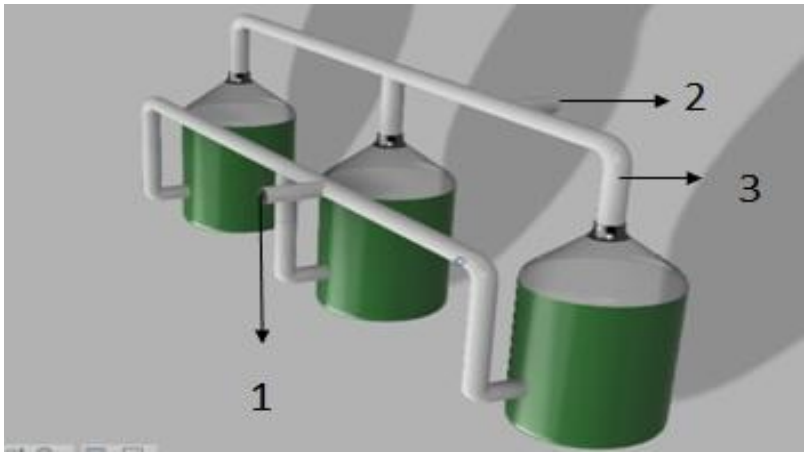

Fig.3.1 Algae chambers connected with inlet and outlet of the exhaust

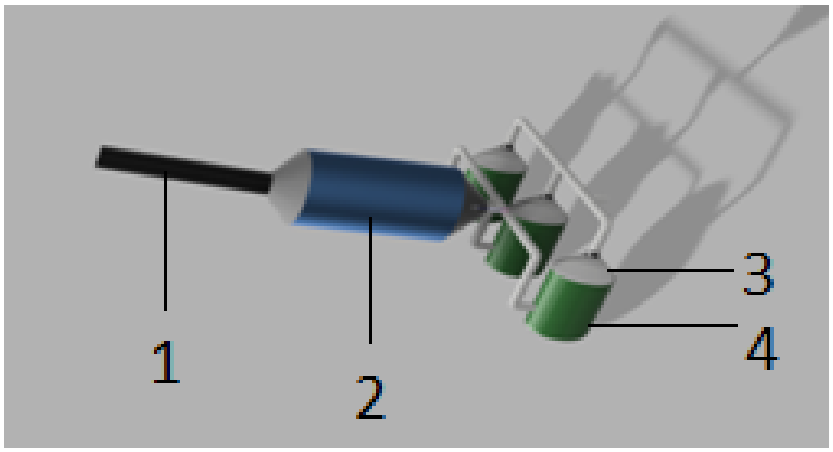

Fig.3.2 Algae chambers connected with three way catalytic converter

IV. Experimental Procedure

The three chambers of algae are used in the application (each chamber of 1 liter capacity). The chambers are connected with PVC pipes of 0.75 inch diameter. The engine exhaust is connected to the catalytic converter and the outlet of the catalytic converter is connected to the bio catalytic converter as shown in Fig.4.1.

Fig.4.1 Three way catalytic converter with Algae chambers

After the three way catalytic converter the exhaust gases now enter into the algae chambers. Algae are a simple, non-flowering, and typically aquatic plant of a large assemblage that includes the seaweeds and many single-celled forms.

Algae are diverse group of aquatic organisms that have the ability to conduct photosynthesis. Certain algae are familiar to most people like kelp or phytoplankton. However, there exists a vast and varied world of algae that are not only helpful to us, but are critical to our existence. Primarily the algae are not highly differentiated in the way that plants are. Algae are capable of photosynthesis and produce their own nourishment by using light energy from the sun and carbon dioxide in order to generate carbohydrate and oxygen. The most important contribution of algae to our environment and well- being is the generation of oxygen through photosynthesis. The algae which are used in the bio catalytic converter is the green algae which are collected from a pond. This algae is introduced in a container containing water. The algae is stirred well and the algae solution is prepared as shown in the Fig.4.2. This algae solution is poured in the three chambers of bio catalytic converter.

Fig.4.2 Algae

The emission reduction pipe is fitted with three way catalytic converter and bio catalytic converter. The three way catalytic converter reduces the HC and CO into water vapor and carbon dioxide. Now these gases enter into bio catalytic converter. The carbon dioxide which enters into the bio catalytic converter will be the food to the algae. The algae absorbs the carbon dioxide and releases equivalent amount of oxygen in the presence of sunlight by a process known as photosynthesis, thus reducing the amount of harmful emissions [9]. During this process a residue known as Lipid is formed in the chambers. Bio diesel can be extracted from these lipids by a process known as Transesterification [8].

V. Results And Discussions

The exhaust gas emission was checked by exhaust gas analyzer which is commercially available and used in Roads and Traffic Authority. The regulation limits of HC and CO are 1500 ppm and 3% Volume respectively. The results which we have obtained from experimental investigation by incorporating bio catalytic converter with the three way catalytic converter were 450 ppm and 1.91% volume respectively against regulation. Whereas the results which we have obtained with only three way catalytic converter were 660 ppm and 2.77% volume respectively against the regulations.

The emission levels of HC and CO at the outlet of bio catalytic converter with the incorporation of three way catalytic converter are shown in the Fig.5.1. The emission levels of HC and CO at the outlet of three way catalytic converter are shown in the Fig.5.2.

Fig. 5.1 Emission values from bio catalytic converter

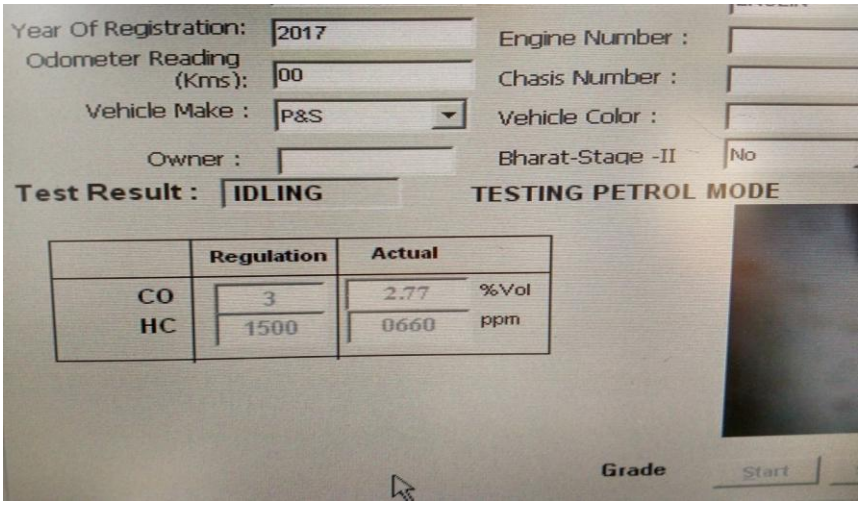

Fig. 5.2 Emission values from 3 way catalytic converter

TABLE 5.1: Comparison of experiment results against the regulation standards

Emission	Regulation as per standard	Engine exhaust	Catalytic converter exhaust	Bio catalytic converter exhaust
CO	**3%**	**8.66%**	**2.77%**	**1.91%**
HC	**1500 ppm**	**9230 ppm**	**660 ppm**	**450 ppm**

From the experimental results as shown in the above table 5.1, it has been observed that 7.6% of CO and 56% of HC are reduced with the three way catalytic converter against regulation. Whereas 36.3% of CO and 70% of HC are reduced with the incorporation of bio catalytic converter with the three way catalytic converter in comparison with the regulation. It has been observed that there is a lot of improvement in decreasing the emission with incorporation of bio catalytic converter with three way catalytic converter.

VI. Conclusion

The following are conclusions derived from experimental investigation of engine exhaust gas emissions by incorporating bio catalytic converter with three way catalytic converter.

1. Bio catalytic converter has been designed and incorporated with three way catalytic converter for reducing harmful emissions.
2. Experimental investigation has been carried out with bio catalytic converter and without bio catalytic converter.
3. It is evident that there is a lot of emission reduction with bio catalytic converter compared with three way catalytic converter.
4. It is observed that there is a reduction of 70% HC and 36.3% CO against the regulation standards with bio catalytic converter.

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