Available online at www.derpharmachemica.com

Scholars Research Library

Der Pharma Chemica, 2015, 7(12):56-61
(http://derpharmachemica.com/archive.html)

ISSN 0975-413X
CODEN (USA): PCHHAX

Ecofriendly catalytic converter to reduce biochemical effect of exhaust gases

Jitin Malhotra, Mohit Bhandwal, R. K. Tyagi, Anirudh Kalia, Sajal Pandey and Agnivesh Rahul

Department of Mechanical and Automation, Amity University, Uttar Pradesh

---

ABSTRACT

This research focuses on reducing the harmful emission from the engine. As with the escalation in the number of vehicles, the emission is also increasing significantly, which results in the growth of human diseases like asphyxia, coughing, asthma, choking of lungs and many more. The discarded components of the catalytic converter produce an eco-friendly device. The experimental method reduces the harmful pollutants such as Carbon Monoxide (CO), Nitric Oxide (NOx) and Hydrocarbons (HC) in a remarkable way, which helps in dropping some disease that originate due to emission by automobiles.

Keywords Emission, Asthma, Lungs, Smog, Hemoglobin.

INTRODUCTION

Mobile sources generate air pollution that is of great concern for global warming in the world. In the last 60 years, the vehicle count has increased exponentially from 40 million to over 700 million and has been projected to rise to 2 billion by the year 2030 [1]. Due to the environmental and biological impact automobiles emission is an area of concern [2]. The primary pollutants from the car exhaust include CO, HC, and NOx. CO accounts for the half of all the anthropogenic air pollutants in the urban area and contributes around 64% of CO pollution in developed countries. Emission from diesel engines compared to petrol engines is more dangerous and so is a matter of major public concern. As per WHO report, Delhi is the most polluted city in the world in comparison to Beijing [3].

The harmful effects on the environment and humans have led to various researches and inventions to reduce these vehicular exhaust emissions from internal combustion engines. Catalytic Converter is the most efficient device utilized in the exhaust system to reduce exhaust emissions that work on chemical reactions. In India, it is mandatory to use converters in the exhaust system of vehicles.

CO widely known as cellular asphyxiate a colorless, odorless and tasteless gas; produces a condition of asphyxia by binding to hemoglobin in a reversible manner. The high partial pressures of O_2 antagonizes the binding of CO to hemoglobin. CO is toxic as it interferes with the primary production of Oxyhemoglobin (as shown in equation 1) and also it has almost 200 times more affinity to bind to hemoglobin than O_2, resulting into Carboxyhemoglobin (as shown in equation 2). It further blocks the human Oxygen delivery system by stopping the other oxygen bound to the hemoglobin resulting in a condition of asphyxia [4, 5, 6].

$Hb(aq) + 4O_2(g) \rightarrow Hb(O_2) + 4(aq)$ ……. (1)

$Hb(aq) + CO(g) \rightarrow HbCO(aq)$ ……..... (2)

Other pollutant NOx having its chemical name as Nitric Oxides, usually including various combinations of Nitrogen and Oxygen in different proportions (except N_2O, Laughing Gas). It is a reddish-brown, highly reactive gas that has

a suffocating odor and an adamant oxidizing behavior. Its causes irritation to eyes and throat, headache, nausea. Prolonged exposure can cause violent coughing, breathing problems and cyanosis. The further harmful effects include acid rain, depletion of ground-level ozone, and smog formation [7].

Hydrocarbons, usually exist in the form of Particulate Matter in the emission and environment. Its harmful effects include Asthma exacerbations, increased respiratory problems, and the decrease in lung function. These Particles at a micro level associated with aerosol particles are already present in the environment, including Benz[a]anthracene (BaA) and benzo[a]fluoranthene (BbF), which is having a tumor initiating behavior. These particles are so small in the size that it accumulates in the nasal regions and lungs that result in the choking of the windpipe [8, 9].

The literature review shows various methods for reducing the toxic levels of pollutants. Use of Bio-Fuels reduces a significant level of CO and HC, but the NOx shows inconsistent behavior [10-12]. Another method includes the modification in the fuel injection system, which shows the reduction in the HC, NOx [13, 14]. Other methods include the adaptive fuel injection techniques, Exhaust Gas Recirculation (EGR), and some mathematical modeling shows the exhaust gasses after treatment process [15-19].

If world will pay attention on un-conventional energy cradles than diseases originated due to exhaust gases, mitigate completely [24].

This research focusses on the development of an Ecofriendly device from the discarded automobiles and comparing it with this new device and without it. The catalyzing action of the new device provokes the emission to disintegrate further into some harmless gasses.

MATERIALS AND METHODS

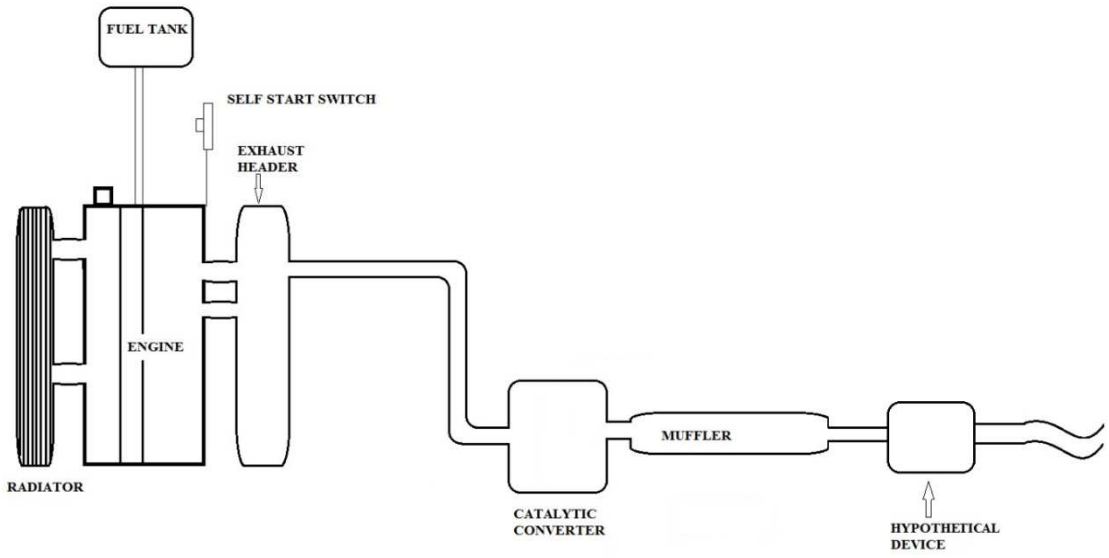
2.1 Experimental

The setup as shown below in Figure 1 consists of a diesel engine with its complete exhaust system and a hypothetical Eco-friendly device attached at the end.

This Ecofriendly device is designed in such a manner to reduce the emission by passing the exhaust gasses through it by doing the oxidation and reduction of the exhaust gasses.

The AVL DIGAS 444 Automobile Exhaust Gas Analyzer measures the emission and displays the values. The Diesel Engine setup used in this experiment is a Tata Indica V2 diesel engine (1405cc) having emission standards of BharatStage III.

Figure 1. Complete Setup of Diesel Engine with Hypothetical Device



2.2 Catalytic Converter

A Catalytic Converter is a large metallic box having a dense honeycomb structure inside it. These honeycomb structures are of ceramic and coated with the catalyst material depending on the chamber. The motive of using the

honeycomb structure is to increase the effective area of the exhaust gasses so that more emission gets oxidized and reduced to less harmful byproducts [20, 21].

A French chemical engineer Eugene Houdry invented the Catalytic Converter, who further filled his invention in 1950, and received a patent ("US Patent 2,674,521: Catalytic converter for exhaust gasses") four years later on April 6, 1954.

The catalytic converter has two chambers and is named as the reduction and oxidation chambers.

The first chamber consists of Platinum and Rhodium coated ceramic honeycomb structures, which reduces the NOx emissions by acting as a Reduction catalyst. When an NOx molecule passes through this compartment, its molecules break apart into N_2 and O_2 [22, 23].

The overall reaction showing the reducing behavior of Platinum and Rhodium are:

$2NO \rightarrow N_2 + O_2$……..... (3)
$2NO_2 \rightarrow N_2 + 2O_2$……..... (4)

Exhaust gasses now flow through the other chamber formed by Platinum and Palladium, which acts as an oxidizing catalyst. Here disintegration of HC and formation of CO_2 takes place with the extra O_2 in the presence of catalysts. The reactions corresponding to the oxidation behavior are:

$2CO + O_2 \rightarrow 2CO_2$ ..... (5)
$C_xH_{2x} + 2xO_2 \rightarrow xCO_2 + 2xH_2O$….. (6)

2.3 Ecofriendly Hypothetical Device

After prolonged usage, the automobiles get discarded, and the materials from the catalytic converter i.e. Platinum, Palladium, and Rhodium do still have some life left inside them, so a new device development and testing process, called as an Ecofriendly device is to be done. This device has the waste catalyst materials that after gone through cleaning process both chemically and physically, packaged in a new device shell. This device further installed at the end of the exhaust system, reduces the emission. The working of this new device is similar to a full-fledged catalytic converter, but the size of this is comparatively smaller and is cost effective as if compared to the original.

RESULTS AND DISCUSSION

The experiments were carried out on the diesel engine setup with two conditions initially in the normal condition Default System and other System after connecting the hypothetical Eco-friendly device. The results of the tests show a considerable reduction in the emission of CO (%Vol.), HC (ppm Hex.) and NOx (ppm Vol.). The values at various RPM values were analyzed and further compared for both test conditions.

Table 1.Shows the average values for both test conditions

	Default System	System with Hypothetical device
CO (%Vol.)	0.287	0.173
HC (ppm Hex.)	33	19
NOx(ppm Vol.)	250	179

The hypothetical device reduces the pollutants i.e. CO, HC, and NOx to a considerable amount.

The percentage decrease in each of the pollutants is given below followed by their corresponding graphs:

a) Carbon Monoxide:

The emissions from the exhaust after being passed on from the eco-friendly device in addition to the traditional one further acts as an oxidizing catalyst (Platinum and Palladium), resulting in the further oxidation of CO to CO_2. The following graph shows the values obtained at various RPM values and a considerable 39.72% reduction in the CO emission after using this recycled converter.

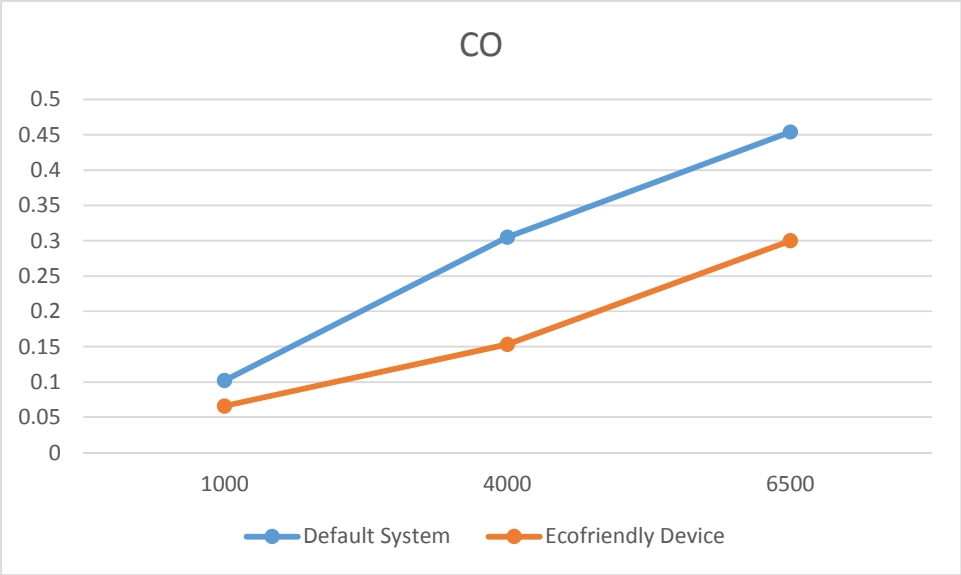


Figure 2.The graph indicates the values of CO for both test conditions

b) Hydrocarbon(Particulate Matter):

In this case also the Ecofriendly device acts as an oxidizing catalyst (Platinum and Palladium), resulting in the further oxidation of unburned Hydrocarbons and into CO_2 and H_2O. The following graph depicts the values obtained at various RPM values and a considerable 42.42% reduction in the Hydrocarbon emission after using this recycled converter.

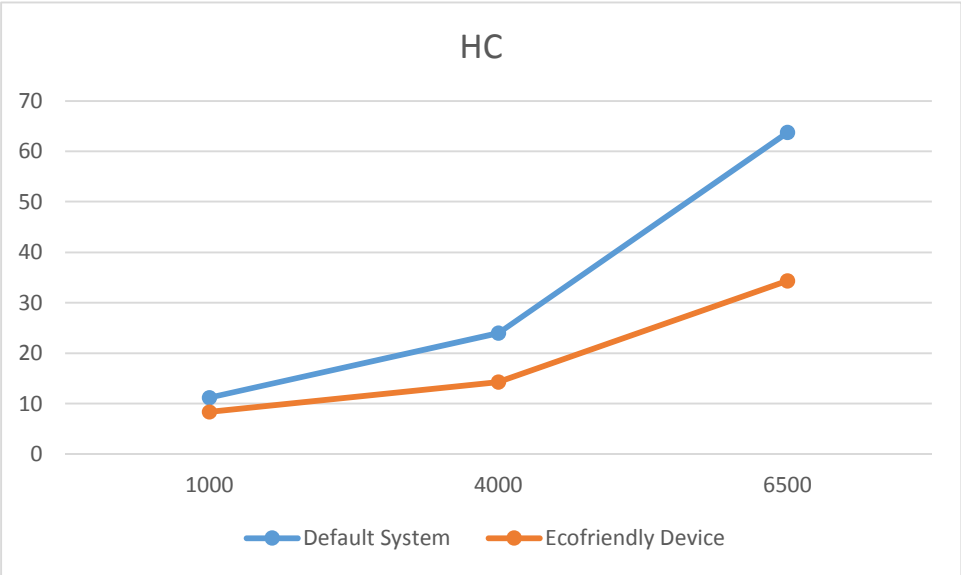


Figure 3. Graph showing the values of HC for both the conditions

c) Nitrous Oxides:

In this case also the Ecofriendly device acts as an oxidizing catalyst (Platinum and Rhodium), resulting in the further reduction of Nitrous Oxides into Nitrogen (N_2) and Oxygen (O_2) molecules. Following graph plots, the values obtained at different RPM values, resulting in a considerable 28.40% reduction in the NOx emission after using this recycled converter.

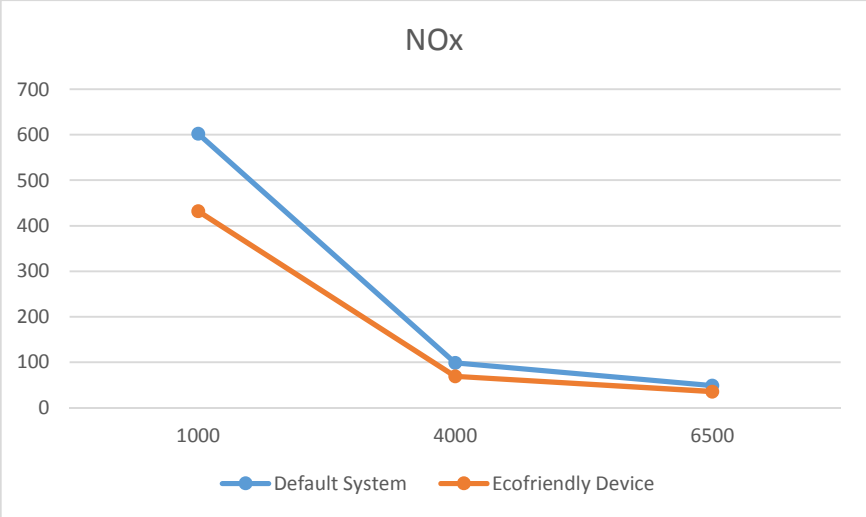


Figure 4. Graph showing the values of NOx for both the conditions

CONCLUSION

A new Ecofriendly device development and testing for reducing harmful vehicular emission. We have utilized the waste material from the discarded automobiles Catalytic Converter to make an Ecofriendly device. The major benefits linked to this device is recycling the waste material. The cost of making this device is quite low in comparison to a complete Catalytic Converter. This device further performs the reduction and oxidation of the pollutants to reduce the emission to a less harmful one. The decrease in the pollutants achieved through this new device is CO by 39.72%; HC by 42.42%; and NO by 28.40%. If total no of car/automobiles implemented with this device than the reduction of pollutants can be significantly large. Therefore, diseases enrichment can be mitigated by placing suggested device.

REFERENCES

[1] D. Sperling, D. Gordon,Two Billion Cars: Driving Toward Sustainability, Oxford University Press, New York, **2009**, 1.
[2]W.Mc Dermott,*Scientific American*, **1961**, 205, 49-57.
[3]A. Anand,BBC, 19 April 2015. (Magazine)
[4]D.J. Kaczorowski,B. S. Zuckerbraun; *Current Medical Chemistry*, **2007**, 14, 2720-2725.
[5]J.Haldane, *J. Physiol*,**1895**, 18, 201-217.
[6]F.J. WRoughton,R.C. Am. Darling, *J. Physiol*.,**1944**, 141, 17-31.
[7]D. A. Wink, J. B. Mitchell, *Free Radical Biology & Medicine*, **1998**, 25, 434-456.
[8] R.M. Dickhut,E.A.Canuel, K.E. Gustafson, K. Liu, K.M. Arzayus, S.E. Walker, G. Edge Combe, M.O. Gaylor, E.H. Macdonald, *Environ. Sci. Technol*., **2000**, 34, 4635-4640.
[9] M. Sagai, H. Saikto, T. Ichinose, M. Kodama, Y. Mori, Free Radical Biology & Medicine, **1993**, 14, 37-47.
[10] Y-p G Wu, Y-f Lin, *Appl Energy*,**2012**, 91, 29-35.
[11] E G Giakoumis, *Appl Energy*,**2012**, 98, 273-291.
[12] S Bari, *Appl Energy*,**2014**, 124, 35-43.
[13] K Ryu, *Appl Energy*, **2013**, 111, 721-730.
[14] H K Suh, *Appl Energy*,**2011**, 88, 5013-5019.
[15] B. R Kumar, S.Saravanan, *Fuel*,**2015**, 160, 217-226.
[16] H Wei, T Zhu, G Shu, L Tan, Y Wang, *Appl Energy*,**2012**, 99, 534-544.
[17] S Lee, S Park, C Kim, Y-M Kim, Y Kim, C Park, *Appl Energy*,**2014**, 129, 10-16.
[18] A Irimescu, G Vasiu, G T Tordai, *Appl Energy*,**2014**, 121, 192-206.
[19]M.Schejbal, J.Stepanek, P.Koci, M.Marek, M.Kubicek, *Chem. Eng. Sci*.,**2010**, 49, 943-952.
[20] R.K. Tyagi, R. Ranjan, *International Journal of AmbientEnergy*, **2015**, 36, 5, 235-241.
[21] S.K.Sharma, P.Goyal, R.K.Tyagi, *International Journal of Ambient Energy*, **2015**; doi: 10.1080/01430750.2015.1020567 (published online).
[22] R. K.Tyagi,R.Ranjan, *Journal of Petroleum Technology and Alternative Fuels*, **2013**, 4, 125-130.
[23]R.K.Tyagi,S.K. Sharma,A. Chandra, S.Maheshwari, P.Goyal, *Journal of Engineering Science and Technology*, **2015,** 10, 1188-1202.

[24] Ram K. Tyagi, *Journal of Energy Southern Africa*, **2015,** 26, 3, 100-104.

Abbreviations

CO	Carbon Monoxide
HC	Unburned hydrocarbon (Particulate Matter)
CO_2	Carbon Dioxide
O_2	Oxygen
Hb	Hemoglobin
NOx	Nitric Oxide Gases