

Development of Eco-Friendly Silencer

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Abstract— Automobile Silencer is a device used to reduce the noise produced by the engine. Silencer is used in automobile vehicles to reduce the noise produced by the exhaust gases of the engine. Silencer is also used in many other engines and generators. The size, shape and construction vary according to the type and size of the engine. The main pollutants contribute by automobiles are carbon monoxide (CO), unburned hydrocarbon (UBHC), oxides of nitrogen (NOx) and Lead. In the present work, an eco-friendly silencer is developed to reduce the pollution level from automobiles. As the exhaust smoke enters into the eco-friendly silencer system, the perforated tube converts high mass bubbles in to low mass bubbles, after that it is made to pass through the activated carbon layer which is embedded between glass fiber membranes to make filter like structure that surrounds the perforated tube which purify the gases. Activated carbon is highly porous and possesses extra free valences so it has high adsorption capacity. Hence eco-friendly silencer reduces pollution.

Keywords—Silencer, Exhaust gases, Activated carbon, Adsorption

I. INTRODUCTION

An automobile was first invented in Germany and France in the late 1800s. Americans quickly came to dominate the automotive industry in the first half of the twentieth century. Automobile emissions cause immediate and long-term effects on the environment. Car exhausts emit a wide range of gases and solid matter. Automobile emissions cause air pollution, global warming, acid rain and cause damage to human health. Engine noise and fuel spills also cause pollution. Cars, trucks and other forms of transportation is the single largest contributor to air pollution.

In the present work an attempt has been made to develop an eco-friendly silencer, which reduces the particulate emissions from the exhaust. Also the activated charcoal used in the developed system oxidizes the carbon monoxide to carbon dioxide thus emission of carbon monoxide reduces.

As the exhaust smoke enters into the eco-friendly silencer system, the perforated tube converts high mass bubbles in to low mass bubbles, after that it is made to flow through the activated carbon layer which is embedded between glass fibre membranes to make filter like structure that surrounds the perforated tube which filters the gases. Activated carbon is highly porous and possesses extra free valences so it has high adsorption capacity. Hence eco-friendly silencer reduces pollution.

II. FABRICATION OF THE MODEL

The eco-friendly silencer is a device that is built at an economic cost with an objective to reduce the emission of pollutants such as CO, HC emissions and to improve the oxygen utilization for to chemical treatment of the exhaust smoke by utilizing the high absorptivity and high porosity properties of activated charcoal. The working model of the eco-friendly silencer consists of a perforated tube where the large smoke mass is broken into small smoke bubbles. The perforated tube is made of a mild steel tube having small perforations of 6 mm holes on its outer periphery. The tube is

surrounded by an activated charcoal filter element in which activated charcoal is embedded in between two layers of glass fiber membrane. Finally, the smoke from the filter holes is collected in an outer casing which allows safe conditioned smoke into the atmosphere without causing the much pressure drop.

A. Materials/Components used for fabrication

Mild steel tubes:

Mild steel is one of the most commonly used construction materials. It is very strong and can be made from readily available natural materials. It is known as mild steel because of its relatively low carbon content.

Mild steel is especially desirable for construction due to its weldability and machinability. Because of its high strength and malleability, it is quite soft. This means that it can be easily machined compared to harder steels. It takes a nice finish and is polishable. However, it cannot be hardened through heat treatment processes, as higher carbon steels can. This is not entirely a bad thing, because harder steels are not as strong, making them a poor choice for construction projects.

Perforated tube:

It is a tube having perforation over its circumferential periphery; main function of this component is to split the mass flow of smoke into small smoke bubbles.

Dimensions of the perforated tube are as follows:

Length: 600 mm

Diameter: 45 mm

Holes drilled on tube: 90

Diameter of holes: 6 mm



Fig. 1 Perforated tube

Outer casing:

It is made up of mild steel. One side of the outer shell is threaded to cover the flange at the end of the casing; the other side of the outer casing is fixed with pipe to let the smoke out through it.

Dimensions of outer casing are as follows:

Outer diameter: 110 mm

Inner diameter: 105 mm

Length: 425 mm



Fig. 2 Outer casing

Galvanized Iron (GI) flange:

A flange is a method of connecting pipes, valves, pumps and other equipment to form a piping system. It also provides easy access for cleaning, inspection or modification. Flanges are usually welded or screwed. Flanged joints are made by bolting together two flanges with a gasket between them to provide a seal.

Activated charcoal Filter:

Activated charcoal is a porous material which can adsorb volatile chemicals on a molecular basis, but does not remove larger particles. The adsorption process when using activated carbon must reach equilibrium thus it may be difficult to completely remove contaminants. Activated carbon converts contaminants from a gaseous phase to a solid phase, when aggravated or disturbed contaminants can be regenerated in indoor air sources. Activated carbon can be used at room temperature and has a long history of commercial use. Other materials can also absorb chemicals, but at higher cost.

A gram of activated carbon can have a surface area in excess of 500 m², with 3,000 m² being readily achievable. Carbon aerogels, which are more expensive, have even higher surface areas, and are used in special applications.



Fig. 3 Activated charcoal filter



Fig. 4 Activated charcoal granules

Glass fiber material:

Glass fiber is a material consisting of numerous extremely fine fibers of glass. Glassmakers throughout history have experimented with glass fibers, but mass manufacture of glass fiber was only made possible with the invention of finer machine tooling. In 1893, Edward Drummond Libbey exhibited a dress at the World's Columbian Exposition incorporating glass fibers with the diameter and texture of silk fibers. Glass fibers can also occur naturally, as Pele's hair.

Glass wool, which is one product called "fiberglass" today, was invented in 1932–1933 by Russell Games Slayter of Owens-Corning, as a material to be used as thermal building insulation. It is marketed under the trade name Fiberglass.

Glass fiber when used as a thermal insulating material is specially manufactured with a bonding agent to trap many small air cells, resulting in the characteristically air-filled low-density "glass wool" family of products.

Glass fiber has roughly comparable mechanical properties to other fibers such as polymers and carbon fiber. Although not as rigid as carbon fiber, it is much cheaper and significantly less brittle when used in composites. Glass fibers are therefore used as a reinforcing agent for many polymer products to form a very strong and relatively light weight fiber-reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), also popularly known as "fiberglass".



Fig. 5 Glass fiber membrane

III. RESULTS AND DISCUSSION

In the present work, an eco-friendly silencer is fabricated and tested with four stroke diesel engine and four stroke petrol engine. In this working model of the eco-friendly silencer consists of a perforated tube where the large smoke mass is broken into small smoke bubbles. The perforated tube is made of a mild steel tube having small perforations of 6 mm holes on its outer periphery. The tube is surrounded by an activated charcoal filter element in which activated charcoal is embedded in between two layers of glass fiber membrane. Finally, the smoke from the filter holes is collected in an outer casing which let the safe conditioned smoke into the atmosphere without causing the much pressure drop.

A. Testing with TATA 407 and Hyundai SANTRO vehicles

The developed eco-friendly silencer is tested with the vehicle with following details.

Test-1 with four stroke diesel engine:

Make: Tata Motors
 Model: TATA- 407
 Vehicle number: KL13P2191
 Type of vehicle: Tempo

Technical specifications: -
 Engine: 2956 cc 4 SP Turbo Intercooled
 Fuel used: Diesel
 Emission norms: BS-III

Maximum torque: 245 Nm @ 1400-1600 rpm

Test-2 with four stroke petrol engine:

Make: Hyundai Motor
 Model: SANTRO
 Vehicle number: MH43N0950

Type of vehicle: Car
 Technical specifications: -
 Engine: 1498
 Fuel used: Petrol
 Emission norms: BS-III
 Maximum torque: 96.1 Nm @ 3000 rpm

B. Discussions on the results of four stroke diesel engine

In the present work, the four stroke diesel engine is tested in emission testing center with and without eco-friendly silencer.

Hartridge Smoke Unit (HSU) is the measure of opacity. In case of diesel vehicles, the smoke density is checked. If density of smoke emitted by the vehicle is less than 65 Hartridge Smoke Unit (HSU), the vehicle is certified as non-polluting. HSU must be as low as possible. If the HSU is high means that more particulate emission.

Fig. 6 shows the emission testing without eco-friendly silencer and results obtained from this are the average value of HSU is found to be 45.1%.

Fig. 7 shows that the emission testing with eco-friendly silencer and results obtained from this is the average value of HSU is found to be 44.6%. Hence using the eco-friendly silencer, the HSU is reduced by 0.5%.

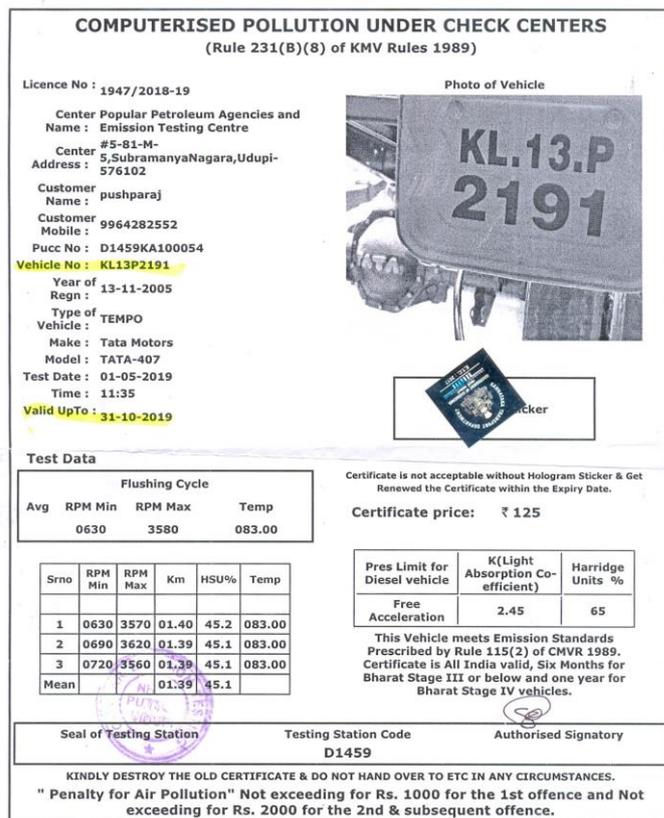


Fig. 6 Emission testing results without eco-friendly silencer

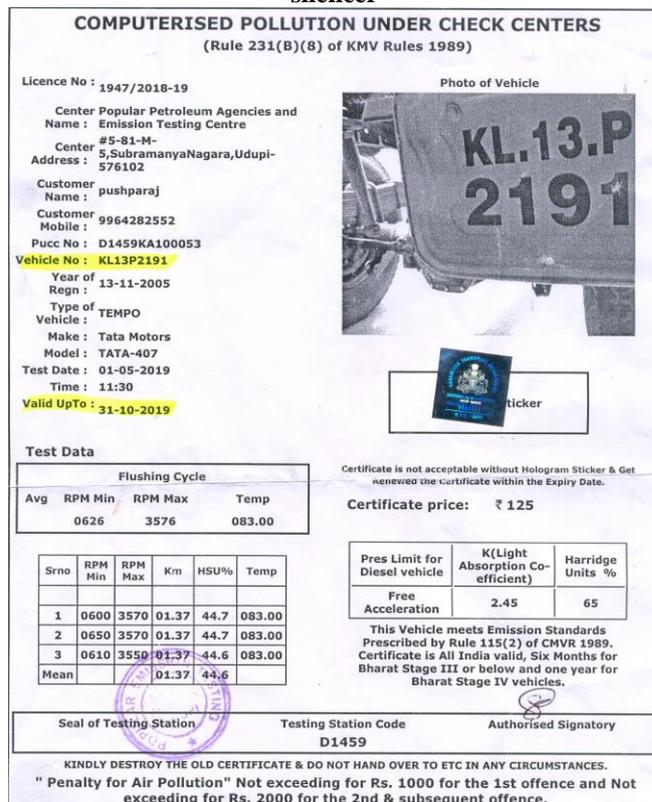


Fig. 7 Emission testing results with eco-friendly silencer

C. Discussions on the results of four stroke petrol engine

In the present work, the four stroke petrol engine is tested in emission testing center with and without eco-friendly silencer.

COMPUTERISED POLLUTION UNDER CHECK CENTERS (Rule 231(B)(8) of KMV Rules 1989)
This Vehicle meets Emission Standards Prescribed by Rule 115(2) of CMVR 1989. Certificate is All India valid, Six Months for Bharat Stage III or below end one year for Bharat Stage IV vehicles.

Licence No : 1600/2016-17
Center Name : GRACE ETC
Center Address : No.2-54(A)7, Mahadevi Commercial complex, Near NH-66, Padu Grama, Kapu Hobli, Udupi Taluk and District

Customer Name : SHEKHAR SALIAN
Customer Mobile : 9741627388
Pucc No : P1111KA100184
Vehicle No : MH43N0950
Year of Regn : 16-09-2005
Type of Vehicle : 4 Wheeler
Type of Engine : 4 STROKE
Make : Hyundai Motor
Model : SANTRO
Fuel : PETROL
Catalyst : Catalyst
Test Date : 18-05-2019 12:15
Valid Date : 17-11-2019

Photo of Vehicle
MH-43 N-0950

	Petrol Test		Gas Test		Unit
	Pres STD	Measured level	Pres STD	Measured level	
CO	3.0	2.05	--	--	% Vol
HC	1500	271	--	--	PPM
CO ₂	--	10.3	--	--	%Vol
O ₂	--	6.53	--	--	PPM

Hologram Certificate price: ₹ 90

Seal of Testing Station Testing Station Code (P1111) Authorised Signatory
KINDLY DESTROY THE OLD CERTIFICATE & DO NOT HAND OVER TO ETC IN ANY CIRCUMSTANCES.
"Penalty for Air Pollution" Not exceeding for Rs. 1000 for the 1st offence and Not exceeding for Rs. 2000 for the 2nd & subsequent offence.

Fig. 8 Emission testing results without eco-friendly silencer

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Make : Hyundai Motor
Model : SANTRO
Fuel : PETROL
Catalyst : Catalyst
Test Date : 18-05-2019 12:17
Valid Date : 17-11-2019

Photo of Vehicle
MH-43 N-0950

	Petrol Test		Gas Test		Unit
	Pres STD	Measured level	Pres STD	Measured level	
CO	3.0	0.85	--	--	% Vol
HC	1500	219	--	--	PPM
CO ₂	--	11.8	--	--	%Vol
O ₂	--	3.62	--	--	PPM

Hologram Certificate price: ₹ 90

Seal of Testing Station Testing Station Code (P1111) Authorised Signatory
KINDLY DESTROY THE OLD CERTIFICATE & DO NOT HAND OVER TO ETC IN ANY CIRCUMSTANCES.
"Penalty for Air Pollution" Not exceeding for Rs. 1000 for the 1st offence and Not exceeding for Rs. 2000 for the 2nd & subsequent offence.

Fig. 9 Emission testing results with eco-friendly silencer

Fig. 8 shows the emission testing results without eco-friendly silencer. From the obtained results, it is found that CO emissions are 2.05% by value, Unburnt Hydrocarbon emission are 271 ppm, CO₂ emissions are 10.3% by volume and oxygen are 6.53 PPM.

Fig. 9 shows the emission testing results with eco-friendly silencer. From the obtained results, it is found that CO emissions are 0.85% by volume, Unburnt hydrocarbon emission are 219 PPM, CO₂ emissions are 11.8% by volume and oxygen are 3.62 PPM.

From the above results, it is clear that CO emissions were reduced by 1.2%. This means that Carbon Monoxide has undergone oxidation to produce Carbon dioxide (CO₂) in the exhaust is increased by 1.5% and percentage of oxygen in the exhaust is decreased by 2.91 PPM. Also from the results, it is found that Unburnt hydrocarbon (HC) emissions are reduced by 52 PPM.

Thus installation of eco-friendly silencer in four stroke petrol engine reduces the harmful emission such as carbon monoxide (CO) and unburnt hydrocarbon (HC).

CONCLUSION

Environmental pollution is major problem in most of the developed and developing countries across the world. Industries and automobiles are the major cause for air pollution. Automobile emissions contain harmful gases such as carbon monoxide, oxides of sulphur and Nitrogen along with unburnt hydrocarbons and particulate matter. To address this issue, an eco-friendly silencer is developed in the present work. This silencer is tested with four stroke diesel and petrol engines to check for the harmful emissions. From the results obtained, the following conclusions were made.

1. When the eco-friendly silencer is tested with four stroke diesel engine, the Hartridge Smoke Unit (HSU) is reduced by 0.5%. Since the HSU is the measure of smoke opacity, the particulate emissions are reduced. Particulate emissions are the major problem particularly in the case of diesel engines.
2. When the eco-friendly silencer is tested with four stroke diesel engine, carbon monoxide (CO) emissions were reduced by 1.2%.
3. This means that Carbon Monoxide has undergone oxidation to produce Carbon dioxide (CO₂) in the exhaust is increased by 1.5% and percentage of oxygen in the exhaust is decreased by 2.91 PPM. Also from the results, it is found that Unburnt hydrocarbon (HC) emissions are reduced by 52 PPM.
4. Thus installation of eco-friendly silencer in four stroke petrol engine reduces the harmful emission such as carbon monoxide (CO) and unburnt hydrocarbon (HC).

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