

Noise and Emission Control of A Single Cylinder Diesel Engine & Heat Recovery using Aqua Silencer

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Abstract- One of the key threats to society and the environment is known to be air pollution, which has a detrimental impact on human beings and the environment. The main contributor to air pollution is the emission of gases from vehicles such as carbon dioxide, unburned hydrocarbons, carbon monoxide, etc. In view of addressing this major contributor, the paper concentrated on changing the traditional silencer by incorporating a modified Aqua Silent, which minimizes the generation of such a polluting weapon. Compared to traditional silencer, Aqua Silencer is fitted with small modifications to the engine exhaust tube. The activated charcoal layers manage the emission of the modified aqua silencer. Environment harmful gases are absorbed efficiently within the silencer and keep engines environment friendly. Aqua silencer also addresses the noise pollution concern as sound produced within water is less audible because of small sprockets in water molecules lower its amplitude and so lowers the sound. Also the heat carried away from the exhaust of the engines are wasted here the aqua silencer also works for heat recovery i.e. the heat from the engine is used to heat the water which can be used in the industry or etc for different purposes.

Keywords- Aqua silencer, charcoal layer, perforated tube, emission control, heat recovery system.

I. INTRODUCTION

Background -The aqua silencer is an attempt in reducing the increasing emission from automobiles and industry engine's exhaust system. Aqua silencer is used to minimize the harmful effect of polluting agent in exhaust gases. In addition to the emission control the aqua silencer also lowers the exhaust sound reducing the sound pollution. This report presents an idea regarding design, fabrication

and installation of an aqua silencer on a stationary single cylinder diesel engine.

Motivation -It has been long observed that diesel engines play a crucial role in the transport industry, agriculture, mining and many other industries. Considering the available fuel resources and the present technological development, diesel fuel is evidently indispensable. In general, the consumption of fuel is an index for finding out the economic strength of any country. In spite of everything, we cannot ignore the harmful effects of the large mass of the burnt gases, which erodes the purity of our environment every day. An aqua silencer is used to control the noise and emission in IC engines. The reason why we opt for an aqua silencer is that, air pollution and noise pollution causes physical ill effects to human beings and also the environment. The main contributor of air pollution is automobiles releasing gases like carbon dioxide, unburned hydrocarbons, etc. In order to cut down on emission of these gases, we can use an aqua silencer.

Outline -An aqua silencer consists of a perforated tube which is installed at the end of the exhaust pipe. The perforated tube contains holes of different diameters. Around the circumference of the perforated tube, activated charcoal layer is provided. The charcoal layer absorbs the carbon content in the exhaust and therefore purifies the exhaust. After the charcoal layer the exhaust comes in contact with the lime water which further purifies the exhaust, the lime water used here act as a cleaning agent. The water & charcoal is used so it is called as hybrid Aqua silencer & it is useful in marine & Boats, Automobile etc.

II. DEVELOPMENT OF MODIFIED AQUA SILENCER.

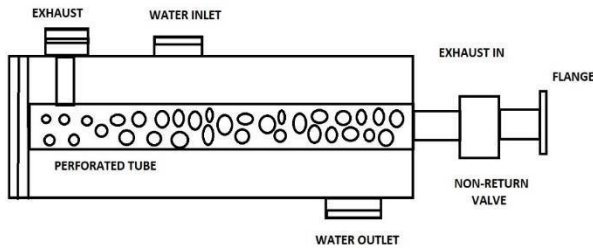


Fig1 Schematic diagram of aqua silencer

The emission can be controlled by using the activated charcoal layer and Lime water. Activated charcoal layer is highly porous and possess extra free valences so it has high absorption capacity and lime water chemically reacts with the exhaust gases from the engine and release much less polluted gases to the environment. The noise and smoke level is considerably less than the conventional silencer; there's no need of a catalytic converter and it is easy to install.

HEAT RECOVERY SYSTEM

The exhaust heat when directly exposed to the atmosphere creates harmful effect to the environment resulting increase in global warming. Thus, introducing a copper coil inside the system which conventionally transfers the exhaust heat to the coils further to the fluid flowing in the coil. Resulting decrease in the final exhaust gas heat. moreover, the heated fluid can be further used where preheating is required.

OBJECTIVE

The following are the objectives of this project:

- Emission control of a stationary single cylinder four stroke diesel engine.
- Reduce the noise of exhaust of the engine.
- Reduce the temperature of the exhaust gas before releasing in the atmosphere.
- Providing average hot water to the engine for cooling.

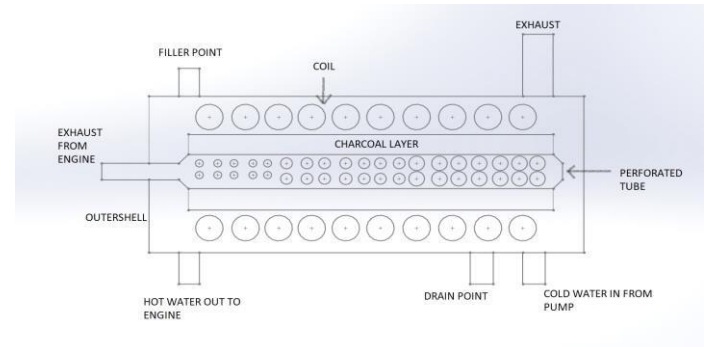


Fig2 2D layout of the system

This system comprises of 2 stages. The first stage is designed for the purification of exhaust gases from the exhaust manifold, and the second stage comprises of a helical copper coil which act as a heat exchanger.

Exhaust Treatment

Exhaust inlet to the silencer

Exhaust gas from the outlet of combustion chamber enters the silencer this exhaust is at temperature higher than 200

Perforated tube.

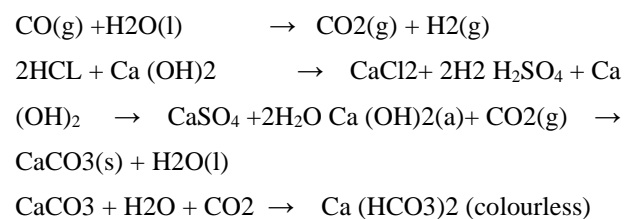
The mass exhaust will breakdown to small bubbles here in this process. The exhaust from the engine enters the perforated tube and passes from the holes of four different sizes which leads to breakdown of the large mass of exhaust gas to break down into smaller masses.

Charcoal layer.

Captures the exhaust particles (carbon, Sulphur & particulate matter). Exhaust gas from the combustion chamber contains harmful contents which are been absorbed by the activated charcoal layer here in this process

Lime water.

To reduce the noise & act as a wash for the system. The solution here act as a wash for the system the contains trapped by the activated charcoal are still harmful so here in this process the lime water nullifies the effect of the present particles and make it harmless.



Exhaust outlet from silencer

The exhaust having low emission, less noise, low temperature is released in atmosphere. After all the process been done the exhaust which has been fully treated for emission control and noise control is been released out in the atmosphere. This exhaust which is been set free to the atmosphere causes no harm to the environment or human beings.

Heat Recovery System.

Water inlet

The exhaust from the engine is at a high temperature this exhaust contains lots of heat which is of no use i.e. waste Here the heat is used to heat fluid which can be used in industries for different applications. Water with the help of pump is been pumped to the silencer (copper coils)

Copper coils

It acts as a heat exchanger. The cold water inside the tube gains heat from the exhaust, which makes the water hot and also cools the exhaust. Fluid pumped to the copper coil gains heat from the exhaust present in the silencer and in this way the heat which was been wasted earlier can be used for further industrial applications.

Water outlet

Average hot water is obtained at the outlet of the copper coils. which can be used in further industrial applications.

III. DESIGN

Aqua silencer & Heat recovery combine unit

Our project is an essential part of the whole setup, according to which this whole setup is designed. The dimensions of Aqua silencer & Heat recovery unit are done accordingly. This component alone consists of several different components i.e.perforated tube, activated charcoal layer (mesh), copper coils & stand

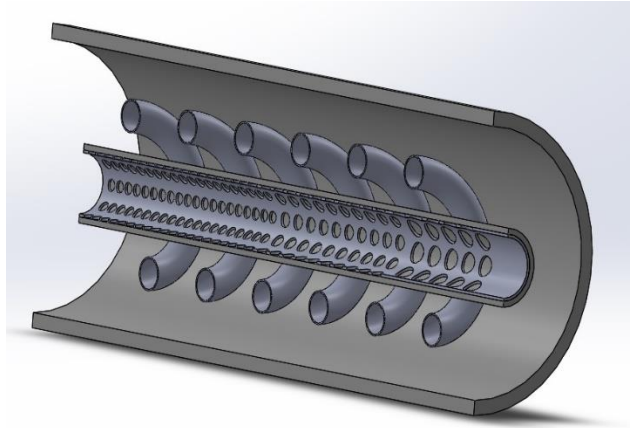


Fig 4 3D Cross-section View

The exhaust tones are calculated using the following

Formulae:

CFR = Engine Speed in RPM/60 For a two-stroke engine

CFR= Engine Speed in RPM/120 ...For a four-stroke engine

EFR = N * (CFR)

CFR= 2200/120 ...For a four-stroke engine

=18.34Hz

EFR = n *(CFR)

=1 *18.34

=18.34 Hz

The first 4 harmonics are to be suppressed as higher order has very little effect on noise. The diameter of the holes drilled should suppress these frequencies.

Volume swept by each cylinder:

Swept volume (Vs)

$$V_s = (3.143 * D * D * L) / 4$$

$$= (3.14 * 0.080 * 0.080 * 0.062)$$

$$= 0.3116 \text{ lit}$$

Silencer volume: Volume of silencer must be at least 12 to 25 times the volume considered. Volume can be adjusted depending on the space constraint.

Factor consider is = 16

$$\text{Silencer Volume} = \text{Factor Consider} \times \text{Volume} = 0.3116 * 16 = 4.98 \text{ Lit}$$

$$\text{Diameter of hole to be drilled}(d) = 1.29 * n^{0.5} = 1.29 * 1^{0.5} = 1.29 \text{ mm}$$

i.e. $d > 1.29 \text{ mm}$



Fig 3 Aqua silencer & heat recovery unit.

PERFORATED TUBE

diameter of perforated tube ID:-40mm OD:- 44mm

And length= 10 * Pipe diameter <math>L < 16 * \text{Pipe diameter}</math>

440 <math>L < 704</math>

Therefore L= 500mm



Fig 5 Perforated tube

It's made up of stainless-steel grade 304 of outer diameter 42 mm, inner diameter 38mm and length 600 mm. stainless steel is selected because the perforated tube is directly in contact with the exhaust gas so it can with stand high temperature and will not rust easily.

Perforated tube consists of holes of four different sizes i.e.

- 96 holes of 3 mm diameter
- 100 holes of 5 mm diameter
- 68 holes of 8 mm diameter
- 24 holes of 10 mm diameter

CHARCOAL LAYER

As the diameter of perforated tube is selected as 44mm OD. The diameter of charcoal layer is selected accordingly

I.D.:- 44mm

OD:-52mm

Length :- Same as the length of perforated tube. i.e. 500mm



Fig 6 Activated charcoal

Here activated charcoal is used to purify the exhaust i.e. the carbon and other polluting contaminate. This contaminates get absorbed by the charcoal layer.

Size of the activated charcoal layer particles is 8 mm – 12 mm in size

Also in the earlier systems there was no method of refilling the activated charcoal after the maintenance period without destroying the mesh which leads to again make the mesh every time the maintenance is done but here we have made an arrangement which will be easy for refilling the activated charcoal without destroying the mesh.

COPPER COILS

Here for the heat recovery system a copper coil of outer diameter 12.83 mm and inner diameter of 10.12 mm is being circulated in a spherical coil form inside the outer shell

Material of the coil is selected as copper because it is suited for heat exchange application as it has high heat transfer coefficient.

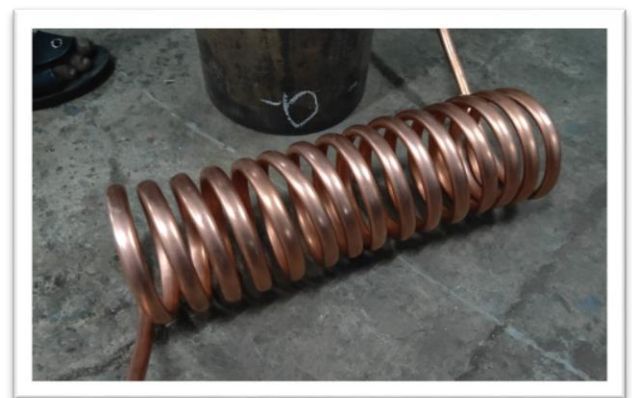


Fig 7 Copper Coils

OUTER SHELL

It is made up of mild steel outer diameter 195 mm inner diameter 175 mm and 500mm in length

Flange arrangement is done for maintenance purpose thirteen tapped holes are drilled on the flange paper gasket of thickness 8mm is used between the flanges for making the system leak proof.





Fig 8&9 Outer shell with flange arrangement

DETAIL DIMENSIONS

SR.	COMPONENT	MATERIAL	QTY	DIMENSION (mm)
1.	Perforated tube	SS	1	OD= 42 ID=38 LENGTH=600
2.	Outer shell	MS	1	OD= 195 ID=175 LENGTH=500
3.	Flange	MS SS	2 1	OD=220 THICKNESS=5
4.	Coil	Copper	1	OD=12.83 ID=10.12

Table 1 Measured Dimensions of Components

IV. RESULTS & DISSCUSION

Table 2 Emission Control Table.

Experiment	Light absorption coefficient – “K” (Permissible Limit – 2.450)
Without Setup	1.25
With Setup (charcoal layer)	0.07234
With Setup (Charcoal Layer +CaCO ₃)	0.05334

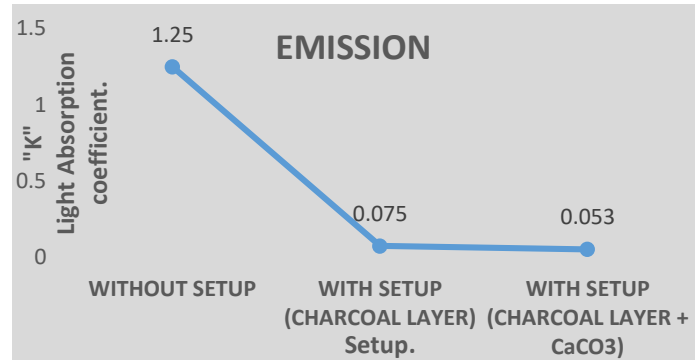


Fig 10 Graph of Emission Control.

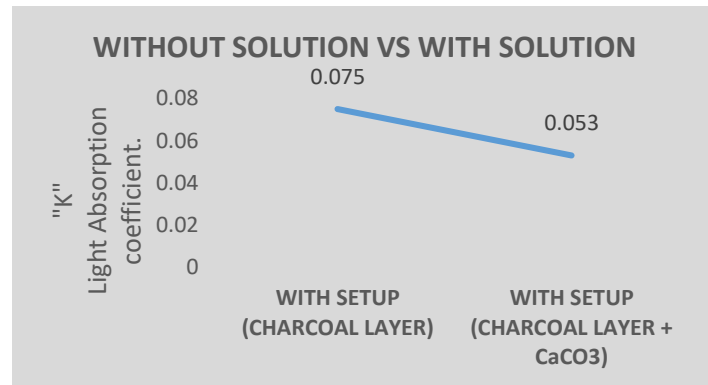


Fig 11 Graph of without Vs With solution

V. CONCLUSION

1. While experimenting with the setup the emission count was 0.053K and 0.075K which lies within the permissible limits i.e. 2.45K
2. The emission count with CaCO₃ is 0.053K and the emission count without CaCO₃ is 0.075K which shows that we have an 29.34% of drop in the emission with CaCO₃ Solution.

VI. FUTURE WORK

To see if any other solution in replacement of CaCO₃ can give the same or better result. The copper coils arrangement is to be done in such a way that it extracts more amount of heat from the silencer. Making the model smaller in size so it can be used in automobiles.

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