Reduction in Emissions and Noise using AQUA-SILENCER

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Abstract: Air pollution is the most serious issue from the public health point of view as an every individual person breaths approximately 22000 times a day, inhaling about 15 to 22 kg of polluted air daily causing undesirable aesthetic and physiological effects. Further the air pollution contributes heavily to contamination of our environment so it is imperative that serious attempts should be made to conserve earth's environment from degradation.
An aqua silencer fitted to the exhaust pipe of engine can control exhausts emission and noise effectively as compared to that of conventional silencer, it is cheaper, no need of catalytic converter and easy to install.
Sound produced under water is less hear able than it is produced in atmosphere. This mainly because of small sprockets in water molecules, which lowers its amplitude thus, lowers the sound level. Because of this property of water is used in this silencer and hence its name AQUA SILENCER.

I. INTRODUCTION

Air pollution can be defined as addition to our atmosphere of any material, which will have a dexterous effect on life upon our planet. The main pollutants contribute by automobile are carbon monoxide (CO), unburned hydrocarbon (UBHC), oxides of nitrogen (NOx) and Lead.
An aqua silencer System is designed to replace conventional single unit engine silencers on board structures. With its light weight and slender design, it offers a minimal 'footprint' while optimizing the entire exhaust system for low noise and reduced back pressure [1]. It is used to control the noise and emission in IC engines. The reason why we go for aqua silencer is, in today life the air pollution causes physical ill effects to the human beings and also the environment. The main contribution of the air pollution is exhausts from automobile like carbon dioxide and un-burnt Hydrocarbon.

In order to avoid these type of gases by introducing this aqua silencer. It is fitted to the exhaust pipe of the engine. Sound produced under water is less hear able than it produced in atmosphere. This mainly because of small sprockets in water molecules, which lowers its amplitude thus, lowers the sound level. The emission can be controlled by using the activated charcoal layer and it is highly porous and possesses extra free vacancies so it has high absorption capacity. So absorb the gases from the engine and release much less position to the environment. The noise and smoke level is considerable less than the conventional silencer further there is no need of catalytic converter and easy to install [2].
In this silencer, the Charcoal and Water is used so it is called hybrid aqua silencer, and it is useful in automobile, industry, DG sets & DG machines, Marin and Boats also so, it is known as hybrid universal aqua silencer.

II. WORKING AND LAYOUT

Basically an aqua silencer consists of a perforated tube which is installed at the end of the exhaust pipe. The perforated tube may have holes of different diameters. The very purpose of providing different diameter hole is to break up gas mass to form smaller gas bubbles the perforated tube of different diameter. Generally 4 sets of holes are drilled on the perforated tube. The other end of the perforated tube is closed by plug. Around the circumference of the perforated tube a layer of activated charcoal is provided and further a metallic mesh covers it. The whole unit is then placed in a water container. A small opening is provided at the Top of the container to remove the exhaust gases and a drain plug is provided at the bottom of the container for periodically cleaning of the container. Also a filler plug is mounted at the top of the container. At the inlet of the exhaust pipe a non-return valve is provided which prevents the back flow of gases and water.

III. DESIGN OF AQUA SILENCER

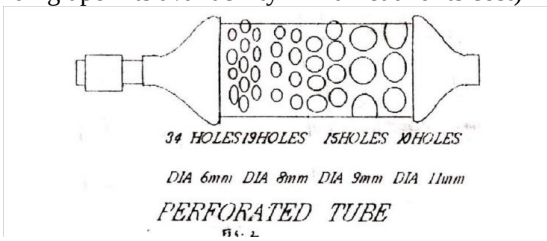
STEP 1: BENCHMARKING

As per design methodology we benchmarked same kind of engine models to set the target of transmission loss of muffler.
Engine data: **Hero Honda Splendor**
Bore (D) = 50 mm
Stroke (L) = 49.5 mm
No. Cylinders (n) = 1

Engine power (P) = 6.15kw (8.36ps)@ 8000rpm
Max. RPM (N) = 8500 rpm
Allowable back pressure for muffler = Not available (in H2O)
Transmission Loss Noise target (muffler) = 30 dB.
STEP 2: TARGET FREQUENCIES
To find fundamental frequency
Cylinder Firing Rate (CFR):
CFR to be calculated as follows,
CFR =8000/120 = 66.66
STEP 3: MUFFLER VOLUME CALCULATION
Swept volume (Vs): $(\pi \times d^2 \times L)/4$
$= (3.14 \times 50^2 \times 49.5)/4$
= 97143.75 x 10^-6 Lit.
Volume to be consider for calculation
Volume = (n) x Vs/2 = 0.48
Silencer Volume Factor Consider Volume 2.26485*Lit*
Assumed Factor =4.7083
STEP 4: INTERNAL CONFIGURATION OF MUFFLER AND CONCEPT DESIGN
Diameter of muffler calculated as:
$Vm = (\pi/4) \times d^2 \times L$
$0.00226 \times 10^{-6} = (3.14/4) \times D^2 \times 0.342$
D=0.091750 m
D=91.75mm……..Diameter of muffler
Step 5: TAIL PIPE DESIGN:
Generally Tail Pipe Diameter and shape is taken the same as selected by OEM or manufacturer for lesser flow resistance and optimum flow characteristics. Hence,
Tail Pipe Diameter: 23.48 mm (From Hero Honda splendor as seen below).

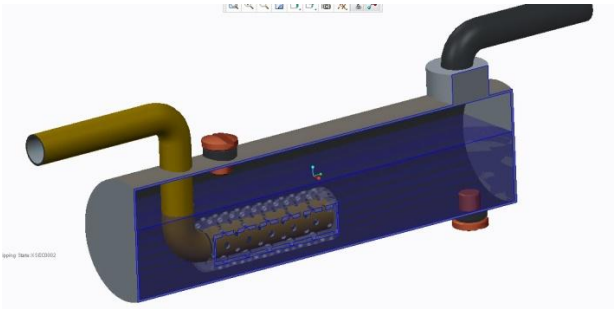
STEP 6: SELECTION OF OTHER PARAMETERS

1) Charcoal Meshed around perforated tube to capture Pollutants.
2) The perforated tube remains completely immersed in water to maximize pollutants capture.
3) Inlet and Outlet extension to be kept in configuration as shown in CAD model below.
4) L_a= Length at which Perforation starts on pipe = 5mm
5) L_b= Length at which perforation ends = 180mm
6) Diameter of perforation: variable from 6mm to 11mm (referring to research paper) as seen below, for breaking of gas bubbles in different sizes.
7) A drain plug and refill cap is provided for replacement of water and maintenance.
8) A non return valve is provided before perforated pipe to prevent water entering engine
9) Material : SS (Any grade depending upon its availability in market and its cost)



STEP 7: CAD MODEL

The Following is the CAD model of proposed Aqua silencer configuration for this design report:



IV RESULT AND DISCUSSION

This chapter includes the observation tables from experimentation for both standard silencer and aqua silencer. Also include the result tables for same. The graphs showing difference between standard and aqua silencer are plotted in included. The discussion over the result is done in this chapter.

Assumptions

- Surround noise is negligible.
- No losses in engine.
- No leakage from silencers
- No losses in analyzer

Available data

Inlet temperature of air at engine= $36°C$

Radius of pulley = R_{pulley}=4 in= 0.102 m

Observation Tables

According to the experimentation the observations are noted for different parameters using different instruments.

For standard silencer:

Table 4.1 observations for standard silencer

OBS. NO.	Engine speed (rpm)	T_1 (kg)	T_2 (kg)	CO (%)	UBHC (ppm)	CO_2 (%)	SOUND LEVEL
1	2300	No load	No load	0.09	500	1.74	80
2	4100	2	6	0.701	310	2.54	82
3	5600	3	9	0.956	280	6.47	85
4	6200	4	12	1.132	220	7.68	87

After taking the readings for standard silencer it is unbolted from the engine exhaust and aqua silencer is fitted with bolts. The same readings for aqua silencer are noted down which are given in following table.

Table 4.2 Observations for Aqua Silencer

OBS. NO.	Engine speed (rpm)	T_1 (kg)	T_2 (kg)	CO (%)	UBHC (ppm)	CO_2 (%)	SOUND LEVEL
1	2300	No load	No load	0.060	103	0.72	70
2	4100	3	8	0.689	104	2.08	73
3	5600	3	12	0.810	91	1.87	75
4	7000	3	12	0.884	76	2.77	76

The observations are as per shown in the table 4.1 and table 4.2. From the reading of dynamometer tensions are noted in terms of weights (kg).

Result Tables

Using these tensions the torque acting on engine is calculated. From torque the brake horse power is found out.

For that purpose the tensions T_1 and T_2 are first converted in Newton by multiplying it by 9.81 (g) and further calculations are done.

Table 4.3 Result for Standard Silencer

Obs. No.	Engine Speed N (rpm)	Torque T (Nm)	Brake Horse Power BHP (W)
1	2300	-	-
2	4100	3.99738	1715.409

3	5600	8.00496	4691.9
4	7000	8.00496	5864.967

Table 4.4 Result for Aqua Silencer

Obs. No.	Engine Speed N (rpm)	Torque T (Nm)	Brake Horse Power BHP (W)
1	2300	-	-
2	4100	5.0031	2146.99
3	5600	8.99334	5271.296
4	7000	8.99334	6589.12

4.3 Graphs and Discussion

The result table shows the difference in brake horse power and the torque of standard and aqua silencer. The BHP increases in case of aqua silencer. It is because the torque on engine with aqua silencer increases. Aqua silencer is absorptive type of silencer therefore back pressure on engine decreases which results in increase in brake power.

The comparative graphs of BHP and torque shows how the values vary with standard silencer and aqua silencer.

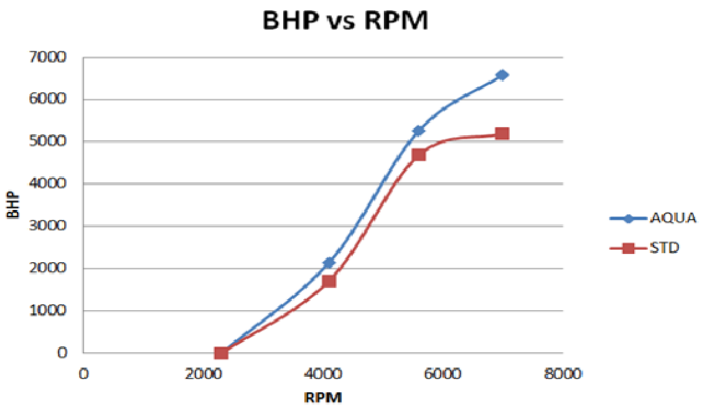


Fig 4.1 Comparison of BHPs Between Standard And Aqua Silencer

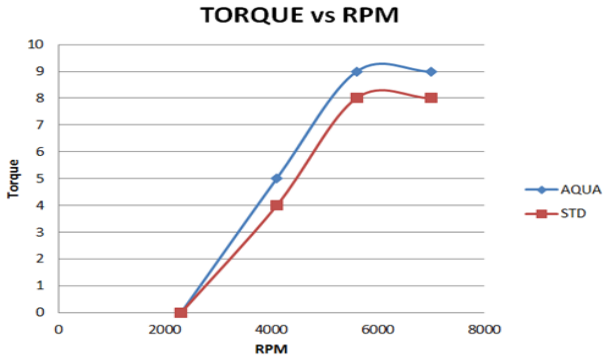


Fig.4.2 Comparison of Torque Between Standard And Aqua Silencer

Observation table shows the amount of emission coming out of the exhaust system of engine. Table 4.1 shows emission for standard silencer and table 4.2 shows for aqua silencer. From observation tables it clearly seen that there is decrease in the amount of CO, UBHC and CO_2 .

Comparative graphs for CO,UBHC and CO_2 are as follows;

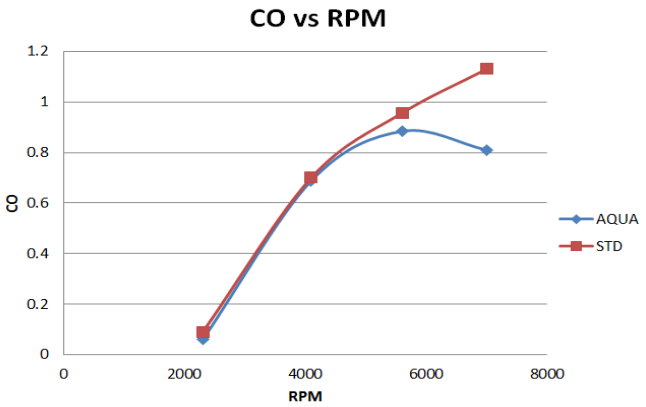


Fig 4.3 Comparative Graph ForCO Emission For Standard And Aqua Silencer

From observation table 4.1 and table 4.2 and fig4.5 it is clearly seen that there is about 20-30% cut off in CO emissions by using aqua silencer. It means the charcoal layer efficiently adsorb the carbon monoxide so that less emissions are sent out to the environment.

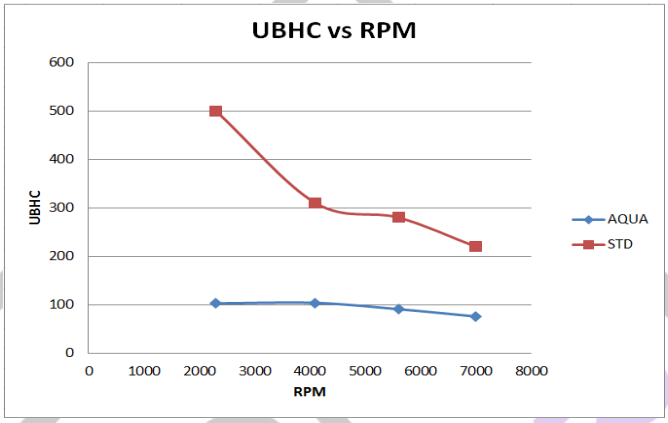


Fig 4.4 Comparative Graph Of UBHC For Standard And Aqua Silencer.

Fig 4.6 shows the graphs of UBHC emission from engine with standard and aqua silencer. It is clearly seen that the unburnt hydrocarbon emission decreased in huge amount. Around 70-80% of unburnt hydrocarbons get adsorbed in aqua silencer.

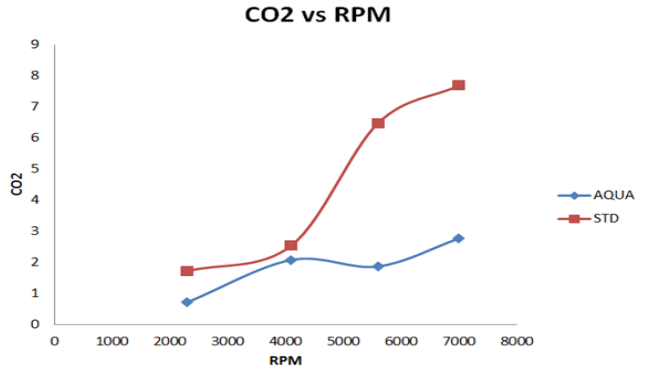


Fig 4.5 Comparative Graph of CO_2 Emission For Standard And Aqua Silencer.

According to fig 4.7 there is decrease in CO_2 emissions with use of aqua silencer than the standard silencer. The amount of CO_2 adsorbed by charcoal layer is around 40-50% which is plays crucial role in environment. So it can be stated that aqua silencer effectively reduces CO_2 coming out of the engine exhaust which causes greenhouse effect.

The objective of this project was to reduce emission from exhaust system along with the noise reduction. The reduction in noise is seen in the table 4.1 and table 4.2. The noise is reduced because of aqua silencer. Around 10-15 dB sound is damped. The graphical comparison is as follows

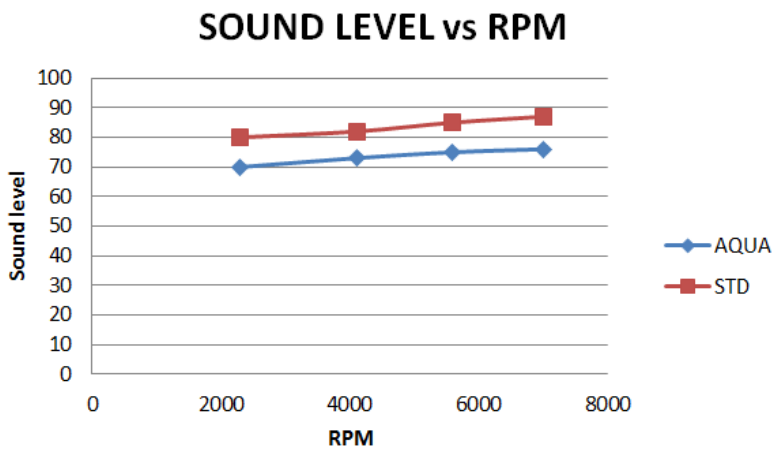


Fig 4.6 Comparative Graph for Sound Level by Standard and Aqua Silencer

From all observation tables, result tables and graphs it can be stated that aqua silencer reduces the exhaust gases coming out of the engine exhaust. Also it reduces noise mush better than standard silencer.

IV. CONCLUSION

The aqua silencer is more effective in the reduction of emission gases from the engine exhaust using perforated tube and charcoal. By using water as a medium the sound can be lowered and also by using activated charcoal in water we can control the exhaust emission to a greater level. The water contamination is found to be negligible in aqua silencer. It is smokeless and pollution free emission and also it is very cheap. It can be also used both for two wheelers and four wheelers and also can be used in industries

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2. Proceedings of the International Conference on Mechanical Engineering 2005 (ICME2005) 28- 30 December 2005, Dhaka, Bangladesh ICME05-TH-47