

Fabrication and Testing of Portable Twin Filter Aqua Silencer

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Abstract: Purity of air is most important from the public health point of view, because every individual person breathes approximately 22000 times per day, inhaling about 15 to 22 Kg of air daily. Polluted air causes physical ill effect decides undesirable aesthetic and physiological effects. Air pollution can be defined as addition to our atmosphere of any material, which will have a deleterious effect on life upon our planet. The main pollutants contribute by automobiles are carbon monoxide (CO), unburned hydrocarbon (UBHC), oxides of nitrogen (Nox) and Lead. Automobiles are not only source of air pollution, other sources such as electric power generating stations, industrial and domestic fuel consumption, refuse burning, industrial processing etc. also contribute heavily to contamination of our environment so it is imperative that serious attempts should be made to conserve earth's environment from degradation. A twin filter silencer is an attempt in this direction; it is mainly dealing with control of emission and noise. A twin filter silencer is fitted to the exhaust pipe of 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. Because of this property, water is used in this silencer and hence its name as "Twin Filter Silencer". Due to this we reduce the noise and emissions from the exhaust.

Keywords: Twin Filter Silencer; Unburned Hydrocarbon; Air Pollution; Carbon Monoxide; Water Molecules.

1. INTRODUCTION

Air pollution in the world has emerged as the focus of environmental remediation efforts because of their toxicity and threat to human beings. Due to rapid growth of industrialization and urbanization with new technological advancements, the existing environments are contaminated by emission from automobile and industries containing organics, color, heavy metal etc. The environment contamination particularly by air pollutants from industrial effects and their persistence in food chain has been of major concern as it is posing a serious threat to environment including fisheries. Also diesel engines are playing a vital role in Road and sea transport, 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, we cannot ignore the harmful effects of the large mass of the burnt gases, which erodes the purity of our environment every day. Hence the removal of toxic air pollutant contaminants from atmosphere is one of the most important environmental and economic issues today.

2. TYPES OF SILENCERS

Mufflers are installed within the exhaust system of most internal combustion engines, although the muffler is not designed to serve any primary exhaust function. The muffler is engineered as an acoustic soundproofing device designed to reduce the loudness of the sound pressure created by the engine by way of acoustic quieting. The majority of the sound pressure produced by the engine is emanated out of the vehicle using the same piping used by the silent exhaust gases absorbed by a series of passages and chambers lined with roving fiberglass insulation and/or resonating chambers harmonically tuned

to cause destructive interference wherein opposite sound waves cancel each other out. An unavoidable side effect of muffler use is an increase of back pressure which decreases engine efficiency. This is because the engine exhaust must share the same complex exit pathway built inside the muffler as the sound pressure that the muffler is designed to mitigate. Some vehicle owners remove or install an aftermarket muffler when engine tuning in order to increase power output or reduce fuel consumption because of economic or environmental concerns, recreational pursuits such as motorsport and hyper milling and/or for personal aesthetic acoustical preferences. Although the legality of altering a motor vehicle's OEM exhaust system varies by jurisdiction, in many developed parts of the world, modification of a vehicle's exhaust system is usually highly regulated if not strictly prohibited

1. Baffle type
2. Wave cancellation type
3. Resonance type
4. Absorber type
5. Combined resonance & absorber type.

2.1 Baffle Type:

It is generally cylindrical in shape with a number of baffles spot welded inside. There are many designs of baffles, but the principle in all cases is the same that is, closing in any direct passage for the gas. Major drawback of the muffler is their low efficiency. Because of the restrictions provided to the flow by the baffles, the back pressure is increased, thus causing loss in engine power.

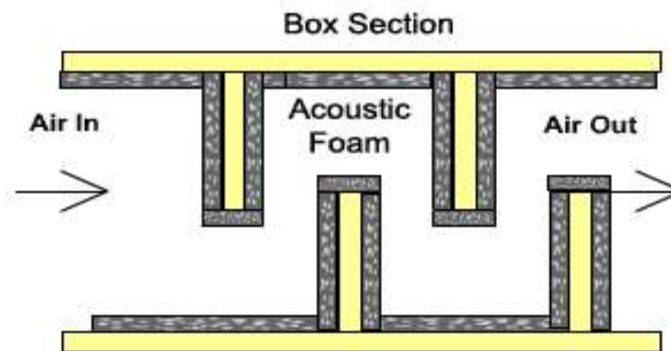


Figure 2.1 Baffle type muffler

2.2 Wave Cancellation Type:

In this type, exhaust gases are divided into two parts. The lengths of these paths are so adjusted that after they come out of the muffler, the crests of one wave coincide with the troughs of the second wave, thus the cancelling each other and reducing the noise to zero theoretically. This is achieved if the lengths of the two passages differ by half the wave length. In practice this type of muffler does not eliminate noise completely, because this is possible only at one frequency for which muffler is designed, whereas the noise is a combination of different frequencies. However, appreciable noise reduction is achieved. In this the resistance to the main gas flow is very small as compared to the baffle type.

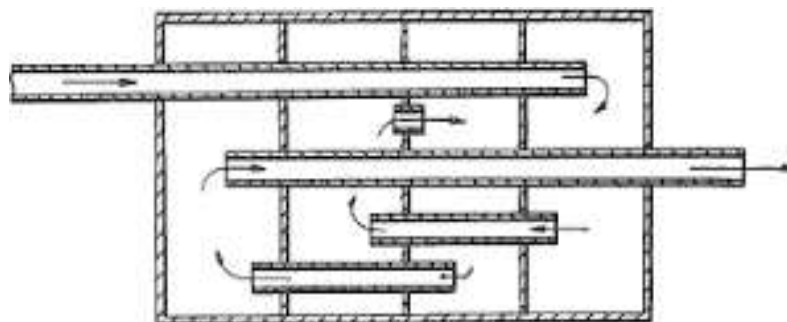


Figure 2.2 Wave cancellation type muffler

2.3 Resonance Type:

These are also called Helmholtz type, after the person who originated the idea. It consists of a number of Helmholtz resonators in series, through which a pipe containing access ports passes. The exhaust gases flow through this type and thus experience no resistance. Series of resonators eliminate the fundamental and higher harmonics of the engine noise.

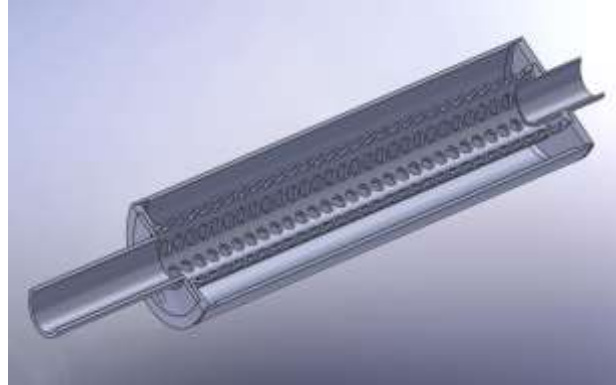


Figure 2.3 Resonance type muffler

2.4 Absorber Type:

The sound absorbing material, usually fiber glasses, is placed in this case around the perforated tube through which the exhaust gases pass. The sound is reduced by conversion into heat by the sound absorbing material. Such mufflers are commonly known as glass-packs and are quite common in performance and raising cars due to their little resistance to flow. These essentially attenuate at higher frequency sounds and produce the deep, throaty sound usually associated with a high performance engine. A common design is a cylindrical can with a perforated tube which is surrounded by packing material.



Figure 4.4 Absorber type muffler

2.5 Combined Resonance and Absorber type:

It is seen that the absorber type muffler, has a drawback in that it is not efficient in reducing noise of low frequency. To obviate this defect, this is combined with a resonant chamber. It has been found that this type is more efficient than either the simple resonance or the absorber types.

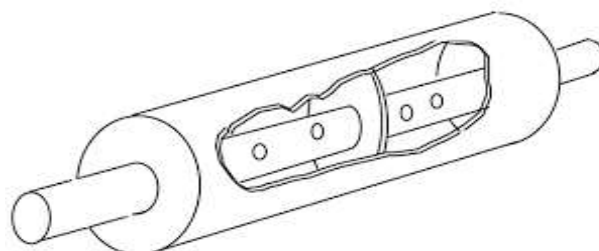


Figure 2.5 Combined resonance & absorber type muffler.

3. CONSTRUCTIONAL DETAILS

Basically a twin filter 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 as well.

3.1 COMPONENTS:

1. Perforated Tube.
2. Charcoal Layer.
3. Lime water
4. Outer Shell.
5. Ball Valve

3.1.1 Perforated Tube:

The main function of the perforated tube is to suppress the sound and increase the performance. Number of holes is provided on the surface of the tube. It is used to convert high mass bubbles to low mass bubbles. The charcoal layer is pasted over the perforated tube. The exhaust gas from the engine cylinder is passed through these holes so large gas bubbles are converted to smaller gas bubbles. Hence the noise is reduced. Perforated tube is an essential part of a twin filter silencer.



Figure 3.1 Perforated Tube

3.1.2 Charcoal Layer:

The charcoal layer has more absorbing capacity because it has more surface area. This charcoal is called as activated charcoal. It is produced by heating the charcoal for several hours in a burner. Its surface area gets increased. Charcoal layer is provided on the surface of the perforated tube. Charcoal is highly porous and possesses extra free valences. So the charcoal is a good absorbing medium. Hence the gases may purify. Different types of charcoal are available. But activated carbon charcoal is commonly used in twin filter silencer. Charcoal may be activated to increase its effectiveness as a filter. Activated charcoal readily adsorbs a wide range of organic compounds dissolved or suspended in gases and liquids. In certain industrial processes, such as the purification of sucrose from cane sugar, impurities cause an undesirable colour, which can be removed with activated charcoal. It is also used to absorb odors and toxins in gases, such as air. Charcoal filters are also used in some types of gas mask.



Figure 3.2 Activated Charcoal

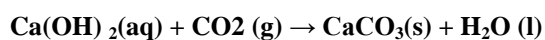
3.1.3 Lime Powder:

Lime water is the common name for a saturated solution of calcium hydroxide. Calcium hydroxide, Ca(OH)_2 is sparsely soluble in water (1.5 g/L at 25 °C) Pure limewater is clear and colour less, with a slight earthy smell and an alkaline bitter taste of calcium hydroxide. The term lime refers to the alkaline mineral, and is unrelated to the acidic fruit. Limewater is prepared by stirring excess calcium hydroxide in pure water, and filtering off the excess insoluble Ca(OH)_2 . When excess calcium hydroxide is added to limewater, a suspension of calcium hydroxide particles remains, giving it a milky aspect, in which case it has the common name of milk of lime. Milk of lime is an alkaline solution with a pH of 12.3.



Figure 3.3 Limestone powder

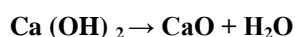
Carbon dioxide passes through limewater, giving a milky solution. This is due to the insoluble suspension of calcium carbonate formed:



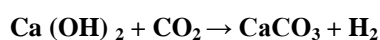
If excess CO_2 is added, the following reaction takes place:



When heated to 512 °C, the partial pressure of water in equilibrium with calcium hydroxide reaches 101 KPa, which decomposes calcium hydroxide into calcium oxide and water.



Limewater turns milky in the presence of carbon dioxide due to formation of calcium carbonate, a process called carbonizations.



3.1.3.1 Properties of Lime Powder:

Calcium hydroxide, traditionally called slaked lime, is an inorganic compound with the chemical formula Ca(OH)_2 . It is a colour less crystal or white powder and is obtained when calcium oxide (called lime or quicklime) is mixed, or slaked with water. It has many names including hydrated lime, caustic lime, builder's lime, slack lime, or pickling lime. Calcium

hydroxide is used in many applications, including food preparation. Limewater is the common name for a saturated solution of calcium hydroxide. A suspension of fine calcium hydroxide particles in water is called milk of lime. The solution is called limewater and is a medium strength base that reacts with acids and attacks many metals.

Table 3.1 Properties of lime

Properties	
Molecular formula	Ca (OH) ₂
Molar mass	74.093 g/mole
Appearance	White powder
Odour	Odourless
Density	2.211 g/cm ³ , solid
Melting point	5800C (loses water)
Solubility in water	0.189 g/100mL (00C) 0.173 g/100mL (200C) 0.066 g/100mL (1000C)
Solubility product, K _{sp}	4.68×10 ⁻⁶
Solubility	Soluble in glycerol and acids Insoluble in alcohol
Acidity (pK _a)	12.4
Basicity (pK _b)	2.37
Refractive index (n _D)	1.574

3.1.4 Outer Shell:

The whole setup was kept inside the outer shell. It is made up of steel. The water inlet, outlet and exhaust tube was provided in the shell itself. The first process deals with manufacturing the outer shell of the silencer. First the metal sheets are cut using the gas cutter. Thus the manufacturing process must be extremely flexible. The shape of the outer shell has a cylindrical shape that is formed by a three roll bending mill. The rolling process is efficient in creating this cylindrical shaped shell which takes approximately three passes to obtain the final shape. The rolling process requires high skills because the material properties of the sheets changes from pass to pass, and sheet to sheet. The operator must take these into account to produce a well-shaped shell. Once the shell has taken its shape welding the seam is required. At this seam there is an overlap, where a consumable electrode welding procedure known as submerged arc welding (SAW) takes place. The welding is done by hand and requires a qualified and experienced welder.



Figure 4.4 Outer shell.

3.1.5 Ball Valve:

A ball valve is a valve with a spherical disc, the part of the valve which controls the flow through it. The sphere has a hole, or port, through the middle so that when the port is in line with both ends of the valve, flow will occur. When the valve is closed, the hole is perpendicular to the ends of the valve, and flow is blocked. The handle or lever will be in line with the port position letting you "see" the valve's position. The ball valve, along with the butterfly valve and plug valve, are part of the family of quarter turn valves.



Figure 4.5 Ball Valve

4. WORKING PRINCIPLE

The exhaust gas from the engine cylinder is enters in to the twin filter silencer through perforated tube. Through the perforated tube gas first enters in to the primary filter of the silencer. Perforated tube is a special tube having different diameter sections. So the perforated tube converts high mass bubbles in to low mass bubbles. At the primary filter calcium hydroxide reacts with toxic gases & reduces its concentration. After that they pass to the secondary filter consist of charcoal which again purify the gases. A charcoal is highly porous and possesses extra free valances. So it has high adsorption capacity. Finally the exhaust gases escape through the opening in to the atmosphere. The twin filter silencer is more effective in the reduction of emission gases from the engine exhaust gas using water and lime stone mixture. By using water and lime stone mixture the back pressure will remain constant and the sound level is reduced. By using water as a medium the sound can be lowered and also by using limestone in water we can control the exhaust emission to a greater level. The water contamination is found to be negligible in twin filter silencer, because the amount of acidity level in twin filter silencer is expected to be below the dangerous acidity. It is smokeless and pollution free emission and also very cheap. Hence twin filter silencer reduces both noise and pollution. The twin filter silencer's performance is almost equivalent to the conventional silencer

5. RESULT AND COST EVALUATION.

5.1 RESULTS:

5.1.1 Test-1:

The screenshot displays a software interface for pollution testing. It includes fields for 'Basic Details' (PUCC Number, Name, Address, Contact Number, Test Date/Time) and 'Vehicle Details' (Registration Number, Vehicle Type, Manufacturer, Model, Engine, Fuel, Date of Manufacture, Engine Number, Chassis Number, Odometer Reading). A 'Test Results' table shows various parameters for Fuel 1, Fuel 2, and Regulations. A 'Vehicle Image' shows a Suzuki car with license plate DL 2C J 1148. A red banner at the bottom right indicates 'Test Result Failed'.

	Fuel 1	Fuel 2	Regulation
CO	4.365		3.0 %
HC	41.2		1500 ppm
CO2	11.33		
O2	1.03		
Propane	770		
NOx	0		

	Fuel 1	Fuel 2
Lambda	0.9039	
AFR	13.287	
RPM	0	

	Fuel 1	Fuel 2
AP	101.2	
ST	38	
PEF	0.526	
DT	0	

Figure 5.1 Pollution testing on petrol engine without twin filter silencer

5.1.2 Test-2:



Figure 6.2 Pollution testing on petrol engine with twin filter silencer.

5.1.3 Test-3:

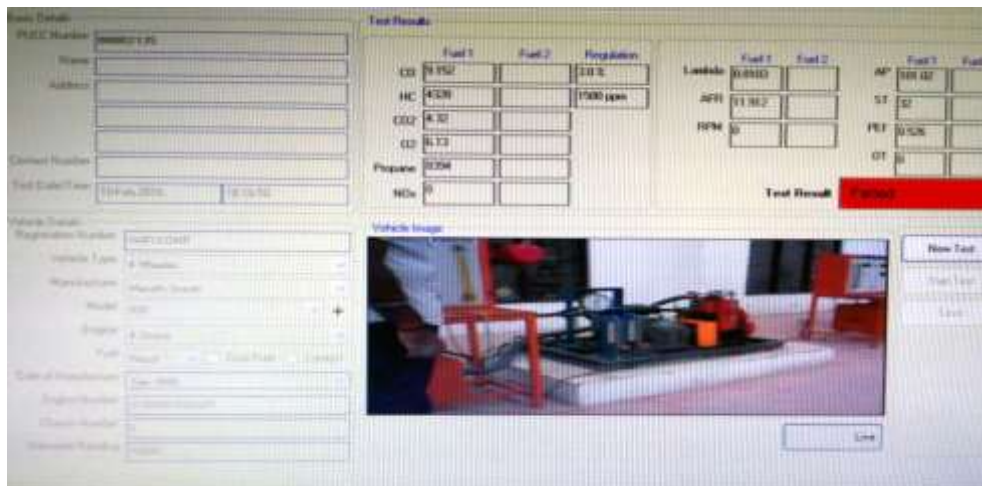


Figure 6.3 Pollution testing on a stationary petrol engine without twin filter silencer.

5.1.4 Test-4:



Figure 5.4 Pollution testing on a stationary petrol engine with twin filter silencer.

In test-1, Maruthi 800 model petrol engine is used. The CO & HC values, without the twin filter silencer are 4.365 & 412 respectively & the values with the twin filter silencer are 1.445 & 196 respectively.

In test-2, the stationary petrol engine is used. The CO & HC values, without the twin filter silencer are 9.152 & 4328 respectively & the values with the twin filter silencer are 0.06 & 10 respectively.

5.2 COST EVALUATION:

SI No:	Materials	Required quantity	Price for unit quantity	Total price (INR)
1	Sheet Metal (Gauge-18)	4×3 Sq. Ft	INR 50/- for 1 Sq. Ft	600/-
2	GI Pipe (1 inch)	4 Ft.	INR 27.5/- for 1 Ft.	110/-
3	Ball Valve (0.75 inch)-Brass	1 no	INR 309/-for 1 piece	309/-
4	End Cap (1.5 inch)-CI	2 nos	INR 80/- for 1 piece	160/-
5	Labour charge for rolling sheet & bending GI pipe			3700/-
6	Welding & pollution testing charges			2000/-
7	Chemical [Ca(OH) ₂]			1000/-
8	Transportation cost			700/-
Total				8579/-

6. CONCLUSION

The twin filter silencer is more effective in the reduction of emission gases from the engine exhaust using perforated tube and charcoal, by using perforated tube the backpressure will remain constant and the sound level is reduced. By using perforated tube the fuel consumption remains same as conventional system. 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. This twin filter silencer performance is almost equivalent to the conventional silencer. It can be also used both for two wheelers and four wheelers and also can be used in industries.

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