

Construction and Experimental Analysis between cylindrical type & canonical type silencer

Mihir Dutta^{1*}, Susmita Das Puja², Nusrat Sharmin³
^{1, 2, 3} Department of Mechanical Engineering,

Khulna University of Engineering & Technology, Khulna-9203, BANGLADESH

E-mail: mihirdutta.me@gmail.com; pujapuja96.pp@gmail.com; nushrat.keya@gmail.com

Abstract

The silencer is comprised of an outer sleeve and inner sleeve having a number of pours and sound absorbing material including heat-resistant fibers (Glass wool) packed between outer sleeve and the inner sleeve. The sound absorbing materials wound directly around the outside of inner sleeve with two or more turns. It's thickness around the inner sleeve is greater than dimension of a gap between the inner sleeve and the outer sleeve to give interference between it and the inner and outer sleeves. Inlet pipe of the silencer is connected to the exhaust pipe of the engine by means of thread. One tube of the manometer is fitted on inlet pressure measurement tube hole and other on the another pressure measurement tube hole of the silencer. The pressure head was measured in centimeter scale to determine pressure drop. It plotted against speed that provides information that high pressure drop in cylindrical than canonical
Keywords: Absorbing material, rpm, muffler, glass wool

1. Introduction

A muffler is a part of the exhaust system of an automobile that plays a vital role. If the high pressure exhaust gases are allowed to enter atmosphere directly from the exhaust manifold, a loud unpleasant noise would be heard like firing of a gun. This noise is due to the large difference in pressure between the exhaust gases and the atmosphere. For quiet operation of the motor vehicle, it is desirable to this noise as much as possible. This is done by using a muffler in the exhaust system. Muffler is so called silencer. A muffler is connected between the engine exhaust pipe and the tail or output pipe. The function of a muffler is to reduce the pressure of the exhaust gases are sufficiently to permit them to be discharged to the atmosphere silently. To reduce the pressure the exhaust gases are permitted to expand slowly and to cool in the muffler. The capacity of the muffler should be sufficiently large to permit the gases to expand to nearly atmospheric pressure before they are discharged into air. Also, the muffler should not have any appreciable restriction to flow that will raise back pressure excessively. Backpressure usually refers to the pressure exerted on a moving fluid by obstructions or tight bends in the confinement vessel along which it is moving, an automotive exhaust muffler with a particularly high number of twists, bends, turns and right angles could be described as having particularly high backpressure. Backpressure in the exhaust sense of them, is usually termed as being a "bad thing" for performance. Backpressure prevents free flow of the exhaust gases from the engine and, as a result, not all of the burned gases will be exhausted from the cylinder. Such gases dilute the incoming combustible gases and engine power is reduced. However, in the interest of reducing exhaust sound to levels allowable by public noise ordinances we use muffler. Without a muffler the typical car exhaust noise exceed 110dB. [1]

2. Sound absorbing material

A muffler uses a sound absorbing material for preventing high frequency sound and a sound absorbing material such as glass wool is wound around the outer periphery thereof or internally filled. Although the glass fiber used as a sound absorbing material accomplishes the quality which can withstand use in various temperature ranges, the resistance property with respect to acid things or alkaline things included in the exhaust gas is insufficient. The glass fiber may be, therefore, degraded/broken and emitted into the air together with the exhaust gas.

3. Glass wool

Glass wool is a form of fiberglass where very thin strands of glass are arranged into a spongy texture similar to steel wool. Glass wool is used widely as an insulating material. Glass wools are typically made from a fused mixture of sand and recycled glass materials. The glass wool traps air, which makes it an ideal insulation material against heat, cold and noise. Because it is also flexible, elastic and lightweight, glass wool is relatively easy to install. After the fusion of a mixture of natural sand and recycled glass at 1450°C, the glass that is produced is converted into fibers. The cohesion and mechanical strength of the product is obtained by the presence of binder that “cements” the fibers together. Ideally, a drop of bonder is placed at each fiber intersection. This fiber mat is then heated to around 200°C to polymerize the resin and is calendared to give it strength and stability. The final stage involves cutting the wool and package it in rolls or panels under very high pressure before palletizing the finished product in order to facilitate transport and storage

4. Absorber type Muffler

It consists of perforated tube, around which a sound absorbing material, like fiber glass or glass wool, is placed. The exhaust gases pass through the perforated tube. The sound absorbing material reduces the high pressure fluctuation of the the noise intensity. These through type or reverse flow type.

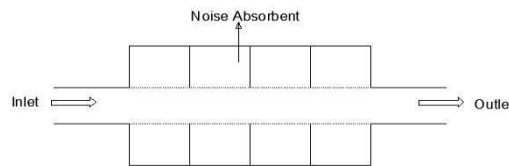


Fig 1: Absorber Type Muffler.

5. Construction Cylindrical

The silencer is comprised of an outer sleeve, an inner sleeve having a number of pores and sound absorbing material including heat-resistant glass wool between the outer sleeve and the inner sleeve. The sound absorbing material is wound directly around the outside of inner sleeve with two or more turns so that the thickness of wound sound absorbing material around the inner sleeve is greater than dimension of a gap material and the inner and the outer sleeves. The sound absorbing material with the inner sleeve is press-fitted into the outer sleeve. Sound absorbing material is prevented from being blown out by exhaust gas flowing through the inside of the inner sleeve so that the silencer is improved in durability. The dimension stability of the outer diameter of sound absorbing material wound around the inner sleeve can be gained so that the press-fitting operation of sound absorbing material wound around the inner sleeve can be performed stably and the density of sound absorbing material can be stabilized. The silencer comprises outer sleeve and inner sleeve formed with a number of pores. Sound absorbing material including heatresistant fibers of glass wool or the like is wound around the outside of inner sleeve with two or more turns. Sound absorbing material with inner sleeve is press-fitted into outer sleeve. This material has the predetermined size according to size of a gap formed between the inside of outer sleeve and outside of inner sleeve. Both end portions of sound absorbing material are cut in such a manner that both end portions of the material are shaped gradually thinner toward the respective edges there of overlaps each other, by which the thickness of sound absorbing material wound around inner sleeve becomes uniform. Therefore, when sound absorbing material with inner sleeve is press-fitted into the inside of outer sleeve, a uniform press-fit resistance can be obtained. Accordingly, worker can smoothly press-fit the material with inner sleeve into outer sleeve without the necessary of any deflection of force, by pressing inner sleeve into outer sleeve in parallel with outer sleeve. After sound absorbing material is wound around the outside of inner sleeve with given turns, inner sleeve and sound absorbing material are press fitted into outer sleeve. Inner sleeve and sound absorbing material are held together as a unit by the projected portion of glass cloth, so that the slippage of sound absorbing material to inner sleeve which can be prevented from being caused by axial thrust applied to inner sleeve when sound absorbing material with inner sleeve is press-fitted into outer sleeve. Exhaust gases having high pressure and temperature flow in the inside of inner sleeve is brought into contact surface of sound absorbing material through a plurality of holes. The density of sound absorbing material in silencer can be suitably set, so that the number of degrees of freedom in altering sound absorbing performance and setting operation of the sound absorbing material into outer sleeve can be stably performed. The silencer can be used for reducing exhaust sound in automobile, where four stroke four cylinder diesel or petrol engine is used. The silencer is comprised of cylindrical body formed with an opening at front and rear ends. Inlet pipe is connected with exhaust pipe of internal combustion engine. Cylindrical body is comprised of inner sleeve having a number of holes and outer sleeve co-axially surrounding inner sleeve,

wherein inner sleeve and outer sleeve forms a double walled pipe. Sound absorbing material is wound inner sleeve with two or more turns and press-fitted into the outside of outer sleeve. The internal space of inner sleeve is separated into four exhausts gas expansion chambers from the left toward the right of the drawing. First separator has a number of small holes and first exhaust gas expansion chamber are communicated with second exhaust gas expansion chamber through small holes. Further, first communication pipe is mounted through second separator and third separator and second exhaust gas expansion chamber is communicated with third exhaust gas expansion chamber through first communication pipe. Further, second communication pipe is communicated with fourth exhaust gas expansion chamber through second communication pipe. Furthermore, exhaust gas emission pipe for communicating fourth exhaust gas expansion chamber with the outside of silencer is mounted through third separator and rear cap. Length of the first, second, third and fourth separator is 4, 5.5, 3, 4 inches. Diameter of the outer sleeve is 3.5 inches. Diameter of the inner sleeve is 3 inches. Gap between outer and inner sleeve is 0.5 inches. Metal sheet of thickness .125 inches is used for this silencer. All the joining of metal and pipe is done by gas welding.



Fig 2: cylindrical silencer

Canonical

The silencer is comprised of moderated body formed with an opening at front and rear ends. Inlet pipe is connected with exhaust pipe of internal combustion engine. Moderated body is comprised of inner sleeve having a number of holes and outer sleeve canonically surrounding inner sleeve, wherein inner sleeve and outer sleeve forms a double walled pipe. Sound absorbing material is wound inner sleeve with two or more turns and press-fitted into the outside of outer sleeve. The internal space of inner sleeve is separated into three exhausts gas expansion chambers from the left toward the right of the drawing. First separator has a communication pipe and first exhaust gas expansion chamber are communicated with second exhaust gas expansion chamber through communication pipe. First communication pipe is mounted through first separator and second exhaust gas expansion chamber is communicated with third exhaust gas expansion chamber through second communication pipe. Exhaust gas emission pipe for communicating third exhaust gas expansion chamber with the outside of silencer is mounted through rear cap. Length of the first, second, third separator is 2.5 inches, 13.5 inches, 2.5 inches. Diameter of the outer sleeve of one is 3 inches. Diameter of the outer sleeve of another is 2.25 inches. Diameter of the inner sleeve of one is 2 inches. Diameter of the inner sleeve of another is 3.25 inches. Gap between outer and inner sleeve is .25 inches. Metal sheet of thickness .125 inches is used for this silencer. All the joining of metal and pipe is done by gas welding.



Fig 3: Canonical Muffler

6. Operation

Cylindrical

Exhaust gas came from an exhaust port of internal combustion engine is collected into pipe by means of a manifold and collected gas is sent into silencer body. First expansion of exhaust gas which reached silencer body is made in first expansion chamber, then gas is sent through small holes, while being squeezed by small holes, into second gas expansion chamber, in which second expansion of gas is made, then exhaust gas is sent through first communication pipe, into third expansion chamber, in which third-expansion of exhaust gas is made. Then, exhaust gas is sent through second communication pipe, into fourth expansion chamber, in which fourth-expansion of gas is made. Then, finally,

gas is exhausted to the outside of silencer through emission pipe. While gas exhausted from internal combustion engine passes through first, second, third and fourth expansion chambers. Expansion and shrinkage of exhaust gas are repeated. Sound absorbing material which inserted between inner and outer sleeve decreases exhaust noise. So, decrease exhaust noise is made in steps.

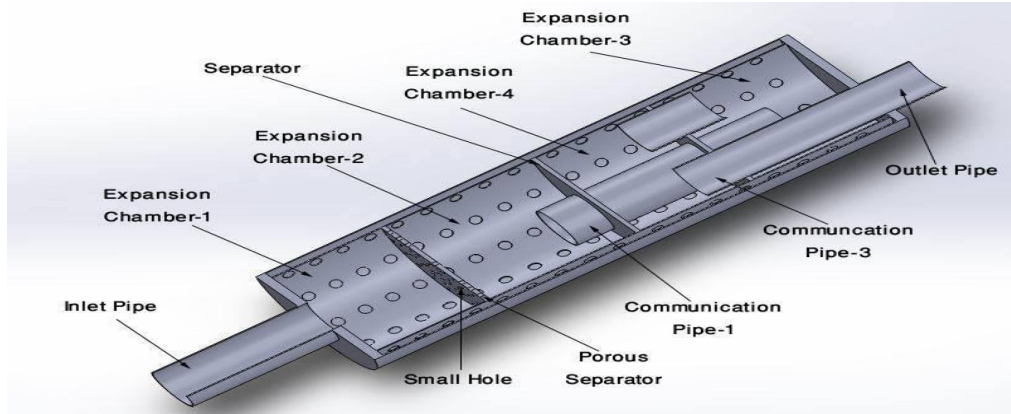


Fig 4: 3D Sectional View

Canonical

Exhaust gas exhausted from an exhaust port of internal combustion engine is collected into exhaust gas pipe by means of a manifold and collected gas is sent into silencer body. First expansion of this gas which reached silencer body is made in first exhaust gas expansion chamber, then gas is sent through a communication pipe, while being squeezed by communication pipe, into second gas expansion chamber, in which second expansion of gas is made, then exhaust gas is sent through second communication pipe, into third expansion chamber, in which third expansion of exhaust gas is made. Then, finally, gas is exhausted to the outside of silencer through exhaust gas emission pipe. While exhaust gas exhausted from internal combustion engine passes through first second and third gas expansion chambers. Expansion and shrinkage of exhaust gas are repeated. Sound absorbing material which inserted between inner and outer.

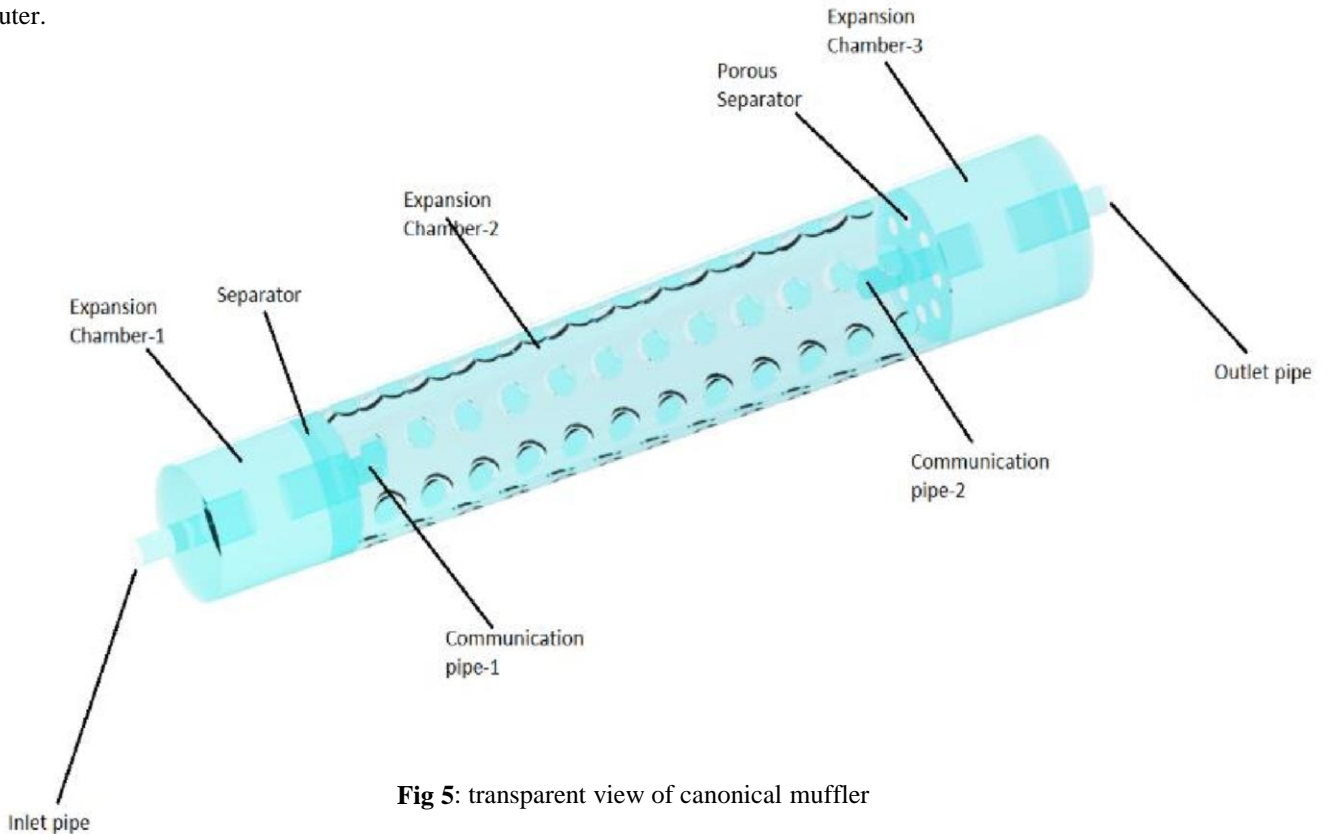


Fig 5: transparent view of canonical muffler

7. Calculation & Result Analysis

Performance of the silencers can be measured by measuring the pressure drop in the silencers. If the pressure drop in silencer is high then low pressure exhaust gases will enter in the atmosphere. So sound will be reduced. Pressure drop can be measured in various ways. In this test a u-tube water is used, where water is used as liquid. A tachometer is used for measuring the rpm of wheel. Inlet pipe of the silencer is connected to the exhaust pipe of the engine by means of thread. Stainless steel tube of millimeter diameter is welded on the hole. This stainless still tube on the hole is used for measuring the static pressure difference between two points by u-tube manometer, when pressure is measured between inlet and outlet. Two tubes of the manometer are fit on any two hole on the stainless steel tube of the silencer and the pressure head measured in centimeter scale

No.	Cylindrical Muffler		Canonical Muffler	
	rpm	Speed	rpm	Speed
1.	120	3.2	144	2.2
2.	182	5.4	213	4.3
3.	392	6.8	395	5.7
4.	550	9.5	430	6.8
5.	684	11.3	527	8.9

For evaluate the pressure drop,

$$P = \rho_w g h_w$$

Where

P = Pressure drop in the unit of N/m^2 .

ρ_w = Density of water at $36^\circ C$.

g = Gravitational Acceleration. h_w

= Pressure head in unit of mete Sample

Calculation:

Pressure drop between inlet and outlet pipe, $= \rho_w g h_w$; for 120rpm
 $= (993.72 * 9.81 * 3.2 * 10^{-2}) N/m^2$

= 311.95 N/m^2 .

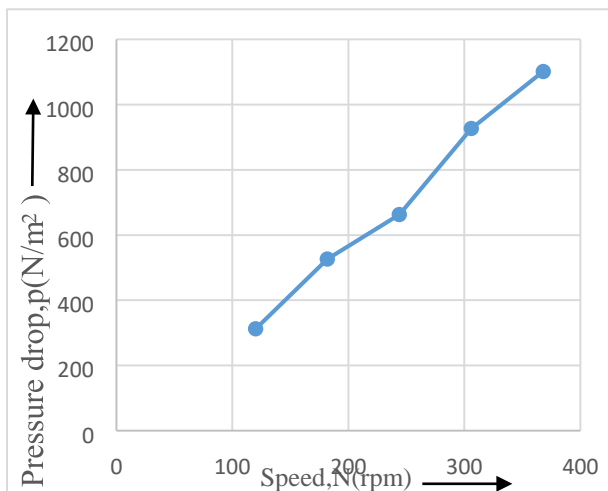


Fig 6.1.: pressure drop, P (N/m^2) vs. speed, N (rpm) for cylindrical silencer

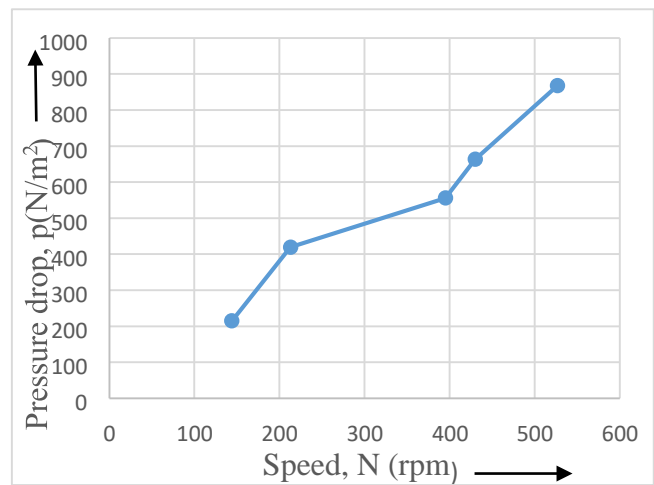


Fig 6.2.: pressure drop, P (N/m^2) vs. speed, N (rpm) for canonical silencer.

In figure 6.1, a graph is plotted between pressure drops vs. speed for cylindrical muffler. In the figure 6.2, by same process pressure drops are plotted against speeds...

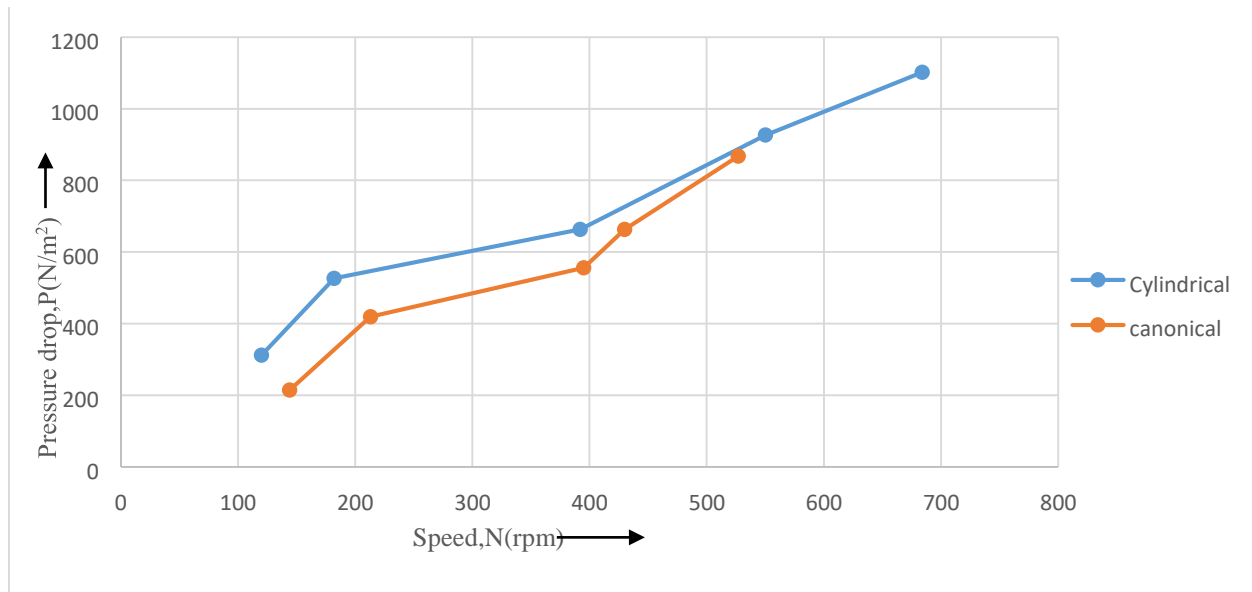


Fig 6.3: pressure drop, P (N/m²) vs. speed, N (rpm) for both silencers.

The silencer has been constructed according to the concern. All the metal sheet and pipe was joined by gas welding. Muffler that has been constructed reduces the noise in two steps. It reduces sound by decreasing the exhaust pressure nearly atmospheric pressure and by sound absorbing material which traps air and reduces sound. Static pressure drop in the silencer has been measured for various speed of the engine and it has been measured for inlet and outlet of the silencer by manometer. The drop of pressure with speed is shown in graph for cylindrical and canonical silencer. From figure 6.1, it can be seen that pressure drop increases with increasing of speed for cylindrical silencer. In cylindrical silencer, graph shows a straight line similarly to $y=mx$. It means pressure drop becomes linearly with increasing of speed. The reason is if engine speed is high more exhaust gas will leave the engine cylinder. So more pressure will be dropped in the silencer. . From figure 6.2, it can be seen that pressure drop increases with increasing of speed for canonical silencer. In canonical silencer, graph shows a straight line similarly to $y=mx$. But in cylindrical, pressure drop is increased more than the canonical. The reason is if engine speed is high more exhaust gas will leave the engine cylinder. So more pressure will be dropped in the silencer.

8. Conclusion

A silencer or muffler is a part of the exhaust system of an automobile. Without muffler, high pressure exhaust gases enter into the atmosphere and will produce unpleasant noise like a gun fire. So it is desirable to reduce this noise as much as possible by using a silencer or muffler in exhaust system. There are various type of silencer for reducing for which performance various types of muffler are combined.

References

- [1]. William H. Crouse & Donald I. Anglin, Automotive Mechanics, Tenth edition, 1993, McGraw-Hill Book Company, Singapore.
- [2]. Joseph Heitner, Automotive Mechanics, Second edition, 1967, Wadsworth publishing company, California 94002, USA