

## Modification of Muffler design to increase exit velocity

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**Abstract.** The Muffler is the most predominant part of an automobile exhaust system. The function of the Muffler is to evacuate the exhaust gases from the combustion chamber, attenuating the sound created by the engine. Any minute change in the Muffler can alter the performance of the engine. The main objective of this work is to increase the exit velocity of the Muffler. A Maruti alto 800cc muffler was taken, examined and a 3d model was created. This model was analyzed for velocity at the outlet of the muffler using CFD. Alternate designs had been developed and were analyzed. Results were compared to obtain an optimized model. Modeling was done in UG NX 11.0, the analysis was carried out in CFX (fluent) Workbench 18.0.

**Keywords.** Muffler, exit velocity, UG NX 11.0, Workbench CFX (fluent)

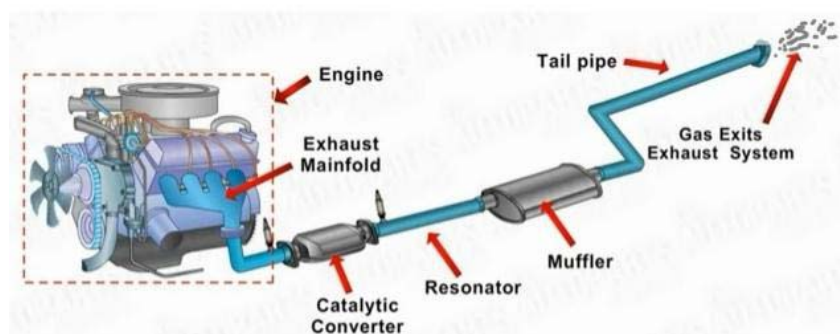
### 1. Introduction

The Muffler is a part of an exhaust system. It can be defined as a mechanical device which is used to reduce the noise created by internal combustion and also to reduce the vibrations. They are also used in generators and other engines. The size and shape of the engine depends on the specification of the engine. Muffler consists of fiber wrappings, resonators, series of pipes, chambers.

#### 1.1. Importance

- They provide with a fast and efficient path for the burnt gases to leave the muffler chamber.
- To reduce the noise levels created by the internal combustion in the engine.
- Harmful emissions are converted and a low harmful gas is emitted comparatively.

#### 1.2. Parts of an exhaust system



**Figure 1.0.** Components of an automobile exhaust system

Various parts of an automobile exhaust system are

- Exhaust manifold
- Catalytic converter
- Resonator
- Muffler
- Tailpipe

The exhaust manifold gives a passage for the burnt gases in the combustion chamber to the catalytic converter where the conversion of harmful gases takes place through some reactions. Now, these gases enter the muffler where the noise created by the engine is reduced and exhaust gases are made to travel in an efficient path. Through the muffler, these gases are released into the atmosphere via tailpipe. The muffler and the tailpipe lie in the rear end assembly whereas the remaining components lie in the front end assembly. The temperature range for front end assembly is  $>600^{\circ}\text{C}$  and for the rear end  $< 600^{\circ}\text{C}$ .

### 1.3. Working of a Muffler



**Figure 1.1.** Showing sectional view of a muffler

The first expansion chamber consists of an inlet pipe for exhaust gases and holes are drilled in the inlet pipe. Some of the gases come out through these holes and travel inside the first expansion chamber, as more gases come out space gets reduced and sound waves get canceled out due to friction. The sound waves with more intensity travel further into the second expansion chamber. Here sound waves collide with each other and to the wall and get canceled. The waves with the highest intensity pass through both the expansion chambers and enter into a Helmholtz resonator. In this sound waves hit the wall and come back with same frequency. This action makes them cancel out each other. Now, these gases are made to travel into the third expansion chamber, here the noise is reduced further due to friction. Now, these gases from the third expansion chamber flows out into the atmosphere through the tailpipe with considerably low noise levels and harm.

### 1.4. Residual exhaust gases

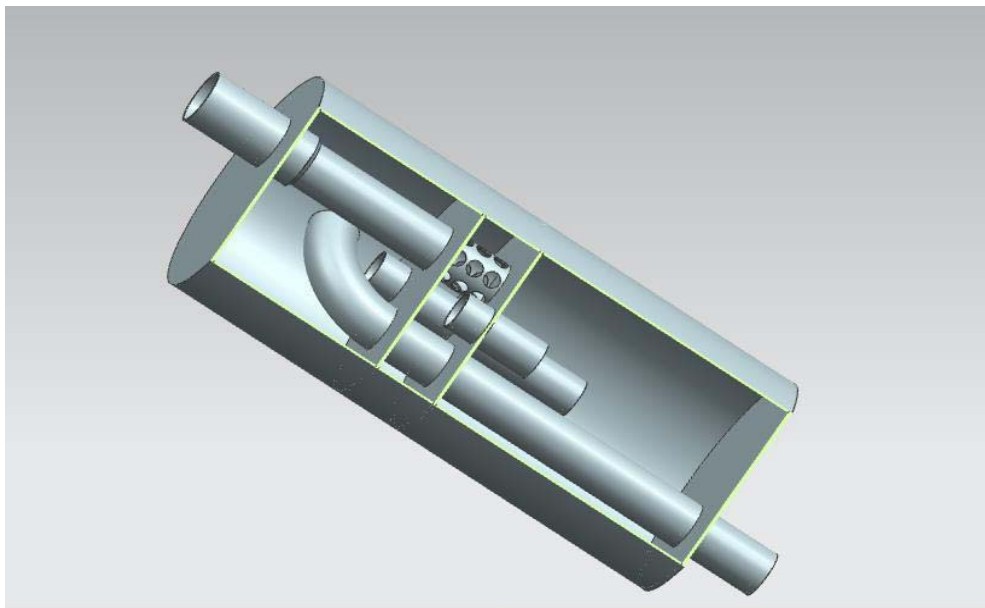
In an IC engine combustion takes place inside the combustion chamber. The air-fuel mixture is sent to the combustion chamber through the inlet manifold. Now comes the compression stroke where the piston compresses the mixture whereas the piston compresses the mixture and spark is delivered which ignites the mixture and combustion takes place which is followed by an expansion stroke. After the power stroke or expansion stroke, the piston moves out to evacuate the exhaust gases from the combustion chamber through the exhaust manifold. Theoretically, we assume the combustion to be a perfect combustion which means there are no residual gases inside the combustion chamber. But experimentally there are few gases left over inside the combustion chamber. By increasing the exit

velocity of the exhaust gases we can evacuate the residual exhaust gases to maximum extent which is the key point of this project.

## 2. Modeling

A Maruti Alto 800cc muffler was taken for this project. The outer wrapping of the muffler was removed and required dimensions were noted down. A 3D model was developed in UG NX 11.0 with the following data (All dimensions are in mm)

Outer chamber length	330
Outer chamber diameter	150
Thickness	1
First chamber length	115
Second chamber length	40
Third chamber length	175
Inlet pipe which is a stepped one with first section 35 diameter and 70 length. Second section with 30 diameter and 135 length.	
Number of holes	18
Diameter of hole	10
Outlet pipe which is a stepped one with first section 30 diameter and 215 length. Second section with a radius of curvature 50 and 30 diameter.	



**Figure 2.0.** Showing the existing model of Maruti Alto 800cc muffler.

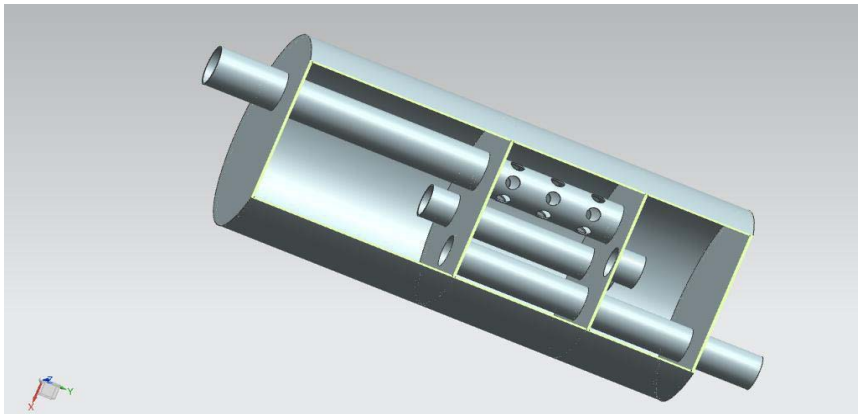
4 alternate designs have been proposed.

## 2.1. Proposed designs

### 2.1.1. Proposed design 1

The proposed design 1 is shown in the figure below. The following are the changes done in the existing model:

- First chamber length was increased to 150mm, second chamber length was increased to 100mm and third chamber length was decreased to 80mm.
- Inlet pipe length was taken as 300mm and outer diameter 30mm.
- Outlet pipe of length 230mm and 26mm outer diameter was introduced.

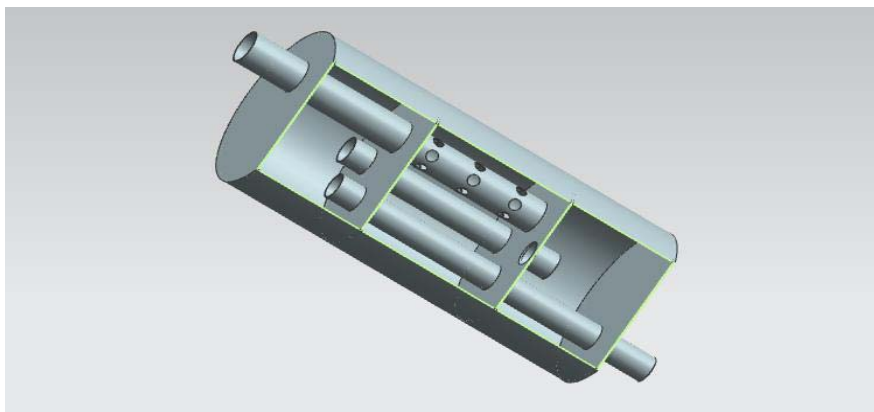


**Figure 2.1.** Design 1

### 2.1.2. Proposed design 2

The proposed design 2 is shown in the figure below. The following are the changes done in the existing model:

- First, second and third chamber lengths were changed to 100mm, 130mm and 100mm respectively.
- Inlet pipe of length 280mm and outer diameter 30mm was introduced.
- Outlet pipe dimensions were changed to length 300mm and outer diameter 24mm.

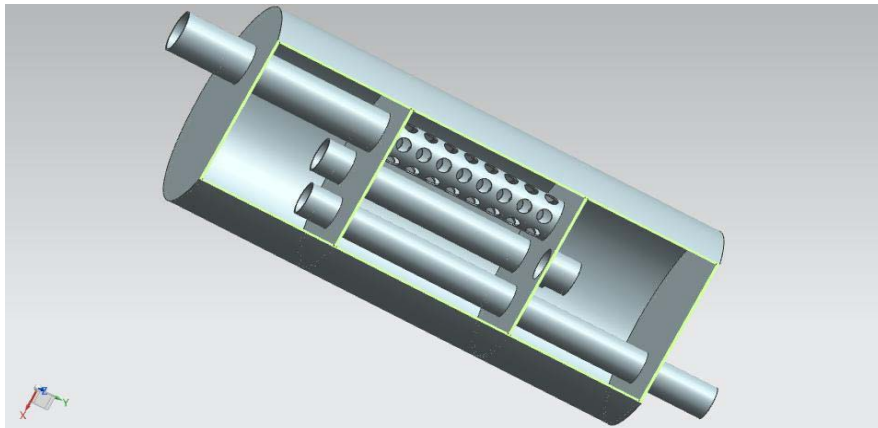


**Figure 2.2.** Design 2

### 2.1.3. *Proposed design 3*

The proposed design 3 was a modification to design 2 which has the following change:

- Number of holes 48
- The diameter of holes : 10mm

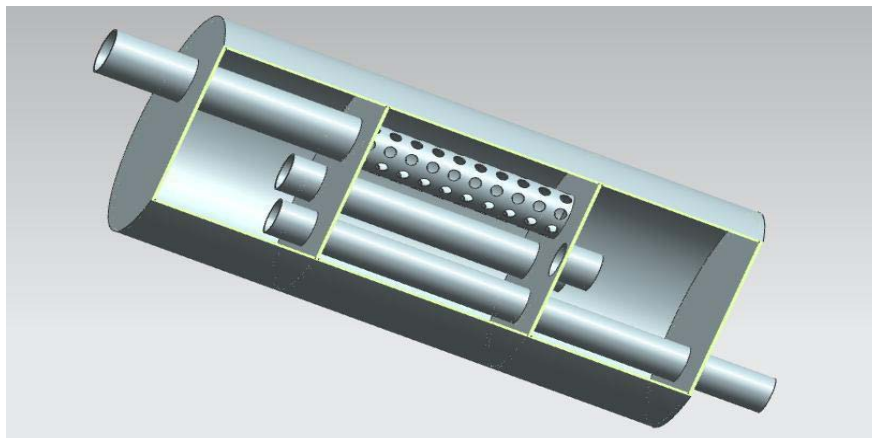


**Figure 2 3.** Design 3

### 2.1 4. *Proposed design 4*

The design 4 is also a modification to design 2 but the only change was:

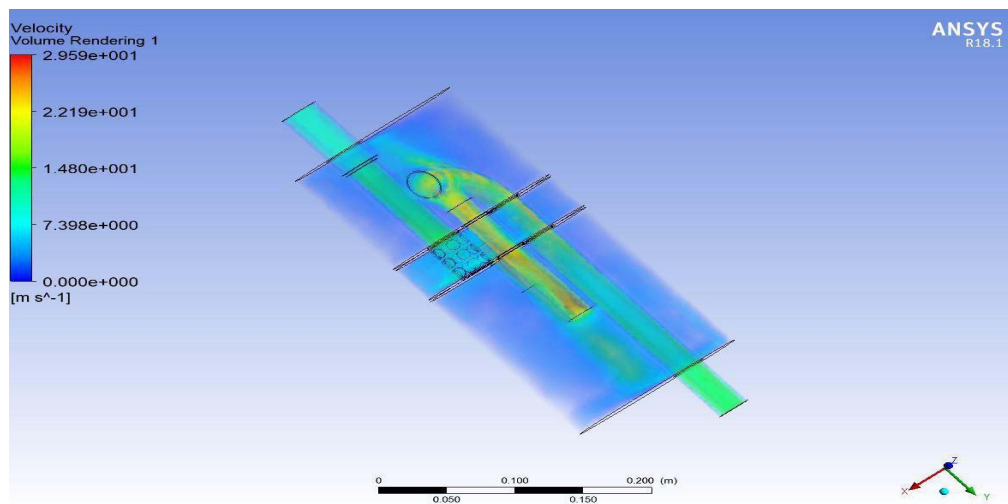
- Number of holes 80
- The diameter of holes : 7mm



**Figure 2 4.** Design 4

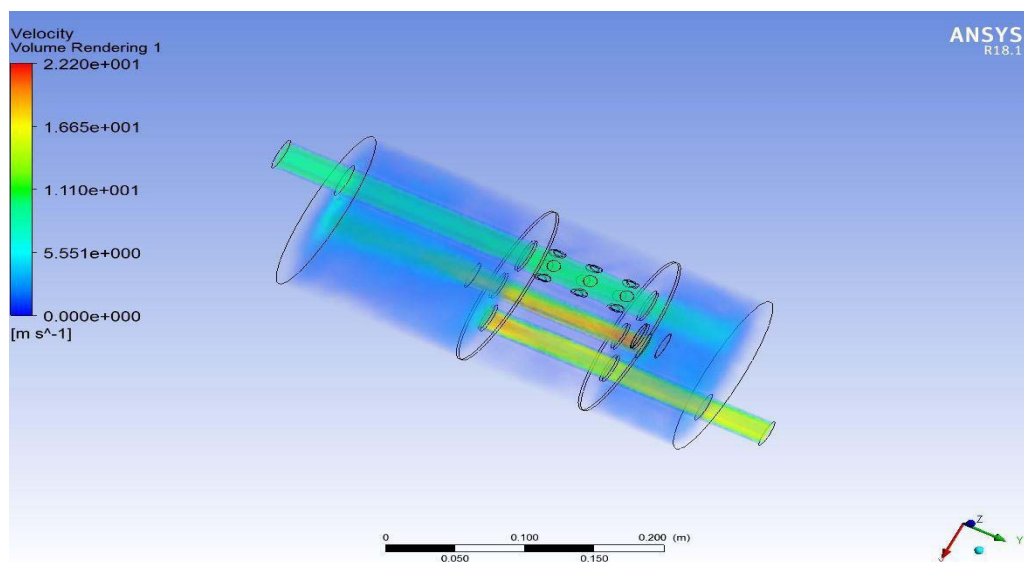
### 3. Analysis and Results

#### 3.1. Analysis of the existing model

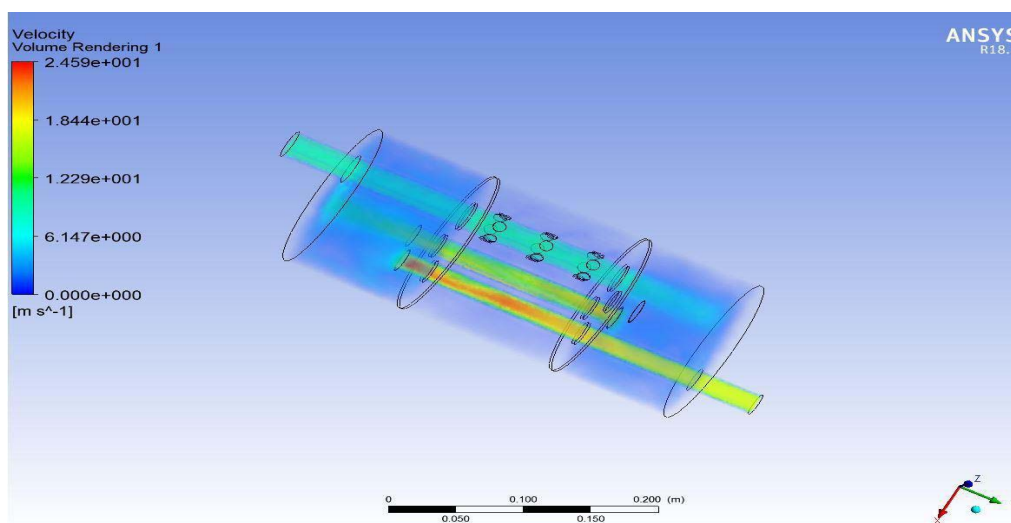


**Figure 3.0.** Velocity volume rendering of existing model

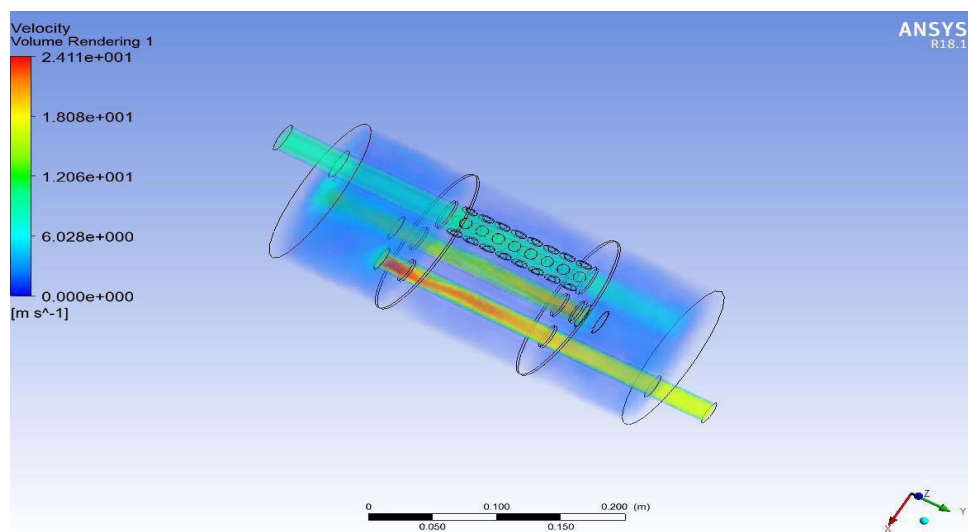
#### 3.2. Analysis of proposed designs



(a)

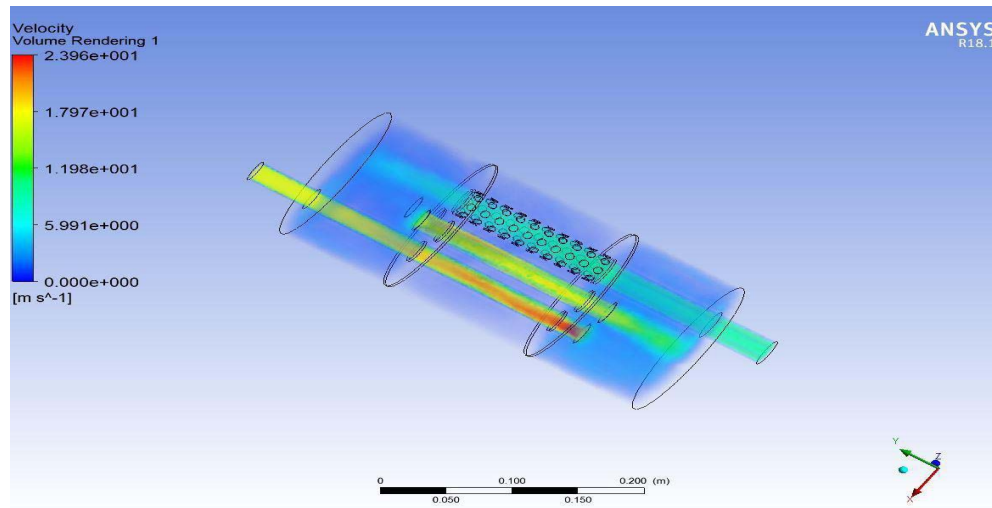


(b)



(c)





(d)

**Figure 3.1.** Showing velocity volume rendering of (a) design 1, (b) design 2, (c) design 3 and (d) design 4

### 3.3. Results

**Table 1.** Comparison between existing model and proposed designs

	<b>Existing Design</b>	<b>Design 1</b>	<b>Design 2</b>	<b>Design 3</b>	<b>Design 4</b>
Inlet velocity* (m/s)	10	10	10	10	10
Outlet velocity* (m/s)	13.873	13.49	16.15	15.86	16.29

## 4. Conclusion

The proposed designs were modeled and analyzed. This was done in order to choose the best proposed design. And accordingly design 4 was selected to be the best design as it gives an increase of exit velocity by 17.42% when compared with the existing model.

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