

# Modification in Muffler Design to Reduce The Backpressure

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**ABSTRACT:** As we know muffler is responsible for noise reduction of the engine and due to this it generates backpressure. Due to worldwide efforts of reducing fuel consumption and making engine more economical and efficient a muffler also affects the fuel consumption of the engine. So with this research paper we aim to reduce the backpressure generated in the muffler which affects the efficiency of the engine by modifying the internal structure of the muffler being used in 150cc engine. For the said purpose we will generate a CATIA model of the muffler being used and perform the computational fluid dynamics(CFD) through ANSYS 16.2 WORKBENCH to check its pressure drop and flow velocity and then we make CATIA model of the same muffler with modification in its design and path for flow of exhaust and then do its CFD and compare it with the original mufflers' backpressure.

**KEYWORDS:** Back pressure, Computational fluid dynamics(CFD), Muffler, Boundary conditions.

## I. INTRODUCTION

Invention of I.C engine has led to many environment issues such as noise pollution and for this mufflers' sole purpose is to reduce noise levels from the engine. But with the reduction of the noise, there is development of back pressure due to which some part of engine power is used to overcome the back pressure generated by the muffler and hence, the engine efficiency is reduced. Thus, the problem lies in the generation of back pressure. The muffler need to be designed in such a way that it generates less and less of back pressure with noise level under tolerable limit.



**Figure 1: muffler**

Exhaust coming from the engine through catalytic convertor enters the muffler through inlet and then reflected at the baffle and after destructive interference of its sound waves enters to the other chamber of the muffler. After traveling

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sufficient path and reduction in sound the exhaust exited the muffler through outlet pipe. In doing this, a great amount of back pressure is generated. There are certain types of muffler out of which two are very common- reactive and absorptive type.

## I. Reactive muffler

Reactive muffler is revered for their ability to silence harsh engine noises. This uses engineered chambers with plates or perforated tubes, exhaust gets reflected from these plates and attenuation of sound happens. Reactive muffler works well in lower and mid-range frequencies but produce higher back pressure.

## II. Absorptive muffler

It consists of a perforated tube, around which a sound absorbing material, like fibre glass or steel wool, is placed. This type of muffler attenuates a wide range of higher frequencies creating less back pressure.

## III. Back pressure

Back pressure refers to pressure opposed to the desired flow of a fluid in a confined place. It is often caused by obstructions or tight bends in the confinement along which it is moving. In an automotive muffler, back pressure is caused by the reflection of exhaust through baffle or tight turns.

## IV. Exhaust system

An exhaust system is usually a guide system for exhaust gases coming out from the combustion chamber of an engine. It takes away the exhaust gases through a systematic path often called exhaust manifold. An exhaust pipe must be carefully designed to carry toxic/non-toxic gases out of the automobile.

## II. METHODOLOGY

Following steps are performed as part of this study-

- Selection of target engine and muffler.
- Creating solid model of target muffler using CATIA V5
- Perform CFD analysis of target muffler using ANSYS 16.2
- Calculation of reading obtained and find outlet velocity and pressure drop.
- Creating solid model of modified muffler using CATIA V5
- Perform CFD analysis of modified muffler using ANSYS 16.2
- Calculation of reading obtained and find outlet velocity and pressure drop.
- Compare back pressure of target muffler with the back pressure of modified muffler.

## III. TARGET ENGINE SPECIFICATION

- Engine- 4 stroke single cylinder.
- Displacement- 147.7cc(150cc)
- Bore- 57centimetre
- Length- 57.9centimetre
- Compression ratio- 9.3:1
- Maximum power- 8.2 BHP at 6000 rpm
- Maximum torque- 10.63 Nm at 4000 rpm

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## IV. CATIA MODEL GENERATION

Target muffler is designed using CATIA V5. Measurements for the design are taken from the target muffler. Then this design is saved with .igs extension to transfer it to ANSYS 16.2 WORKBENCH. Mufflers' internal structure is shown below in the figure with different views-

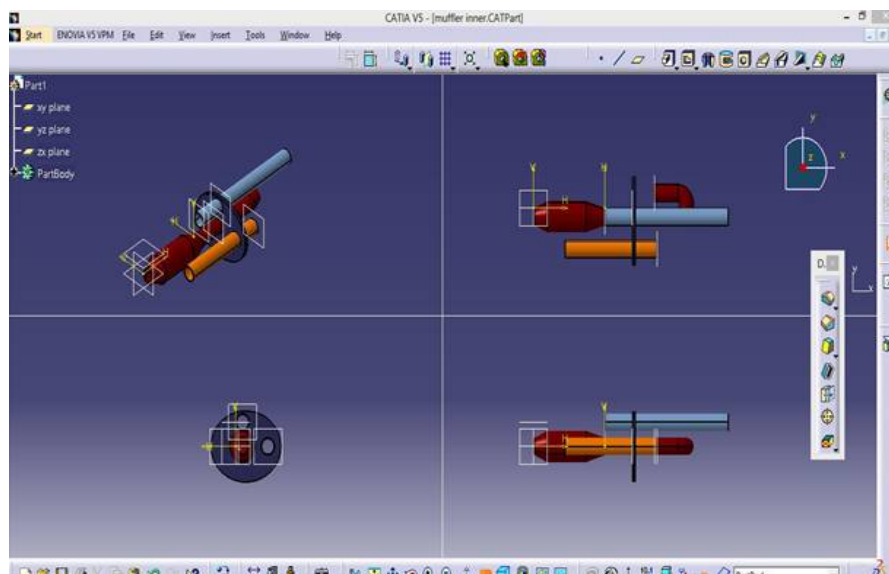


Figure 2: CATIA model (target muffler)

Now after designing the target muffler, modified design of the muffler is designed using CATIA V5 and it is also saved with .igs extension for its CFD analysis in the ANSYS WORKBENCH. Modified mufflers' internal structure is shown below in the figure with different views-

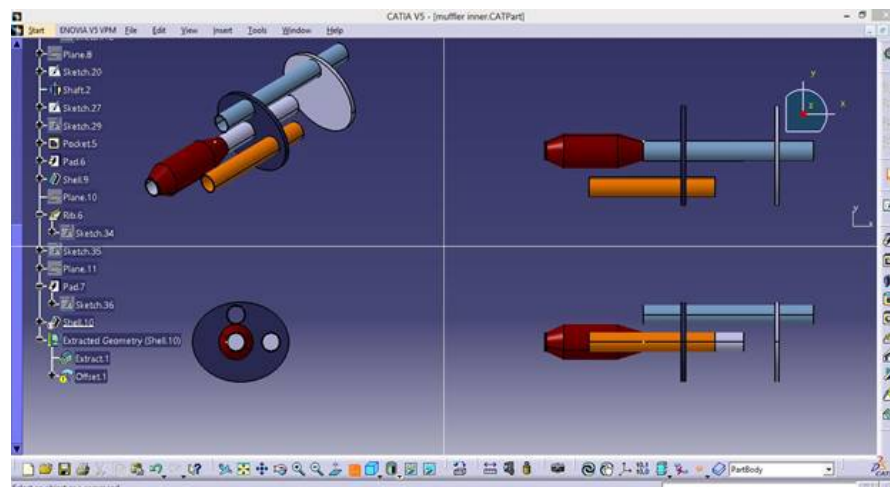


Figure 3: CATIA model (modified muffler)

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## V. BOUNDARY CONDITIONS

### 1. Exhaust gases

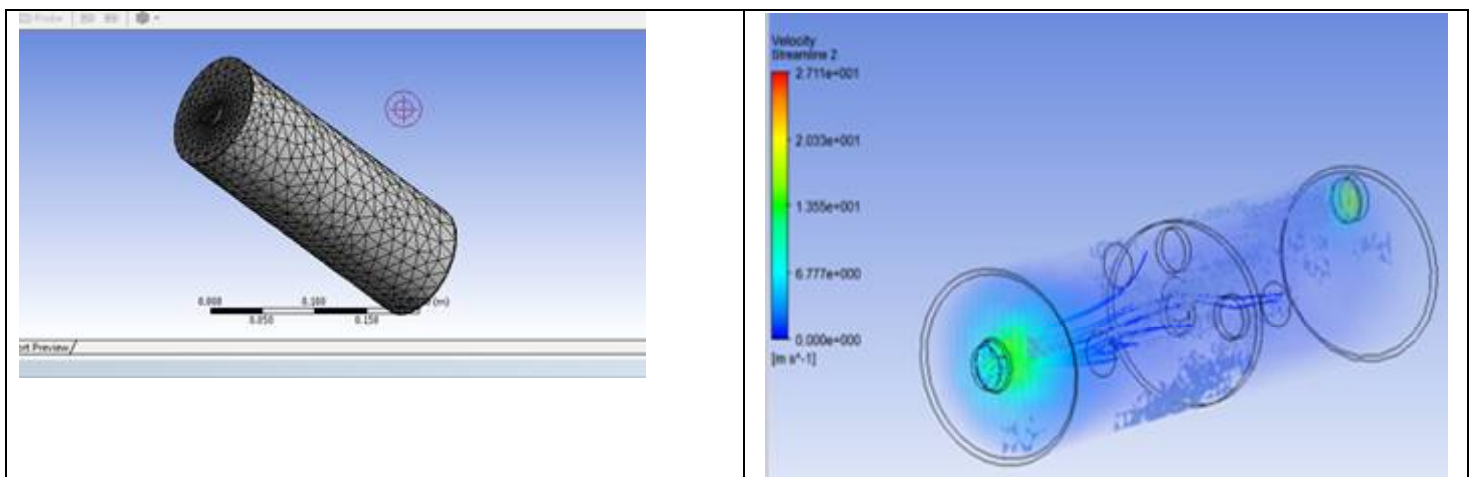
- Temperature = 623 k
- Density = 0.525 kg/cubic metre
- Specific heat = 1.151 kJ/kg-k
- Viscosity = 2.833168e-05
- Thermal conductivity(k) = 0.0466 w/m-k
- Inlet velocity = 19 m/sec

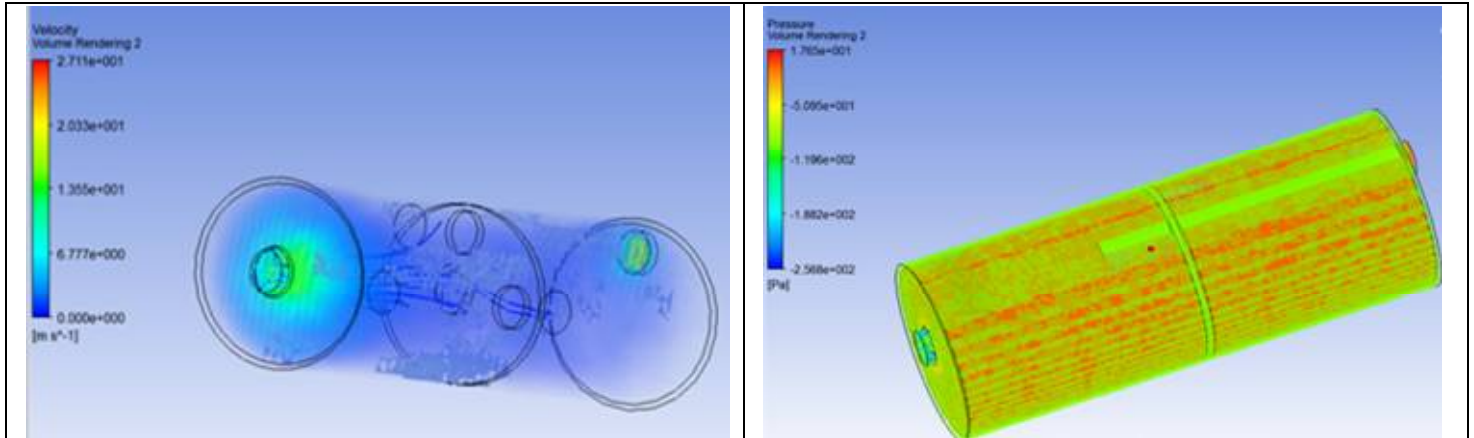
### V. Stainless steel

- Density = 7700 kg/cubic metre
- Specific heat = 420 J/kg-k
- Thermal conductivity = 11.2 w/m-k
- Outlet pressure = 1 atmospheric

## VI. ANSYS WORKBENCH AND FLUENT ANALYSIS

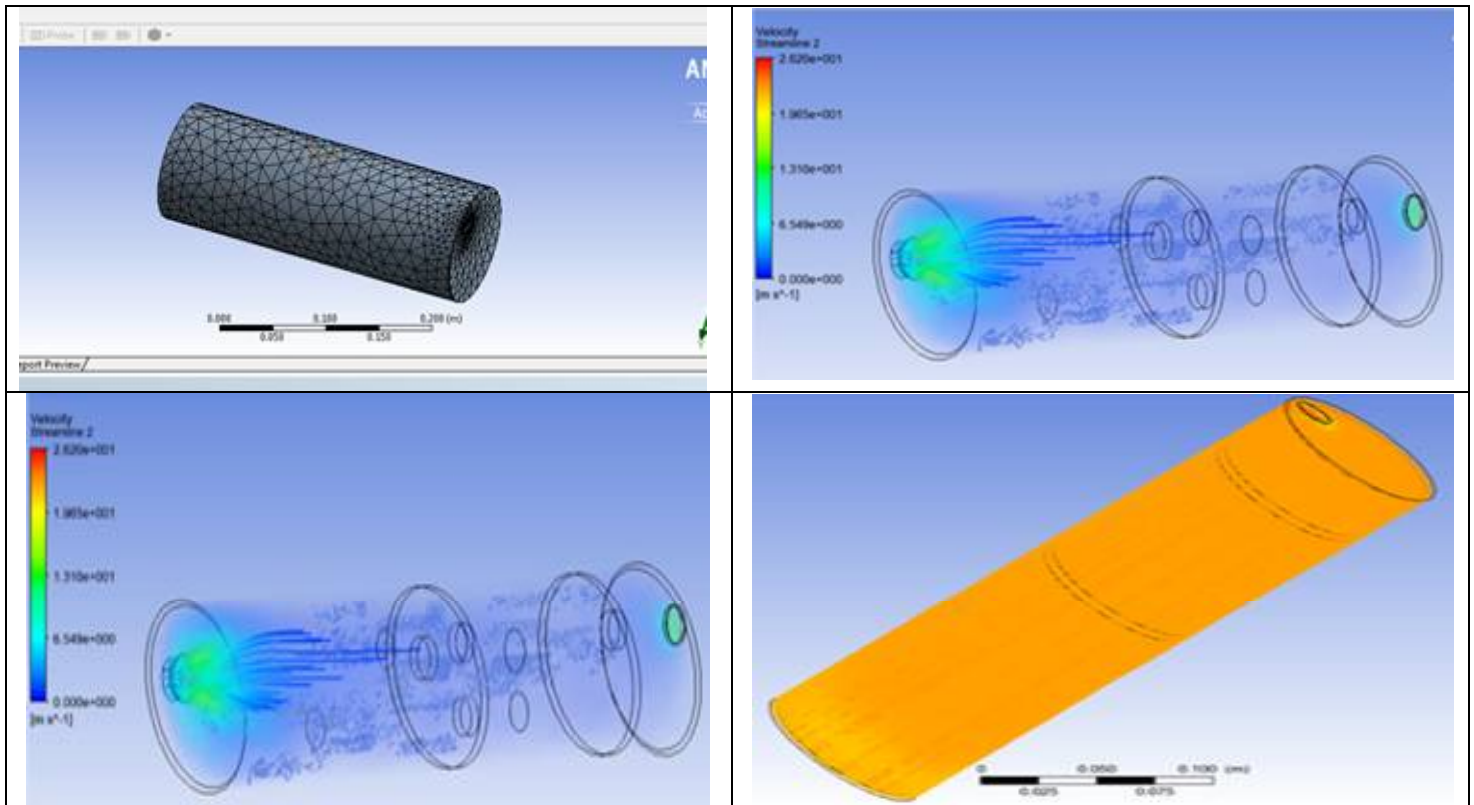
The CATIA model of the target muffler is transferred to the ANSYS 16.2 WORKBENCH and then meshing is done before doing the CFD analysis. Here pre-processing involves surface meshing, volume meshing and setup of boundary conditions for backpressure study. After that boundary conditions are provided and run calculations. Then final result is shown with velocity variation at various parts in the muffler. From here we get velocity at outlet and the pressure drop at outlet.





**Figure 4: ANSYS (target muffler)**

Now the CATIA model of the modified muffler is transferred to the ANSYS 16.2 WORKBENCH for its CFD. Meshing is done to divide the muffler design into several small parts for effective CFD analysis. Here pre-processing involves surface meshing, volume meshing and setup of boundary conditions for backpressure study. After that boundary conditions are provided and run calculations. Then final result is shown with velocity variation at various parts in the muffler. From here we get velocity at outlet and the pressure drop at outlet. After that calculations are done on the basis of analysis for the mufflers- target as well as modified and backpressure is calculated.



**Figure 5: ANSYS (modified muffler)**

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## VII. EXPERIMENTAL OBSERVATIONS

### 1. Target muffler model

From the CFD analysis of the target muffler, we get the following observations. The inlet velocity is taken from the actual reading of the 150cc engine exhaust velocity and the outlet and maximum velocity is taken from the CFD analysis. Table below is showing the values of different velocities-

Inlet velocity	19 m/s
Outlet velocity	13.5 m/s
Maximum velocity	27.11 m/s

**Table 1: target muffler observations**

### 2. Modified muffler model

From the CFD analysis of the modified muffler, we get the following observations. The inlet velocity is taken same for both the mufflers and the outlet and maximum velocity is taken from the CFD analysis. The readings of the table below are compared with the values of the target muffler and is used in the calculation of backpressure. Table below is showing the values of different velocities taken from the analysis-

Inlet velocity	19 m/s
Outlet velocity	13.1 m/s
Maximum velocity	26.2 m/s

**Table 2: modified muffler observations**

## VIII. CALCULATIONS

- Length(l) = 300milimetre
- Density(s) = 0.525 kg/cubic metre
- Diameter(D) = 22milimetre
- Area(A) = 3.7994 square metre
- Velocity(V<sub>1</sub>) = 13.5 m/s (target muffler)
- Velocity(V<sub>2</sub>) = 13.1 m/s (modified muffler)
- Muffler resistance (constant) = 2.5 kpa
- Flow rate(Q) = Area \* Velocity

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- $P_1$  = target muffler back pressure
- $P_2$  = modified muffler back pressure

$$\text{Back pressure}(p) = \frac{l * s * Q^2 * 3.5 * 10^6}{D^5} + \text{muffler resistance}$$

## 1. Target muffler

- $P_1 = (0.3 * 0.525 * 0.0003^2 * 13.5^2 * 3.5 * 10^6) / D^5 + 2.5$
- $P_1 = \mathbf{4.25 \text{ kpa}}$

## 2. Modified muffler

- $P_2 = (0.3 * 0.525 * 0.0003^2 * 13.1^2 * 3.5 * 10^6) / 2.5$
- $P_2 = \mathbf{4.15 \text{ kpa}}$

3. **Drop in backpressure** =  $P_1 - P_2$   
=  $4.25 - 4.15$   
= **0.10 kpa**

## IX. EXPERIMENTAL RESULTS

We have successfully completed the analysis and fabrication of the design. And the results of the experiment are showing decrease in back pressure of the modified design as compared to the original design. This decrease in back pressure will surely lead to the better performance of the engine and longer life with less fuel consumption.

We have not change or disturbed the sound cancelling material in the muffler, we have just change the path of the exhaust flow, our only aim is to reduce the back pressure.

## X. CONCLUSION

- **Fuel consumption:** reduction in back pressure allows engine to use less fuel for the same power. As world is facing a hike in oil pricing and fast extinction of the oil, our work will surely help in contributing some aid to this situation.
- **Power saving:** with this reduction in back pressure the engine power which go waste in doing extra work to eliminate the exhaust is now saved and the engine will be able to deliver more power to automobile.
- With the development in the design of muffler, automobile industry can achieve maximum power through the engine with less noise levels.
- Further study to this research can be done to reduce the sound level much below the standard value, with the back pressure remain untouched or be reduced.

## REFERENCES

- [1] Prashant P. Bornare, Dr. D. S. Deshmukh, Prof. R. Y. Patil, "Experimental Investigation of Backpressure Variation On a Single Cylinder C. I. Engine System Performance", PRAIBHA: IJSSBT, Vol. 2, No. 2, May 2014
- [2] D. S. Deshmukh, M. S. Deshmukh and J. P. Modak, "Experimental Investigation of the Effect of Backpressure on an I. C. Engine Operating Performance" IJ-ETA-ETS, (ISSN: 0974-3588 1 APRIL 2010) Page no. 23-28.
- [3] Mr. Jigar H. Chaudhri, Prof. Bharat S. Patel, Prof. Satis A. Shah, "Muffler Design for Automotive Exhaust Noise Attenuation- A Review" IJERA, ISSN: 2248-9622, Vol. 4, Issue 1 (Version 2), January 2014, pp.220-223



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## International Journal of Innovative Research in Science, Engineering and Technology

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- [4] Sudarshan Dilip Pangavhane, Amol Bhimrao Ubale, Vikram A. Tandon, Dilip R. Pangavhane, "Experimental and CFD Analysis of a Perforated inner Pipe Muffler for the Prediction of Backpressure", International Journal of Engineering and Technology (IJET) 13-05-05-163
- [5] Atul A. Patil, L. G. Navale, V. S. Patil, "Simulative Analysis of Single Cylinder Four Stroke C. I. Engine Exhaust System" PRATIBHA: IJSSBT, Vol. 2, No. 1, November 2013 ISSN (Print) 2277-7261
- [6] Wang Jie and Dong-peng Vue, "The Modal Analysis of Automotive Exhaust Muffler Based on PROE and ANSYS" 2010 3<sup>rd</sup> International Conference on Advanced Computer Theory and Engineering (ICACTE), 2010 IEEE