International Journal of Engineering Works
ISSN-p: 2521-2419
ISSN-e: 2409-2770
Vol. 8, Issue 01, PP. 63-67, January 2021
https://www.ijew.io/
https://doi.org/10.34259/ijew.21.8016367

# Comparison of Sound Pressure Level of Conventional and Modified Mufflers by using CFD Analysis

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Received: 14 January, Revised: 26 January, Accepted: 30 January

***Abstract***— The reduction of noise emitted from the exhaust of internal combustion engine is a real challenge for all automotive industries. Mufflers are designed to reflect sound waves produced by the engine in such a way to cancel the effect of each other by destructive interference between the incoming waves from engine cylinder and reflected waves from the muffler of 2 stroke motorbike engine. Numerical simulation is carried out to study the sound pressure level (SPL) and flow variable like velocity and pressure of conventional and proposed modified reactive muffler. In numerical investigation of Conventional muffler and modified muffler the path of exhaust gases in which it flows is analyzed through large eddy simulation and then Fflowcs Williams and Hawking model are utilized to predict the Sound pressure level of conventional muffler and modified mufflers by using the time flow history of large eddy Simulation at the receiver location and the result of proposed modified muffler are compared with conventional muffler. By comparing the Sound pressure level (SPL) results of conventional and modified mufflers show that the sound pressure level of modified muffler - 01 are 5dB less than the conventional muffler and the sound pressure level of modified muffler - 02 are 15dB less than the conventional muffler which produce sound pressure level of 80dB.The output velocity of exhaust gases is also drop down from 259.1 m/s of conventional muffler to 182 m/s in modified design-2. So the stack pressure inside the expansion chamber of modified muffler-02 is less than the conventional muffler which creates high back pressure so our objective is achieved.

***Keywords***— Sound Pressure level, conventional Muffler, Noise, Large Eddy Simulation.years.

## I. INTRODUCTION

The Muffler is a device which reduces the amount of noise emitted by the engine. Muffler is connected to the exhaust pipe of internal combustion engine of motorbike so that to suppress the acoustic flow waves which is produced during the combustion process. All internal combustion engine produce noise of different levels. The intensity and magnitude of noise level depend on the development of vehicles' by means of scavenging, the type of fuel, number of cycles etc. The main purpose of the muffler is to reduce the noise of the engine exhaust before going toward into atmosphere. Mufflers are mostly used to reduce the intake and exhaust noise from pumps, compressor and internal combustion engine. Presently two type's techniques are used for noise control one is active technique and the other is passive method. Active noise techniques for noise control are emerging, but nowadays mostly used passive method to control exhaust noise. Passive mufflers are categorized to reactive or dissipative based on their attenuation. Reactive muffler reflects sound waves back towards the engine cylinder and dissipative muffler used porous media to absorb the sound due to exhaust gases. Internal combustion engine equipped with an exhaust muffler to suppress the acoustic pulses generated during the combustion process. A highly intensity pressure wave generated by the combustion in the engine cylinder propagates along the exhaust pipe and radiated from the exhaust pipe termination. An exhaust system in a motorcycle consists of three parts namely exhaust header, exhaust tube, and exhaust muffler as shown in Fig 1. In all muffler tail pipe length can have an important effect. The tail pipe acts as a resonant cavity that couple with the muffler cavity Due to increased environmental concern requiring less noise emission combined with reduced emission of harmful gases.


Figure 1. Bike muffler[1]

For this purpose, a lot of people has done work in the field of acoustic. In 2016 N. Deshmukh et all. [1] Study the effect of radial jet at the upstream of muffler on temperature and acoustic pressure. The radial jet was introduced at different reservoir pressure at the downstream of a muffler. The simulation study has been carried out to find the temperature and pressure distribution of inside the muffler with and without the radial jets and experiments were carried out to validate the results.

In 2013 D. Tutunea et all.[2] studied the fluid dynamic performance of exhaust muffler by using CFD analysis. He simulated the pressure distribution of muffler in CFD and pressure loss is predicted. In 2016 Shaoqi Zhou et all.[3]is presented his work on flow induced noise simulation using detached eddy simulation and finite element acoustic analogy methods to study the performance of exhaust muffler. In 2015 puneetha et all. [4] Analyze four different model of exhaust muffler and concludes the best for least pressure drop. Back pressure is obtained from flow field analysis virtual simulation for back pressure testing is performed in computational fluid dynamic analysis using Acusolve CFD.The back pressure generated across the muffler is determined by measuring the mass flow rate at inlet and outlet of exhaust muffler. In 2016 Suyog, s Mane et all. [5] Studied back pressure of exhaust muffler using CFD simulation to avoid tedious experimentation and the flow simulation is carried out by using K-ε turbulent model. Because K-turbulent model is most suitable for the simulation having less converging time. Total four cases have been analyzed including the base model three modification has been made in the geometry. By reducing the baffle spacing produce less back pressure with the reduction of back pressure of 9.60%. In Ayush Lal. [6] Studied flow field of exhaust muffler using CFD Analysis to select optimum design for IC engine. Two muffler has been modeled and CFD simulation of both muffler is carried out in Ansys fluent. Based upon gas flow analysis the optimum model is selected In 2015 Pradyumna et all. [7] is presented his work on CFD analysis of flow through a resistive muffler of LCV diesel engine by simulating the flow inside the muffler and study the internal flow which effect the performance of muffler. The method is used to study the pressure distribution is simulated and pressure loss is predicted for structure modification. The experimental results verify the Assembly performance of muffler that modified one is better than the original. From the literature review and all other aspect some findings are highlighted below

- As the diameter of perforation is increased the back pressure reduce sharply and perforation has a remarkable effect on back pressure
- As no of perforation is increased the back pressure reduces and low back pressure can improve fuel economy
- The CFD simulation software is used for modeling and simulation. the simulation gives the information about the Velocity field, pressure field, sound pressure level, density etc

Now here in our work two different modifications is made in the conventional muffler by changing the perforation hole, exhaust pipe length and then the modification is studied for sound pressure level and other flow variable which affect the noise of exhaust muffler.

## II. METHODOLOGY

### A. 3D CAD Model

Ansys workbench 18.1 design modeler is used for CAD modeling of exhaust mufflers as shown below. Two different modifications are made in conventional muffler and analyzed it individually in Ansys Fluent 18.1 by LES simulation. With the help of CFD simulation the muffler design is optimized.

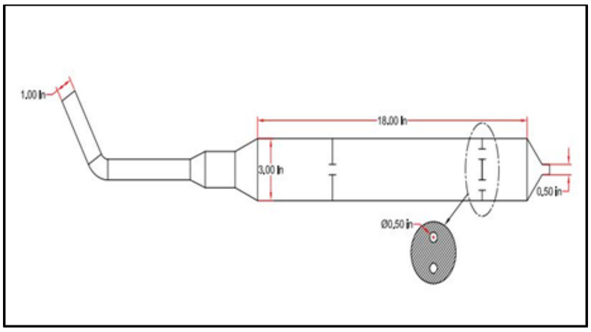


Figure 2. Layout of conventional Muffler

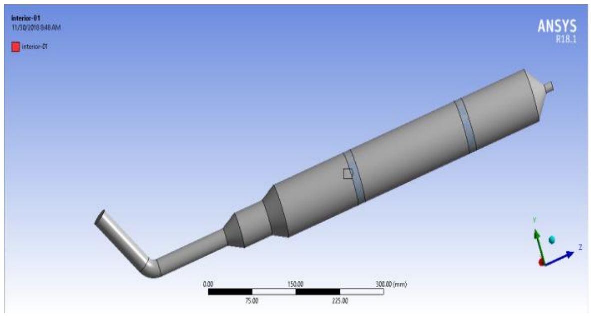


Figure 3. CAD Model of conventional Muffler

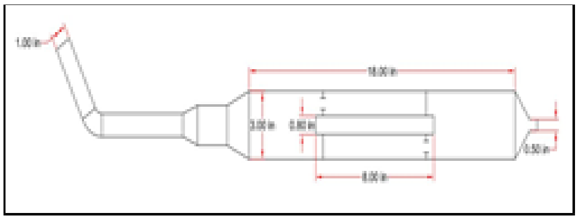

Figure 4. Layout of Modified muffler -01

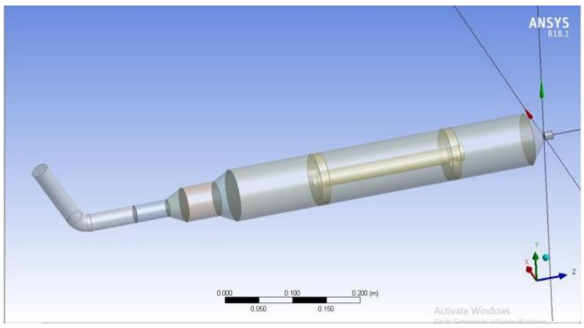


Figure 5. CAD Model of Modified muffler-01

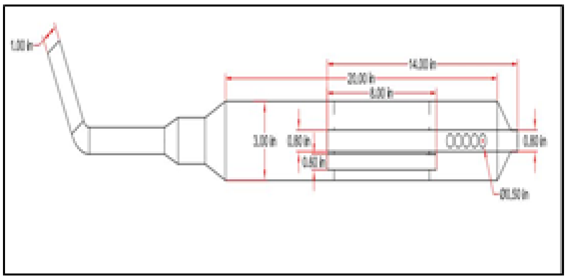

Figure 6. Layout of Modified muffler -02

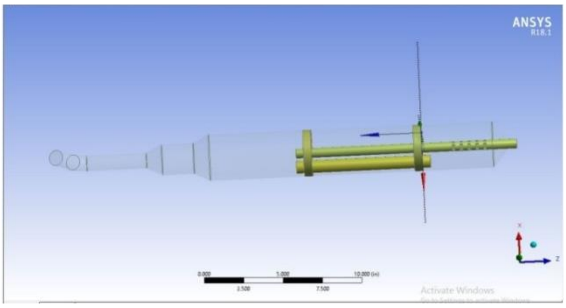

Figure 7. CAD Model of Modified muffler-02

## III. Acoustic Mesh and Boundary Condition

An Ansys workbench is used for meshing the exhaust mufflers. The structure acoustic mesh has to be created having spacing of 2mm in order for better performance and fine mesh requirement of LES simulation for accurate solution.

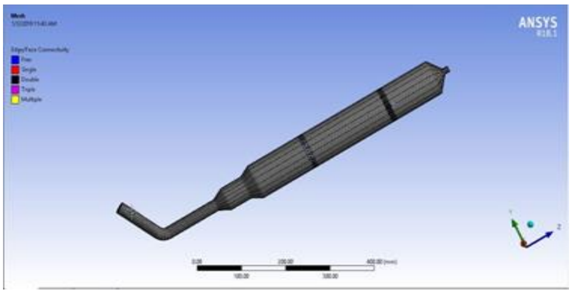

Figure A. Conventional muffler

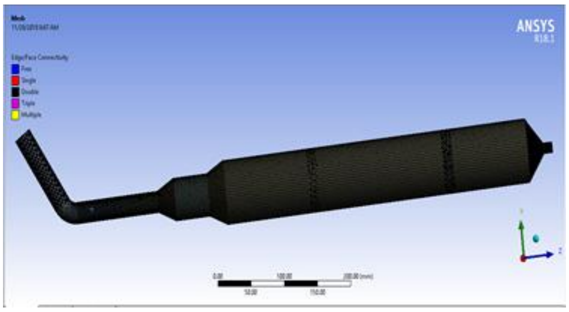

Figure B. Modified muffler -01

The minimum grid size is 1mm resulting in total of 1.5 million to 2 millions of elements. The working fluid is gas with the density modeled assuming the ideal gas condition. The boundary condition in this case consist of inlet velocity 50 m/s, outlet pressure is set as atmospheric pressure so velocity and pressure data has been measured at the outlet boundary of exhaust muffler and consider as a permeable boundary Fourier transform take the pressure values from the time history of LES simulation to evaluate the sound pressure Level at the receiver location through FWH model. As given figures A, B, C.

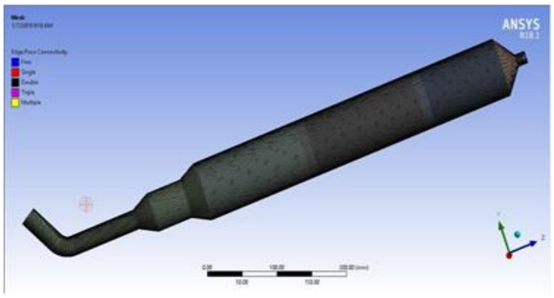

Figure C. Modified muffler -02

## IV. Result and Discussion

Firstly, the large eddy simulation is performed for all geometry as shown in figure below then from accurate time history of flow variable at outlet boundary to predict the sound pressure level at the receiver location through Fflowcs Williams and Hawking model and the result of proposed modified muffler are compared with conventional muffler.

### *A. Conventional Muffler*

In conventional muffler as the exhaust gas is enter into the muffler chamber having an inlet velocity of 50 m/s there is an inner plate with a single hole which guide the flue gases to inter into the 2nd chamber where they expand and pass through another perforated plate having two hole equally spaced and the gas enter into the 3rd chamber and expelled out to the atmosphere as shown in fig 8.The standard muffler is a reflective type have 18in expansion chamber length during expansion the gases energy is lower due to destructive interference. The simulation result of conventional muffler as shown in fig 8 show that velocity at the outlet is 259.1 m/s which is higher than the inlet velocity 50 m/s which is due the pressure rise in the expansion chamber due to stack up gas flow between the expansion chamber and outlet of pipe which push the exhaust gases with higher velocity and this also indicate high back pressure. In fig .8 CFD simulation result conventional muffler show the variation of velocity from inlet to outlet of exhaust muffler and the plot in fig 9 indicate that conventional muffler produce a sound pressure level of 85 dB.

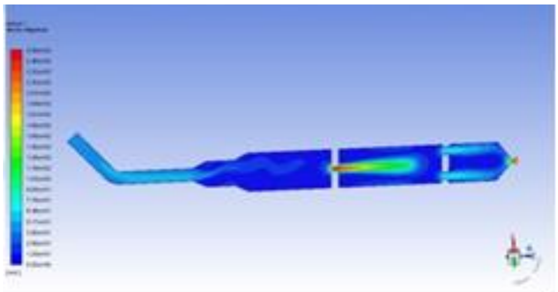

Figure 8. Velocity distribution of Conventional Muffler

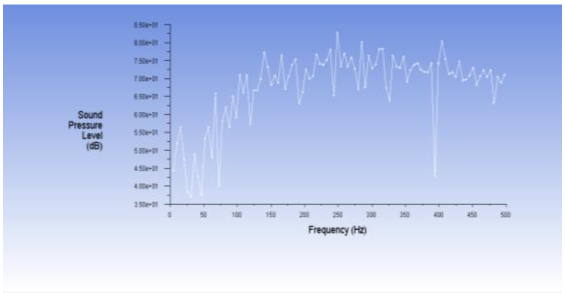


Figure 9. Sound pressure level of Conventional muffler

### *B. Modified Muffler-01*

In fig 10 shows the flow analysis which is carried out for modified muffler-01. The modification we made that we place a pipe between the 1 & 2nd chamber which carries 70% exhaust gases directly from 1st chamber to the 3rd chamber which help to reduce the effect of gas flow stack up in the expansion chamber. In modified muffler-01as the exhaust gas enters into the 1st expansion chamber a part of total gas flow straight into the 3rd expansion chamber and the remaining gas is pass into 2nd chamber through 1st hole and guided into the 3rd expansion by the 2nd hole in the plate where they interfere with the gas come out straight from 1st expansion chamber to the 3rd expansion chamber due to middle pipe. A destructive interference occurs in the 3rd chamber due to which the pressure inside the cylinder chamber is reduce which is turn reduce the outlet velocity from 259.1 m/s to 232 m/s as shown in fig 10. The plot in fig 11 show that the modified muffler -01 produce sound pressure level of 80dB.

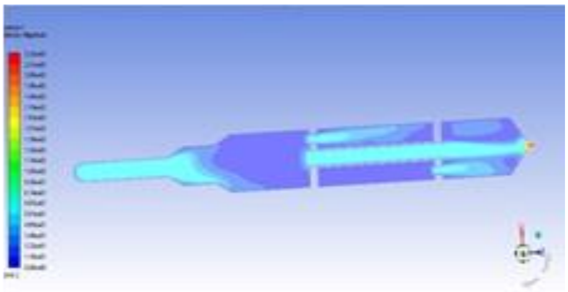

Figure10.velocity distribution of Modified Muffler-01

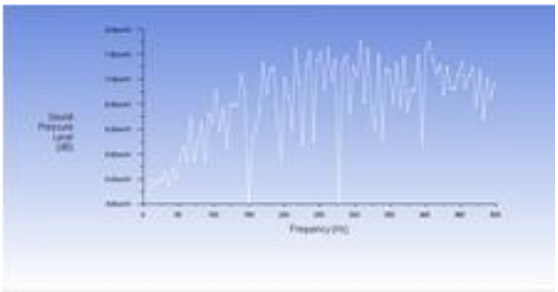

Figure 11. Sound pressure level of Modified muffler -01

### *C. Modified Muffler-02*

In fig 12 shows the flow analysis which is carried out for modified muffler-02. In modified muffler-02 as the exhaust gas enter into the 1st expansion chamber a part of total gas flow straight into the 3rd expansion chamber and the remaining gas is pass into 2nd chamber through perforated hole and guided into the 3rd expansion by the 2nd hole in the perforated plated where they interfere with the gas come out straight from 1st expansion chamber to the 3rd chamber expel through small perforation hole in the pipe which lower the pressure wave pulses and due to middle pipe which take exhaust gases from 1st to 3rd chamber reduce the pressure stack inside the cylinder chamber which create the high back pressure so reduction in velocity occur at the outlet of exhaust muffler from 259.1 m/s to 182 m/s as shown in fig 12.The plot in fig 13 show that the modified muffler-02 produce sound pressure level of 70dB.

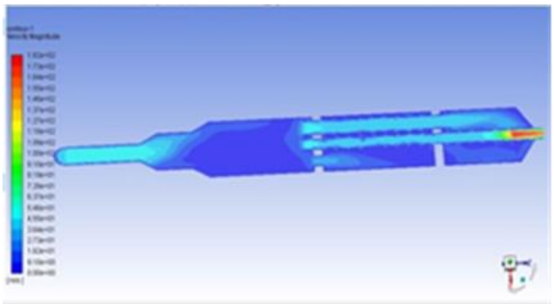

Figure 12. Velocity distribution of Modified muffler -02

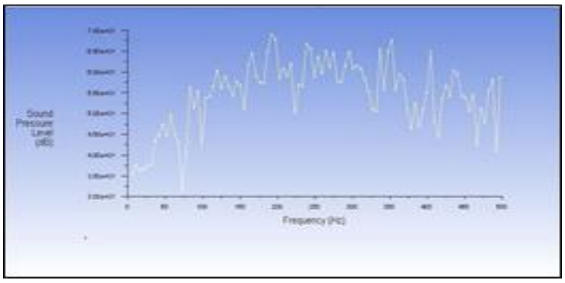

Figure 13. Sound pressure level of Modified muffler -02

TABLE I. NUMERICAL RESULT OF SOUND PRESSURE LEVEL

| Mufflers | Modified Muffler | Conventional Muffler | Percentage Reduction |
|---|---|---|---|
| **Muffler-01** | 80 dB | 85dB | 5.8 % |
| **Muffler -02** | 70dB | | 17.6 % |

TABLE II. COMPARISON OF PRESSURE & VELOCITY OF CONVENTIONAL AND MODIFIED MUFFLERS

| **Velocity (m/s)** | | | |
|---|---|---|---|
| **Mufflers** | **Modified Muffler** | **Conventional Muffler** | **Percentage Reduction** |
| **Muffler-01** | 232 m/s | 259.1m/s | 10.4 % |
| **Muffler -02** | 182 m/s | | 29.4 % |
| **Pressure (Pa)** | | | |
| **Muffler-01** | 28060.57 | 36850.68 | 23.85 % |
| **Muffler -02** | 24454.04 | | 33.64 % |

## CONCLUSION

Comparative numerical study of sound pressure level (SPL) of exhaust muffler of 70cc motorbike is carried on modified geometries including the base geometry which is taken as reference geometry. After the flow analysis of exhaust muffler show that more sound reduction of about 15dB occur in muffler-02 which is more than muffler-01 of 5dB as compared to conventional muffler produce a sound pressure level of 85dB. Modified muffler-02 produce less stack pressure as compared to conventional muffler because the outlet velocity of modified muffler-02 muffler is less as compared to modified muffler-01 and conventional muffler so we say that modified muffler-02 is the best optimized design.

It can also be concluded that our study is limited to 70cc Honda motorbike so the study can be extended to more complex geometries of other vechicles by considering the back pressure and maintenance issues which affect the performance of exhaust muffler in attenuating the noise.

## REFERENCES


[1] Selvaraj, N.V. and N.N. Deshmukh, Experimental and Simulation Study to Reduce Engine Noise. Indian Journal of Science and Technology, 2016. 9(34).

[2] Tutunea, D., M. Calbureanu, and M. Lungu, The computational fluid dynamics (CFD) study of fluid dynamics performances of a resistance muffler. Recent Advances in Fluid Mechanics and Heat & Mass Transfer, 2013: p. 31-34.

[3] Liu, K., et al., Flow-induced noise simulation using detached eddy simulation and the finite element acoustic analogy method. Advances in Mechanical Engineering, 2016. 8(7): p. 1687814016655683.

[4] Puneetha, C., H. Manjunath, and M. Shashidhar. Backpressure Study in Exhaust Muffler of Single Cylinder Diesel Engine using CFD Analysis.

[5] P. B. p. D. Suyong s.Mane, "CfD analysis of Back pressure of reactive muffler," IJIERT, December 2016.

[6] A. L. V. prof Amar pandhare, "CFD Analysis of flow through muffler to Selectoptimium muffler model of Ci engine," IJLTET, May 2014.

[7] K. Pradyumna saripalli, "Cfd Analysis on flow through a resistive muffler of LCV engine," IJSTS, June 2015.

[8] Pangavhane, S. D. ( Oct-Nov 2013). Experimental and CFD Analysis of a Perforated Inner Pipe Muffler for the Prediction of Backpressure. International Journal of Engineering and Technology (IJET) 11.

[9] Mr. Sumit Surve, M. S. (2014). Acoustics and Flow Field Analysis of Perforated

[10] Flow-induced noise simulation using de element acoustic analogy method (2016).Advances in Mechanical Engineering ,tached eddy simulation and the finite

[11] Sileshi kore et all .Performance evaluation of reactive muffler using cfd Deparment of mechanical engineering Addis Ababa institute of technology Addis Ababa university.



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**How to cite this article:**

Zahoor Ullah, Hassan Ahmed, Dr. Kareem Akhtar "Comparison of Sound pressure Level of Conventional and Modified Mufflers by using CFD Analysis", International Journal of Engineering Works, Vol. 8, Issue 01, PP. 63-67, January 2021, https://doi.org/10.34259/ijew.21.8016367.