ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 8, Issue 12, December 2021

A Review on the Mufflers used in Automotive Vehicles

[1],*Ujjal Kalita, [2]K.Anjaneyulu, [3]Sandip Dey, , [4]Manpreet Singh

[1]Phd Scholar, Mechanical Dept. LPU, Punjab
[2],[3]B.Tech, Mechanical Dept. LPU, Punjab
[4]Professor, Mechanical Dept. LPU, Punjab
*corresponding author: Email: ujjal.19355@lpu.co.in

***Abstract*— In the 21st century, the automotive industry is booming. A major problem with internal combustion engines (I.C.) is that they are an important cause of noise pollution. It is for this reason that mufflers are used to reduce the noise produced. Although mufflers are not designed to perform any of the main output functions, they are included within the I.C. engines. It is designed as a sound protection device that reduces engine pressure. But mufflers need structure and geometry, if you think the physics behind it are very confusing. The muffler design developed into a repetitive process with trial and error. Recent research in this area has made it possible to do so through analytical and experimental methods.**

Modern engines are required to have more engine electricity and also are required to fulfil the stern pollutants standards. In a car, the exhaust muffler plays an essential position in decreasing the sound of the car, in addition to the experience itself. So as to preserve a preferred noise and at ease ride, the modes of a muffler need to be analyzed. In this study a literature review was performed on all the different aspects that could be taken while designing an exhaust muffler. Here dynamic modal analyses had been purchased using CAE evaluation to determine the mode size, strain and deformation of the exhaust muffler.

***Index Terms*— Muffler, Insertion Loss, Transmission Loss, Back Pressure**

I. INTRODUCTION

The muffler, also known as a silence, is a device that transmits gases from an internal combustion engine to reduce noise from the engine air. To be as effective as noise reduction, noise reduction must slow the exhaust gases and absorb sound waves or cancel them out by interfering with visible waves from the same source.A typical sound-absorbing material used on dull objects is a thick layer of fine fibres; the strands are made to move by sound waves, thus converting sound energy into heat. Mufflers reduce sound waves by distraction, known as active mufflers. These instruments usually divide the waves into two part that follow different paths and then reunite and exit the stage (without step), thus cancelling and reducing noise. [1]

Noise exists anywhere human beings live, particularly in business towns, due to the fact the life of humans has knotted with machines and demanding noise has been produced whilst the engine of the system is running. The noise comes from the exhausters of jet engines, cars, funnels of powerhouses, and so forth. Four types of automobile noise resources threaten human hearing whilst they're interior. They may be engine noise, wind noise, avenue noise, and exhaust noise.

Usually, noise manipulates protection requirements come into play when the generation of noise cannot be averted and must be addressed in a few manners. Commonplace answers consist of using silencers or enclosures/cabins. Noise management is important to protect the protection of human/workers, as well as the comfort stages of these outdoor the place of work but nonetheless near sufficient to be affected. Noise safety requirements refer to many reasons engaged in avoiding injuries or suffers because of the effects of sound. Whether or not by designing devices in a way as to lower noise product, controlling that noise earlier than it touches people, or thru the use of non-public shielding gadget inclusive of earmuffs, noise protection takes many forms, every created to meet the particular forms of noise exists in surroundings.

Noise protection requirements search for lowering the incidence of terrible effects of noise, coming from temporary distraction to quick form of listening to loss, all of the ways via to continuous hearing loss or deafness. While public surroundings are in endanger due to noise are generating via motors, and this is an instance of noise protection requirements for productions are using in cities. Furthermore, those standards are not only using in determining where noise needs to be attenuated but also in guiding the method, from the initial measurement of noise to the choices available to lessen it, their productivity, execution, and normal outcome of noise safety plans.

The noise cancelling system will lower the amount of noise emitted by the automobile into the environment.

There are two main types of mufflers that are currently being used in automobiles:

1. Mufflers that reflect light
2. Mufflers that dissipate energy

A reflective muffler is made up of tubular elements of various transverse dimensions that are joined together in order to cause impedance mismatch at each junction and, as a result,

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 8, Issue 12, December 2021

the reflection of a large portion of the incident acoustic electricity back to the source, whereas dissipative mufflers are made up of ducts lined on the inside with acoustically absorptive substances. Each muffler is unique in terms of manufacture, geometry, and application criteria.

The following are some of the parameters that influence total muffler performance:

1. Design of the muffler
2. Muffler substance
3. Keep the flow inside the muffler to a minimum.

The muffler is made up of four primary parts:

- The inlet pipe
- A pipe for the outlet
- Perforated tube
- Muffler shell

After extensive research and testing, it was discovered that noise reduction is inversely related to backpressure, which is not a desirable attribute. As a result, an optimal muffler architecture must be implemented in order to achieve maximum noise reduction while minimizing returned strain.

A. Basic requirement of muffler design

When constructing a muffler for an automobile utility, several factors must be taken into account. Affordable insertion loss, backpressure, length, stiffness, desired sound, affordability, weight, compact shape, and fashion are examples of practical criteria. Some needs are spelled out in detail below.

B. Adequate Insertion Loss (I.L.)

The sound pressure of the noise source is reduced to a specific level by a good muffler. The noise inside the exhaust device created by the engine is diminished by automotive mufflers. The muffler's efficiency or attenuation capability is generally measured in insertion or transmission loss. The difference between radiated acoustic forces with and without a muffler is termed as insertion damage. The difference between the incident sound energy (in decibels) at the moment of access to the muffler and the sound energy conveyed through the muffler is known as transmission loss. Muffler designers must determine the amount of insertion damage required to manufacture the appropriate muffler for a vehicle utility [2, 3].

C. 1.3 Selection of size

The right selection and size of the silencer is critical for ensuring that strain drop, acoustic performance, and many precision format specifications are fulfilled. The best sort of engine exhaust silencer is chosen based on the engine's resource, the amount of time it will be used, and the degree of noise reduction necessary. In addition, the chosen silencer length must permit the desired amount of exhaust fuel float, while keeping the rain reduction within certain limitations. The available space has a significant impact on the size and, as a result, kind of muffler that may be employed. A muffler's shape may be optimised for maximum attenuation, but if it doesn't fit within the space limits, it's useless.

D. 1.4 Backpressure

The greater static force put on the engine through the muffler due to the restricted influx of exhaust gases, the higher the back pressure. The exhaust gases are pushed to travel through multiple geometric adjustments in a reactive muffler where particular attenuation is achieved, and a true amount of reduced back stress may be created, lowering the engine's energy output. Back pressure must be kept to a bare minimum to minimize energy losses, especially if the vehicle's overall performance is to be improved.

E. 1.5 Cost and Weight

The larger a muffler is, the more it weighs and the higher the manufacturing costs. Every gram saved on a high-performance automobile is critical to its overall performance. Supporting a muffler effectively is always a challenge, and the larger the muffler, the more difficult it is to direct. The mounting mechanism for a muffler is designed to not only support the weight of the muffler, but also to offer vibration isolation so that the vibration of the exhaust device isn't always conveyed to the chassis and then to the passenger compartment. Hard rubber inserts and mounts that isolate or hose down vibration from the muffler to the chassis are typically used to complete this vibration isolation. As a result, a compact, light-weight muffler is appropriate.

F. Design parameters of the muffler

Selection of muffler grade:

There are a variety of exhaust muffler types to select from, depending on the needed insertion loss and special needs. The technique for determining the muffler grade is also described below:

Industrial/Commercial:
IL = 15 to 25 dBA
Body/Pipe = 2 to 2.5
Length/Pipe = 5 to 6.5
Residential Grade:
IL = 20 to 30 dBA
Body/Pipe = 2 to 2.5
Length/Pipe = 6 to 10
Critical Grade:
IL = 25 to 35 dBA
Body/Pipe = 3
Length/Pipe = 8 to 10
Super Critical Grade:
IL = 35 to 45 dBA
Body/Pipe = 3
Length/Pipe = 10 to 16

Step 1: Unsilenced noise level (UNL=104 dB@1m, for example) When measured 1 metre from the pipe outlet, the overall noise level from maximum unsilenced engine exhaust structures ranges from around a hundred dBA to one hundred

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 8, Issue 12, December 2021

twenty dBA.

Step 2: Determine the requirements for exhaust noise.

RNC = ENC – 5 (dBA)

(For example, to satisfy a noise level of 65 dBA, build a muffler that can handle 60 dBA.)

Step 3: Determine the amount of unsilenced exhaust noise at the receiver site.

The following equation shows a distance adjustment based on free-area spreading.

Lp (Xr)UNL= Lp (Xo) – 20 log (Xr/Xo)

Where Xr = the reflection distance consider for calculation

Xo = the distance at which unsilenced noise level (UNL) is measured

Step 4: Determine the muffler's needed insertion lack by subtracting the receiver noise requirements from the unsilenced receiver noise level. Keep in mind that a five-decibel safety factor is commonly suggested to account for the fact that real muffler overall performance frequently falls short. Calculating the Insertion loss allows you to choose the appropriate exhaust grade from the available options.

UNL-ENC + 5 = IL

Engine exhaust tones: To give greater interest to improve transmission loss, one would want to determine the objective frequencies. The maximum power rpm of the engine is required to calculate the goal frequencies, which is calculated as follows: (7, 9)

Rate of cylinder firing (CFR)

For a two-stroke engine, CFR = RPM/60; for a four-stroke engine, CFR = RPM/120.

EFR = n* CFR (n=number of cylinders)

Engine firing rate (EFR): EFR = n* CFR (n=number of cylinders)

G. Design of muffler:

a) Selection of chamber length:

Selection of chamber length based on exhaust gas temperature:

Temperature of maximum exhaust gas: (If not available, then consider following)

T = 1200 degrees Fahrenheit — for a gasoline engine

T = 900 degrees Fahrenheit — for diesel engines

Find the dominant frequency (f) and use it for calculation by using a frequency analyzer to perform sound analysis.

.According to the ASHARE Technical Committee, the chamber length should be assume that the requirements of the chosen muffler grade match those of the supercritical grade (Similar procedure follows for other grades).The diameter of the exhaust pipe equals the diameter of the silencer inlet pipe [6, 7]

IL = 35 to 45 dBA

L1: ten* exhaust pipe diameter L1: sixteen* exhaust pipe diameter

Body/pipe = three Length/pipe = ten to sixteen

b) Selection of Body diameter (S2)

H. Supercritical grade body diameter

Assume that the requirements of the chosen muffler grade match those of the supercritical grade (Similar procedure follows for other grades)

Body diameter (S2) = 3* engine exhaust pipe diameter

Muffler volume calculation yielded a body diameter.

(n*Vs*faster)/2 = (*L1*(S2)2)/4

Muffler volume (Vm) = (n*Vs*faster)/2

= (*L1*(S2)2)/4

The silencer's volume should be at least 12 to 25 times the area under consideration. Depending on the available area, the extent can be changed.

Body diameter from muffler volume calculation

$Vm = \frac{Q*Vp*N}{1000*\sqrt{T*n}} = \frac{\pi*L1*(S2)^2}{4}$

(VP=Engine swept volume, T=no. of stroke, N=RPM)

Q= constant according to different requirements can be chosen between 5 and 6

Tailpipe length:

Exhaust tailpipes could have resonances which can increase engine tones. To keep away from amplification of tones, use the quick tailpipe.

Optimum tailpipe length (L2) $= \frac{c}{Four*F1} - \frac{S3}{2}$ [7 ,8]

(f1=fundamental firing frequency, c= speed of sound in fps)

Pressure drop:

Theoretically, it's far very hard to calculate particular strain drop due to the complex inner shape of the silencer; but following equations provide approximate stress drop, and it have to no longer exceed the required limits. The stress drop calculated can be checked with the stress drop calculated from the economic FEM software program.

Exhaust flow rate (CFM) $= \frac{Engine\ Displacement(CU\ in)*RPM*Eff*(exh.teamp.^{o}F+460}{C*641760}$ [8 ,10]

Efficiency = 0.85 for naturally aspired engine, 1.4=for turbocharged, C=1 for two-cycle engine, C=2

For a four-cycle engine, exhaust gas velocity (V) $= \frac{Exhaust\ flow\ rate(CFM)}{silencer\ inlet\ area(ft2)}$

Pressure drop (ΔP) $= C*\left(\frac{V}{4005}\right)^2*\left(\frac{530}{T^{o}F+460}\right)$

C= pressure drop coefficient, ΔP=pressure drop inches of water.

II. LITERATURE REVIEW

Vinod Sherekar & P. R. Dhamangaonkar (2014) stated the methodology followed To Automotive Muffler Mufflers Design Principles are an indispensable a part of the engine gadget and are extensively used with inside the air flow gadget to lessen noise transmission resulting from exhaust gases. The layout of the muffler is a complicated operation that impacts the functions of engine noise, output, and gas efficiency. This paper discusses the various performance

requirements of automotive mufflers such as weight loss, malfunction, backpressure, cost, and weight. They concluded that the muffler could have been designed in a variety of ways to achieve optimal performance. Some of them are mentioned above, but their performance in the car itself proves its construction [11].

S.Balamurugan, N.Jeyaprakash & K.Manikandan (2015) stated that the methodology followed to for the main purpose of our research is to build a four-diesel diesel engine. A muffler is a tool used to reduce the amount of noise emitted by an internal combustion engine. They concluded that by using this type of lubricant, we could reduce the amount of toxins emitted from the engine, leading to a path leading to the production of friendly cars. It reduces fuel consumption by about 0.5%, reduces the pressure for repetitive emissions, and thus increases the range of continuous flow over the conventional engine. It also reduces wear on engine components, indicating that the health of the component will increase to a certain level. With this concern, this project will be a success.[12]

Aunik Ahmed and Dibakar Das claim that the procedure was followed in the construction and construction of the suction type and compared it to the existing engine muffler, and there are two types of muffler, the absorption type muffler, and the active muffler. The project faced difficulties after various mufflers and eventually designed and created a suction-type muffler. After we have created the thinner material in our design using a thin sheet metal and steel wool, comparing its performance in three dimensions, no shrinkage condition, laboratory laffler condition, and our newly designed shaft condition. In each case, we calculate the loss of inputs, binding the use of a particular fuel (BSFC), and a specific fuel (SFC). And finally, we showed with a snapshot that our designed muffler performs better than the laboratory muffler condition and not the muffler condition. Of course, we did not achieve our desired result because the soft metal was no longer used as building materials and the available steel wool was not as quality as we expected [13].

Pradyumna Saripall & K. Sankaranarayana stated the methodology followed to exhaust pollution has become one of the most important pollution problems with applications in the automotive industry, and a tired muffler is designed to improve engine performance. The computational Fluid Dynamics (CFD) method was used to test the aerodynamic performance of the muffler. The muffler research resistance is related to the fields of acoustics, fluid dynamics, heat transfer, and road construction. They found different muffler models designed for LCV diesel engine extraction, and the flow has been simulated using ANSYS FLUENT. The flow characteristics obtained by imitation are promising [14].

P. Srinivas & Venkata Ramesh Mamilla stated the methodology followed to Design and analysis of Automobile Exhaust Muffler in car. The click-through button plays an important role in reducing car noise, as well as the ride itself. In order to maintain the required volume and flow smoothly, the scalpel systems need to be analyzed. Here powerful methods are used to determine the shape of the mode, the pressures, and the deformity of the blast curve using the CAE analysis. They found that a double expansion room provides better results compared to a single expansion room. The loss of double room extension is 42.48, which is more than necessary and satisfactory. Strong analysis was performed to determine mode formation and pressures, as well as functional impairment using CAE analysis [15].

G. Gnanendhar Reddy & N. Prakash stated the methodology followed to the design and construction of Reactive Muffler IC engines is one of the major sources of noise pollution. Mufflers are usually available with an exhaust system. After a fire, high-pressure gas pressure enters the soft chamber and the other gases that indicate and pass through the fire chamber are called backpressure. It creates mechanical pressure in the fire chamber and reduces engine performance. Reducing weight, increasing the ability to absorb sound from a muffler with minimal backpressure can increase engine performance. The purpose of this study was to increase engine noise and reduce back pressure. The muffler is designed to meet the potential requirements of installation losses, low back pressure, space issues and stiffness, producing low noise. So a good muffler design should provide excellent noise reduction. The input loss is maximum at 3500 rpm at 16.2 dB. The maximum noise level for a new muffler installation is 80.5 dBA at 3500 rpm as the position for a non-installed installation. The variation loss of the old and new installer is 10.7 dBA at 2500 rpm. The built-in muffler is able to reduce high noise and low noise. The muffler reduces the volume of a low frequency, which sleeps between 200 Hz to 500 Hz. By replacing the existing muffler with the existing model it has been reduced compared to the Mahindra mix Mdi 3200 Di [16].

Vaibhav& D. Prajapati stated the methodology followed to The Construction and Analysis of Muffler Noise Vehicle Dirt is a very important issue in modern life, so reducing noise is necessary. Muffler is a very important part of a car exhaust system to reduce the noise produced by engine combustion products as it passes through the exhaust system, concluding that various constructions are created in comparison to the existing Marti-Suzuki Wagon car model and modelled on the software. From the simulation it has been concluded that form 1 is much better for pressure loss so with high pressure loss there is a lot of noise reduction. Design 6 which is a combination of muffler and resonator also called twin muffler also has a higher pressure loss than the existing structure. So in reducing the noise level we can choose the design 1 and design 6. But the fit and constant reduction combined with the increase in pressure loss will increase the negative back pressure on the engine [17].

M Rajasekhar Reddy & K .Madhava Reddy stated the methodology followed to Design and Use of Automotive Fog

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 8, Issue 12, December 2021

Machine Tracks The modern-day assignment targets to enhance the frequency of NSD (Nash Shell Damper) through controlling the noise stage of the diesel engine through constructing a comparable fluid dispenser, as exhaust noise is one in all the most important individuals to standard engine noise. The TATA INDICA TURBOMAX TDI BSIV diesel engine became examined for testing. In this observe Muffler length became measured through Benchmarking, developing CAD fashions. CAD fashions are made on CATIA V5 R19, later those muffler CAD fashions are despatched to HYPER MESH for pre-processing work. Free evaluation is carried out in this FEA Method system the usage of NASTRAN Software. The stress and sturdiness of the version are discovered from the effects received with inside the evaluation to make sure the achievement of the design. They concluded that with inside the case of destiny research, a splendid settlement might be reached on this regard. If the identical check had been now no longer carried out with inside the desire of putting off any other noise, the analyst may want to strive to distinguish the gadget better, possibly the usage of a bungee cord gadget. If extra correct records may be received, the analyst can see the effects of the gadget evaluation to assist locate the proper lubricants [18].

Pooja & Vishnu Lokhande stated the methodology followed to Exhaust Muffler Design Analysis with VOC Emission filter The main source of noise pollution is IC Engine. In today's world people need clean air that is free of pollution, so they need help to control the noise and pollution of the air. The human being is physically and mentally a creature affected by noise and air pollution. Muffler is used for noise reduction produced by IC Engine Finish. The design and manufacture of a spray dispenser is the main objective of this study. By using the number of back mufflers the sound pressure with free gases can be reduced. The muffler output rig for testing engine is designed. The test is made with a built-in and built muffler and a small 88 DBA audio without the loading speed with the maximum speed of 5100RPM available. In this paper we discuss the complexity behind the various mufflers and the current muffler with noise reduction, design and performance testing, concluding that model production is done based on construction. The complete assembly is fully assembled according to the design. Muffler geometric parameters analysis was performed. From the trial it is concluded that a maximum of 11.61% noise reduction is possible. And high pollution control occurs by using a layer of coal as a pollution control. This also shows that the project is feasible and has a wide range in the automotive sector. The tests performed on the muffler show that it is possible to meet the expectations and has not failed [19].

Krunal C. Chaudhari & Prof. R.Y.Patil stated the methodology followed to Investigation of the Geometric Parameter on Muffler Performance Using CFD Analysis Internal combustion engines are usually fitted with a pressure pump to compress the acoustic pulse generated by the fire process. Recent methods of materials used to determine the flow characteristics and values of the background pressure of the muffler. After using this method, the effect of different parameters can be tested without prototyping and the best muffler can be determined in the construction process. In addition time and money can be saved. They concluded that the decrease in Exhaust pressure in the base case model is 90.008%, Exhaust pressure pressure in elliptical shell model is 89.22%, Exhaust pressure pressure in base case with Length extension of inlet pipe by 40 mm model is 90.615%. Then we conclude that the base of the expanded case The length of the inlet pipe by 40 mm model works better in reducing the discharge pressure compared to the base case model and the elliptical shell model [20].

Niles Kurangal & Dr. Sangram Patil stated the methodology followed to CFD testing and mimicry of an existing Car Vehicle Equipment is a tool used to reduce the noise and vibration of gases emitted by an internal combustion engine. Therefore, it becomes a necessary equipment in cars for proper emissions of nearby gas. Due to the wrong design some reduction reduces the flow rate of weight due to increased fuel consumption, greater pressure drop across its cross section and higher sensitivity to knocking. Therefore, recent studies have been conducted to increase weight flow and reduce pressure reduction. In the current work the existing 4-wheeled vehicle driver is tested by study to determine the flow rate, velocity and temperature and simulations are performed on the CFD to confirm the test results. In the current study of muffler CFD mimic tone simulation was performed to determine the output of pressure drop, temperature, temperature transfer wall [22]. It is noticeable in the line that modifying the existing muffler with a perforation diameter of 4 mm pressure drop is observed at approximately 177 MPa compared to the existing 350 MPa [21]

III. METHODOLOGY

Step 1. Start work on this project with survey books. Numerous research papers related to this topic have been collected. After reading these papers, we learned about weight loss.

Step 2. After that, the required muffler is selected for project.

Step 3. After selecting on the elements, we 3D Model using CATIA software.

Step 4. Comparisons of Computational Fluid Dynamics (CFD) muffler will be made with the help of ANSYS Fluent software.

Step 5. The preparation of the prepared Model will be done, after which the test reading is not down.

Step 6. A comparative analysis between the test result and the CFD, and the result and conclusion will be drawn

IV. Conclusion

From the different literature reviews it can be concluded

that an automotive muffler should be designed to meet all necessary requirements as stated above, like good enough insertion loss, minimal backpressure, space constraints, be long lasting, mild weight, be cost-powerful. There could be many possible muffler design answers for a specific scenario and plenty of feasible approaches to predict a muffler's insertion loss. The muffler may be designed by means of numerous techniques to achieve excellent performance. Some of them are stated above, but the layout is tested by means of its performance on a vehicle itself.

REFERENCES

[1] M.L. Munjal, Acoustics of ducts and mufflers with application to exhaust and ventilation system design, John Wiley & Sons, 1987
[2] M.L. Munjal, Plane wave analysis of side inlet/outlet chamber mufflers with mean flow, Appl. Acoustics, 52, pp.165–175, 1997
[3] M.B. Xu, A. Selamet, I.J. Lee, N.T. Huff, Sound attenuation in dissipative expansion chambers, J. Sound Vib. Vol. 272,pp. 1125–1133, 2004
[4] T W Le Roy, Muffler characterization with implementation of the finite element method and experimental techniques Michigan Technological University, 2011.
[5] A. Elsayed, C. Bastien, H. Medina, S. Jones, H. Kassem, Enhancing Noise Attenuation in Exhaust Mufflers on Response to Baffle Configuration, Int. J. Eng. Manuf.vol 7 pp. 12–25, 2017
[6] U. Kalita, M. Singh, Design and CFD analysis of flow through a reactive muffler of four cylinder diesel engine, recent trends in Engg. Design, Lecture Notes of Mechanical Engg,pp. 211-223, 2021
[7] P.O.A.L. Davies, R.J. Alfredson, Performance of Exhaust Silencer, J. Sound Vib. Vol. 15, pp.175–196, 1971
[8] D. Potente, General design principles for an automotive muffler, Annu. Conf. Aust. Acoust. Soc. 2005, Acoust. Chang. Environ., pp. 121–126, 2005
[9] O.Z. Mehdizadeh, M. Paraschivoiu, A three-dimensional finite element approach for predicting the transmission loss in mufflers and silencers with no mean flow, vol 66, pp. 902–918, 2005
[10] M.L. Munjal, Recent advances in muffler acoustics, Int. J. Acoust. Vib, vol. 18, pp.71–85, 2013
[11] V. Sherekar, P.R. Dhamangaonkar, Design principles for an automotive muffler Int. J. Appl. Eng. Res, Vol. 9 pp. 483–489,2014
[12] S. Balamurugan, N. Jeyaprakash, K. Manikandan, Design and Fabrication of Muffler for Four Stroke Diesel Engine, Int. J. Sci. Eng. Technol. Vol. 4, pp. 136–140, 2015
[13] A. Ahmed, Design and construction of absorption type muffler and compare it with engine ' s existing muffler prepared by, (n.d.).
[14] P. Saripalli, CFD Analysis on Flow Through a Resistance Muffler of LCV Diesel Engine, Int. J. Sci. Technol. Soc. Vol. 3, 2015
[15] P. Srinivas, V.R. Mamilla, G. Lakshmi, N. Rao, M. Ahmed, Design and Analysis of an Automobile Exhaust Muffler, Ind. Syst. Eng. Vol 1, pp.10–15, 2016
[16] G. Gnanendhar Reddy, N. Prakash, Design and fabrication of reactive muffler, Int. J. Chem. Sci. Vol.14, pp.1069–1076, 2016
[17] V.D. Prajapati, Design and Analysis of Automotive Muffler, Vol 5, pp. 384–389, 2016
[18] M.R. R, Components That Influence Airflow Out of the Engine Are As Three-Way,Int. J. Automob. Eng. Res. Dev.Vol. 2, pp. 11–21, 2012
[19] P.V. Lokhande, Design Analysis of Exhaust Muffler With VOC Emission Filter,Int. Res. J. Eng. Technol. pp. 699–709, 2012
[20] 20. J.H. Chaudhri, P.B.S. Patel, P.S.A. Shah, Muffler Design for Automotive Exhaust Noise Attenuation - A Review, Vol 4, pp. 220–223, 2014
[21] U. Kalita, M. Singh, Optimization of a reactive muffler used in four-cylinder petrol engine into hybrid muffler by using CFD analysis, Materials Proceeding Today, (2021)
[22] N. Patil, S. Chaudhary, CFD analysis of exhaust backpressure for four-stroke ciengine, Vol.3,pp. 247–252, 2018.