International Journal of Inventive Engineering and Sciences (IJIES)
ISSN: 2319-9598 (Online), Volume-9 Issue-6, June 2022

Experimentation Analysis of Noise Reduction in Motorbike Silencer

Gourab Gopesh Biswas, M. R. Phate

Abstract*: In this new era, noise pollution is very high. The one reason for this noise pollution is noise or sound which is generated by the exhaust system of the motorbike. So, it is necessary to reduce the noise from the exhaust of the motorbike. In this, original silencer reverse engineering has done and analyse it then three modification model of the silencer with it analysis are done and from that results one modified silencer are selected and forward for the manufacturing. After fabrication of the silencer, two tests are conducted. First, the test is conducted with original silencer then it is conducted with modified silencer. From that data, transmission loss of original and modified silencer are calculated and compare it. From that, noise reduced to 5DB.

Keywords: Noise Pollution, Motorbike, Exhaust System, Transmission Loss, Noise Attenuation

I. INTRODUCTION

Sound is described as a propagating disturbance through a physical or elastic medium (like air, water or gas) [1]-[5]. In a modern city life, sound is as irritating not pleasant or useful. Such unpleasant or unwanted sound is called as noise [35]. In other words, noise is the wrong sound in the wrong place and at wrong time. Silencers are the device or mechanical equipment which are specially use for attenuation of noise [36]. Its purpose is to reduce the noise. Silencer are used in all sectors like automotive industries for vehicles, aeronautic industries, food industries for ventilation, oil and gas plant and power generation plants, etc. in all these sectors silencers are used for reduction of noise [6]-[12]. As we known, motorcycles are very essential for the people for the work [21]-[25]. And for today era, noise pollution is a one and important factor for the human being and the environment [13]-[20]. And as it is mention above silencer play an essential role in it. So, the primary objective is to analyse and modify the silencer. The main purpose is to reduce the noise from the motorcycle exhaust [26]-[28]. To test in the actual conditions to determine its actual results of noise [29]-[34].

II. RESEARCH METHODOLOGIES

A. Mathematical equations

In this, some formula are used to determine the transmission loss and to convert sound pressure level into sound power level. For analysis and testing, transmission loss is essential and its formula is:

$$TL = 10log_{10}\frac{W_i}{W_t} \ldots \quad (1)$$

Where,
TL = Transmission Loss
W_i = Sound Power Level of Incident in watts
W_t = Sound Power Level of transmission in watts (For original and modified)

And to determine the sound power, formula is:

$$L_W = 10log_{10}\left(\frac{W}{W_{ref}}\right) \ldots \quad (2)$$

Where,
W = Sound Power Level in Watt for original silencer and modified silencer and also for incident sound
W_{ref} = Reference Sound Power = $1x10^{-12}$ Watt

When, sound is measure, it is in the form of sound pressure level. To convert it into sound power level, use this formula:

$$L_W = L_P + 10log_{10}(S) \ldots \quad (3)$$

Where,
L_W = Sound Power Level
S = Surface area of imaginary sphere = $4\pi r^2$
r = Distance from the point of sound source (inlet port) to the point of the imaginary surface (outlet port)

B. Analysis of original silencer

Figure 1 shows the original silencer which is use for analysis.

Fig.1. Original Silencer

In that, it contains catalyst converter, diffused pipe, baffle plate, resonator pipe. These all components are totally inside the expansion chamber. The function of the silencer is like a diffusive silencer with resonator. As the exhaust manifold is not the part of the silencer or it is a separate part from the expansion chamber, so we have not considered it for the analysis. But, as catalyst converter is the internal part of the silencer, so we have considered it. For modelling of original silencer, dimensions of each component are taken by using vernier caliper and measuring tape. For modelling, ProE/Creo software is used. Figure 2 shows modelling of the original silencer in cut section.

Manuscript received on 25 May 2022.
Revised Manuscript received on 17 June 2022.
Manuscript published on 30 June 2022.
* Correspondence Author
Gourab Gopesh Biswas*, Department of Mechanical Engineering Design, All India Shri Shivaji Memorial Society College of Engineering, Pune (Maharashtra), India. Email: gourabgopesh98@gmail.com
Dr. M. R. Phate, Department of Mechanical, All India Shri Shivaji Memorial Society College of Engineering, Pune (Maharashtra), India.

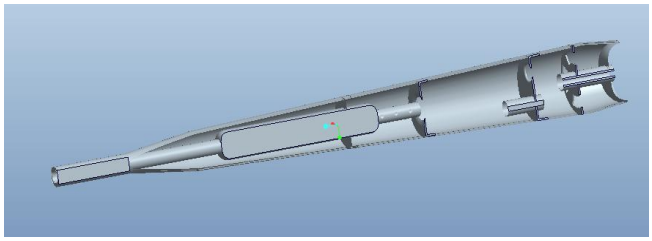

Fig.2. Cut section of original silencer

After modelling, model is analyzing in Ansys software. For analysis of transmission loss, harmonic acoustic section for analysis of transmission loss in the silencer. Data for gas and steel for analysis are mention below:

Table - I. Data of exhaust gas

Properties	Values	Units
Density	1.161	kg/m^3
Isotropic Thermal Conductivity	0.0263	W/m^0K
Specific Heat at Constant Pressure	1.007	KJ/kg^0K
Viscosity	0.896	$N.sec/m^2$

Table - II. Data of mild steel

Properties	Values	Units
Density	7850	kg/m^3
Isotropic Thermal Conductivity	0.1622	W/m^0K
Specific Heat at Constant Pressure	$1.1635X10^{-03}$	KJ/kg^0K

After these data, analyzing gets started. After discretization of the model, boundary conditions are set that is frequency range from 0-100Hz at 10 intervals and set its input and output port. After that, solutions are given for transmission loss and start analyzing. Results of the analysis are as shown in figure 3.

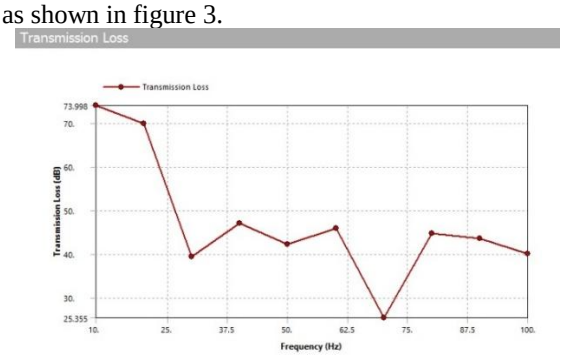

Fig.3. Graph of transmission loss vs frequency of original silencer

C. Analysis of modified silencer

After the analysis of original silencer, three modified silencer are created and analyse it. In that, first modification is done by removing the resonator unit from the original silencer which as shown in figure 4.

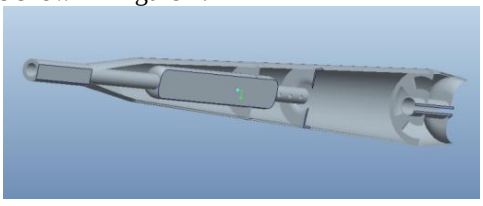

Fig.4. Cut section of modified 1 silencer

In second modification, diffuse plate is removed instead of resonator unit which is as shown in figure 5.

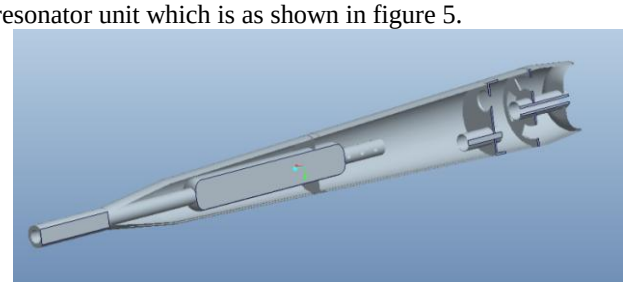

Fig.5. Cut section of modified 2 silencers

In last modification, both resonator unit and diffuse plate are removed which is as shown in figure 6.

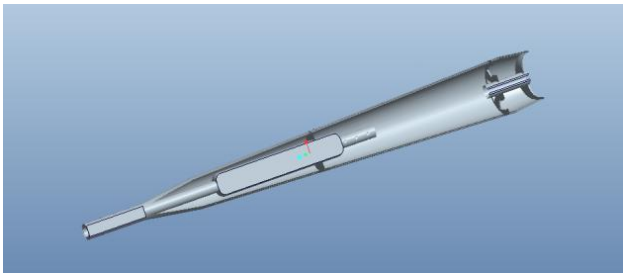

Fig.6. Cut section of modified 3 silencers

So, three modified models are analysed from that, transmission loss of modified 3 silencer is higher than other two and original silencer. So, modified 3 silencers are selected for the testing.

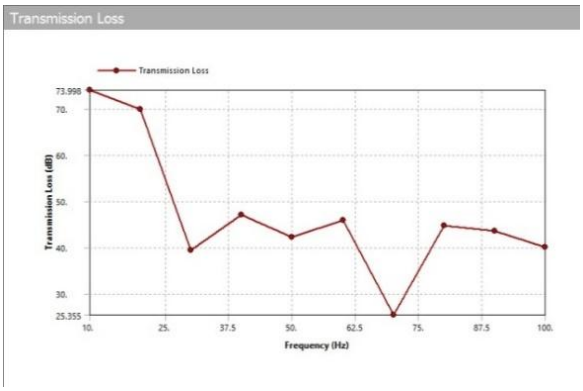

Fig.7. Graph on transmission loss vs frequency on modified 1 silencer

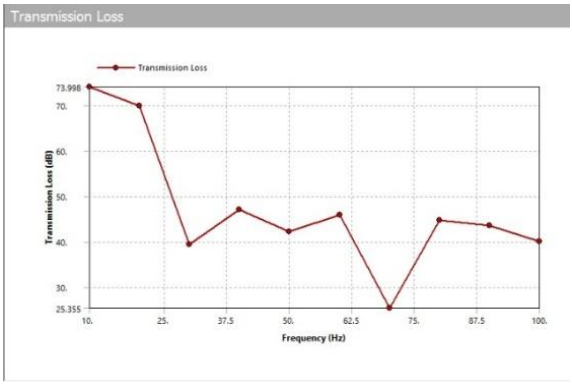

Fig.8. Graph on transmission loss vs frequency on modified 2 silencers

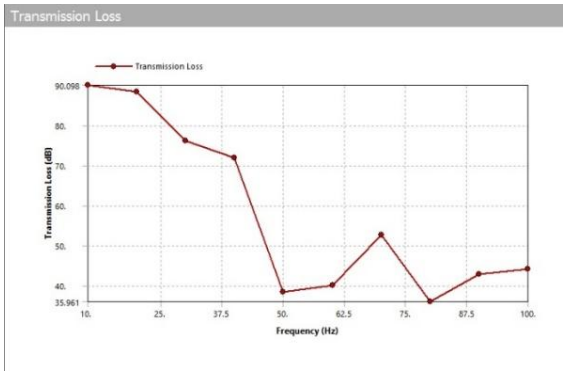

Fig.9. Graph on transmission loss vs frequency on modified 3 silencers

D. Manufacturing of modified silencer

As the model 3 is selected for the modification, it is undergo manufacturing. In that, manufacturing is nothing but to remove the resonator unit and diffuse plate. By using gas cutter, resonator unit and diffuse plate are removed.

Fig.10. Silencer after cutting the components

After removing the components, weld the cover plate which was cut by using oxy-acetylene welding and modified silencer are installed in the bike.

Fig.11. Modified silencer install in bike

E. Experimentation/Test

Testing is conduct on the original silencer and modified silencer. First test is conduct on the original silencer then on modified silencer. Also, test is conducted on non-silencer to get the incident sound. Live test are conducted or it is also called field test, the test which is conduct on the actual environment to determine the actual noise in the environment from the silencer. Below there are some requirements are mention for conduction of test. In this, sound level meter are used for test. Sound level meter are used for measuring of noise which is coming out from the engine and the silencer. Here, bike is run at test site at different speed. At different speed, sound and flow are measured by seating on the backside and facing opposite to rider side. So, the readings and results are mention in next chapter.

III. RESULTS AND DISCUSSION

After the conduction of test in original and modified silencer, readings of sound are found on the both the silencer.

The noise of the environment = 70.4 DB Here, observation table of original silencer and modified silencer are shown below and readings are on the basis of speed of the vehicle.

Table -III. Observation tables of original silencer

Sr. No.	Speed (km/hr)	Sound (DB)
1	0/Idle	86.9
2	10	96.9
3	20	97.8
4	30	98.6
5	40	100.4
6	50	102.8

Table - IV. Observation tables of modified silencer

Sr. No.	Speed (km/hr)	Sound (DB)
1	0/Idle	78.3
2	10	93.7
3	20	93.8
4	30	95.1
5	40	95.7
6	50	96.2

Also, the sound of exhaust gas without silencer is measure and their observation tables are mention below.

Table - V. Observation tables of incident sound

Sr. No.	Speed (km/hr)	Sound (DB)
1	0/Idle	106.5
2	10	124
3	20	126.1
4	30	128.9
5	40	129.2
6	50	129.9

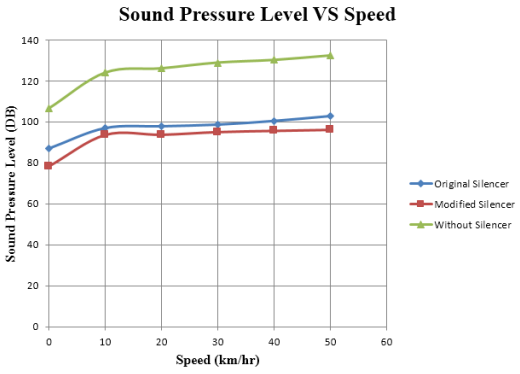

Fig.12. Graph of sound pressure level vs speed of the silencers

All the readings are the sound pressure level. From the above table, it is found that, the noise reading is the combine of sound of exhaust gas of the silencer and the environmental sound. So, the subtracted the total sound with the environment sounds by using formula of subtraction of decibel. The formula is as shown below:

$$L_p = 10log_{10}\left[10^{(L_{P1}/10)} - 10^{(L_{P2}/10)}\right] \ldots \quad (4)$$

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Where,
L_P = Particular Sound Pressure Level
L_{P1} = Combine Sound Pressure Level
L_{P2} = Environmental Sound Pressure Level
The table of the subtracted sound pressure level of original, modified and without silencer is mention below.

Table - VI. Calculated values of subtracted sound pressure level of each silencer

Sr. No.	Speed (km/hr)	Subtracted Sound Pressure Level (DB)		
		Original Silencer	Modified Silencer	Without Silencer
1	0/Idle	86.8	77.5	106.4
2	10	96.8	93.6	123.9
3	20	97.7	93.7	126
4	30	98.5	95	128.8
5	40	100.3	95.6	129.1
6	50	102.7	96.1	129.8

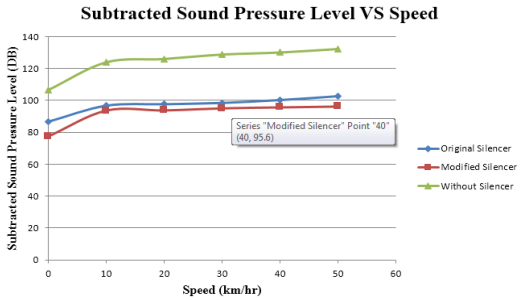

Fig.13. Graph of subtracted sound pressure level vs speed of the silencers

By using equation (1), (2) and (3), we have found the transmission loss of original and modified silencer.

Table - VII. Transmission loss of original silencer

Sr. No.	Speed (km/hr)	Transmission Loss (DB)
1	0/Idle	19.59
2	10	27.1
3	20	28.29
4	30	30.29
5	40	29.8
6	50	29.59

Table - VIII. Transmission loss of modified silencer

Sr. No.	Speed (km/hr)	Transmission Loss (DB)
1	0/Idle	28.89
2	10	30.29
3	20	32.31
4	30	33.8
5	40	34.5
6	50	36.2

From these two results, graph of transmission loss vs speed of the vehicle to compare the results and the results are as shown in figure 14.

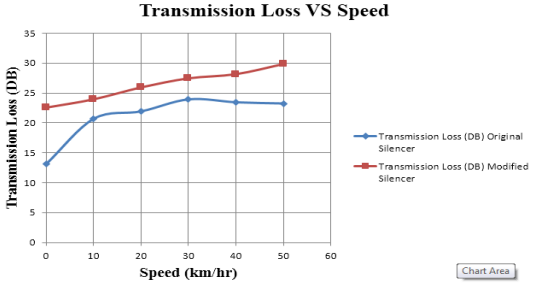

Fig.14. Transmission loss vs speed of original and modified silencer

From the above graph, it is found out that noise is reduced properly in the modified silencer. To determine whether the noise are in the limit of 100 DB or not average sound pressure level are calculated. The formula for this is:

$$L_{avg} = 10 log_{10} \left[\frac{1}{n}\sum_{n=1}^{n} 10^{(L_{pn}/10)}\right] \ldots \quad (5)$$

Where,
L_{avg} = Average Sound Pressure Level in DB
n = Number of sound pressure level measured
L_{pn} = n^{th} number of sound pressure level
From the equation (5), the average sound pressure level of original silencer is 100.85 DB which is beyond the limit of 100 DB but the average sound pressure level of modified silencer is 96 DB which is lower than 100 DB. So, noise is reduced to 5 DB.

IV. CONCLUSION

So, the original silencer is analyse and from that three modified silencer are model and again analyse it. After analyzing, the model is selected and put it for the manufacturing and done the test in the field. From the test, noise test is conduct on original and modified silencer. After the test, transmission loss is calculated and average sound pressure level. From that, it is conclude that from the test results, noise is reduce to 5DB and all the sound which are measure at different speed, all the sound levels are below the 100 DB as per the standard norms of the emission noise. So, noise is reduced to 5DB..

REFERENCES

1. Dr. D. W. Herrin, Design of Mufflers and Silencers, University of Kentucky, Department of Mechanical Engineering, pp. 1-43.
2. Istvan L. Ver, Leo L. Beranek, Noise and Vibration Control Engineering: Principles and Applications, 2nd ed., John Wiley and Sons, INC, New Jersey, 2006, pp. 279-345.
3. D. A. Harris (ed.), Noise Control Manual, Springer Science plus Business Media, New York, 1991, pp. 45-52. [CrossRef]
4. Dario Bogdanovic, Calculation methods for predicting attenuation of parallel baffle type silencers: For use in power plant ducts and exhausts, Chalmers University Of Technology, Goteborg, Sweden, 2014, pp. 1-90.
5. Elden F. Ray, Industrial Noise Series Part VIII: Absorptive Silencer Design, Universalaet, June 10, 2013.
6. X.W. Zhang, Z.H. Yao, F. He, Numerical simulation of the flow field of a diffused pneumatic silencer, Applied Mathematical Modelling, 33 (2009), pp. 3896-3905. [CrossRef]
7. Paul Williams, Ray Kirby, James Hill, Mats Abom, Colin Malecki, Reducing low frequency tonal noise in large ducts using a hybrid reactive-dissipative silencer, Applied Acoustics, 131 (2018), pp. 61-69. [CrossRef]
8. R. Kirby, J.B. Lawrie, A point collocation approach to modelling large dissipative silencers, Journal of Sound and Vibrations, 286 (2005), pp. 313-339. [CrossRef]
9. R. Kirby, A comparison between analytic and numerical methods for modelling automotive dissipative silencers with mean flow, Journal of Sound and Vibrations, 325 (2009), pp. 565-582. [CrossRef]
10. M. Cervenka, M. Bednarik, Optimized compact wideband reactive silencers with annular resonators, Journal of Sound and Vibrations, 484 (2020), 115497. [CrossRef]
11. Cecil R. Spark, Design of High-Pressure Blow-off Silencers, The Journal of the Acoustical Society of America, Volume 34, Number 5, May 1962. [CrossRef]

12. Simon Kubas, Andrej Kapjor, Martin Vantuch, Alexander Caja, Determination of pressure loss of silencers during air transport in air conditioning, Transportation Research Procedia, 55 (2021), pp. 707-714. [CrossRef]
13. P. Brandstatt, W. Frommhold, Program for the computation of absorptive silencer in straight ducts, Applied Acoustics, 43 (1994), pp. 19-38. [CrossRef]
14. Mohamed Filsuf M. A, Dr. S. Sankar, Christy Mathew, Sreejith K. V, Design and Development for Exhaust Back Pressure Reduction with Noise Control for Motorcycles, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 7, Issue 5, May 2018.
15. Raimo Kabral, Hans Rammal, Fabio Auriemma, Janek Luppin, Risto Koiv, Heiki Tiikoja and Juri Lavrentjev, A Novel Design for Cruiser Type Motorcycle Silencer Based on Micro-Perforated Elements, SAE International, Monday, August 20, 2018.
16. Key Fonseca de Lima, Philippe Dea Cirino, Nelson Luis Maurios Legat Filho and Nilson Barbieri, Multi-frequency sequential and simultaneous parametric shape optimization of reactive silencers, Applied Acoustics, 171 (2021), 107543. [CrossRef]
17. E.M. Sanchez-Orgaz, F.D. Denia, L. Baeza, R. Kirby, Numerical mode matching for sound propagation in silencers with granular material, Journal of Computational and Applied Mathematics, 350 (2019), pp. 233-246. [CrossRef]
18. P. Wang, T.W. Wu, K. Ruan, H. Zhou, Impedance-to-scattering matrix method for large silencers Part II: Integral formulation, acoustic reciprocity and practical issues, Engineering Analysis with Boundary Elements, 119 (2020), pp. 235-245. [CrossRef]
19. F.D. Denia, E.M. Sanchez-Orgaz, J. Martinez-Casas and R. Kirby, Finite element based acoustic analysis of dissipative silencers with high temperature and thermal-induced heterogeneity, Finite Elements in Analysis and Design, 101 (2015), pp. 46-57. [CrossRef]
20. Chunqi Wang, Lixi Huang, Analysis of absorption and reflection mechanisms in a three-dimensional plate silencer, Journal of Sound and Vibration, 313 (2008), pp. 510-524. [CrossRef]
21. Guangyu Zhang, Xiaoyu Wang, Lei Li, Xiaodong Jing and Xiaofeng Sun, Control of thermo acoustic instability with a drum-like silencer, Journal of Sound and Vibration, 406 (2017), pp. 253-276. [CrossRef]
22. Mehta Nirav, Sachindra Doshi, Experimental Investigation on Innovative Modification of Aqua Silencer, Materials Today: Proceedings, 4 (2017), pp. 1209-1214. [CrossRef]
23. D. Duc Nguyen, Manokaran Vadivel, Sutha Shobana, Sundaram Arvindnarayan, Jeyaprakash Dharmaraja, Rathnam Krishna Priya, Phuong Nguyen-Tri, Gopalakrishnan Kumar and Soon Wong Chang, Fabrication and modeling of prototype bike silencer using hybrid glass and chicken feather fiber/hydroxyapatite reinforced epoxy composites, Progress in Organic Coatings, 148 (2020), 105871. [CrossRef]
24. Lingfeng Chen, Xiaoyu Wang, Lin Du and Xiaofeng Sun, A three dimensional analytical approach for large rectangular splitter silencers in the presence of means flow, Journal of Sound and Vibration, 513 (2021), 116404. [CrossRef]
25. Margus Villau, Hans Rammal and Juri Lavrentjev, Innovative fibreless HVAC duct silencer based on micro-perforated elements, Materials Today: Proceedings.
26. Ahmed Elsayed, Christophe Bastien, Steve Jones, Jesper Christensen, Humberto Medina, Hassan Kassem, Investigation of baffle configuration effect on the performance of exhaust mufflers, Case Studies in Thermal Engineering, 10 (2017), 86-94. [CrossRef]
27. Om Ariara Guhan C P, Arthanareeswaren G, Varadarajan K N, CFD Study on Pressure Drop and Uniformity Index of Three Cylinder LCV Exhaust System, Procedia Engineering, 127 (2015), 1211-1218. [CrossRef]
28. Dmitry M. Stadnik, Alexander A. Igolkin, Victor Y. Sverbilov, Kirill M. Afanasev, The muffler performance effect on pressure reducing valve dynamics, Procedia Engineering, 176 (2017), 706-717. [CrossRef]
29. Xun Liu, Shou-Jie Xu, Chu-Qi Su, Xiao-Hong Yuan, Yi-Ping Wang, Research on characteristics of thermoelectric generator with integrated muffler and catalytic converter, Energy Reports, 8 (2022), 510-519. [CrossRef]
30. Jun Fu, Minghui Xu, Wei Zheng, Zengfeng Zhang, Yong He, Effects of structural parameters on transmission loss of diesel engine muffler and analysis of prominent structural parameters, Applied Acoustics, 173 (2021), 107686. [CrossRef]
31. Yaqiang Xue, Guoyong Jin, Tiangui Ye, Kangkang Shi, Saifeng Zhong, Chuanmeng Yang, Isogeometric analysis for geometric modelling and acoustic attenuation performances of reactive mufflers, Computer and Mathematics with Applications.
32. Yongan Zhang, Pei Wu, Yanhua Ma, He Su, Jing Xue, Analysis on acoustic performance and flow field in the split-stream rushing muffler unit, Journal of Sound and Vibration, 430 (2018), 185-195. [CrossRef]
33. Dr. K. Ashok Reddy, A Critical Review on Acoustic Methods & Materials of a Muffler, Materials Today: Proceedings, 4 (2017), 7313-7334. [CrossRef]
34. C.P. Om Ariara Guhan, G. Arthanareeswaran, K.N. Varadarajan, S. Krishnan, Exhaust System Muffler Volume Optimization of Light Commercial Vehicle Using CFD Simulation, Materials Today: Proceedings,54 (2018), 8471-8479. [CrossRef]
35. Ajay Kashikar, Rohit Suryawanshi, Naynish Sonone, Ravikant Thorat, Shubham Savant, Development of muffler design and its validation, Applied Acoustics, 180 (2021), 108132. [CrossRef]
36. Dr. M. L. Munjal, Formula of acoustics, Chapter 11: Muffler acoustics, Springer.

AUTHORS PROFILE

Gourab Gopesh Biswas, ME student of Mechanical Engineering Design at All India Shri Shivaji Memorial Society College of Engineering. BE in Mechanical Engineering at Imperial College of Engineering and Research. Diploma in Mechanical Engineering at Bhivrabai Sawant Polytechnic. Working as a Design Engineer as a profession at Chandan Tech Solution Pvt. Ltd. Having 3 year experience in this company which is related to the piping (Oil and Gas Refinery and Power plant) and plant design field. Now continuing job and education for ME.

Dr. M. R. Phate, Ph. D. in Mechanical Engineering, M. Tech in Mechanical Engineering, MBA in Human Resource, BE in Mechanical Engineering. Professor and Institute NBA Coordinator in mechanical engineering department at All India Shri Shivaji Memorial Society College of Engineering.