Evaluation Of Pass By Noise Performance Of Passenger Car By Modified Muffler

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Abstract: The sound quality of any product plays an important role for its marketing and popularity. Here in this research we are trying to improve the sound quality of passenger car. So for the sound quality of car, we are trying to modify the exhaust system.In the exhaust system, are using baffle plate with perforation. Firstly we use single baffle with perforation and increase the baffle plate up to three baffle plates.This project deals with four different models of chambered exhaust muffler with perforation in baffles and concludes the best possible design for good sound quality. In this exhaust system along with baffles plate, we also use absorptive materials to improve the sound quality. Absorptive materials for this research we are using the glasswool and rockwool. For this research we have performed all the simulation in Ricardo wave build software. So after simulation in Ricardo wave build software, we conclude that the muffler with having three baffle plate along with rockwool as an apsorptive material give the best result as compare to other cases.

Index Terms: Sound Quality Analysis, Wave 1-D, Glasswool, Rockwool.

1. INTRODUCTION

The quality of sound is determined by several parameters such as the loudness, the sharpness and the roughness boom. Determining all the sound quality parameters is important because the perception of the human ear cannot be measuring by any one value. All the parameters play their part in determining whether a sound is pleasant to listen or not by a human ear. The sound quality parameters measured in this analysis are as follows: the loudness, the sharpness, the roughness, boom etc [1]. The sound quality of vehicle noise has become a very important task for the acoustic engineers. As vehicles become more quiet, the customer's sensitiveness for the acoustical comfort increases. On the one hand, no disturbing noises should be heard and on the other hand, the perceived sound quality, for example from the power train, should fulfill the expectations of the perceiver with reference to the sound quality. The subjective judgment of pleasantness or sound comfort is influenced by both sound and vibration [2,12]. Vehicle sound quality measurement is essential part in view of growing economy, increased market requirement and aspirations of the customer. Now a day's government rules and norms are stringent about vehicle noise pollution[3,13]. Here virtual prototype plays an important role to achieve the desired sound quality of vehicle. Sound Quality describes those parameters of sound which allow the ear to distinguish sound like accuracy, enjoyability, intelligibility [10,14].

2. LITERATURE REVIEW

In 2015 Amit Kumar Gupta, Ashesh Tiwari presents their paper.The main aim of this paper is to use of FEA as well Experimental Method for Muffler's Transmission Loss Measurement. FEA is generally used for virtual prototyping. So it saves the substantial amount of time and resources. The acoustic characteristics of single expansion chamber muffler with single central inlet, single central outlet is also investigated in detail by experimental method as well FEA results. By comparing the Experimental results with FEA results shows the validation of results [4]. In 2015 Amit Kumar Gupta, Ashesh Tiwari told that, Acoustic Muffler's characteristics are calculated by Transmission Loss and Insertion Loss. Single expansion chamber is generally used as noise reduction elements in exhaust systems. To quantify its effectiveness, transmission loss is commonly used as a parameter comparing the transmitted with incident sound pressure level. Mufflers are typically arranged along the exhaust pipe as the part of the exhaust system of an internal combustion engine to reduce its noise [5]. In 2016 Amit Kumar Gupta says that, the measurement of the acoustical transmission loss of extended inlet and extended outlet tube on single expansion chamber for noise reduction with same gas volume. A muffler (silencer) is an important noise control device for reduction of machinery exhaust noises other noise source which involves the flow of gases. Mufflers are typically arranged along the exhaust pipe as the part of the exhaust system of an internal combustion engine to reduce its noise [6]. In 2016 Amit Kumar Gupta presents his paper.The main aim of this paper is to use of TMM, FEA (Wave 1-D & Comsol) as well experimental method (two load method). Afterword to achieve by proven results analysis is done for convergent and divergent cylindrical duct. Also FEA based tool Comsol Multiphysicsand Wave 1-D is used to validate and comparing the results. FEA tool is used for virtual prototyping which hasalready validated with various case studies [7]. In 2015 Amit Kumar Gupta, Ashesh Tiwari told that Muffler acts as noise reduction element on exhaust system. Here the transmission loss of central inlet and central outlet muffler of single expansion chamber has been compared and validated in three methods namely transfer matrix method, FEA and an experimental method for this purpose. Several researchers have worked in the area of noise attenuation on central inlet by changing the position of outlet as side outlet but no one emphasizes on offset of the central inlet and central outlet position. Thereafter the finite element analysis tool Ricardo wave 1-D and comsol multiphysics is used to evaluate transmission loss for various offset position of inlet and outlet duct of the muffler [8].

3. RESEARCH METHODOLOGY

- Measurement of Static Noise and transient Noise of vehicle by using 1D simulation.
- BY establishing Color Map by using 1D simulation.
- Frequency spectrum analysis by FEA.
- An Improvement of Sound Quality by the modification of exhaust system etc.

4. SOUND QUALITY SIMULATION

The virtual simulation tool RICARDO WAVE is used for sound quality investigation. This is accomplished by applying a one-dimensional finite difference approach of the theoretical thermo fluid equations of the working fluids of the defined system. In order to analyze the sound quality of an engine with WAVE ,it must first be created with the preprocessor WAVEBUILD. This canvas provides the ability to create and synthesize all of the building blocks representing the various ducts, volumes and other engine component. WAVEBUILD also allows for the input of the required physical data and operating conditions of the engine [4,11]. For this purpose 4 cylinder, 8 valve model used for the simulation, the model appears as in figure1.

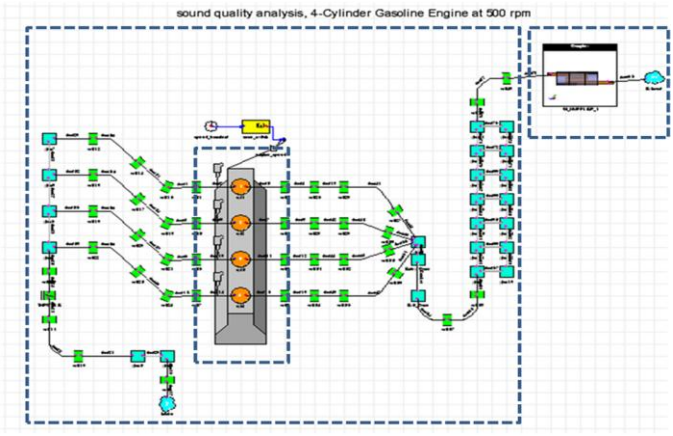

***Figure 1**: Ricardo Wave 1-D GUI for sound quality analysis.*

Sound quality was determined for steady state conditions for engine speeds from 500 to 5000 rpm. Similar analysis were performed for transient runs between the same rpm range. The coordinate system used for simulation is global and the exhaust is set at the position.

4.1 POST PROCESSING IN WAVE POST

Wave post can create both “acoustic plots” and “audio outputs” from data obtained in an acquisition. This enables you to create many types of plots, both 2D & 3D, to view the results of acquisitions. Figure 2 are color map representations of the induction noise. Figure 3 shows the frequency of the engine noise for the rpm range of engine model for transient and steady state.

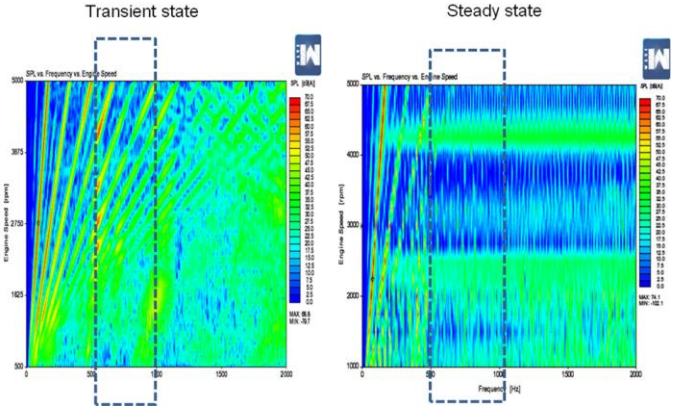

***Figure 2:** Colormap Representation for Transient and Steady State.*

Here ,the various colours represent the amplitude of the predicted sound pressure level. Similarly ,figure illustrates the same for the engine at steady state. The yellow and orange streaks representing the fundamental and subsequent harmonic frequencies are more apparent with more red showing on the map of model at transient state [3,9]. This shows higher amplitudes of sound at the fundamental frequencies which are obviously associated with the speed of engine . Also, the steady state engine simulation has less of the higher sound pressure level represented by the green color. Similarly ,it has more of the lower sound pressure level represented by the mid and dark blue shades.

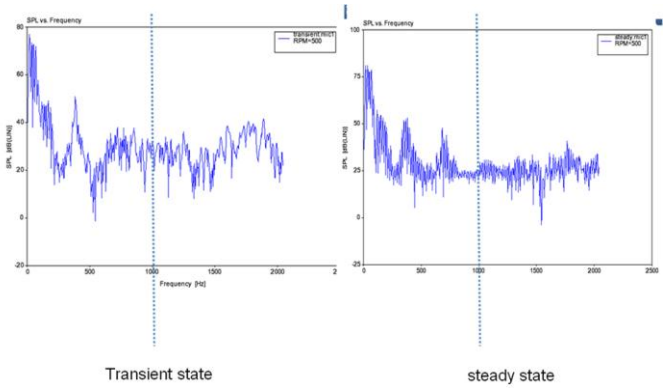

***Figure 3:** SPL Vs Frequency Graph for transient and steady state.*

5. SOUND QUALITY MANIPULATION

Sound quality can be modified either by Intake noise cancellation or by Exhaust. A muffler is noise reduction element on exhaust system. The basic term used for noise attenuation is transmission loss (TL). **Sound quality** can be modified either by Intake noise cancellation or by Exhaust. A muffler is noise reduction element on exhaust system. The basic term used for noise attenuation is transmission loss (TL) [6]. For manipulation of sound quality of the engine the volume of muffler is keeping constant for central inlet and outlet. Following design conditions are applied to analyzing the manipulation of sound quality of the engine-

1. Volume of the muffler is kept constant for all the modelling and design work and by keeping the length of muffler as constant i.e. 500mm.
2. Modelling of cylindrical central inlet and outlet, convergent duct and divergent duct by keeping the same volume, i.e. diameter 130mm and by keeping the diameter of central inlet and outlet tail pipe as constant i.e. 30mm.
3. Modelling of circular expansion chamber by keeping the length of inlet and outlet tail pipe as 110mm.

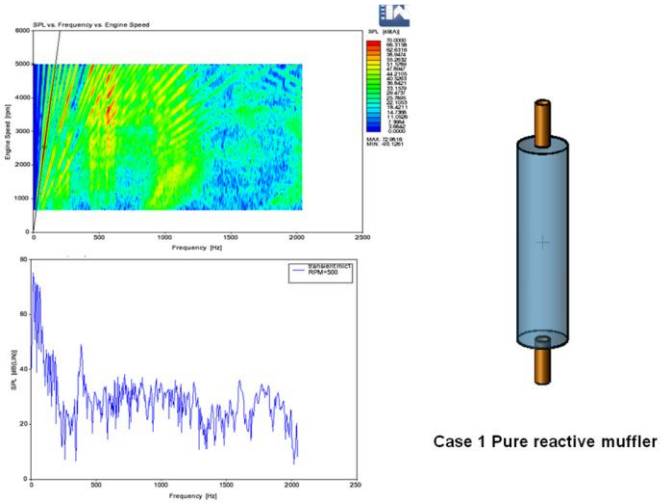

Figure 4: *Schematic representation of colormap and SPL vs Frequency graph for pure reactive muffler.*

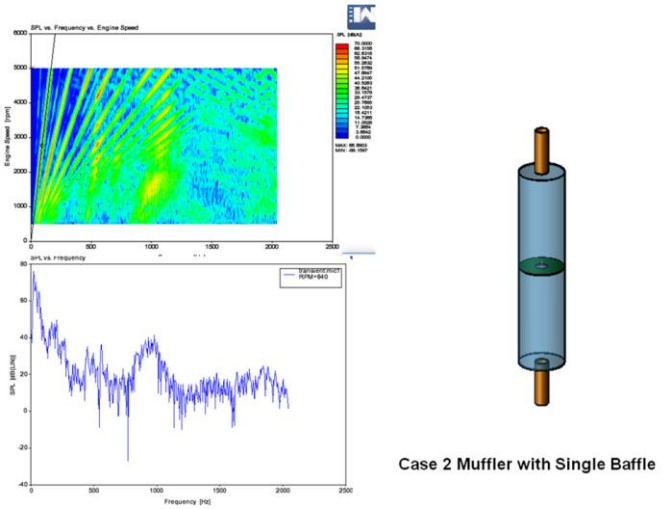

Figure 5: *Schematic representation of colormap and SPL vs Frequency graph for muffler with single baffle plate.*

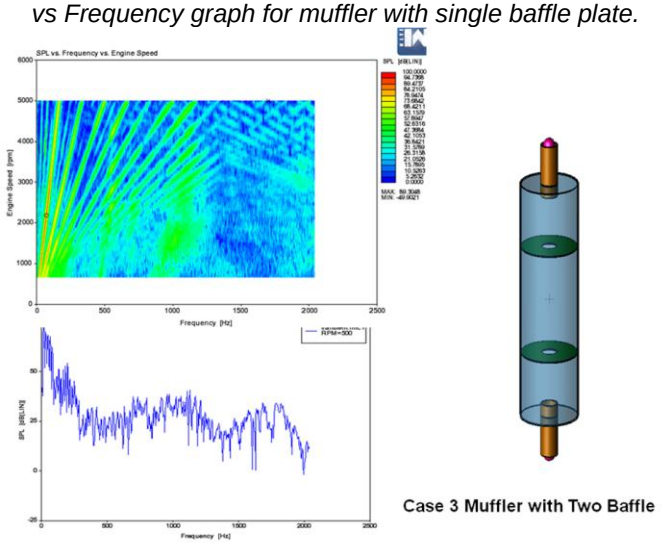

Figure 6: *Schematic representation of colormap and SPL vs Frequency graph for muffler with two baffle plates.*

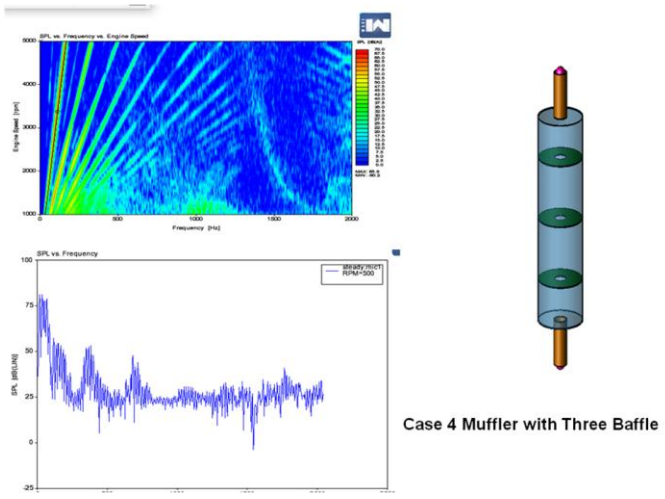

Figure 7: *Schematic representation of colormap and SPL vs Frequency graph for muffler with three baffle plates.*

6. RESULTS AND DISCUSSION

Table 1: *Calculation of Sound Quality Parameters for muffler without absorptive material*

Types of Muffler	***Phones***	***Sones***	***Sharpness***	***Boom***
Simple Muffler	*23.21*	*0.31*	*1.84*	*51.30*
Single Plate Baffle	*21.47*	*0.27*	*1.66*	*48.39*
Two Plate Baffle	*20.31*	*0.25*	*1.61*	*47.66*
Three Plate Baffle	*18.35*	*0.22*	*1.50*	*44.89*

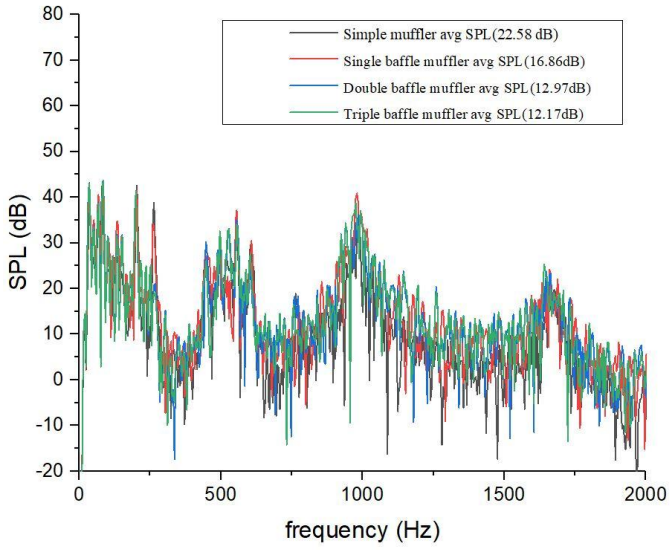

Figure 8: *Comparison graph for four cases of muffler*

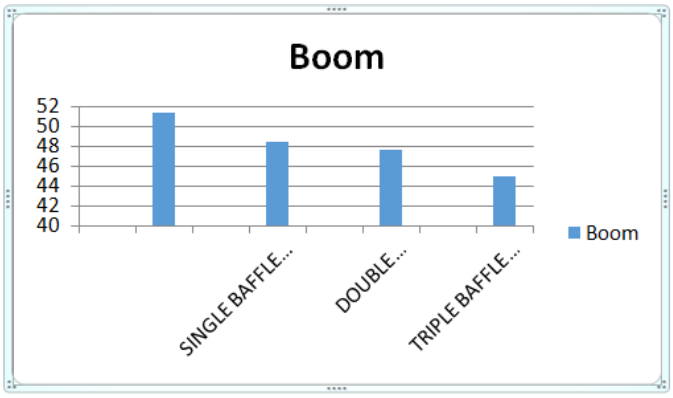

Figure 9: *Comparison Bar chart for four cases of muffler.*

Table 2: *Calculation of Sound Quality Parameters for muffler with Glasswool as an absorptive material.*

Types of Muffler	Phones	Sones	Sharpness	Boom
Simple Muffler	22.84	0.30	1.63	49.30
Single Plate Baffle	20.52	0.26	1.51	43.29
Two Plate Baffle	19.23	0.23	1.46	42.36
Three Plate Baffle	19.11	0.23	1.45	41.84

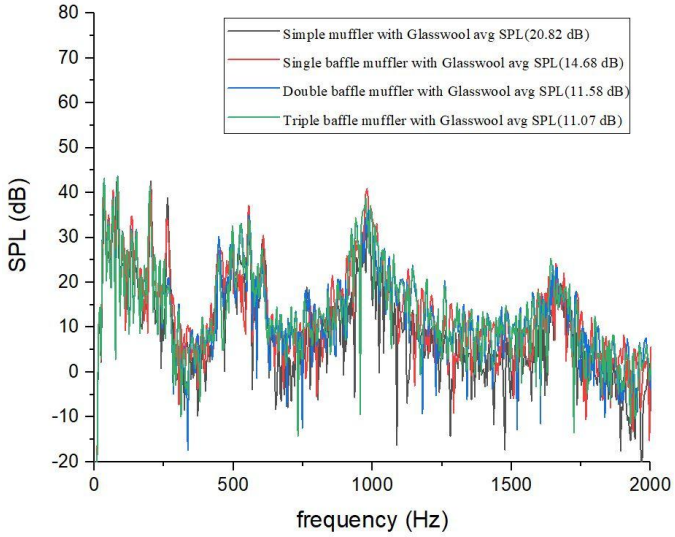

Figure 10: *Comparison graph for four cases of muffler with Glasswool as an absorptive material.*

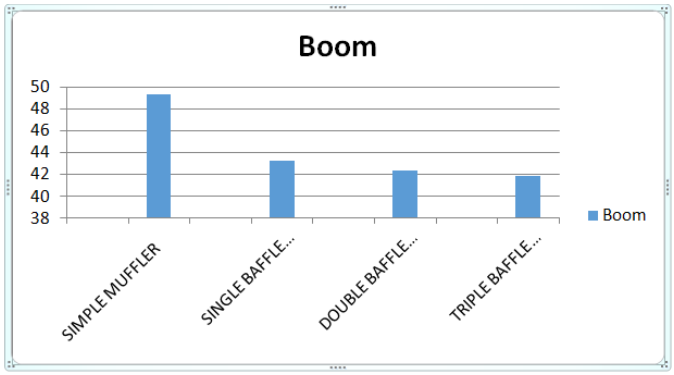

Figure 11: *Comparison Bar chart for four cases of muffler with Glasswool as an absorptive material.*

Table 3: *Calculation of Sound Quality Parameters for muffler with Rockwool as an absorptive material.*

Types of Muffler	Phones	Sones	Sharpness	Boom
Simple Muffler	14.85	0.171	1.58	48.36
Single Plate Baffle	13.82	0.160	1.49	42.25
Two Plate Baffle	12.53	0.148	1.42	41.05
Three Plate Baffle	12.06	0.144	1.41	40.85

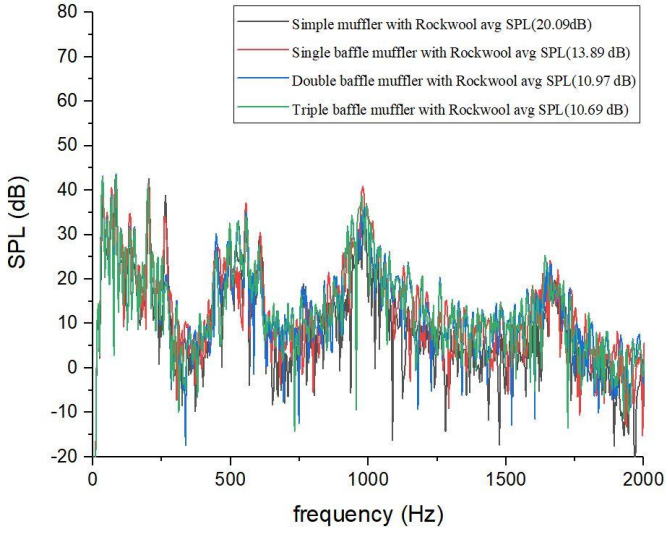

Figure 12: *Comparison graph for four cases of muffler with Rockwool as an absorptive material.*

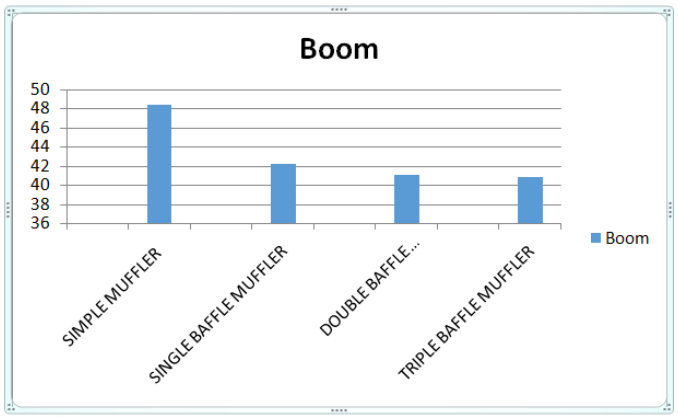

Figure 13: *Comparison Bar chart for four cases of muffler with Rockwool as an absorptive material.*

7. CONCLUSIONS

After carrying out analyses and studying the manufacturing feasibility of muffler designs, following conclusion are drawn. By using reactive muffler we are getting the higher pressure level and more noise as we can see it in the results obtained form the acoustic plot. So by implementing baffles plates inside the muffler with perforation have good result and we are getting drop in sound pressure level and getting good acoustic plots and audio output. Here we installed firstly one baffle plates with perforation of 2mm hole and 5% flow area and we are getting better result as compare to previous one. Further we increase the baffle plate up to 2 and kept the perforation of 2mm hole and 5 % flow area and again we are getting good result. Further we increase baffle plate up to 3 and this is our final muffler in which we kept perforation of 2mm hole and 5% flow area. Further by the help of absorptive material i.e. Glasswool and Rockwool we also absorb the noise and by the plots we can see that absorptive material plays an important role in improving the sound quality. We are getting better result by the help of rockwool material as compare to glasswool as an absorptive material. So we can say that rockwool has better tendency to absorb noise than glasswool.

8. REFERENCES

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