Review of Muffler Performance by changing design parameters

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Abstract: This study has been undertaken to review the design parameters of muffler, so that new proposed design attributes can be undertaken for enhancing the performance index thereby leading to reduction of transmission losses and acoustic noise for better environmental control. The design analyses have been carried out by meteorological estimation by using measurement gauges. The proposed design will configure the muffler chambers in such a way that adequate acoustic noise reduction can be carried out efficiently leading to the next generation muffler design. The new muffler design can be easily incorporated in present automobiles with less cost but leading to better environmental control.

Index Terms **- muffler, design parameters, transmission losses, acoustic noise, measurement gauges.**

I. INTRODUCTION

Noise from the automobile is generated by several sources such as the internal combustion engine, the brake system, the inlet and exhaust system and the flow around the body of the automobile. The authors paid attention to the exhaust system which is believed to be one of the main factors of noise pollution of the urban environment. Intake and exhaust system noise draws a huge contribution to the interior and exterior noise of cars. Exhaust system contributes the major noise of automobiles. About the sound pressure levels, the untreated exhaust noise is often ten times greater than all the structural noise of the system combined [1]. Thus, there has been a great deal of research and development in the area of predicting muffler performance [2:7].Muffler performance from a designer's standpoint is characterized by either the Transmission Loss (TL) or Insertion Loss (IL) of the muffler. Transmission Loss is the ratio of the sound power of the incident (progressive) pressure wave at the inlet of the muffler to the sound power of the transmitted pressure wave at the outlet of the muffler [8]. The benefit of TL is that it is a parameter of the muffler alone and the source or termination properties are not needed. Because of the simplifications, the TL is the most common parameter for muffler performance. Insertion loss is defined as the difference between the acoustic pressure radiated from the source with and without the muffler attached [8]. The IL is a more accurate method of determining muffler performance as it is measured in actual operating conditions with the source properties applied.

The commercial automotive mufflers are generally of a complicated shape with multiply connected parts and complex acoustic elements. Typically mufflers are classified under two different categories, dissipative and reflective [9]. A dissipative muffler is based on the principle of converting the exhaust noise energy caused by fluctuating pressure waves into heat. This is done using sound-absorbing materials such as porous sound attenuating woven fibres and perforated tubing. Another benefit of dissipative mufflers is that the pressure drop across the system is relatively low because the flow path is not significantly altered by flow reversals, twists and turns, or by any other means. Reactive silencers generally consist of several chambers and tubes. Those configurations can provide effective noise attenuation at lower frequencies but fail to attenuate higher-frequency noise and usually produce a high pressure drop due to the presence of baffles and flow reversals [10].

In order to improve transmission loss, in exhaust muffler, baffles are being tried for reduction of the noise emitted to the atmosphere. In this study, a multi-chamber muffler with selective sound-absorbing material like, glass fibre and rock wool will be considered to predict the transmission loss (TL). Accurate determination and control of noise from automobiles is significant in automotive exhaust system design and development [11]. Noise can be defined as unwanted sound. Numerous parameters like insertion loss (IL), transmission loss (TL) characterizes muffler noise in an automobile. Among the transmission loss and insertion loss, TL is most widely used in acoustical practice [12]. Source of the noise is independent and hence is the benefit of measurement of transmission loss. For evaluation transmission loss performance, prediction of white noise forms the key. Transmission loss (TL) is usually measured using the three-point approach (decomposition method) or four pole methods; the four-pole method is carried out by a two-source method and two-load method [13].

Using baffles in exhaust mufflers have been reported to enhance the TL of muffler by more than 50% [14]. Roy [15] investigated the effect of internal completely circular baffles with single centred holes on the transmission loss using harmonic Boundary Element Method (BEM) with and without extensions on baffles. It was found that the TL in the lower frequency spectrum is reduced while the mid to high frequency spectrum is greatly increased using baffles. Horoub [16] investigated the effect of tapered connected expansion chambers by connecting different sizes of expansion chambers. Computational Fluid Dynamics (CFD) studies for the several connected expansion chambers showed that extension on baffles reduced the pressure drop in the muffler compared to single expansion chamber of the same size due to the reduction in the secondary flow losses and separations [17]. Other studies investigated the effect of baffle spacing on the Sound Pressure Level (SPL) [18] showing that reducing spacing between baffle reduced the SPL. Another parameter that was investigated by Gupta and Tiwari [19] was the effect of hole arrangements in perforated tubes on transmission loss.

II. Transmission Loss (TL)

Accurate prediction of sound radiation characteristics from reactive mufflers is significant in automotive exhaust system design. The most commonly used parameter to evaluate the sound radiation characteristics of muffler is sound transmission loss (TL) [19-26]. Transmission loss is a standout amongst the most much of the time utilized criteria of muffler performance since it tends to be anticipated in all respects effectively from the known physical parameters of the muffler. Numerous devices are accessible to recreate the transmission loss attributes of a muffler. They shift as far as intricacy and suppositions. Anyway explanatory models whenever created give exact outcomes particularly in low and mid frequency region in the blink of an eye by straightforwardly applying the created recipe. Such a created equation can be helpful to speak to performance attributes of the muffler for relative examination of structure options at design stage. Parrot et al, 1973[28] improved a standard transmission line theory for designing an expansion chamber muffler as an application of helicopter. A computerized method using EXRSIL and FORTRAN was used. They conducted an optimization procedure that adjusts muffler component lengths to achieve minimum transmission loss over a specified frequency range. The results showed that three-stage expansion chamber muffler together for the exhaust pipe-Y-connector for combining the exhaust gases from all cylinders reduced the exhaust noise and no significant engine performance loss. Amiya and Mohanty, in 1993[29] carried out experimental and numerical investigations for passive mufflers. A multi domain boundary element method (BEM) works as a numerical techniques for modelling such mufflers and predicting (TL). To successfully incorporate perforates and sound absorbing materials in boundary element models, experiments were conducted to determine the perforate transfer impedance and the propagation constant. TL of a reactive and dissipative mufflers obtained using an analytical one-dimensional solution, thus BEM validated. They discussed various techniques to determine TL. It was found that an excellent results were found between experimental and boundary element method. Development a formula for predicting transmission loss (TL) of a long rigid duct was conducted by Chen et al, 1998 [21]. By adding some improvements like Helmholtz resonator, experimentally great results were obtained. They concluded that the acoustic interaction between two acoustic filters can be ignored if the distance between them is great enough. In the previous work by Yeh et al. 2003 [30], the graphical analysis of optimal shape designs was discussed in order to improve the performance of sound transmission loss (TL) on a constrained single expansion muffler. Typically mufflers are classified under two different categories, dissipative and reflective. Moreover, Yeh et al, 2004 [31] Presented optimal design of a single chamber muffler with side inlet/outlet. They described both the graphic analysis and the computer aided numerical assessment. They obtained the results and then verify them with Kuhn-tucker condition for accuracy. The simulated results showed that STL of muffler is exactly maximized at the desired frequency.

III. Methodology

The main aspect of this project is to study the muffler performance and try to improve the said performance by changing the alignment of the holes on the tube and by adding baffles to reduce the sound generated. The flowchart below shown in Fig.1 denotes the various steps involved.

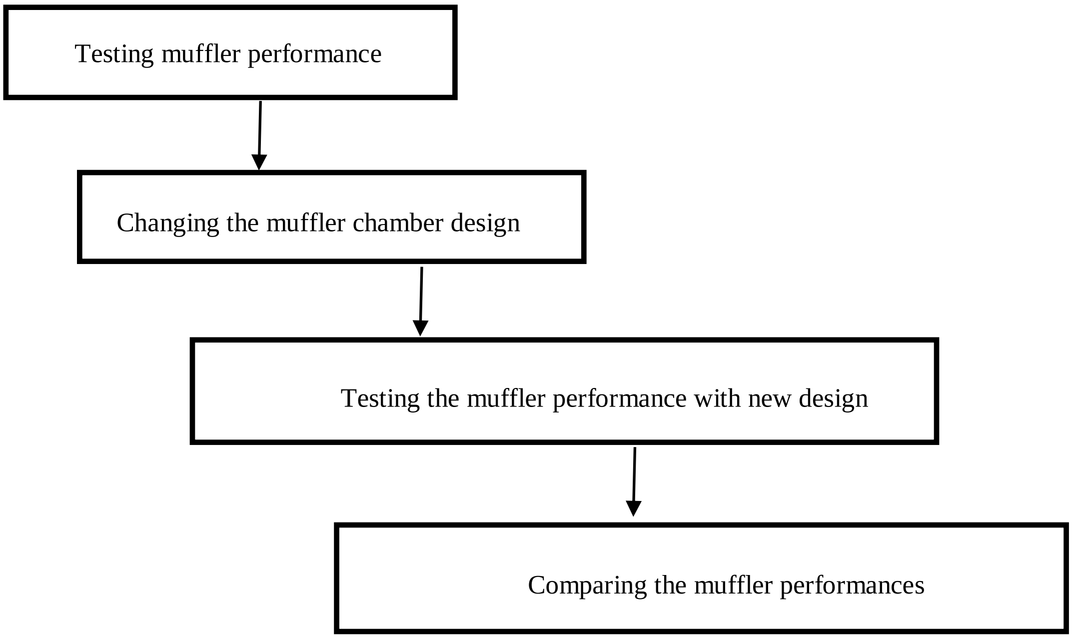

Figure 1 flowchart of the project

IV. Experimental Setup

The Fig.2 demonstrates the experimental setup for determining the muffler performance.

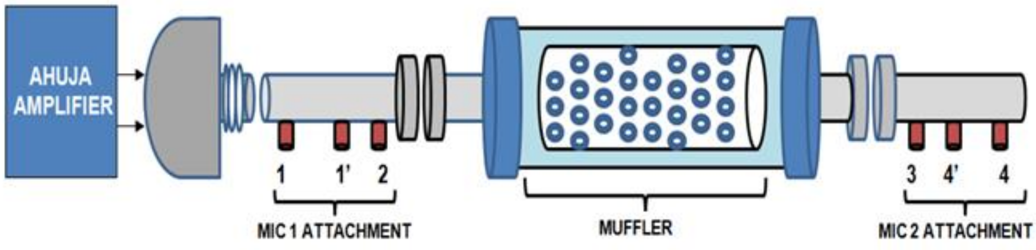

Figure 2 experimental Setup for muffler performance

V. Expected Outcomes

- The new muffler design would help in reducing the exhaust noise
- The muffler would be able to aid in the reduction of harmful exhaust gas

VI. References

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