Design Modification and Acoustic Analysis of Silencer for Agriculture Diesel Engine – A Literature Review

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Abstract— The main drawback of Diesel engine is its noise which is harmful for human being. Reduction of noise is current issue in today's life. Silencer collects exhaust gas from Diesel engine, reduces the noise level of it and leave to atmosphere. The engine efficiency is depends on how the exhaust gas is removed from the cylinder. The main objective of silencer is to attenuate a sound by reducing exhaust gas pressure, but it causes back pressure which affects engine efficiency. In this literature review, the recent researches on design of Silencer for diesel engine exhaust manifold, their performance evaluation using experimental methods as well as Numerical methods (CFD), various geometrical types of exhaust manifold and their impact on the performance had been collected and discussed.

Keywords- Silencer, Muffler, Exhaust noise reduction, Design

I. INTRODUCTION

Internal combustion engines are generating the acoustic pulse by the Combustion process. The noise created by internal combustion engine has been a constant source of problem to the atmosphere. So the problems of reducing engine noise consist of mainly the attenuating exhaust noise. This noise is controlled through the use of silencers and mufflers. A silencer has been the traditional name for noise attenuation devices, while a muffler is smaller, mass-produced device designed to reduce engine exhaust noise. Exhaust mufflers are widely employed to muffle the noise of an engine body or the noise of other predominant sources in engines.

The silencer is a device for reducing the amount of noise emitted by the Engine. It is manufactured as an acoustic soundproofing device designed to reduce the loudness of the sound pressure created by the engine by way of Acoustic quieting. The noise of engine is created due to pressure difference between exhaust gas from its exhaust manifold and the atmosphere. It is required to reduce the exhaust gas pressure by using silencer. Silencer changes the direction of flow of exhaust gas with the help of baffle arrangements at its inside which results minimum pressure difference between exhaust gas at the outlet of silencer and atmosphere. If pressure difference reduced this reduces noise level too. The silencer designed for agriculture diesel engine (i.e. 5 HP to 10 HP engine) should withstand against high pressure and temperature exhaust. In this journal, summary of recent researches on Silencer/Muffler is discussed with their performance, performance estimation methods and various designing techniques.

Design of mufflers is a multifarious function that affects noise characteristics and fuel efficiency of engine. As the invention of the internal combustion engine, the noise created by it has been a constant source of problem to the atmosphere. So the problems of reducing engine noise consist, mainly in attenuating exhaust noise. Good design of the muffler should give the best noise reduction and offer optimum backpressure for the engine. A resistance against the flow of exhaust gases stems the flow is called as back pressure and it causes an extra pressure inside the engine. Because of the back pressure, volumetric efficiency decreases and specific fuel consumption increases. Therefore, there must be specific limitations for the back pressure.

II. LITERATURE SURVEY

Filsuf et al. (2018) studied that Back Pressure reduction was the process of reducing the resistance created by the exhaust system that had been created for Noise Reduction so as to meet the standards of Noise Pollution within the atmosphere. The design was based on the concept of reducing the Back Pressure created inside and to maintain the noise at the tail pipe of the exhaust system by the introduction of new concept of Wedge Theory which had been designed and Analyzes on ANSYS Software for its advantages, and also the introduction of Pressure Maintainer Valve helped in maintaining the reduced back pressure for, so as to maintain a correct ratio.

Ajaykanth et al. (2018) has worked on exhaust system silencer; in which after the combustion the high intensity gas pressure through the muffler chamber and some of the gases reflected again passes through the combustion chamber it is called back pressure. It creates vacuum pressure in combustion chamber and decreases the engine performance. Reduction of weight, increasing the capability of noise absorption from the muffler with minimal back pressure can increase the performance of the engine. The objective of this study was to optimize noise level of engine and reduce back pressure. This project mainly targets on designing a muffler to reduce the noise and back pressure. Based on new muffler design parameters, a model is fabricated

and tested. A muffler was designed that meet the requirements likely adequate insertion loss, minimal backpressure, space constraints and durability, produce the minimal sound. Hence good design of the muffler should give the best noise reduction.

Kakadiya et al. (2017) had presented work on six different arrangements of Mufflers were designed and compared noise level for all Mufflers. From comparison it is found that the dual exhaust type Mufflers gets better reduction in noise compare to the single centre exhaust type and single side exhaust type Mufflers. This dual exhaust type Muffler provides reduction in noise by 29.56 db in case study of 5 HP diesel engines. Muffler can be design by the different arrangements like single exhaust, dual or twin exhaust, centre inlet – centre outlet, side inlet – side outlet, changing the numbers of chambers, changing length of absorptive part of muffler, changing the diameter of perforation holes etc. The muffler can be designed by various methods to achieve good performance. Combined muffler gives better reduction in noise compare to the single reactive muffler or absorptive muffler. Noise reduction in three chamber type mufflers is low compare to the four chamber type mufflers, therefore if number of chamber increases in muffler it gives better reduction in noise.

Mane et al. (2016) had studied on back pressure of a muffler using CFD. At different engine velocities, the flow field of a given geometry of muffler was simulated and the total back pressure inside the muffler is calculated. The muffler was then simulated for different configurations in an attempt to minimize the back pressure. It was resulted out that the perforated tube is the most critical parameter from back pressure point of view. The change in diameter of the perforated tube and that of the holes on the tube changes the back pressure significantly. The least value of back pressure from CFD simulation is 356.55Pa. The experimental and CFD values for base model are observed in good agreement with each other.

Ghude et al. (2016) had studied the experimental and reproduction results for altered suppressor were exhibited. The standard suppressor with various change were displayed in Autodesk Inventor programming and tried for acoustical execution in COMSOL a reproducing programming. Clamor estimation for various suppressor alterations are completed tentatively utilizing Fast Fourier Transform. Relatively changed intelligent suppressor with astounds demonstrates decrease in clamor level and least fuel utilization. Particularly focusing on the engine under study, this paper tackles the problem of the inconvenience caused due to the noise produced by the engine by determining a suitable muffler design for it by actual modification and by doing acoustical analysis of 3D model of muffler in COMSOL software. Comparative study of the muffler modifications helps to determine the best design type for noise reduction, taking into consideration the effect of the design on fuel economy.

Priyadarsini et al. (2016) had studied on project that deals with four different models of chambered exhaust muffler and concludes the best possible design for least pressure drop. SolidWorks 2014 version was used to design the exhaust mufflers. Numerical analysis for backpressure testing was conducted by Flow Simulation of SolidWorks 2014. Heat balance test on single cylinder diesel engine was performed to know the mass flow rate of the exhaust gases. Flow trajectories were viewed to know the flow of exhaust gases through the muffler. The cut plots for pressure and exhaust gas velocity are viewed. Pressure drop was calculated across the exhaust muffler by viewing the pressure distribution. After carrying out flow simulations on muffler the best performance was observed due to placing the plates perpendicular to inlet of muffler. The position of inlet was middle of the width of the muffler.

Ramganesh et al. (2015) had showed the project which is about the study of the silencer utilizes the Hyper mesh tool as a pre-processor for element generation followed by the simulation of flow and subsequent analysis using computational fluid dynamics, Fluent software. The simulation of flow through the silencer and prediction of the back pressure for the same has been successfully carried out using computational fluid dynamics. The above investigation and analysis has put forth a collective idea that the back pressure of any silencer mainly depends on the porosity of the pipes in the expansion chamber. However they are not the only factor determining the value of back pressure because the porosity of the central plate also plays an equal dominating role. This work can further be extended in the future in the direction of optimization of the silencer for reduced back pressure and analyzing the same for effectiveness of the sound attenuation quality.

Singh et al. (2015) had studied that maximum amount of the sound pressure produced by the engine was emanated out of the vehicle using the same piping used by the silent exhaust gases absorbed by a series of passages and chambers lined with roving fiberglass insulation and resonating chambers harmonically tuned to cause destructive interference where in opposite sound waves cancel each other. Mainly mufflers were generally used to increase the engine efficiency and reduction in noise pollution and all types of exhaust emission. The biggest advantage was to improve the environmental condition of ambient. Larger the diameter of the pipe hole, low value of back pressure and hence lower will be the transmission loss which makes the vehicle highly instance sound.

Saripalli et al. (2015) had worked on Computational Fluid Dynamics (CFD) method was used to explore the aerodynamic performance of the muffler. Resistance muffler research relates with the fields of acoustics, fluid dynamics, heat transfer and mechanism design. The project report simulated the field by numerical method with Cosmos Flow and analyses the effect which the internal flow field has on the performance of the muffler. With this method the pressure distribution in the muffler is simulated and the pressure loss is predicted for the structure modification. The experiment results verify that the assembly performance of the muffler modified is better than the original muffler.

Puneetha et al. (2015) has worked on comprehensively analyzing four different models of exhaust muffler and concluded the best possible design for least pressure drop. Virtual simulation for back-pressure testing is performed by Computational Fluid Dynamic (CFD) analysis using Acusolve CFD. Finite Element (FE) model generation of the muffler structure was performed using Hyper Mesh as the preprocessor. The structural mesh is modeled using 2D shell elements, wherein the internal tubes with fine perforated holes were considered. The CFD fluid meshing was done with tetra elements using AcuConsole as the CFD preprocessor. The back pressure generated across the muffler was determined by measuring and inputting the mass flow rate of the exhaust gases entering the muffler inlet pipe. Field View is used for post processing the CFD results and reviewing the airflow streamlines. The exhaust gas velocity and pressure plots are studied across the internal tubes and perforated holes, and the back pressure was measured.

BABU et al. (2014) had studied a finite element approach is presented for modeling and analysis of expansion type muffler were used often in the modern day's automotive exhaust system. The component was analyzed by using Pro-Mechanica FEA tool, modal analysis was carried out on the expansion muffler to avoid resonance condition, natural frequency and mode shapes were presented. The design of silencer of SI engine was a key issue to attenuate or emphasize certain spectral components of tailpipe noise. The optimization of complex shape silencer system was generally a time-consuming operation, which must be carried out by means of concurrent experimental measurements and numerical simulations. This paper, aims to reduce exhaust noise produced from the exhaust system of C-12 portable 4-stroke SI engine. Exhaust gases from the engine is high pressure, these gases the noise would be tremendous for this reason, the exhaust gases are made to flow through a muffler, it consists of series of metal plates and tubes with required design aspects. Pressure of the gases is reduced when they pass through an expansion type muffler so that the gases out through tail pipe quietly.

Shao (2011) had worked on problem of noise pollution of internal combustion engine by engine was mostly constructed as a mixture or combination of perforated ducts, baffle or perforated baffle, expansion chamber, etc., and the noise reduction is limited and backpressure is high hence the fuel efficiency is low. In order to solve the problems of traditional exhaust silencers with poor characteristics of noise reduction in low-frequency range and high exhaust resistance, a new theory of exhaust silencer of diesel engine based on counter-phase counteract and split-gas rushing has been proposed. Taking the single-cylinder diesel engine CG25 as the experimental engine, the author measured the exhaust noise and its spectra. By comparing the results of the new types of mufflers to those without a muffler and those with the original muffler of the engine, the new theory of muffler had been verified.

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III. OBSERVATIONS:

1. CFD can be conveniently used as a tool for back pressure analysis of muffler.
2. After the study of different types of muffler and designing methods; it concludes that combination type of muffler is more efficient than reactive and absorptive mufflers.
3. The reflective muffler with baffles is the better design amongst the four designs studied as it achieves a balance between sound pressure level and fuel consumption.
4. The change in diameter of the perforated tube in muffler and that of the holes on the tube changes the back pressure significantly.

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