A Literature Review on Design and Development of Industrial Generator Silencer

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Abstract— This paper describes the literature review of a Design And Development Of Industrial Generator Silencer. Diesel engine generator sets in heavy industry plants and residential/official buildings can cause serious noise problems. Diesel generators are used very commonly in shops, offices and in industry, today in order to supply power during power shutdowns .Exposure to noise causes detrimental effects on neuroendocrine, cardiovascular, respiratory and digestive systems. Chronic exposure to noise causes fatigue and interferes with concentration, thus reducing work efficiency. Experimental studies on the assessment and control of near-field noise levels due to the operation of a generator were undertaken by employing ant vibration mounts (made up of rubber, polyurethane foam, wool– felt).The enclosure of generator is made up of CRCA sheet of 2mm thickness and use Polyurethane foam of 25mm thickness inside the enclosure which reduce noise level. The muffler is made up of CRCA sheet of 1.2mm thickness, inner assembly is made up of same material. The generator muffler is enclosed with 3mm thick wool-felt for better sound absorption and thermal resistant. The wool-felt reduce the noise level 2dB(A). Silencer is installed to reduce noise where large quantities of high pressure air or gas are discharged into the open air. In this paper CFD analysis technique is used to modify the existing geometry of silencer.

Key words: Computational Fluid Dynamics (CFD), CREO PERAMETRIC, silencer

I. INTRODUCTION

A silencer may be defining as an "element in the flow duct that acts to reduce the sound transmitted along the duct while allowing free flow of the gas through the flow passage". It is also an important noise control element for reduction of machinery exhaust noise, fan noise and other noise sources involving flow of gas.

A. Types of Industrial Generator Silencer:

- Reactive Passive silencer.[perforated pipe]
- Absorptive Passive silencer.[glass wool]
- Reactive and absorptive silencer.

1) Reactive Passive silencer.[perforated pipe]:

In this type of muffler Inlet and outlet tube are extended in chambers. Reactive mufflers generally consist of several pipe segments that interconnect with a number of larger chambers. The noise reduction mechanism of reactive silencer is that the area discontinuity provides an impedance mismatch for the sound wave travelling along the pipe. This impedance mismatch results in a reflection of part of the sound wave back toward the source or back and forth among the chambers. The reflective effect of the silencer chambers and piping (typically referred to as resonators) essentially prevents some sound wave elements from being transmitted past the silencer. The reactive silencers are more effective at lower frequencies than at high frequencies, and are most widely used to attenuate the exhaust noise of internal combustion engines.

2) Absorptive Passive Silencer [glass wool]:

This type of muffler design uses only absorption of the sound wave to reduce the noise level without messing with the exhaust gas pressure. Ti is known as glass pack muffler and it reduces backpressure but producing higher noise. The sound produced by this type of muffler is much higher compared to the other type of mufflers.

3) Reactive and Absorptive Silencer:

Some silencers combine both reactive and absorptive elements to extend the noise attenuation performance over a broader noise spectrum. Combination silencers are also widely used to reduce engine exhaust noise.

II. LITERATURE REVIEW

I found that very few researches have been done on industrial silencer and among these papers I describe overview of some selected research papers.

A. Flow Considerations in Industrial Silencer Design:

1) Objective:

- How to typical silencer unit is analyzed and calculate the pressure drop with different method.
- How to low interactions of silencer with their upstream and downstream equipment.

2) Conclusion:

- The flow through a model silencer is examined with numerical simulation. Static pressure recovery takes place along a long distance downstream of the silencer. The pressure drop through the model silencer from numerical simulation agrees well with testing data and result from empirical method.
- The exiting flow of the silencer baffles can affect the downstream equipment performance and system stability depending on where the equipment is located in the flow path downstream of the silencer baffles. For silencers with high inlet velocity and non-uniform inlet flow conditions, special design on the inside flow structure and construction should be considered to make sure that the acoustic absorption material is properly protected.

B. Design Optimization of Industrial Steam Vent Silencer for Noise Reduction CFD Simulation.

1) Objective:

- To run the simulations for the steam vent silencer with different designs of the pressurized inlet diffuser and find the optimum design for it with different number of holes with different diameter
- How to reduce the noise.

2) Conclusion:

- CFX Solver was used to run the simulations, the results obtained shows the design of the pressurized inlet diffuser with 24 number of holes of 45 mm diameter gave satisfactory results with flows from the diffuser to the plenum section taking place smoothly and with less turbulence and also the Transmission loss for the design was around 40 dB which is higher compared to all other designs. Hence the design of the diffuser with 24 holes of 45 mm diameter is recommended for the design.

C. Design and Performance Measurement of Compressor Exhaust Silencer by CFD:

1) Objective:

- By using CFD analysis technique to modify the existing geometry of muffler and noise reduction with allowable backpressure is achieved.

2) Conclusion:

- 3 dimensional CFD method is used for modeling of absorptive silencer. Back pressure and transmission loss are compared theoretically and by CFD. It is found that the proposed silencer has less back pressure and transmission loss increases up to 10- 18 dB. Noise level is under control as per occupational safety and health standards.

D. Reactive Silencer Modeling by Transfer Matrix Method and Experimental Study:

1) Objective:

- To investigates the acoustic performance of a reactive silencer for two special cases using numerical and experimental techniques.
- How to the principles of TMM for predicting the transmission losses (TL) of a silencer are briefly presented.

2) Conclusion:

- A major disadvantage of the simple expansion chamber is that in certain applications time varying tones and their harmonics may align simultaneously with the periodic through and cause a severe deterioration in acoustical performance. The problem may be partly solved by using extended-tube elements. The model for 3 expansion chambers computed without end corrections fails at considerably lower frequency while exhibiting a TL close to that of a simple expansion chamber without baffle in its valid frequency range.
- Transmission loss values obtained for both single chamber and three chambers mufflers configurations under test are higher than the predicted ones over the frequency interval 200 Hz … 1 kHz. The three chambers muffler configuration provides considerably better TL values than the single chamber muffler configuration.

E. An Advancement to Reduce Pollution Effectively by Using TI Nanotubes in Aqua Silencer:

1) Objective:

- How to Aqua Silencer is used in the exhaust to direct the gas from the engine after going through the process of reducing the toxic gases and also water is used to reduce the exhaust noise.
- To increase the life time of the silencer functioning by using Titanium Nano-tubes along with charcoal which has the ability to absorb the toxin gases

2) Conclusion:

- The reduction of the air pollution and water pollution along with eliminating noise. These research portraits on the effective way of managing vehicle parameters as per emission norms.

F. Design Analysis and Performance Evaluation of Reactive Silencer by SYSNOISE:

1) Objective:

- To properly predict the performance of a silencer system, many factors need to be involved in the calculation. Geometrical concerns, absorptive material characteristics, flow effects (turbulence), break out noise, self-generated noise, and source impedance all need to be included in the design calculations of insertion loss (IL).
- Which method is ease of use for calculating TL values. FEM and BEM are the traditional laboratory method or 4-pole transfer matrix and the 3-point methods.

2) Conclusion:

- The use of the finite element method and the boundary element method to aid in acoustical engineering design is increasing rapidly. When used in conjunction with the FEM and the BEM, the traditional, 4-pole and 3-point methods can be powerful tools for designing acoustical silencer systems. The BEM has been shown to be quite slow when compared to the FEM.
- There is a modified 4-pole method that has been shown to be just as fast as the 3-point method, but the code required for this method, was not possible to implement with SYSNOISE. The 3-point method, on the other hand, is just as accurate and easier to use. It is faster than the traditional and 4-pole methods and lends itself very well to repeated computational runs for optimization. The 3-point method, therefore, is a great tool for evaluating the response of modifying individual parameters such as baffle spacing, absorptive material properties, overall silencer length and width, and effects of multiple small chambers.

G. Design and Fabrication of Exhaust Silencer for Construction Equipment:

1) Objective:

- To reduce the back pressure in the exhaust silencer. By using the software computational fluid dynamics (CFD) the back pressure will be reduced. Then the muffler will be fabricated.

2) Conclusion:

- The modeling of muffler, result of exhaust flow will be analyzed. The flow analysis is done in the CFD. The exhaust flow can be varied and the back pressure will be recorded. If the back pressure values can be below the existing pressure value and it can be fabricated and it noise level will be measured. Thus noise level will be compare to both existing and new

design. If the noise level will be below it can be suggested for manufacturing to reduce the nose level.

H. Silencer Design for Automotive Exhaust Noise Attenuation:

1) Objective:

- To reduce the noise different types of mufflers and and designing methods are studied.
- to reduce the noise different modification into the existing silencer likes change the shapes, change the diameter of perforated tube, number of holes, change the a absorptive materials etc.

2) Conclusion:

- Different types of muffler and designing methods are studied. After studying this methods and procedures for designing a muffler, we conclude that combination type of muffler is more efficient than reactive and absorptive mufflers.

I. Controlling Low Frequency Noise using a Passive Silencer:

1) Objective:

- How a suitable exhaust silencer or muffler could help to not only reduce overall noise levels but would target the low end of the frequency spectrum to systematically reduce LFN.

2) Conclusion:

- While it is not possible to completely illuminate LFN from an internal combustion engine using a passive type silencer it can be significantly suppressed allowing for both regulatory compliance, safety of workers, and maintaining an acceptable quality of life for nearby residents. Using a rigorous four point program of accurate analysis of the noise including LFN being generated combined with effective engineering and design, followed by quality controlled manufacturing of the noise suppression equipment, concluding in experienced installation will get the results needed by operators to meet stakeholder expectations. Any shortcuts, to save time or money, can and will likely result in failure to meet those expectations resulting in higher costs in the end not to mention the incalculable cost of lost credibility and confidence by the local community which could be reflected in a backlash to further development in the region.

J. A Practical Approach towards Muffler Design, Development and Prototype Validation:

1) Objective:

- How to establish a design methodology to make design process simpler and less time consuming by making use of acoustic theories and experience, practical approach to get better design.
- How to predict design quality at earlier stage of muffler design, evaluate quality of design, set targets for proto design and improves the same throughout the product design steps and reduce cost of proto development.

2) Conclusion:

- A methodology has been developed for optimum design stages and less cost for muffler design by balancing various parameters. a brief background on evaluation of muffler concept design for the proto type and validation with new approach. A practical approach for muffler design to optimization of product development time & cost by balancing conflicting requirements like Noise & Back pressure
- This design methodology will help designers in understanding the importance of each step of designing in detail from concept level to validation level. This approach serves the purpose of reducing the number of iterations, product development time and cost with better design. Although the practical approach has become an important tool in making muffler design more of art than a science, the need for design verification will always be necessary at end of each step.

K. A New Type of Compact Silencer for High Frequency Noise:

1) Objective:

- To reduce this type of noise a new type of silencer based on micro-perforated plates and optimized using the so called Cremer's acoustic impedance is proposed and investigated experimentally because in modern IC engine design super-chargers are utilized to increase the fuel conversion efficiency. These components are also recognized as strong high frequency noise sources in the engine compartment. For installations under such limited space and high sound pressure conditions innovative noise control concepts are essential.

2) Conclusion:

- To get better insight of the sound damping mechanism, another set of quantities, describing the sound power distribution, were derived and analyzed. It was confirmed experimentally that the proposed compact silencer, optimized according to the Cremer's impedance is a very effective solution for noise control.

L. Experimental and CFD Analysis of a Perforated Inner Pipe Muffler for the Prediction of Backpressure:

1) Objective:

- To see the effect of change in dimensions of perforation diameter and change in porosity of internal perforated tube is investigated using CFD analysis and the simulated data is compared with experimental results.
- To reduce the back pressures up to 75% by change the value of porosity.
- To change in diameter of holes has remarkable effect on back pressure.

2) Conclusion:

- The various dimensions of the muffler are varied keeping some dimensions constant and then the effect on Backpressure is observed. It can be seen that the backpressure varies nonlinearly and it cannot be predicted by any equation.
- Varying the porosity of the muffler has pronounced effect on the backpressure. The Backpressure is reduced greatly if the porosity is doubled.

– if the diameter of the hole is increased the backpressure decreases sharply. There is sharp change in backpressure values even if hole diameter is slightly changed.

III. CONCLUSION

From the literature review and all other aspects, some highlights of finding are below.

1) If the diameter of the hole is increased the backpressure decreases sharply. The change in diameter of holes has remarkable effect.
2) A practical approach for muffler design to optimization of product development time & cost by balancing conflicting requirements like Noise & Back pressure.
3) Transmission loss values obtained for both single chamber and three chambers mufflers configurations under test are higher than the predicted ones over the frequency interval 200 Hz … 1 kHz. The three chambers muffler configuration provides considerably better TL values than the single chamber muffler configuration.
4) For silencers with high inlet velocity and non-uniform inlet flow conditions, special design on the inside flow structure and construction should be considered to make sure that the acoustic absorption material is properly protected.
5) Design methodology emphasis on modern CAE tools for optimization of overall system design to choose the best concept.
6) Three methods used for calculating TL values using both the FEM and BEM are the traditional laboratory method (hereafter referred to as traditional), the 4-pole transfer matrix and the 3-point methods.
7) The Backpressure reduced almost by 75% if the porosity is doubled. Also, if the diameter of the hole increases the backpressure decreases sharply by 40%. The change in diameter of holes has remarkable effect on back pressure.
8) The CFD simulation software can be used in designing and simulations .The simulations give valuable information regarding the velocity field, pressure field, density field and temperature field of the exhaust muffler. This is important because save time and many in the production process through the identification of eventual problems before the exhaust muffler is build.
9) Reduce the production costs by more than 40% percent through design optimization.

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On the day of presenting literature review report on "DESIGN AND DEVELOPMENT OF INDUSTRIAL GENERATOR SILENCER", I hereby take this opportunity to express my thankfulness to my parents, my daughter and all the persons who either knowingly or unknowingly helped my cause.

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