ISSN (Online) : 2319 – 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization *Volume 3, Special Issue 4, April 2014*

Two days National Conference – VISHWATECH 2014

On 21st & 22nd February, Organized by

Department of CIVIL, CE, ETC, MECHNICAL, MECHNICAL SAND, IT Engg. Of Vishwabharati Academy's College of engineering, Ahmednagar, Maharastra, India.

Design Analysis and Performance Evaluation of Reactive Silencer by SYSNOISE

Mrs.Varsha Chitale-Patil, Mr.Amol R.Patil, Prof.R.B.Patil

Student of ME CAD/CAM, Dept. of Mechanical, JNEC, BAMU Aurangabad, Maharastra, India.

Student of ME Design, Dept. of Mechanical, SSBT ,NMU, Jalgoan,Mahatrastra, India.

Proffessor , Dept. of Mechanical , JNEC,Aurangabad, BAMU,Maharastra, India.

Abstract: Noise pollution created by engines becomes a vital concern when concern used in residential areas or area where noise creates hazard. Issues concerning the design and use of large-scale silencers are more prevalent today than ever before. The main sources of noise in an engine are the exhaust noise and the noise produced due to friction of various parts of the engine. The exhaust noise is the most dominant.

With the increased use of large industrial machinery and the increase in public awareness and concern for noise control, the desire to be able to able to properly design silencer for specific application is increasing. Due to the size and expense of silencers, it would be beneficial to have means to predict the insertion loss (IL) or transmission loss (TL) characteristics at the design stage. To properly accomplish this, many factors such as geometry, flow effects, break out noise, and self generated noise must be considered.

There are a number of methods currently used to model and investigates the acoustic performance (TL) of mufflers including analytical methods such as the TMM, computational methods including the use of FEM & BEM & experimental measurement techniques .The use of finite element method (FEM) & the boundary element method (BEM) can aid in the prediction & design.

Keywords: Sysnoise software,FEM,BEM

1INTRODUCTION

A silencer is an important noise control element for reduction of machinery exhaust noise, fan noise, and other noise sources involving flow of a gas. In general, a silencer may be defined 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. A silencer may be passive, where the sound is attenuated by reflection and absorption of the acoustic energy within the element. An active silencer is one where the noise is canceled by electronic feed forward and feedback techniques.

With the ever-increasing computational speed and storage capacity of computers, the use of the finite element method (FEM) and the boundary element method (BEM) in design is growing rapidly. One area that lends itself very well to these methods is the design of silencer systems for noise control. There is much work that has been done for smaller systems such as those used in automobiles and small engines, however, the design of much larger systems (such as the parallel baffle type used for gas turbines and other large industrial machines) is still largely guesswork and empirical extensions of previous results. Due to the large size, difficulties in testing and high costs of these silencer systems, the ability to accurately predict the performance before construction and commissioning would be very beneficial.

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). But rather to establish the metrics to be used to compare each of these design parameters and to discuss the concerns arising from implementation. Note also, that the methods are applicable only to transmission loss (TL) calculations as they are in-duct in nature. IL values are preferred for most applications as final design criteria; however, the TL values are still very useful when comparing the performance of one silencer geometry to the next.

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. Note that the standards are intended for measuring IL and not TL, but the methods are similar. Each of these methods give similar results for TL, however, there are differences in terms of computational time, ease of use, and specific applications. The traditional method involves two complete in-duct calculations with and without the silencer installed. The difference between the two resulting frequency response curves is the TL. Historically, the 4-pole method has been the preferred computational method and examples of its ability to agree with theoretical and experimental TL values are widely documented .More recently, however, the 3-point method has been given attention.

It is easily derived from the fundamental wave equation, and is somewhat less difficult to implement and modify, than the 4-pole method. As stated before, all three methods will give the TL values, however, unlike the traditional and 3-point methods, the 4-pole method also gives the pressure and particle velocity values at the inlet and outlet (known as the 4-pole parameters) of the silencer section being evaluated. When designing silencer systems in multiple stages, the 4-pole parameters are necessary for continuity between the sections. However, if the system is being evaluated as one single entity, or if the desire is to evaluate one section by making a change and re-evaluating that one section, then the 4-pole parameters are not required

The main advantage of the 3-point method is that only one computational run is required while the traditional1 and 4-pole methods require two runs with different geometry and different imposed boundary conditions respectively. Thus, the 3-point method reduces the computational time greatly. It must be noted that there is an improved formulation for the 4-pole method that is faster than the original, while still maintaining the 4-pole parameters . Due to the programming options in SYSNOISE (the numerical program used in this study), however, it was not possible to evaluate the improved 4-pole method and compare it to the other methods. SYSNOISE is an FEM/BEM based computational acoustics program that allows users to input a geometry, impose boundary conditions, select environmental parameters,and solve the system of resulting equations in one, two or three dimensions.

Once the system has been solved, a host of post-processing options are available to determine the various performance characteristics. Using command line code, it was possible to perform the calculations for all three methods, utilizing both FEM and BEM, and in both two and three dimensions.

II.FEM/BEM

Sysnoise has the ability to perform both FEM and BEM computations. It is, however, worth spending some time discussing the basic principles for each when applied to solving silencer systems. The FEM is primarily used when only the interior acoustic field of geometry is to be computed. Solving purely exterior problems, or coupled interior-exterior problems with the FEM, requires large domains to be modeled with approximate terminating boundary conditions. Alternatively, infinite elements, like the wave envelope method, can be used in these situations. Both strategies require extensive convergence testing to be trusted. In order to perform the TL calculations, the desired region is divided up into a grid of nodes and elements. The fundamental theory behind FEM shows that each element interacts only with the elements directly adjacent to it. With wise node numbering, the result is a banded coefficient matrix for the resulting system of equations, which can be solved faster than a full coefficient matrix. Since the entire acoustic domain is considered for calculation, there also exists the ability to assign different element types, and material properties (such as porosity and density) to different sections of the mesh. This is useful when trying to properly model absorptive materials. The BEM can be used to compute the interior, exterior, or both fields simultaneously. Unlike the FEM, the BEM only requires the perimeter of the silencer to be divided into nodes and elements and then solved. Also unlike the FEM, each node in the BEM mesh is inter-linked with every other node, which forms a full coefficient matrix. This greatly increases the computational time as the number of nodes increases. It is for this reason that the FEM is preferable for TL calculations.

ISSN (Online) : 2319 – 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization Volume 3, Special Issue 4, April 2014

Two days National Conference – VISHWATECH 2014

On 21st & 22nd February, Organized by

Department of CIVIL, CE, ETC, MECHNICAL, MECHNICAL SAND, IT Engg. Of Vishwabharati Academy's College of engineering, Ahmednagar, Maharastra, India.

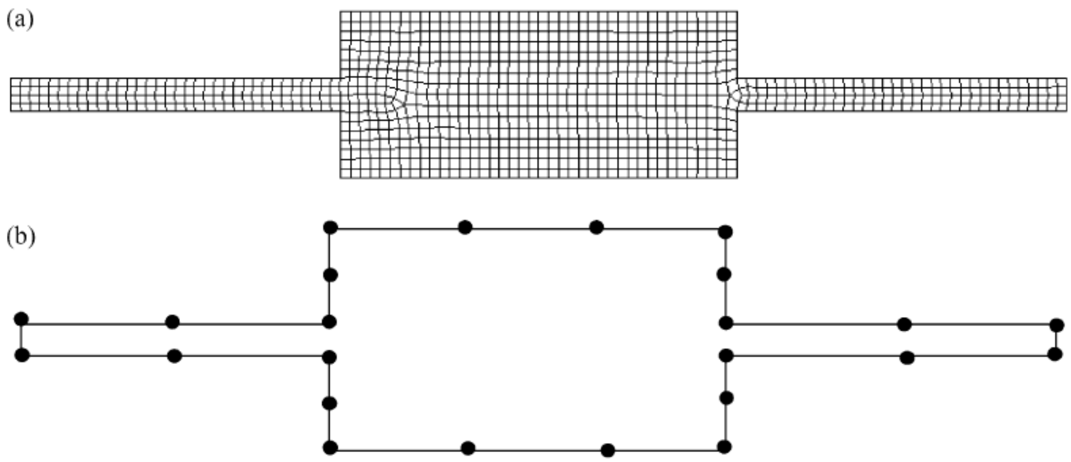

Fig.1(a) Finite element mesh (b) example boundary element mesh for single expansion chamber

III.THE TRANSFER MATRIX METHOD

TMM use the transfer matrix of a silencer element as a function of the element geometry, state variables of the medium, mean flow velocity, and properties of duct liners, if any. The results presented below correspond to the linear sound propagation of a plane wave in the presence of a superimposed flow. In certain cases, the matrix may also be influenced by nonlinear effects, higher order modes, and temperature gradients; these latter effects, which can be included in special cases, are discussed qualitatively later in this section, but they are excluded from the analytical procedure described below. The following is a list of variables and parameters that appear in most transfer matrix relations of reactive elements.

1.3 4-Pole transfer matrix method:-

The development of the 4-pole method is well known and can be found in almost any silencer design. Time will then be spent in explaining the resulting formulas and how to implement them in a FEM/BEM modeling scheme. Using the 4-pole method, a silencer system is evaluated at the inlet and outlet sections by the sound pressure and normal particle velocity ***Fig.2 1*** illustrates the measurement locations for a single expansion chamber silencer.

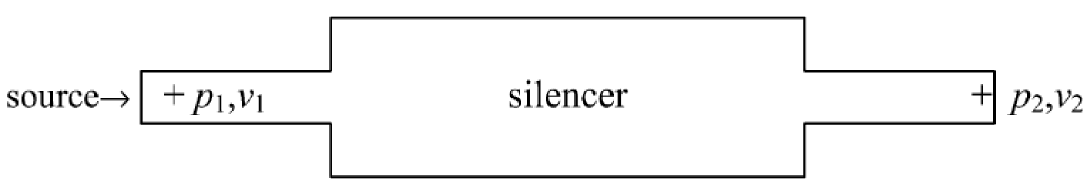

Fig.2 4-Pole transfer matrix method measurement points.

IV.LITERATURE REVIEW

[1]S. Bilawchuk , K.R.fyFe, "Comparison And Implementation of the various numerical methods used for calculating transmission loss in silencer system" Applied Acoustics 64 (2003)903-916

ISSN (Online) : 2319 – 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization *Volume 3, Special Issue 4, April 2014*

Two days National Conference – VISHWATECH 2014

On 21st & 22nd February, Organized by

Department of CIVIL, CE, ETC, MECHNICAL, MECHNICAL SAND, IT Engg. Of Vishwabharati Academy's College of engineering, Ahmednagar, Maharastra, India.

1. The use of the FEM & BEM to aid in acoustical engineering design is increasing rapidly. When used in conjunction with the FEM &the BEM, traditional,4-pole & 3-point method can be powerful tool designing acoustical silencer system.
2. The BEM has been show to be quiet slow when compared to the FEM. It should therefore, only be used when the modeling demands its flexibility, such as for insertion loss prediction (due to the interior/exterior coupling required) Also, the fundamental difference between the 4-polemethod &3-point method indicate that each one is better suited to certain specific design applications.
3. The 4-pole method is better suited if a cascade of muffler element is used. The method produces the 4-pole parameter necessary for continuity between adjacent sections. It is slower than the 3-point method &therefore is not recommended for multiple runs or optimization. The 3-point method, therefore is a great tool for evaluating the response of modifying individual parameter such as baffle spacing ,absorptive material properties, overall, silencer length 7 ct &effect of multiple small chambers.

[2]K.S. Anderson (2008) "Analyzing Muffler Performance using the Transfer Matrix Method", Producing of the COMSOL, Dinex Emission Technology A/S DK-5500, Middelfart, Denmark.

1. He did work on exhaust noise, legislation target, customer expectation &cost reduction, which call for design optimization of the exhaust system.
2. One solution is to use three dimension linear pressure acoustics & calculate the transfer matrix of the muffler. The transfer matrix is the basis for the calculating either the insertion loss or transmission loss of the muffler.
3. the 3D simulation in comsol of different muffler configuration are verified by measurements in a flow acoustic test rig using the two source method .

[3]F.Masson, P.kogan and Herrera (2008), "Optimization of muffler transmission loss by using micro perforated panels", I congreso Iberomericano de Acustica – FIA 2008- A168.

1) w oforked on optimize the acoustic performance of low cost, simple geometry mufflers by using micro-perforated panels (MPP) in their expansion chambers.
2) The transmission loss (TL) given by computational method is compared with laboratory measurements , both for the mufflers containing the micro perforated panels and without them.
3) The optimization calculation is based on easy computating transfer matrix approach. Then, they use the bpundary element method (BEM) in order to compare the evaluation of TL
4) The worke shows that the reactive effect produced by the mufflers geometry is much more important than the dissipative effect provided by the MPP .

[4]N.K.Vijaya sree,M.L. Munjal (2012) "On an integrated transfer Matrix method for multiply connected mufflers " , Journal of sound and vibration , vol 331.

1) The commercial automotive mufflers are generally of complicated shape with multiply connected parts and complex acoustic elements.
2)The analysis of such complex mufflers has always been a great challenge.
3) M.L. Munjal developed an intergrated transfer matrix method to analyze complex muffler.
4)Integrated transfer matrix rated the state variables across the entire cross section of the muffler shell,as one moves along the axis of muffler , and can be partitioned a appropriately in order to relate the state variables of different tubes constituting the cross section .

[5]F.D. Denia ,A. Selamet and F.J. fuenmyora, R. Kirby(2007) "Acoustic attenuation performance of perforated dissipative mufflers with empty inlet /outlet extensions" , Journal of sound and vibration ,Vol.302,pp.1000-1017

Acoustic behavior of perforated dissipative circular muffler with empty extended inlet/outlet is investigated in detail by means of a two dimensional axisymmetrical analytical approach that matches the acoustic pressure and velocity across the geometrical discontinuity, and the FEM presented by Denia etc.

The complex characteristics impendance , wave number ,and perforation impedance are taken in to account

[6]N.S. Dickey, A.Selamet and J.M. Novak (1998), "Multipass perforated tube silencer a computational approach", a journal of sound and vibration vol 211(3),pp.435-448.

A time domain computational approach is applied to predict acoustic performance of multipal pass silencer with perforated tube section.

The study show that the nonlinear one dimensional method may radialy include temporal and special vibration in sound pressure level, orifice flow velocities,and mean duct flow , all of which affect the local orifice behavior of perforated tube element, and there fore the overall noise reduction characteristic.

ISSN (Online) : 2319 – 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization Volume 3, Special Issue 4, April 2014

Two days National Conference – VISHWATECH 2014

On 21st & 22nd February, Organized by

Department of CIVIL, CE, ETC, MECHNICAL, MECHNICAL SAND, IT Engg. Of Vishwabharati Academy's College of engineering, Ahmednagar, Maharastra, India.

V.CASE STUDY

The noise control of a fan's sound exhausted at the outlet is introduced as the numerical case. According to the sound pressure levels measured by octave band sound meter at 1 meter, the dominated (maximum) sound energy is recognized at frequency of 500 Hz. As shown in Figure 6, the available space, which is suitable for the elevated side inlet/outlet silencer is constrained as 0.4W * 0.4H * 0.8L (Lo = 0.8 M and Do = 0.4 M). The O.D. of exhaust pipe is confined to 0.0508 m. To efficiently depress

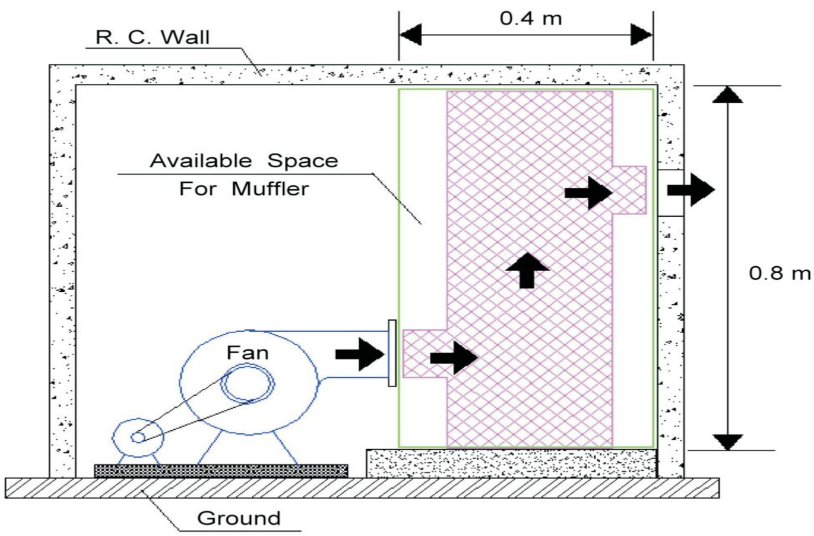

Fig. Elevation of a fan with constrained silencer inside room

the exhausted noise level, the sound energy emitted at the dominated frequency of 500 Hz is thus selected as the primary targeted frequency for noise elimination Moreover, to obtain the maximal noise reduction, the shape optimization of silencer under space constraint is subsequently compulsory. In this study, both of the gradient methods (EPFM, IPFM, FDM) and genetic algorithm together with the graphic analysis will be applied in the following numerical assessments. The related design volume flow rate is confined to 0.8 (m3/s).

VI.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. It should, therefore, only be used when the modeling demands its flexibility, such as for insertion loss predictions (due to the interior/exterior coupling required).Also, the fundamental differences between the 4-pole method and 3-point method indicate that each one is better suited to certain specific design applications. The traditional method, although as accurate as the other two methods (due to the plane wave assumptions and inlet and outlet boundary conditions), is time consuming and more difficult to implement due to the two separate geometry's required. The 4-pole method is better suited if a cascade of muffler elements is used. The method produces the 4-pole parameters necessary for continuity between adjacent sections. It is slower than the 3-point method and therefore is not recommended for multiple runs or optimization. As mentioned before, 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. It does not produce the 4-pole parameters and, as such, the section being evaluated cannot be inter-linked with other sections. In order to perform such an evaluation, all of the sections would need to be created as one large section and then meshed and evaluated. 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.

VII.FUTURE WORK

There is good agreement between the theoretical and limited experimental results with the 3-point computational method. This encourages further work with full three-dimensional models of reactive and parallel baffle silencer systems to better compare the results. Also in the future, additional parameters such as absorption, flow and temperature effects should be added to the model to increase the accuracy. The self-generated noise at the exit and the breakout noise from the sides of the system should also be investigated. Ultimately, the IL of the system is the desired value, so that the total acoustical impact on an installation can be assessed.

ACKNOWLEDGMENT

The authors would like to thank the International Journal of Innovative Research in Science,Engineering and Technology Prof.R.B.Patil JNEC Aurangabad , the Department of Mechanical Engineering for the valuable guidance, and Mr.Amol Patil for the support for this work.

REFERENCES

1. S. Bilawchuk , K.R.fyFe, "Comparison And Implementation of the various numerical methods used for calculating transmission loss in silencer system" Applied Acoustics 64 (2003)903-916
2. K.S. Anderson (2008) "Analyzing Muffler Performance using the Transfer Matrix Method", Producing of the COMSOL, Dinex Emission Technology A/S DK-5500, Middelfart, Denmark.
3. F.Masson, P.kogan and Herrera (2008), "Optimization of muffler transmission loss by using micro perforated panels", I congreso Iberomericano de Acustica – FIA 2008- A168
4. N.K.Vijaya sree,M.L. Munjal (2012) "On an integrated transfer Matrix method for multiply connected mufflers " , Journal of sound and vibration , vol 331.
5. F.D. Denia ,A. Selamet and F.J. fuenmyora, R. Kirby(2007) "Acoustic attenuation performance of perforated dissipative mufflers with empty inlet /outlet extensions" , Journal of sound and vibration ,Vol.302,pp.1000-1017
6. N.S. Dickey, A.Selamet and J.M. Novak (1998), "Multipass perforated tube silencer a computational approach", a journal of sound and vibration vol 211(3),pp.435-448.
7. A.D.Sahasrabudhe,M.L.Munjal and S.Anantha Ramu(1992), "Design of expansion chamber muffler incorporating 3-D effects ", Noise control engineering journal, Vol.38(16),pp27-38
8. A.Selament,P.M.radavich(1997), "The effect of length on the acoustic attenuation performance of concentric expansion chamber an analytical, computational and experimental investigation",Journal of sound and vibration ,vol.201(4),pp.407-426.
9. J.M. Middelberg, T.J. Barber , S.S. Leong, K.P.Byrne and E. Leonardie(2004), "computational fluid dynamics analysis of the acoustic performance of various simple expansion chamber muffler", proceeding of acoustic, gold cost austrelia , pp 123-128.
10. B. Datchanamourty (2004), "Detailed modeling of mufflers with perforated tubes using substructure boundary element method", [M.S. thesis], COE university of Kentucky, Lexington Kentucky.
11. S.Bilawchuk ,K.R. Fyfe, "Comparison and Implementation of the various numerical method used for calculating transmission Loss in silencer system" "Applied Acoustic 64(2003) 903-916
12.R. srinivasan and M.L.Munjal (1998) "A fully automatic 3-D analysis tool for expansion chamber muffler ", Sadhana, vol.23(2), pp.195-212.