Journal of Material Science and Mechanical Engineering (JMSME)
Print ISSN: 2393-9095; Online ISSN: 2393-9109; Volume 2, Number 2; January-March, 2015 pp. 130-133

http://www.krishisanskriti.org/jmsme.html

A Review on Noise Reduction of Centrifugal Blower with Rectangular Splitter Silencer

Anupriya Ashok Kankal[1] and S.R. Patil[2]

[1]PG Student Mechanical Design Engineering AISSMS College of Engineering, Pune-01
Savitribai Phule Pune University, Pune, Maharashtra, India
[2]Mechanical Eng. Department AISSMS College of Engineering, Pune-01
Savitribai Phule Pune University, Pune, Maharashtra, India
E-mail: [1]anupriyakankal@gmail.com, [2]srpatil@aissmscoe.comAbstract

Abstract—*This review aims to assist engineers in understanding and applying passive solutions for reducing industrial blower noise. This paper systematically reviews the extant literature on noise reduction of backward curved centrifugal blower with passive noise techniques, with a particular focus on Dissipative type of silencer for noise control. The review helps for the assessment of the current state of the art in industrial blower's air flow and noise control. It gives a path for improvement in noise reduction with application of dissipative silencer in noise control technologies. Dissipative silencers employ a sound absorbing material to attenuate the sound waves. These types of silencers are commonly used in ducts to attenuate broadband noise emitting from an air moving device, such as a fan or blower. The ducts commonly have a rectangular cross section and use silencers made up of a number of parallel splitters or baffles. The features of this type of silencer are good high-frequency attenuation and minimal aerodynamic pressure loss. The purpose of this paper is to provide a vision for systematically reducing industrial fan noise emissions by implementing splitter silencer in rectangular duct.*

Keywords *: Centrifugal blower, noise reduction, dissipative silencer, splitter, absorbent material.*

1. INTRODUCTION

A blower is rotary, bladed device maintaining the continuous flow of air. It has a rotating impeller with the forward, backward and radial curved blades. These blades exert force on the air, there by maintaining the flow and raising the pressure. Fans do not normally raise the absolute pressure more than 30% [1].Compressors and high pressure fans are called as blowers if they are used to take the atmospheric air and raise its pressure. Noise energy generated by the blower rotation is very much dependent on the diameter and the rotational speed of the blower, typically proportional to the fifth or sixth power of the linear velocity of the type of the blades [2]. The other parameters influencing the noise are construction characteristics, friction, and arrangement of flow paths. Generally a large diameter blower at low rotational speed produces comparatively low noise level. By reducing the diameter and increasing the rotational speed then the same volume flow rate can be achieved. Though in this case, the frequency and the noise level are higher, but still this higher frequency noise can be more effectively attenuated by lining the duct with sound absorbing materials like glass wool, rock wool, etc. and the sound power level of centrifugal blower can be find out by,

$$L_{\text{blower}} = K_w + 10 \log_{10} (V / V_1) + 20 \log_{10} (\Delta P_t / P_1) + C$$

Where;
K w = Specific Sound Level of the Blower
V = Fan Output (Flow Rate) (L / s),
V_1 = Correction Factor for the Flow Rate = 0.472 L/s
ΔP_t = Total blower Pressure (Pa),
P_1 = Pressure Correction Factor
C = Correction factor for the deviation from the most efficient operation region. [3]

This noise generated by the source can be minimized or controlled by introducing the dissipative rectangular splitter type of silencer at the outlet or exhaust duct. The fundamental approach is the utilization of absorptive, parallel, or circular baffle-type silencer. This gives high frequency attenuation at vey minimum aerodynamic pressure losses. The dissipative silencers are the most widely used devices to attenuate the noise in ducts through which fluid flows and in which the broadband sound attenuation must be achieved. They are used in the intake and exhaust ducts of industrial equipments such as fans, blowers, ventilation and access openings of acoustical enclosures, etc. They have an allowed pressure drop that typically ranges 125 to 1500 Pa (0.5-6in. of water). These devices contain fibrous or porous materials and depend on absorptive dissipation of the acoustical energy.

1.1. Difference between fans, blowers and compressors

Fans, blowers and compressors are differing from each other by the method which is used to move the air and by the system pressure rise in them. American Society of Mechanical

Engineers (ASME) has specified the specific ratio i.e. the ratio of the discharge pressure over the suction pressure is used for defining the fans, blowers and compressors and these are given below,

Table1: Difference between fans, blower and compressors in terms of specific ratio and pressure rise

Equipment	Specific ratio	Pressure Rise(mm WG)
Fans	Up to 1.11	1136
Blower	1.11 to 1.20	1136-2066
compressors	More than 1.20	-

Where, 1 K Pa = 102 mm WG = 0.145 PSI = 0.33 ft WG

1.2. Base of noise generation in Blowers

Blower Unbalance is one of the leading causes of vibration in rotating machinery. Unbalance is an unequal distribution of rotor weight along the shaft axis. The causes of irregular mass distribution are porosity in casting, non uniform density of material, inaccurate manufacturing tolerances, maintenance actions, etc. Because of these irregularities the actual axis of rotation does not coincide with one of the principal axes of inertia of the body, and variable disturbing forces are produced which result in vibrations and consequently in noise.

Bearing noise for the constantly running blower is high due to damaged ball or roller bearings and they tend to contribute for the large noise, so well-lubricated sleeve bearings can be used as they are quieter than ball or roller bearings. Generally centrifugal blower runs on the induction motor and the noise level by motor will be high if the impeller is directly mounted on the motor shaft. So to control this noise generally motor is isolated from shaft. Structural Resonance also contributes for noise emissions when a wide range of frequencies are present in most fan and blower noise. If the frequency in a given band is high and corresponds to the natural frequency of some part of the fan the resulting noise may be radiated efficiently. Added bracing can be used to raise the natural frequency of the part to some higher value or damping material may be applied to it in order to reduce the noise radiation. So, if the natural frequency coincides with the frequency of the system then there structural resonance will occur.

1.3. Dissipative silencers

The dissipative silencers are the most widely used devices to attenuate the noise in ducts through which fluid flows and in which the broadband sound attenuation must be achieved. They are frequently used in the intake and exhaust ducts of industrial equipments like fans, blowers, etc. These uses fibrous or porous materials lined on either opposite sides of the duct. The thickness of the material majorly affects the performance of the silencer to the great extent. [3] The use of dissipative (or absorptive) silencer is the classical solution for blower noise attenuation. These devices transform acoustic energy into heat (i.e. dissipate the acoustic energy). The principal advantages of these devices are they provides good absorption at medium and high frequencies and useful for narrow and broadband noise, however the disadvantages are, performance falls off at low frequencies (i.e., attenuation is strongly frequency dependent) and absorptive material can disintegrate under harsh conditions (protective facing material will reduce this problem). The most common configurations of dissipative silencers include parallel-baffle or splitter silencers, round silencers, and lined ducts. Each splitter normally consists of a bulk-reacting fibrous-type material separated from the airway by a thin perforated metal sheet. This helps to maintain the dimensional stability of splitters and airflow between each splitter which helps to lower the pressure drop across the silencer. [2]

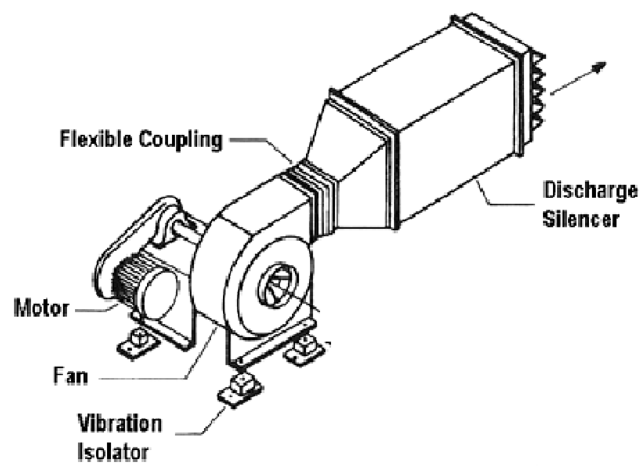

Fig. 1: Generalized arrangement of silencer with blower [11]

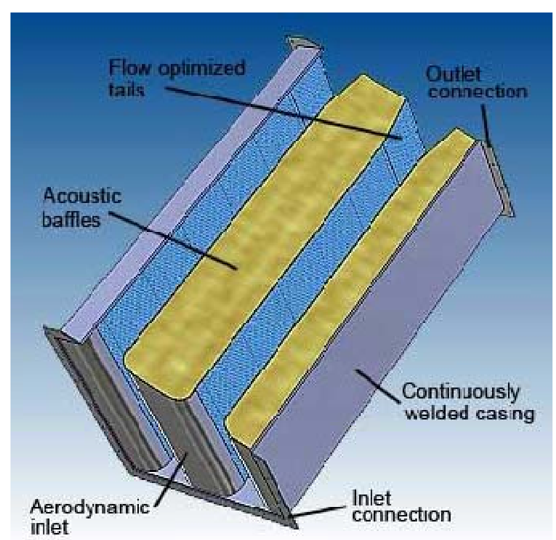

Fig. 2: Basic appearance of a parallel splitter silencer [14]

1.3.1. Performance parameters of splitter silencer

Performance of splitter silencer depends upon

1. Length of baffles / splitters
2. Thickness of baffles / splitters
3. Spacing between them
4. Thickness of absorbent materials.

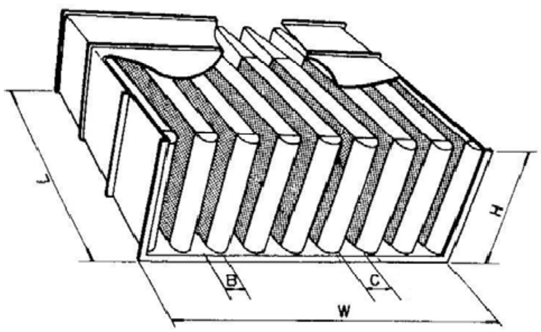

Fig. 3: Splitter Silencer [11]

Where, B = Width of splitter
W = Width of silencer
C = Distance between two splitters
H = Height of silencer
L = Length of silencer

In the estimation of performance of silencer, the term insertion loss has vital importance and which is estimated as the difference between the sound pressure level before and after of installation of silencer to the system. While the linear attenuation for splitter silencer can be find out with the relation,

Attenuation = $12.6 \times (P/S) \times \alpha^{1.4}$ [dB/ft] [11]
Where,
P = Perimeter of duct (inside lining) [inches]
S = Cross-sectional area of duct inside lining [inches]
α = Absorption coefficient of lining material.

2. LITERATURE REVIEW

Years of research and investigation into noise attenuation in air-conditioning and ventilation systems have led to many methods and theories. There are three main groups of noise attenuation are passive type (bulk reacting), non-isotropic (locally reacting) i.e. liners, pod / splitter type absorbers and active attenuators. **Acoust J., 1978**, studied the Sources of broadband noise in FC (forward curved blades) centrifugal fans experimentally using a 0.28 m diameter fan. He found Strong tangential and axial gradients of mean velocity and static pressure in the housing. Very large variations in velocity and velocity fluctuations occurred across the blade passages. A miniature microphone mounted at various points on the blade surfaces showed a large increase in pressure. **T.F.W. Embelton** studied several centrifugal blowers with forward, backward and radial blades at various speeds, capacity and pressure. The attention was given for the noise reduction techniques that are applicable to any type of blowers and he found about 12 dB noise reduction [5]. **A. Cummings** lined opposite sides of the duct with sound absorbing materials. The purpose of the that paper was to study the effects of three dimensional propagation in rectangular ducts with bulk reacting liners incorporating perforated facing material, in the presence of uniform mean flow. He used glass wool and rock wool as bulk reacting lining material. He also discussed application of the model to splitter type silencers [6]. **E. A. Leskov, G. L. Osipov and E. J. Yudin** investigated acoustical effectiveness of different dissipative duct silencers packed with the lightweight porous materials. They measured the noise frequency of different central ventilation systems and they noticed that the dimensions and the costing of the silencers are mainly dependent on the efficiency at frequency range of 125 to 500 cps. The experimental set up consists of 8×1×2 m claydite concrete air duct with volume 60 m^3 they gave a sound field at silencer input, damper to reduce the reflection of sound waves from the duct and faces and carriages to display the microphone along the silencer axis. From the experimentation they found that, frequency attenuation characteristic in silencer depends to great extent on splitter thickness. When the spacing was considerably greater than half the wavelength, the attenuation was majorly dependent on absorption layer rather than splitter spacing. So the spacing between splitter is increased from 115 up to 400mm. When the spacing was greater than wavelength, the attenuation rate per unit length was considerably good [7].

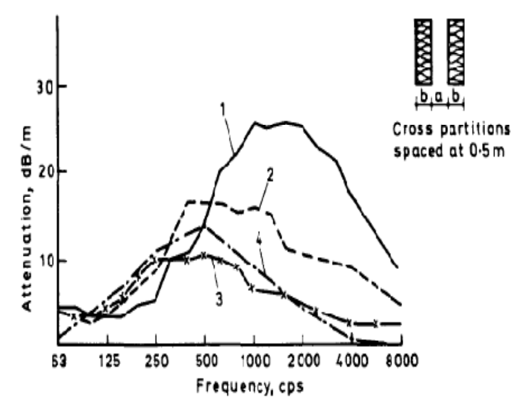

Fig. 4: The influence of splitter thickness on silencer attenuation: (1) b=100mm, a=115mm, ϕ=53%; (2) a=b=200mm, ϕ=50%; (3) a=b=400 mm, ϕ=50% (4) Required attenuation. [7]

Ray Kirby, Ken Amott b, Paul T.Williams and Wenbo Duan, found that the acoustic performance of a splitter silencer changes under the influence of the convective effects of a mean gas flow and so in their article a theoretical model is developed to include the effects of mean flow. The experiment and theory showed that when mean flow is in the direction of sound propagation at low frequencies insertion loss reduces, and at high frequencies the influence of mean flow is generally much smaller. While in the absence of mean flow the theoretical model is shown to be capable of capturing silencer performance over a wide frequency range and for an upper frequency limit of 8 kHz. They also noticed significant problems were encountered with the signal to noise ratio at higher mean flow velocities [8]. **Ramani Ramakrishnan** in his research divided into many small units by installing splitters in the duct. He calculated insertion loss for half unit, single unit and multi-unit splitter silencers. Multi-unit silencer performance is compared to that of a single unit within the full duct and he found that the predicted insertion loss is highest in the case of the single unit silencer. This is due to the tuning of the silencer for the particular combination of frequency, material type (density was approximately 22 kg/m^3), unit size and open-area percentage [9]. **Sabry Allam and Mats A bom**, he used silencer in application to reduce noise of cooling fan inlet for large IC engine. He investigated potential of using splitters made up of micro perforated plates [10].

3. CONCLUSIONS

Centrifugal fans are used in industries these equipments have great applicability in the product development as well as ambient comfort. Among the operational problems in these equipments, the noise frequently arises as principal causes. Fans that operate in the cooling systems involving industrial or vehicle heat exchangers and in building heating and ventilation applications are a source of noise pollution. So, dissipative silencers can be installed in ducts to suppress broadband noise from an air moving device, such as fans and blowers. The ducts commonly have a rectangular cross section and use silencers made up of a number of parallel splitters or baffles. This paper discusses the traditional way of noise control through the use of absorptive, parallel baffle type silencer, known as dissipative silencers and reviews study previously done on the implementation of splitter silencer.

REFERENCES

[1] Alessandro Corsini, A. G. Sheard, "*A Critical Review of Passive Noise Control Techniques in Industrial Fans*", Journal of Engineering for Gas Turbines and Power, Vol. 136, 2014, pp. 44001-9.

[2] W. Neise, "*Review of noise reduction of centrifugal fans*", Journal of engineering for industry, vol.104, 1982, pp. 151-160.

[3] Wan Ho Jeon, "*A numerical study on the effects of design parameters on the performance and noise of a centrifugal fan*", Journal of Sound and Vibration 265, 27 November 2002, pp.221–230.

[4] D.V. Bhope, P.M. Padole, "*Experimental and theoretical analysis of stresses, noise and flow in centrifugal fan impeller*", Mechanism and Machine Theory 39, 2 October 2004, pp. 1257–1271.

[5] T.F.W Embelton, "*Experimental study of noise reduction of centrifugal blower*", journal of acoustic society of America, vol.35, 18 feb1963, pp.700-705.

[6] Cummings, A., "*Sound Attenuation in Ducts Lined on Two Opposite Walls with Porous Material, With Some Application to Splitters*," J. Sound Vibration, vol. 49(1), 1976, pp. 9–35.

[7] E.A.Leskov, G.L.Osipov and E.J.Yudin, "*Experimental investigation on splitter duct silencer*", applied acoustics, vol.3, 20 September 1969, pp. 47-56.

[8] Ray Kirby, Ken Amott b, Paul T.Williams, Wenbo Duan, "*On the acoustic performance of rectangular splitter silencers in the presence of mean flow*", Journal of Sound and Vibration, 1 July 2014, pp.1-17.

[9] Ramani Ramakrishnan and Willie R. Watson, "predicted acoustical performance of multi-unit splitter silencers", Canadian acoustics, vol. 18(3) 1990, pp.3-18.

[10] Sabry Allam, Mats A bom, "*Fan noise control using micro perforated splitter silencer*", Journal of Vibration and Acoustics, Vol. 136, June 2014, pp. 0310171-8.

[11] Alexandre Luiz, Amarante Mesquitaa, André Luiz Amarante Mesquitab, Ernesto Arthur Monteiro Filhoc, "*Use of Dissipative Silencers for Fan Noise Control*", The 2005 Congress and Exposition on Noise Control. 2005.

[12] A Handbook for the Mechanical Designer Second Edition, 1999, pp. 5-15.

[13] Industrial Noise Control and Acoustics by Randall F. Barron Louisiana Tech University Ruston, Louisiana, U.S.A., pp.335-400.

[14] Dario Bogdanovic, ,"*Calculation methods for predicting attenuation of parallel baffle type silencers*", Master´s Thesis, Department of Civil and Environmental Engineering, Division of applied Acoustics Vibroacoustics group, Chalmers University Sweden. 2014