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Noise Reduction Techniques for Forced Draft Fan in Thermal Power Plant using Absorptive Silencer

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Abstract - ***Power station or power plants are industrial facility for electric power generation. Since the early advent of 'steam engine' technology and ample availability of coal and reliable cheap power, people all over the world heavily rely on thermal power stations, but Thermal power plants are one of the noisiest factories. However Prolong exposure to industrial noise can't be neglected, which may cause neurobehavioral change, psychological stress, and unhappiness in daily life without showing the symptoms of chronic / acute diseases. For Thermal power plants, the major noise sources are coal unloading plant, crusher plant, compressor, boiler feed pump, turbine, Forced Draft Fan (F.D. fan), Induced Draft Fan (I.D. fan etc. This paper aims to study different type of noise sources and Silencers used in Thermal power plants and also analyzes the noise source of Forced Draft Fan (F.D. fan) and reduce the noise by a modified absorptive Silencer or Muffler.***

Keywords - ***F.D. fan, I.D. Fan, Noise, Power plant, Silencer.***

I. INTRODUCTION

Power station or power plants are industrial facility for electric power generation. Generally power stations contain one or more generators, and a rotating machine to convert mechanical power into electrical power. Electrical current is created by the relative motion between magnetic field and conductor. Since the early advent of 'steam engine' technology, ample availability of coal and reliable cheap power, people all over the world heavily rely on thermal power stations. About 70% of energy used by India is produced in Coal fired thermal power plants. Thermal power stations produce mechanical power by a heat engine, which transforms thermal energy (by fuel combustion) into rotational energy.

Thermal power plants are the noisiest factories. However, prolong exposure to industrial noise can't be neglected which may be the cause of neurobehavioral change, psychological stress and unhappiness in daily life without showing the symptoms of chronic / acute diseases. Laboratory studies have shown that noise reduces efficiency on some tasks, can upset the sense of balance and can cause blood vessels to constrict, raising blood pressure and reducing the volume of blood flow. For Thermal power plants, the major noise sources are coal unloading plant, coal crusher plant, compressor, boiler feed pump, turbine, Forced Draft Fan (F.D. fan), Induced Draft Fan (I.D. fan), Demineralized plant (D.M. plant), cooling tower, aerial rope way etc. Several types of fans are used in Boiler systems to maintain air flow, re-circulate air and remove exhaust gases. Different fans are used with varied capabilities according to boiler size and air flow requirement. In thermal power plants, draft fans play an important role, as they regulate the air pressure inside boiler system. There are two types of Draft fans – Forced Draft (FD Fan) and Induced Draft (ID Fan). The Forced Draft fan forces outside air into the heating system and Induced Draft fan draws flue gases from the heating system out into the atmosphere. To make the combustion process efficient, both FD fan and ID fans operate in correlation such that it balances the air system in the boiler. In this paper we will study different type of Silencers and focus on Absorptive Silencer, to reduced noise generated by Forced Draft Fans.

II. DIFFERENT TYPE OF SILENCERS FOR FORCED DRAFT FAN

The Duct silencers are used to reduce the noise caused by the fan, air passage through straight ducts and impact of air flowing through components such as elbows, mixing boxes, branches etc. The FD Fan Silencers are normally selected on the basis of the silencing criteria, and maximum allowable pressure drop at rated flow. The flow area throughout the silencer should be sufficient to accommodate the air flow without imposing excessive restriction. These silencers usually designed for size for around 5000 FPM velocity to maximum 7500 FPM velocity to prevent aerodynamic noise generation and excessive self generated noise.

THE DIFFERENT TYPE OF SILENCERS USED IN FD FANS ARE:

A. ABSORPTIVE OR DISSIPATIVE SILENCERS

Absorptive silencers are generally used to reduce noise radiated by forced-draft fans of gas turbines, power stations, combined-cycle plants. Sound-absorbing material, which is protected from blowing perforated sheet and fiberglass, are placed on the channel cross section in absorption (dissipative) mufflers. In the energetic baffle silencers are widely used. The baffle silencers acoustic calculations are well-developed. For high capacity heat power stations the silencer noise reduction could be of about 10 - 25 dBA on the border of noise sanitarium zone. The climatic change factors during the year must take into account while developing the Mufflers. The required silencer reduction can be changed up to 5-8 dB for the same point throughout the year.

B. REFLECTIVE OR REACTIVE SILENCERS

The Reactive Silencers reflect sound waves back to the source. Reactive Silencers are designed to attenuate low frequency noise from machines and have tuned cavities or membranes. The reactive silencers operating principle depends on combination of lambda/4 and Helmholtz-resonators acting as acoustic filters. The reactive silencer has small or negligible pressure loss, may have excellent low frequency performance, and is non-fibrous & cleanable. Expansion chamber is the simplest type of Reactive muffler. These are rarely used in High Voltage AC systems and are suitable for engines requiring maximum engine performance with very low exhaust system back pressures.

C. DIFFUSER OR DEPRESSIVE SILENCERS

To slow down flow velocity diffuser type silencers use perforated pepper pots and prevents low frequency noise generation. These are used for applications involving nozzles, control valves, jet engines etc. The total pressure developed is reduced in several stages across the nozzle, the valve & the diffuser. This provides a better pressure ratio between upstream and downstream and reduces the noise level.

D. ACTIVE SILENCERS

Active noise control (ANC) or active noise reduction (ANR) method is used to reduce noise by the addition of a second sound wave with same amplitude and inverted phase to the original sound, which is specifically designed to cancel the first sound. Active silencers use microphones, speakers and electronics to determine and attenuate noise. These silencers are effective at low frequencies below *300 Hz*. Active silencers are best suited for applications with relatively steady noise fields - like fans, engines or similar. These are not suitable for broadband noise reduction.

III. ABSORPTIVE SILENCERS DESIGN

The absorptive, parallel baffle-type silencer also known as dissipative silencers are frequently used in Thermal power plants Forced Draft fan. These silencers creates pressure drop from 125 to 1500 Pa (0.5-6 in. of water). These silencers transform acoustic energy into heat using sound absorbing material (fibrous or porous materials) in the internal walls. Absorptive Silencers has good absorption at medium and high frequencies and low absorption at lower frequencies (as these materials become effective only when its thickness is at least one-tenth the wavelength). These are useful for narrow and broadband noise.

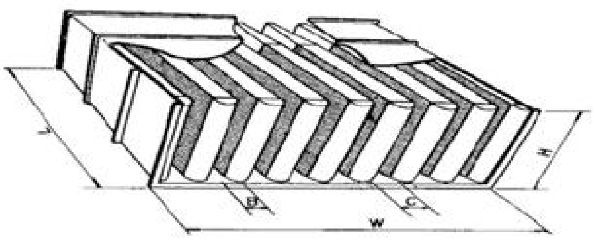

Fig. 1 parallel baffle silencers

The parallel baffle silencers acoustical performance depends basically on three parameters: **baffles length, absorbing material thickness (B) and spacing between baffles (C)**.

The acoustical performance of the silencer is directly proportional to its length. Frequency absorbent characteristics are inversely proportional to absorbent material thickness and baffles spacing. For low frequency absorption Thick layer & wide spacing and for high frequency absorption thin layers and narrow spacing are effective. For good absorption capacity over the widest frequency range, thick layer and narrow spacing between absorbents are best.

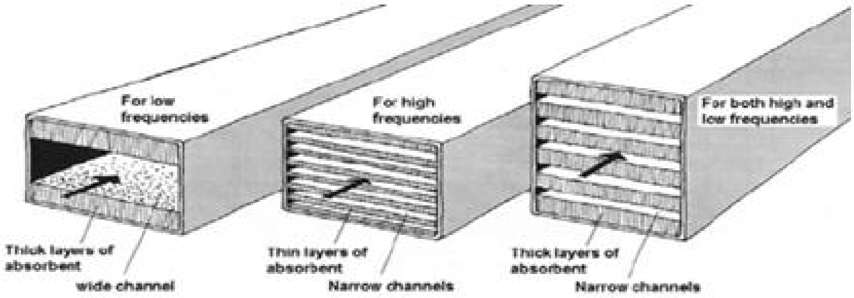

Fig. 2 Absorbing material thickness and baffles spacing example

In order to attenuate the sound at the low end of the frequency spectrum,

The baffle thickness *B* < The wavelength of the frequency under consideration

To attenuate the sound at the high end of the frequency spectrum,

The air passage between layers *C* < The wavelength of the frequency under consideration

A. Attenuation

The linear attenuation can be estimated as :

$$\textbf{Attenuation} = 12.6\,(P / S)\,\alpha^{1.4}\ [\text{dB/ft}] \qquad (1)$$

Where,

P= perimeter of the internal revetment acoustical [in],

S= open cross sectional area of the duct [in2],

A= Sabine absorption coefficient of the absorbent material [dimensionless].

B. Aerodynamic Resistance

The Aerodynamic Resistance for silencer development should be minimum. The Aerodynamic resistance for smoke exhaust fan silencers must be less than 200 - 300 Pa. Aerodynamic drag of the multi-stage baffle silencer is calculated by the below known formula:

$$H = \sum_{i=1}^{n}\left(\xi_{Mi} + \xi_{\square mpi}\frac{l_i}{D_\Gamma}\right)\frac{v^2\rho}{2} \qquad (2)$$

Where,

ξ_{Mi}, $\xi_{mp\,i}$ - *Coefficient of local resistance and coefficient of friction of* i^{th} *stage of the silencer;*

l_i - *Silencer(m)* i^{th} *section length*

D_Γ - *Silencer (m) Cell diameter*

v - *Flow rate at the section between the baffles of the silencer, m/s;*

ρ - *Density of the fluid in the duct, kg/m3;*

n - *The number of stages*

Above formula shows that the Aerodynamic Resistance is highly dependent on the flow rate in the section between the baffles of the silencer, Fluid Density in the duct, as well as the frictional resistance and local resistance.

C. The flow rate

The flow rate in passage cross section is defined as -

$$v = Q/S_{mp} = Q/kS \qquad (3)$$

Where,

Q - Volumetric flow rate, m^3/s;

k - Share of the flow cross section in the place of installation of the silencer.

D. The Hydraulic Diameter

The hydraulic diameter of the cell's silencer is equal to -

$$D_\Gamma = 4S/\Pi \approx 2t, \qquad (4)$$

Where

S - Cell's area of the silencer, m2;
Π - Cell perimeter of the silencer, m;
t - The distance between the middle baffle of the silencer, m.
Coefficient of friction ξ_{mp} depends on the hydraulic diameter of the channel's cell.

E. Coefficient of Local Resistance

The Coefficient of local resistance depends on the resistance coefficients of input and output of the site and is calculated as follows

$$\xi_{м} = \xi_1 (1 - K)^{3/4} + \xi_2 (1 - K)^2 \quad (5)$$

Where,

ξ_1 - *Input Resistance factor;*
ξ_2 - *Output Resistance factor;*
k = Fnp/F - The proportion of the flow cross section in the installation location of the silencer;
Fnp - the cross sectional area for flow, m;
F - Sectional area of the channel at the installation site of the silencer

From the above formulas we can see that drag depends on the square of the Flow rate at the section between the baffles of the silencer. The aerodynamic drag decreases by increasing the share of the flow cross section. Fairings reduce noise generated by the silencer up to about 10 dB, so it is advisable to install Fairings always. It is necessary that the noise generated from the source should be reduced by at least 10 dB after the silencer.

IV. CONCLUSION

In these paper different types of Silencers and designing & noise control through the use of absorptive, parallel baffle-type silencer, also known as dissipative silencers have been studied. Some guidelines and design formulas are given to design a dissipative silencer correctly.

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