NOISE REDUCTION TECHNIQUES FOR FORCED DRAFT FAN IN THERMAL POWER PLANT USING REACTIVE 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 reactive 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 Reactive 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 types 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 provide 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. REACTIVE SILENCERS DESIGN

Reactive silencers are basically chamber and tube type units that may include some packing materials for middle and high frequency performance. These types of silencers are principally used on reciprocating engines (pistons) or other equipment having significant impulse type sound energy. The chamber and tubes are designed (tuned) to the principal impulsive frequencies that need to be attenuated. The attenuation is caused by the chambers and tubes that create internal reflective sound fields that reduce the sound energy. Because these units are tuned for each application, any changes will affect performance and includes connecting ducting, especially tail pipes. Figure 1 shows a combination reactive silencer having a small absorptive pack section.

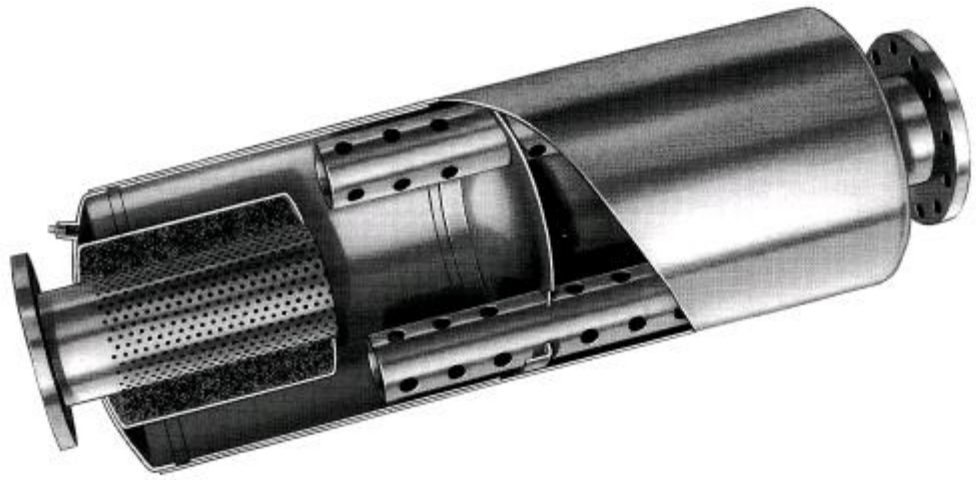

Figure 1 – A typical reactive silencer

The acoustical performance of reactive silencers is usually specified in terms of insertion loss (IL) or transmission loss (TL), a more appropriate metric. The TL and IL become identical in the case when the silencer termination is anechoic (all sound exiting the silencer is perfectly absorbed – no exit or termination affects). The ultimate selection of an evaluation criterion is based on the trade-offs between the desired accuracy in the predictions and the amount of available resources ($). For example, the source impedance required for IL predictions can be determined experimentally but is too costly and time consuming. As a result, the silencer design is generally based on predicted TL, with a clear understanding of the associated approximations. The final evaluation can only be verified by actual field-testing the IL.

DESIGN BASICS

Reactive silencers are generally a series of interconnecting chambers of varying lengths with internal pass tubes and the performance is determined principally by the geometry of the unit. The length of the chamber and pass tube typically controls the tuning (frequency) and the change in diameters controls the amount of attenuation; the greater the change in diameters the greater the attenuation. Multiple chambers can be acoustically coupled to further enhance low frequency attenuation but again the available length can limit the performance.

The tuning of the chamber and pass tubes is based on. wave length reflections and impedance mismatches where changes in cross area occur as exhaust flow enters and exits chambers through smaller diameter pass tubes. The . wavelength is determined by the gas temperature entering the silencer; higher gas temperature cause an increase in the sound of speed (c) creating a larger wavelength, λ.

The speed of sound at atmospheric pressure may be estimated by,

$c = 49.03\sqrt{(T\ °F + 460)}$ ft/s **(1)**

$c = 20.05\sqrt{(T\ °C + 273)}$ m/s **(2)**

Where, T is the temperature in either Fahrenheit or Celsius as appropriate. If the gas is under pressure then the speed of sound must be calculated based on the pressure (P) and density of the gas (ρ). The symbol, $\sqrt{(\ldots)}$ means to calculate the square root of the argument (…).

$c = \sqrt{(1.4P/\rho)}$ m/s or ft/s **(3)**

The . wavelength is then,

$\lambda/4 = c/(4\cdot f)$ feet or meters depending on c **(4)**

where, f is frequency (Hz).

The base attenuation is a function of the change in diameters. A classical simple in-line expansion chamber provides the following transmission loss,

TL = 10 log [1 + . (m – 1/m)2 sin2(kL)] dB **(5)**

where m is the area ratio (large/small), k is the wave number (ω/c) and L is the length of the chamber ($\omega = 2\pi f$). The argument of the sin function becomes unity for a tuned chamber where kL = 1 at that particular frequency (f).

PERFORMANCE CRITERIA

It is critical to clearly state the requirements of the silencer to be supplied and understand what is being specified and how it will be measured for compliance. The following information should be provided as a minimum:

a. Acoustical criterion or criteria.

b. Flow rate, operating temperature and pressure loss limits.

c. Engine data and operating conditions, rpm (fixed or variable speed application), number of cylinders dual or combined, silencer for V bank engines 2 or 4 cycle

d. Machine acoustical data – must be frequency based.

Identify significant engine orders

e. Connection data, orientation, and size limits including weight.

f. All specifications and standards related to the performance requirements.

g. All specifications and standards related to measurements.

IV. CONCLUSION

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

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