Noise Reduction Techniques for Forced Draft Fan in Thermal Power Plant using Inline Diffuser 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 Diffuser 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. Inline Diffuser Silencers Design

This specialized type of silencer is used for noise control in closed systems based on a suitably modified type D diffuser silencer. The fluid is expanded through a multitude of small diffuser bores into a finely woven stainless steel wire mesh. Its typical applications include closed systems requiring muffled in-line expansion of gaseous fluids under pressure without releasing them into the atmosphere. The suitable media includes air and air constituents, steam, natural gas and technical gases. Its noise level reduction is upto 50 dB.

Figure 1 – An Inline Diffuser silencer

The diffuser silencers shall include an internal core of consistent diameter along the entire length in the direction of airflow. The core diameter shall be selected based on the adjacent hub diameter or in the case of C-frame mounted motors, the motor frame size for the respective fan system on which the diffuser silencer is installed. The internal core shall be constructed from lock-former quality type G-90 galvanized perforated steel in the same gauge as the internal diffuser cone. The core shall be supported by a minimum of three welded radial attachment brackets installed at 120 degree angles to each other to provide uniform support. Combustion ratings for the silencer acoustic fill shall be according to NFPA Standard 255.

CONSTRUCTION

A. Four inch long, 11 gauge sleeved end connections shall be provided as standard. When noted, rolled angle flanges shall be factory welded to the sleeve.
B. For units where the minimum diffuser cone diameter is 36” or greater, an additional support rod shall be welded between the radial bracket and the sleeve to prevent a twist from being exerted on the internal core by the fans air flow.
C. All welds shall be touched up with zinc rich paint after fabrication.
D. The internal core and the rectangular outer jacket of the diffuser silencer shall be filled with glass fiber of a density sufficient to obtain the specified acoustic performance.
E. The fill shall be packed under not less than 5% compression to eliminate voids due to vibration or settling. The fill material shall be inert, vermin and moisture proof.

ACOUSTIC AND AERODYNAMIC PERFORMANCE

A. Acoustic ratings shall include Dynamic Insertion Loss (DIL) and Self-Noise Power Levels both for forward flow(air and noise in same direction) and reverse flow(air and noise in opposite direction) with airflow of at least 2000 fpm entering face velocity.
B. Diffuser silencers shall function as pressure regain devices to minimize system pressure losses at the fan. Fan selection are based on the regain performance of the diffuser silencer configurations specified.
C. Any deviations in configuration which adversely affect the fan performance efficiency will not be accepted.
D. Silencers shall not fail structurally when exposed to a differential air pressure of 8 inches water gauge inside to outside the casing.

THERMAL DIMENSIONING

In addition to the correct material selection for the silencer, the thermal expansion in particular of the piping leading to the silencer may have to be taken into account. It can be derived by using the standard formula

$$Dl = l \times a \times DT \times 10\text{-}6 \text{ [m]} \quad (1)$$

MECHANICAL DIMENSIONING

The reaction forces caused by a vertical blow off can be calculated as follows –

$$R = wa2 \times Sa/va \text{ [N]} \quad (2)$$

Where R = reaction force (N)

Sa = outlet surface (m2)

Wa = blow off velocity of the expanded gas (m/s)

Va = specific volume of the expanded gas (m3/kg)

.IV. CONCLUSION

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

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