An Overview of the Design, Performance and Monitoring Aspects of Thermal Power Station ESP's - Indian Scenario

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Abstract

India has an ambitious power generation plan in the near future and continues to depend on coal as a fuel source (presently 58.5% of coal based power generation of the total installed capacity). Based on the high ash content of Indian coals, the electrostatic precipitator (ESP) is an important component of coal fired thermal power plants. With the progress of science and technology, the improvements in ESP are manifold. This paper highlights in the Indian scenario, an overview of electrostatic precipitators and the issues related to the design for structural integrity and performance of the electrostatic precipitator, issues related to improving performance efficiency and monitoring particulate emission.

1.0 Introduction

India presently has a power generation installed capacity of 2,25,793 MW comprising of thermal, hydro, nuclear and renewable (small hydro, urban & industrial waste power, biomass, wind, and solar). Thermal power generation accounts for 68.13% of total installed capacity. Coal contributes towards 1,32,288 MW, gas 20,359 MW and diesel 1200 MW (Source: CEA). It is therefore evident that thermal power plants in India, using coal as a major source of fuel, biomass, and urban & industrial waste are all installed with electrostatic precipitators for particulate emission control.

The electrostatic precipitator design depends on the ash characteristics in terms of quality and quantity and the gas volume to be treated. It also requires proper sizing and optimizing the precipitator efficiency for performance. The precipitator performance depends on several factors such as specific gas volume and the dust load, gas flow rate, particle size and size distribution, particle resistivity, gas temperature, collecting plate and discharge electrode geometry, electrode spacings, current and voltage, and rapping system and frequency. The monitoring involves dust load measurements by isokinetic sampling both at the inlet and the outlet of the electrostatic precipitator to evaluate the system in terms of performance efficiency. The monitoring of particulate emission at the outlet of the electrostatic precipitator is carried out to determine the level of emission, mg/Nm^3 as per pollution control norms.

Fig.1: Electrostatic Precipitator at the Thermal Power Station

This paper highlights in the Indian scenario, an overview of electrostatic precipitators and the issues related to the design for structural integrity and performance of the electrostatic precipitator, issues related to improving performance efficiency and monitoring particulate emission.

1.1 Design for Performance & Structural Integrity of ESP

The design and installations of the electrostatic precipitators in India, comprehensively considers technical data involving number of precipitators per boiler, the number of bus sections, number of electrical fields, total number of electrical fields per boiler, the space distance between the centres of collecting electrodes across the gas path, height & length of collecting electrodes, total collecting area, specific collecting area, gas velocity, treatment time, total number of high voltage rectifier units with voltage rating, and predicted pressure drop across the ESP, the flue gas parameters in terms of gas flow rate and temperature, dust concentration at ESP inlet, moisture in flue gas, required outlet particulate emission, and the coal data. The ductwork and the electrostatic precipitator is also designed to support its load, including wind and snow loads, accumulated fly ash, negative/positive operating pressure, gas temperature and expansion joints are provided to withstand thermal growth.

In practice, it is noticed that inspite of taking the above parameters into account while designing the ESP, an increase in the ash content tends to impact its performance by overloading. Hence, it is required that the coal quality is always matched with the ESP design data through blends to attain the desired efficiency and meet environment emission standards. Bharat Heavy Electricals Limited, is a major manufacturer and supplier of electrostatic precipitators in India through dedicated research and development efforts bringing about several improvements in technology over the years.

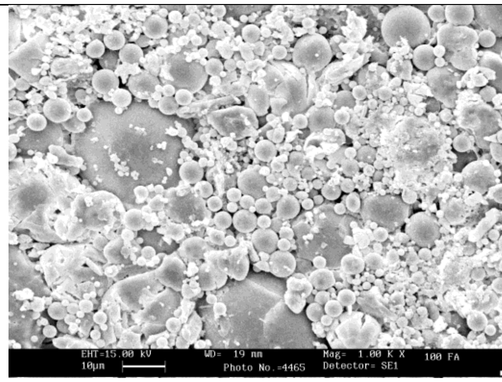
Fig.2: Structural steel supports of electrostatic precipitator

1.2 Performance Efficiency Issues

The design and sizing of the electrostatic precipitator takes into account the ash content in the coal. Based on the coal quality varying in terms of its quality from various sources in India, it is seen that the ash content is increasing and has reached levels of more than 50%. Hence, there is a huge shift from the ESP design data leading to non uniform distribution of particulate matter in the flue gas stream as it enters the ESP thus increasing additional load on the electric fields resulting in frequent tripping of ESP fields. This could be overcome by matching the design coal quality through blending of indigenous raw, washed and imported coal. The physical and chemical properties of fly ash particles originating in the boiler during the combustion of coal also impact the ESP in terms of erosion and corrosion. These fly ash particles are generally spherical, ranging in particle diameter from less than 1 μm up to 300 μm and have varied chemical composition. A typical evaluation of fly ash characteristics is shown in Table 1.

The distribution of particle sizes, chemical composition and the alpha quartz content in fly ash has a direct impact on the erosion of ESP internals through snapping of discharge electrodes. In case of unburnt carbon being high in the fly ash, these tend to combust during the precipitation process in the electrostatic precipitator and lead to buckling of the ESP internals resulting in damage.

Table 1: The typical physical and chemical characteristics of Indian Fly Ash

Characteristic Property	
Particles Morphology	 Mostly spherical
Particle Size (μm)	<1 -300
Hardness (mohs)	5-7
Mineralogy	Quartz, Mullite, Hematite, Magnetite, Lime, Amorphous -Aluminosilicate
Chemical Composition (%)	SiO_2 : 45 - 60 Al_2O_3 : 20 - 30 Fe_2O_3 : 3-5 CaO : 2 - 5 Na_2O : 0.5 - 1 K_2O : 0.5 – 1.5 MgO : 0.5 – 1 TiO_2 : 0.5 – 1.5 SO_3 : 0.3 – 0.5 P_2O_5 : 0.2 – 0.5
Unburnts	0.5 – 2.0

1.3 Particulate Emission Monitoring

The particulate emission monitoring is carried out periodically in thermal power stations using the stack monitoring kit. As per the USEPA guidelines, the emission measurement is required to be made at the sampling ports located in a non turbulent zone which is atleast 4 duct diameters upstream and 8 duct diameters downstream. The older thermal power stations in India meet this requirement. The later ESP's and retrofitted ones do not have proper sampling ports. The sampling ports are also located at positions not accessible to the monitoring personnel.

Fig. 3: Ductwork of the electrostatic precipitator

Fig.4: Sampling ports and Emission Monitoring

The guideline for particulate emission limit across the world is tending towards less than 50 mg/Nm^3, it is required that the ESP's of thermal power plants in India are also provided with the right type of sampling ports both at the inlet and outlet of ESP for evaluation of its efficiency and also monitoring the particulate emission to reach the desired levels.

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