Reducing SPM Quantity in Exhaust Gas Using Ammonia as Reagent in 210MW Thermal Power Station

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***Abstract*—Increased population and industrial development demands sustainable electricity, the majority of which is produced by Thermal Power Stations, which utilize coal as a fuel all over the world. Coal burning results in generation of large quantities of coal residues, which contains very fine particles that tend to become air-borne and which contribute to the formation of Suspended Particulate Meter (SPM). Hence, in order to safeguard the environment against the emission of SPM, pollution control devices, such as cyclone separators, bag filters and Electrostatic Precipitators (ESPs) have been employed. In addition, flue gas conditioning (FGC) is practiced to increase the efficiency of ESPs, with the addition of chemical additives (Ammonia) to the flue gas. This process increases the collection efficiency of the electrostatic precipitators, and thereby results in reduction of the SPM level. However, the effects of the process, which play an important role in efficient FGC, need to be investigated thoroughly before utilizing this method. With this in view, a critical review of various flue gas conditioning techniques employed for controlling the SPM level in thermal power stations is presented in this paper. The present study also reports analyses of data obtained from different thermal power stations in India as well as the rest of the world.**

Keywords*— Thermal power station, exhaust gas, SPM quantity, Ammonia

I. INTRODUCTION

The availability of the electrical energy and it‘s per capital consumption is regarded as an index of national standard of living in present day civilization. The flourishing power generation industry is a sigh of growing gross national products which reflects prosperity of the people. Energy has become synonymous with progress. Therefore the energy is considered a basic input for any country for any country for keeping the wheels of its economy moving. Next to food the fuel and power are the most important items on which national standard of life depend. Therefore every stride has been made to increase the power potential of the nation once the requirement of the food is fulfilled. The production of food also increases with an increase in power. Therefore, the increase in power potential is considered most important among all. The energy in the form of electricity is most desired as it is easy to transport, easy to control, clean in its surrounding and can be easily converted of electricity in the total energy of consumption of country shown a consistent increase in the past year. As the requirement to electricity power is increasing the number of power producing stations. Electricity is developed in Hydro power stations thermal power and Nuclear power stations. The thermal power station are using more the fuel, the exhaust of the power plants pollutes the air. So the exhaust air is treated and they sent to the atmosphere at chimney. Electrostatic precipitator is used in Mettur Thermal power station to treat the exhaust air. The Government has introduced regulations to control the pollution of the environment. The aim of this project is to reducing SPM and improving the performance of ESP in Mettur Thermal power station, and suggesting the solutions. Air pollution may be defined as the presence of impurities in excessive quantity and duration to cause adverse effects on plants, animals, human beings and material. Every day man breaths nearly about 22000 times and inhales approximately about 150 to 22 kg of air. The air is available abundantly on the earth and it contains oxygen, carbon dioxide, nitrogen and small amount of other gases which are harmless to us. However it also contains substances that are harmful like, sulphur dioxide, carbon monoxide, nitrogen oxides, hydrocarbons, dust, soot, smoke, and other suspended matter. Every time we inhale we carry dangerous air pollution into our bodies. These pollutants can cause short term as well as long term effects to the human beings. The air pollution enters into atmosphere by various natural and manmade activities such as forest fires, volcanic eruptions dust storms, rapid growth of industries and vehicles. Pollution in the air causes some physical ill effects besides undesirable aesthetic and physiological effects. The environmental pollution by thermal power plants using fossil fuels poses a serious health hazard to modern civilization. Air pollution by thermal power plant contributing in the cause of various respiratory diseases and lung cancer. The thermal power plant burns the coal contributes to air pollution in large measure in air pollution. The energy industries are one of the largest sources of pollution. A 350MW coal fired station emits about 75 tons of SO2, 16 tons of NO2and 5 tons of ash every day if no safeguards adopted.

L.A.Jimoda et al (2012) investigated Airborne particulate matter has now become an issue in the global environment due to the health problems and environmental degradation it causes. This has necessitated that most developing countries try to set standards for coarse and fine particles due to their noticeable impacts on the environment. This paper is a critical review of how particulate matter in the atmosphere affects visual air quality, human health, soiling and damage to materials, vegetation/animals, soil/water bodies and direct/indirect eradicative forcing. The challenge in this paper is to describe the comprehensive effects of this pollutant so as to identify its minimization in the environments with the view of developing its effective control strategies for adequate air quality management. Nitin G Punekar et al (2002) Increasing population and industrial development insist sustainable electricity, which, in India, mainly depends on coal based thermal power stations for the generation of electricity. However, the combustion of high ash coal results in production of large quantity of ash, which essentially comprises bottom and fly ash. Fly ash particles that are in the form of suspensions in the flue gas contribute to an increased suspended particulate matter (SPM) in the surrounding environment. As such, for safeguarding the environment, reduction in the emission levels of the SPM becomes essential. To achieve this, ammonia flue gas conditioning is explored in the manuscript. S.Shanthakumar et al(2005) investigated the SPM increased population and industrial development demands sustainable electricity, the majority of which is produced by thermal power stations, which utilize coal as a fuel all over the world. Coal burning results in generation of large quantities of coal residues, which contains very fine particles that tend to become air-borne and which contribute to the formation of suspended particulate matter (SPM).Hence, in order to safeguard the environment against the emission of SPM, pollution control devices, such as cyclone separators, bag filters and electrostatic precipitators (ESPs) have been employed. In addition, flue gas conditioning (FGC) is practiced to increase the efficiency of ESPs, with the addition of chemical additives, or sprinkling water to the flue gas. This process increases the collection efficiency of the electrostatic precipitators, and thereby results in reduction of the SPM level. However, the effects of the process, which play an important role in efficient FGC, need to be investigated thoroughly before utilizing this method. With this in view, a critical review of various flue gas conditioning techniques employed for controlling the SPM level in thermal power stations is presented in this paper. The present study also reports analyses of data obtained from different thermal power stations in India as well as the rest of the world. S.S. Bagchil et al (2007) investigated In India coal-fired power plants are equipped with electrostatic precipitators (ESP) to combat the suspended particulate matter emission from the stack. The efficiency of electro precipitator in removal of particulate matter is dependent upon the ability of the particulate matter to accept and release of electric charge. This characteristic of the particulate matter is generally referred to as ash resistivity. An exhaustive literature survey was undertaken to understand the resistivity problem. The resistivity is an electrochemical property and this paper describes the other aspect of ammonia that helps in agglomeration of the particles and enhances the collection efficiency of the electrostatic precipitators.

II. Problem Formulation

Electrostatic precipitator is used in Thermal power station to treat the exhaust air. The Government has introduced regulations to control the pollution of the environment. The problem that we identify from the power plant is the performance of the E.S.P didn‘t meet the expected levels. And the rate of SPM that are emitted through the chimney cross the limit of the government norms. Because of this they paid the penalty for the government. To reduce ash content and to control SPM, earlier the Indian coal was blended with imported coal and consequently the average ash content in the bunker coal was about (Ash content of Indian coal is about 40% and imported coal is about 8%).

III. Experimental Setup

A. *Efficiency Improvement using Ammonia Dosing*

Ammonia dosing was introduced to the flue gases entering in to the ESP units of power plant. Inlet and outlet dust loadings were measured at various stages of ammonia dosing. The various parameters measured under different conditions of experiments. The parameters like collections efficiency (η) migration velocity (ω), deviations in migration velocities ($\Delta\omega$) have been calculated based on Anderson-Dutch relation for the experimental conditions are described. Based on results, some inferences may be drawn as follows:

- There is a significant drop in the out let concentration because of injection of ammonia, although there seems to have some optimum value of ammonia dosing at around 15 Kg/hr (~0.142ppm).
- The ESP collection efficiency is enhanced due to ammonia dosing and so is the migration velocity. The migration velocity rises in the range (16.60-22.82) % as different doses of ammonia conditioning compared to no dosing.
- It is possible to achieve new emission standard (~100 mg/Nm3) using the same ESP units by appropriate amount of dosing of ammonia in to flue gases.

B. *Design Aspects of Ammonia Injections Condition System*

The critical requirements required from power plants for ammonia injections to perform are as follows

- The ash has to be acidic with a PH value less than 7.
- The combined silica and alumina content in the ash should exceed 85%.
- The leached analysis has to be accurate and provided by the customer.

- ESP should be in sound electrical and mechanical condition.
- Minimum secondary voltage of 25 KV and current 200 ma in each field , with minimum 95% of the corona power specified by the ESP supplier and all fields in service.
- Ash handling system functioning properly and evacuating ash continuously from all the hoppers.
- Treatment time as per ESP Design parameter specified by ESP supplier.

C. Equipment's required

Centrifugal pump, Ammonia, Storage Tank, Tube, nozzle and flow control valve.

IV. RESULTS AND DISCUSSIONS

Ammonia filled in the storage tank. Ammonia from storage tank pumped into duct through centrifugal pump by creating vacuum inside the pump. Ammonia injected by the pump through nozzle fixed at one end. Using flue gas duct after boiler before the ESP and inject the ammonia liquid using the pump on top of the flue gas duct near by the feeder floor of unit-1/MTPS-1.

A. Ammonia Dosing Flue Gas Reaction

$2NH_2 + SO_2 + H_2O = (NH_4)_2SO_3$ Ammonium Sulphate (W)
$NH_3 + H_2S = (NH_4)$ HS Ammonium Hydrosulphite
$NO_x + NH_3$ Chemiluminescence

B. Proposed Method

$NO + NO_2 + 2NH_3 = 2N_2 + 3H_2O$

$NO + NH_3 + 1/4O_2 = N_2 + 3/2\ H_2O$

$NO_2 + 4/3\ NH_3 = 7/6\ N_2 + 2H_2O$

$CuSO_4 + NH_3 = [Cu\ (NH_3)_4]\ SO_4$

$CO + NH_3 = CO\ (NH_3)6$

$CO + H_2O = H_2 + CO_2$

$N_2 + 3H_2 = 2NH_3$

$2NH_3 + CO_2 = NH_2\ COONH_4$ (Ammonia carbonate)

NH_2 COONH4 = $H_2O + NH_2\ CONH_2$

C. Model Calculations

- Flow Rate of Flue gas = 363.1m3/sec
- Convert in 8 Hour for flow rate = 8928000 m3/hr
- We used 120000 m3 for 8 Hours ammonia injection = 8928000/120000 = 74.4 µg/m3
- 8 Hours SPM rate = 178.42µg/m3
- SPM rate after ammonia injection reaction = 178.42-74.4 = 104.02 µg/m3

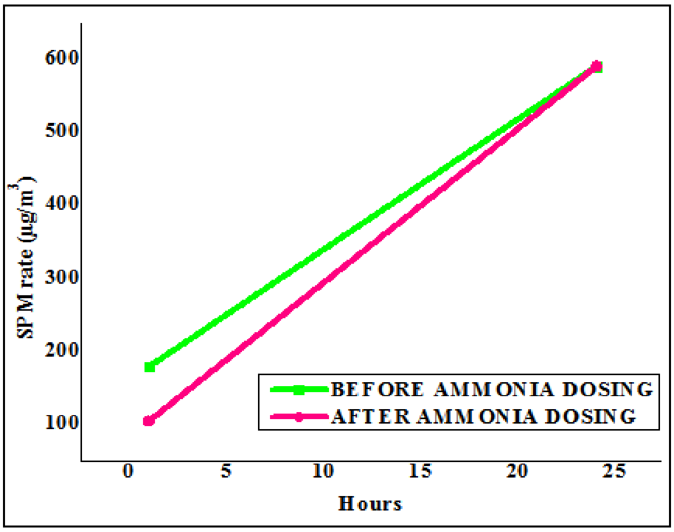

Fig. 1. Effect of Ammonia dosing.

SUMMARY

An effort has been made to review the existing literature on the devices which are employed by various thermal power stations for reducing SPM levels. It has been observed that ESPs are widely employed for this purpose. However, the other SPM emission control methods are less effective, FGC becomes the inevitable choice for improving the performance of ESPs. The results obtained from Ammonia Dosing system has been exceptionally good and the operation of the system has given confidence that the SPM level in the exit flue gas can be maintained as low as possible by adjusting the ammonia feed concentration. SPM levels can be easily controlled to the desired level by simply adjusting the dosing amount of the ammonia flue gas conditioning. These agents are quite helpful in improving the dielectric characteristics of fly ash particles, which results in enhanced ash collection efficiency of the ESP. If the E.S.P performance is not up to the regulations of the government norms it is the fine method to control the SPM level and improve the E.S.P.

Advantages of Ammonia Injections Flue Gas System.

- Agglomerates fine particulate in the gas stream, which produces an attendant reduction in opacity.
- More adhesive fly ash layers collected on the precipitator plates reducing rapping losses.
- Increases space charge.
- Eliminates — fuel plume (SO3 slip)
- Lowers acid dew point.
- Reduces rapper re-entrainment and emissions.

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