Modification of Electrostatic Precipitator Design by Chemical Composition

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Abstract

Electrostatic precipitator is a device used for controlling air pollution. This is used for cleaning of boiler process gases. Process gases contain suspended dust particles; this dust particle is collected on collecting electrode. The effectiveness of electrostatic precipitator is affected by various factors so in this project we are implementing a sparking system for improving ESP system by Executing outside of the ESP by chemical reaction from wet particle. Results show that the proposed model can fulfill the working condition at large amount of dust particles as well as small particles. The model can also provide a theoretical guidance in the related researcher fields.

Keywords: - *hot flues gases, dust particles, ESP's plates, sparking system, chemical reaction*

I. INTRODUCTION

Electrostatic Precipitator (ESP) is the major dust removable equipment of the boiler. It is necessary to evaluate the system for controlling the dust particles of the hot flues gases. Moreover, its resistivity of ESP is the key factor which resists the all types of dust particles at the range of micro. The plates which is placed at the system that can generate the flux due to the high voltages. Electrostatic Precipitator, large industrial emission control equipment, designed to arrest and eliminates dust particles from the exhaust gas stream, ensures a clean and green environment by typically collecting the dust from the gas stream.ESP also implemented for collecting dust particles in Nano form present in various harmful gases such as sulphur, nitrogen, silicon, aluminum, potassium, carbon etc. This project is about designing various equipment's that are necessary for proper functioning of steam system.

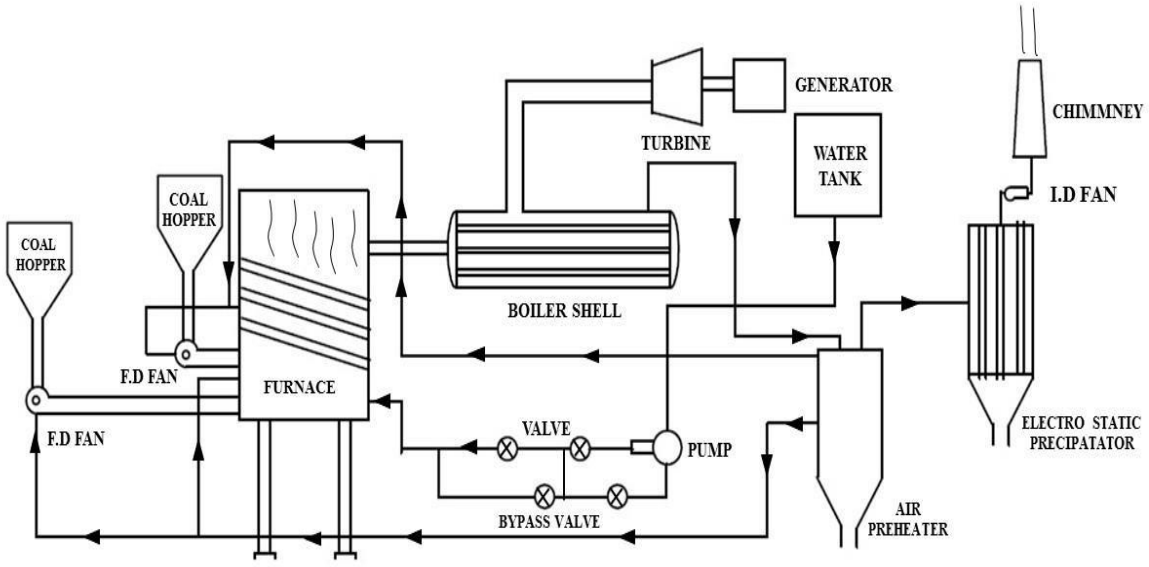

Fig.1:- ESP representation of the Boiler system

II. METHOD

In the practical project, it's necessary to mention the initial condition syndrome for better execution at the proper required system. For the heat transferring to generate the steam , furnace and fuels are required to the burn at the required temperature. In order to simply analyze the thermal resistance inside the borehole, its required to mention the chemical composition which is mention in below:-

A. Chemical composition in boiler furnaces (at Electrostatic precipitator chamber)

- Nitrogen oxide with oxygen for the burning of the fuel that release nitrate with one molecule of oxygen.

$NO + O2 \rightarrow No2 + 1/2O2$

- Carbon monoxide with oxygen at the combustion chamber that release is carbon dioxide with one molecule of oxygen.

$CO + O2 \rightarrow CO2 + 1/2\ O2$

- Sulfur monoxide with oxygen at the burning chamber that releases the sulfate with one molecule of oxygen.

$SO + O2 \rightarrow SO2 + ½\ O2$

- Sulfate with oxygen at the burning chamber that releases the sulfite with one molecule of oxygen.

$SO2 + O2 \rightarrow SO3 + ½\ O2$

- Ferrous oxide with react with oxygen during the high temperature and release the ferric oxide.

$FeO + O2 \rightarrow FeO3$

The compositions of the gases are in different percentages which evaluate the functioning of the system for the reaction of the inside of borehole[6].

Table 1:- different types of dust particles

Item	SiO2	Al2O3	Fe2O3	MgO	CaO	TiO2	Na2O	K2O	Specific resistivity*
Unit	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	Ω·cm
Value	47.63	33.61	8.37	0.74	4.37	0.73	0.11	0.57	4.3×1011

B. Resistivity

- High resistivity can generally be reduced by doing the following:
- Adjusting the temperature
- Increasing moisture content
- Adding conditioning agents to the gas stream
- Increasing the collection surface area and
- Using hot-side precipitators (occasionally and with foreknowledge of sodium depletion).

Thin dust layers and high-resistivity dust especially favor the formation of back corona craters. Severe back corona has been observed with dust layers as thin as 0.1 mm, but a dust layer just over one particle thick can reduce the sparking voltage by 50%[2]. The most marked effects of back corona on the current-voltage characteristics are:

1. Reduction of the spark over voltage by as much as 50% or more;
2. Current jumps or discontinuities caused by the formation of stable back-corona craters; and Large increase in maximum corona current, which just below spark over corona gap may be several times the normal current[2].

C. Plates design

In moving-electrode type, the collecting plates are divided into short strip elements that are joined by chains, and the collecting plates are moved slowly. The dust collected on the collecting plate elements is completely scraped off by rotating brushes provided in the hoppers[5].
The moving-electrode type has the following features.

1. The surface of the collecting plates is clean and there is no back corona. Therefore, fine, highresistivity dust can be efficiently collected.
2. The brushes in the hopper scrape off the collected dust, and there is no reduction of performance due to rapping re-entrainment.
3. Because the equipment always has high collection efficiency, it can be made compact.

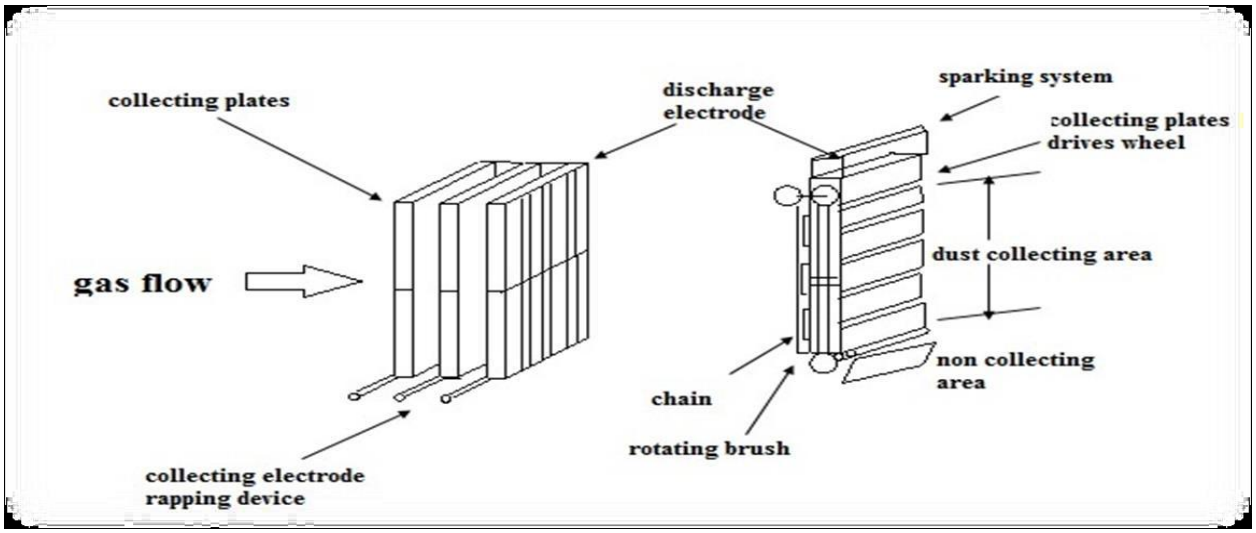

Fig.2:- Design of plates with the sparking system

Fig. 3:- Plates design in solid works

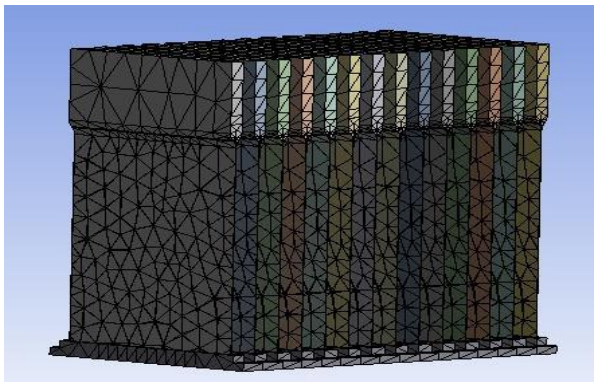

Fig. 4:- plates with meshing

The ESP plates are consisting the important parameter to executing the sparking system. The sparking systems could be placed at the upper level of plates which generate the heat at high range of temperature for occurring the chemical reaction in proper way. By the executing of sparking system , it is necessary to evaluate the storsge tank of the chemical composition and also represent the plate material of carbon steel which used in ESP.

D. Chemical Composition

At the time of chemical reaction, it must be the represented to steam water molecular deformation at the presence of high heat. Also it helps to ESP plates which safe from the corrosion. The water steam deformation is mention in below:-

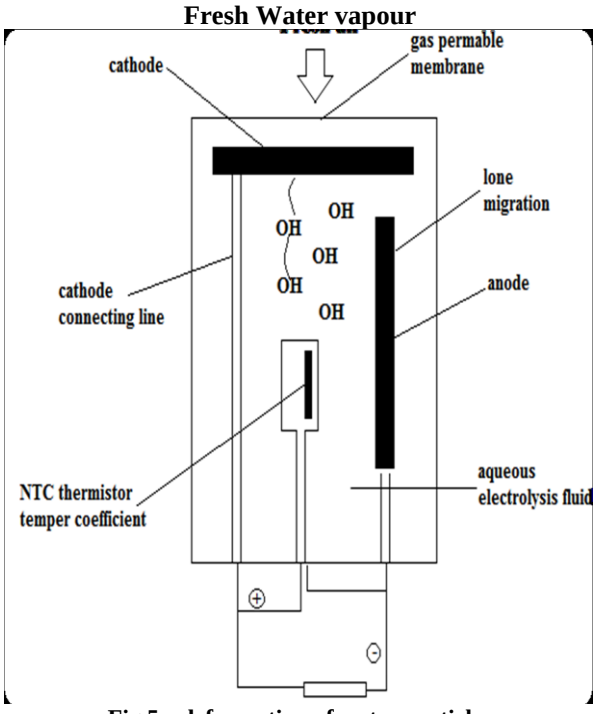

Fig.5:- deformation of water particles

Chemical reaction will be done by adding the Accessories of a sparking system between the two plates at Electrostatic precipitator.

- The sparking system capable to produced high temperature as a 300°C to 500°C that will be enough temp° for the doing the chemical reaction.

- Nitrogen oxide with sulfate oxide done the reaction at the high temp° during the high resistivity.
  $2NO2 + SO2 \rightarrow N2SO4 + O2$

- When wet steam comes with the contact of sulfur oxide then it will be react at the high temp° and done the chemical composition of sulfuric acid and release hydrogen gas.
  $2H2O + SO2 \rightarrow H2SO4 + H2$

- Sodium oxide come with contact of carbon dioxide the at high temp° with presence of wet steam (water) $H2O$. than it should be done the chemical reaction of sodium hydro carbonate with releasing oxygen.
  $2NaO + 2CO2 + H2O \rightarrow 2NaHCO3 + ½\ O2$

- SO2 is an acid gas, and, therefore, the typical sorbent slurries or other materials used to remove the SO2 from the flue gases are alkaline. The reaction taking place in wet scrubbing using a CaCO3 (limestone) slurry produces CaSO3 (calcium sulfite) and may be expressed in the simplified dry form as:
  $CaCO3 + SO2 \rightarrow CaSO3 + CO2$

- When wet scrubbing with a Ca(OH)2 (hydrated lime) slurry, the reaction also produces CaSO3 (calcium sulfite) and may be expressed in the simplified dry form as:
  $Ca(OH)2 + + SO2 \rightarrow CaSO3 + H2O$

- To partially offset the cost of the FGD installation, in some designs, the CaSO3 (calcium sulfite) is further oxidized to produce marketable CaSO4· 2H2O (gypsum). This technique is also known as forced oxidation.
  $CaSO3 + 2H2O \rightarrow CaSO4.\ 2H2O$

- In industry caustic (NaOH) is often used to scrub SO2, producing sodium sulfite
  $2NaOH + SO2 \rightarrow Na2SO3 + H2O$

- A natural alkaline usable to absorb SO2 is seawater. The SO2 is absorbed in the water, and when oxygen is added reacts to form sulfate ions SO4- and free H+. The surplus of H+ is offset by the carbonates in seawater pushing the carbonate equilibrium to release
  CO2 gas:
  $SO2 + H2O + 1/2\ O2 \rightarrow SO42- + 2H+$ ..... (1)
  $2NaHCO3 \rightarrow 2Na+ + 2HCO3-$ ..... (2)

From equation (1) and (2)
$2Na+ + SO42- \rightarrow Na2SO4$

In view of the oxidation of sulfur, the O2 demand is disregarded in the following, since only some fuels contain sulfur and in these cases, as a rule, the sulfur can be disregarded for theO2 demand in view of the comparatively low concentration. For the sake of expedience, differentiation is made between gaseous fuels and liquid as well as solid fuels. Also viewing the oxidation of nitrogen that O2 demand should be increase during the chemical reaction so it must be necessary to evaluate the function of nitrogen gas. At the rainy season a spark light increase the temperature atmosphere that is main reason of reaction between nitrogen & oxygen and it start to react NOx composition. During the reaction time oxygen is more demanded due to 78% nitrogen and 21% oxygen.In the harmful gases not only sulfur or nitrogen but it also necessary to mention the other harmful gases as a carbon dioxide, florin, mercury, chlorine etc. In wet type Electrostatic precipitator the collecting electrode is covered with a water film. This means that there is no back corona due to high-resistivity dust, no re-entrainment due to lowresistivity dust, and no effect due to the electrical resistivity of the dust. Also, the dust collection efficiency is very high. Depending on the washing liquid, it is possible to absorb gases such as SOx, HCl, etc. at the same time.

The collection of the different type of chemical due to the chemical process, it is mention in below[4].

Table 2:- harmful gases remove with the chemical process

Dust	Migration Velocity (m/s)
Zinc Oxide	0.02-0.03
Sulfuric Acid	0.08-0.16
Metal Oxides	0.02-0.03
Calcium Carbonate	0.04-0.05
Smoke Fume pit coal furnace	0.02-0.11
Fly ash from lignite furnace	0.18-0.25
Blast furnace dust	0.05
Smelter dust	0.07-0.09
Blast furnace dust	0.05

E. Analysis of plates

Now, we are using the analysis software for better accuracy of thermal resistance, thermal stresses and natural frequency of the hot flue gases at the presence of convectional water flow. In the software analysis, we are taking some criteria which is mention in analytical parts

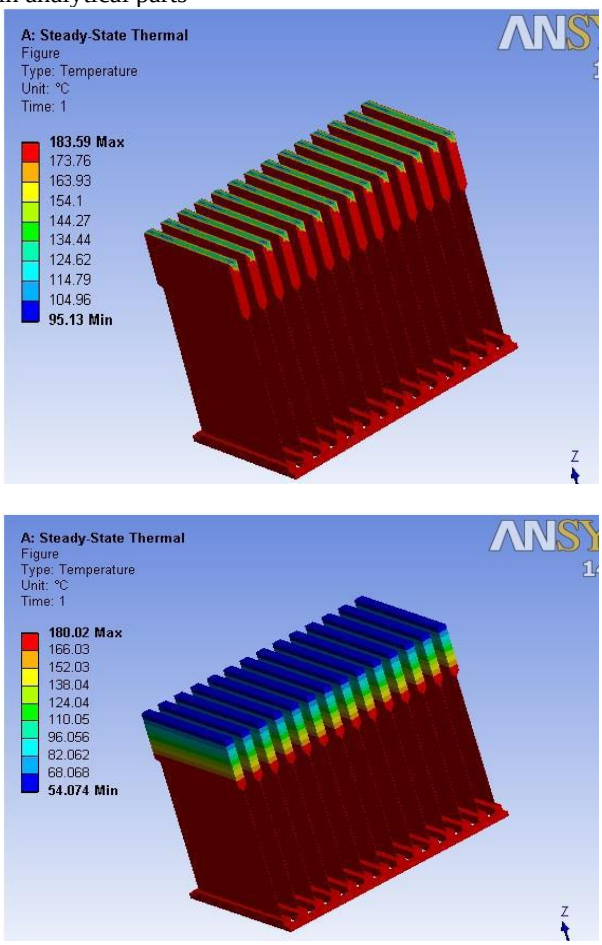

Fig.6 :- Analysis of steady state thermal

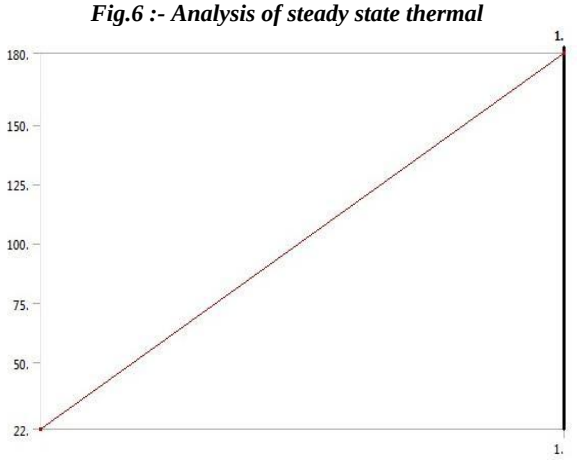

Fig.7:- Steady state thermal graph with temperature (°c)

Table 3:- Material property of the plates

Density	7.75e-006 kg mm^-3
Coefficient of Thermal Expansion	1.7e-005 C^-1
Specific Heat	4.8e+005 mJ kg^-1 C^-1
Thermal Conductivity	1.51e-002 W mm^-1 C^-1
Resistivity	7.7e-004 ohm mm
Compressive Yield Strength	207 MPa
Tensile Ultimate Strength	586 MPa
Young's Modulus	1.93e+005 MPa
Poisson's Ratio	0.31
Bulk Modulus	1.693e+005 MPa
Shear Modulus	73664 MPa

III. CONCLUSION

Based on the theoretical calculations and analyses of the dust particles resistance of Electrostatic precipitator, for comparison of various conditions, this paper has analyzed the main factors which impact on the collection of Nano dust particles. Meanwhile, with the combinations of practical engineering applications, the ways of reducing the harmful gases and enhancing heat transfer of sparking system are discussed. And we've drawn some conclusions.

According to analysis of heat transfer in ESP of the sparking system with wet steam molecules, the thermal resistance inside the plates occupies a large proportion in total thermal resistance, it is an efficient way to improve the heat transfer performance of ESP by increasing thermal resistance inside the plates. Besides, the implement of this project pollution will be totally reduced due to the industrial basis. The world can be free from the pollution by implementing this project in our industries. No any emission can be occurs due to the process. it is the main benefits of this project.

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