Enhanced Temperature Control Logic for Electro Static Precipitator (ESP) Hopper Heaters

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Abstract - *ESPS used to collect fly ash consume huge power to maintain the hopper heater temperature at the required value. In this paper a modification of ESP Hopper heater's temperature control logic is presented. By installing additional temperature sensors and PLC modules to existing system, switching ON-OFF of Hopper heaters can be optimized and large amounts of power can be saved which is also computed theoretically and a case study implemented at JSW Energy validates these calculations.*

Key Words*: *ESP, Hopper, Hopper, Heaters, Optimization, Fly ash.

1. INTRODUCTION

In thermal power plants, large amount of fly-ash is to be collected. ESPs are used to collect the fly-ash after burning the coal as shown in the Fig. 1. Where ever the steam generators are used to generate power, dry-horizontal flow plate types ESPs are used [1]. ESPs contain collecting surfaces and centrally located discharge electrodes. Collecting surfaces are arranged in parallel where flue gas flows in between the plates. Center electrodes are negatively charged using high voltage direct current. Initially particles suspended in the flue gas are charged negatively and attracted towards positively charged collecting electrodes by an electrical field as shown in Fig. 2. After collecting ash particles on the surface electrodes, periodically rapping of electrodes or hammering of electrodes is done and dropped ash is collected in the hoppers [1].

The collecting system encounters a variety of problems. Periodically the hopper must be emptied. Ash level must not touch the bottom of the discharge electrodes. Emptying of the hopper must not be delayed. If the ash collecting in the hopper reaches to the bottom of the discharge electrodes, the electrodes which are in contact with the ash gets short circuited because the mass of the collected ash is in contact with the ground [1].

Electro Static precipitator contains many (more than one) inlets and flue gas is distributed through the inlets almost equally. Hoppers (refer Fig. 3) are arranged in the matrix form which are fixed under ESP. Almost equal amount of ash will be collected in any row perpendicular to the gas flow. More fly-ash will be collected in rows of the ESPs hopper which are near to the inlet of the ESP. 40 to 100 times more fly-ash will be collected in the hopper row present at the inlet side compared to the row present at the ESP outlet side [1].

Most pulverized coal fly-ash is hygroscopic. In the hopper outlets, the ash particles are surrounded by stagnant flue gas. The gas temperature in the hoppers may be below acid dew-point (120-150°) or below the water dew-point (approximately 55-60°) on start-up, shutdown, at low boiler loads, or during the ash removal process. Under these conditions, acid or water is produced by condensation and/ or cementing of the particles can take place. So the collected ash cannot be removed easily from the hoppers. Hoppers contain heaters to increase the temperature of the ash. To reduce the power consumption for ash handling process, fly-ash removal systems are sized to collect ash for long period between hopper empting.

Case study carried out in JSW Energy Ltd. (Vijayanagar) is explained below.

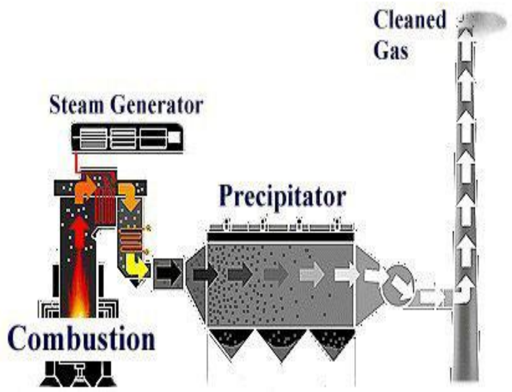

Fig – 1: Flow of Flue Gases through ESP [3]

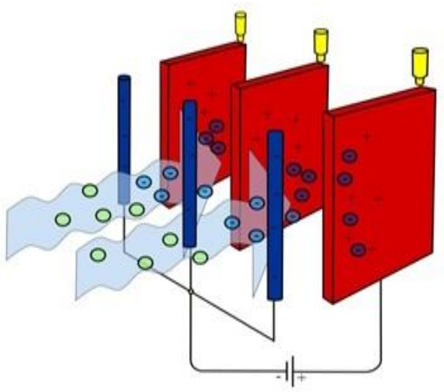

Fig – 2: Conceptual diagram of ESP [2]

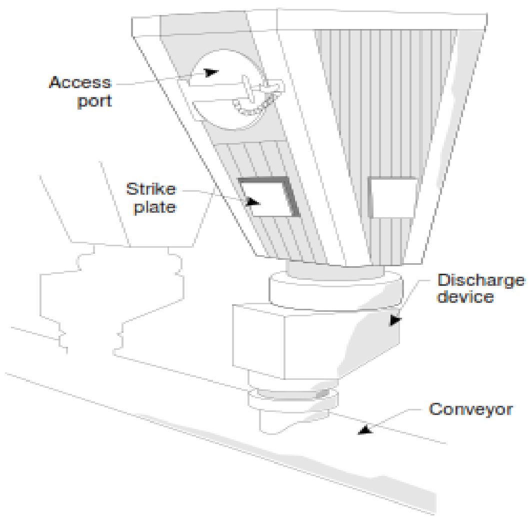

Fig – 3: Hopper [14]

2. ABOUT ORGANIZATION

JSW Energy Ltd. is a part of JSW group in India. JSW Energy Ltd. was started in 1994. JSW energy produces power and other areas of power which involved in are Generation, Transmission, power plant equipment manufacturing and power trading. JSW energy thermal power plant has three branches in India. They are located in Karnataka, Maharashtra and Rajasthan [5].

- JSW Vijayanagar thermal power plant, Karnataka. It is having 1690MW
- Power generation capacity.
- JSW Ratnagiri thermal power plant, Maharashtra. It is having 1200MW power generation capacity.
- JSW Barmer thermal power plant, Rajasthan. It is having 1080MW power generation capacity.

In addition to thermal power plants, JSW Energy Ltd. has two hydro-power plants with a total capacity of 1391MW [5].

Vijayanagar thermal power plant specification [5]:

- 130MW*3units=390MW
- 300MW*4units=1200MW
- 100MW*1unit=100MW

860 MW capacity of power is exported to power grid (KPTCL) and remaining power is used by JSW steel.

3. HOPPER HEATER ON/OFF CONTROL BEFORE MODIFICATION

In JSW energy Ltd. (Vijayanagar) for each 300MW unit there is one Electro Static precipitator (ESP). Each ESP has four flue gas inlets. Every inlet has 12 hoppers in the form of 6 rows and 2 columns. Three heater coils are installed in each hopper [4].

The temperature of fly-ash dropped from the ESP in the each hopper is not same. Fly ash temperature decreases has it moves from ESP inlet side to outlet side. Fly ash present in hoppers at inlet side has more temperature compared to fly-ash present in hoppers at outlet side.

In hoppers ash must be maintained at certain temperature to convey easily and properly. For this reason fly-ash is heated when its temperature is below certain set point [4]. For sensing the temperature of fly-ash, only one temperature sensor was installed to last hopper of every column as shown in Fig. 4 . Based on the last hopper fly-ash temperature of every column, respective entire column hopper heaters were controlled (ON or OFF) [4]. But the temperature of the fly-ash present in hoppers at inlet side of ESP has sufficient temperature. The heaters present in these hoppers need not be in ON condition. Because of this many KW of power will be wasted. That is, unwanted switching ON or OFF of hopper heaters must be stopped.

The Amount of power consumed by heaters per day before modification is as shown in the Table 1:

Table -1: Power Consumption by Hopper Heaters before Modification [4]

No. Of heater coils per Hopper	3
No. Of hoppers for both passes in which heaters are in ON condition during full load operation	48
An average of heaters ON time per day	10hrs
Rating of each coil	2.2KW
Power consumption of heaters per hopper	2.2*3=6.6KW
Total amount of power consumed per day, per unit.	48*6.6KW*10hrs=3168K Whrs.

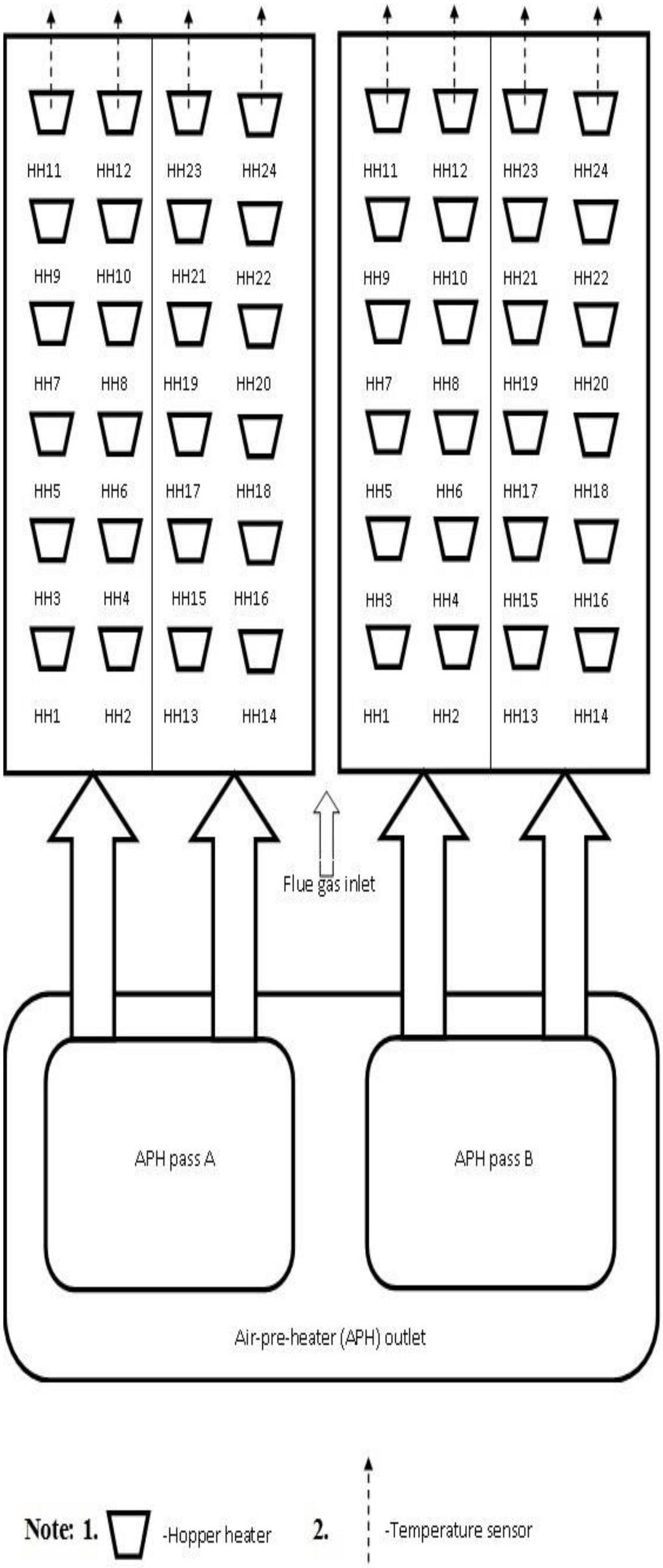

Fig – 4: Hopper Heater Temperature Scheme before Modification [4]

4. HOPPER HEATER ON/OFF CONTROL AFTER MODIFICATION

To overcome the above problem

1. Extra temperature sensors must be installed.
2. Control logic to be changed for smart ON/OFF control of these sensors.

Hopper heater temperature scheme after modification is as shown in the fig. 5.

In row wise, by combining two hoppers which are present adjacently one temperature sensor is installed as shown in the fig. 5. Therefore totally we have to install 24 temperature sensors for one ESP unit. Now by sensing the temperature of particular combined hopper set, ON-OFF logic of hopper heaters of every hopper can be controlled [4]. Thus, we can overcome unwanted switching ON-OFF of hopper heaters. By this large amount of power can be saved.

Average amount of power that can be saved after modification is as shown in the TABLE 2.

Table -2: Power Saved by Hopper Heaters after Modification [4].

No. Of heater coils per Hopper	3
No. Of hoppers for both passes in which heaters need not be in ON condition during full load operation	8
An average of heaters ON time per day	10hrs
Rating of each coil	2.2KW
Power consumption of heaters per hopper	2.2*3=6.6KW
Total amount of power consumed per day, per unit.	8*6.6KW*10hrs=528KWhrs.

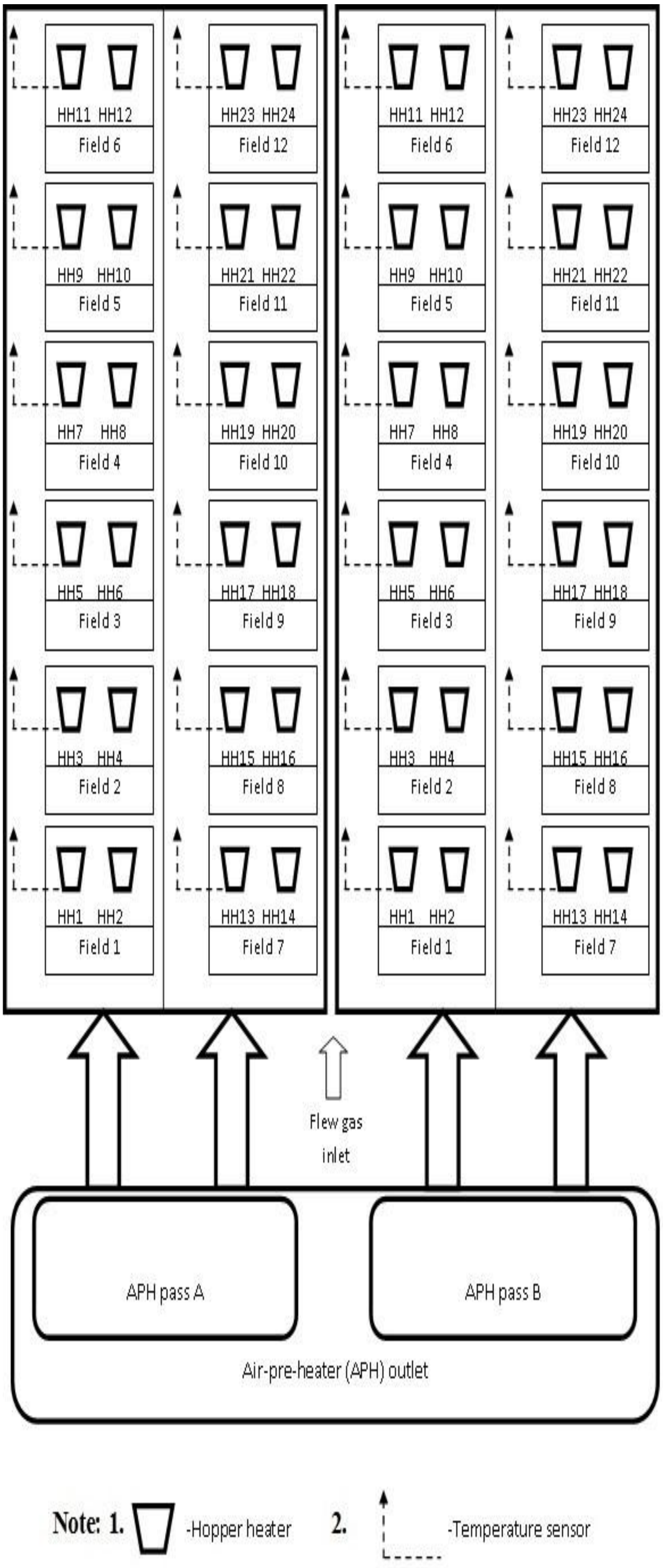

Fig – 5: Hopper Heater Temperature Scheme after

5. CONCLUSIONS

By modifying hopper heaters temperature control logic by installing additional temperature sensors and PLC module to the existing system, hopper heaters can be switched ON when required and can be switched OFF when not required. Thus the power consumption is optimized (i.e. power is saved) and leading to an increased heater's lifetime.

6. FUTURE SCOPE

By installing temperature sensor for all Electro Static Precipitator Hoppers, each and every Hopper heaters can be controlled individually. Power consumption can be further optimized.

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