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RESOLUTION OF HIGH AUXILIARY POWER CONSUMPTION OF ESP HOPPER HEATERS BY THERMAL IMAGING

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A R T I C L E I N F O

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A B S T R A C T

Infrared thermal imaging is a non-intrusive thermal technique that detects transient disparities and provides surface temperatures by way of capturing the radiation energy from the body. Application of this technique in the ESP portion of a power plant has provided extensive data for pioneering design modifications. The purpose of hopper heater modules provided on ESP hopper surface is to avoid clinker formation in the ash being collected at the bottom of ESP. Excessive power intake of the heater elements leads to higher auxiliary power consumption of ESP and has a bearing on the entire power plant operation. The issue of high auxiliary power consumption is resolved by the application of thermal imaging. Extensive data is collected for lucidity and an unambiguous conclusion.

INTRODUCTION

Fly ash is captured and removed from flue gas by Electro Static Precipitators (ESP) located after the Air Pre-Heater (APH) and before Induced Draft fan.ESP hoppers are constantly filled with hot fly ash, which is periodically evacuated by ash conveying system. Due to combined effect of humidity and cooler inner surface, fly ash tends to stick on the sides of the hopper which can cause material build-up and hopper clogging. In addition to lowering performance, this can cause structural damage to the ESP due to overloading. In order to prevent ash build-up, hopper heater modules are provided on outer surface of ESP hopper on 100 % redundancy basis.

Purpose of heaters is to maintain hopper inner surface temperature at about 120^0 C so that ash flows freely without sticking to the walls. Control system is deployed to switch it on or off accordingly. System is designed to achieve the desired temperature within a time period of about 3 hours. Temperature and power consumption control is pivotal for ESP performance [1]-[4].

Problem Definition

The observed auxiliary power consumption in Unit #1, Unit #2 and Unit #3 of the power plant exceeded design value by about 12%, 29% and 42% respectively. Further, the temperature of the inner hopper surface is found to be about 10% below trip value in spite of stand-by heater being ON continually. There are three possibilities for observing such a phenomenon

1. Air ingress into the hopper: Cools the hopper surface and prevents temperature build-up.
2. Malfunctioning of heater module: Improper heating not leading to desired temperatures.
3. Improper insulation application: Heat dissipation to ambient.

Ascertaining the source of the issue from inside the hoppers would be a tedious task and also involve large material investment. Thermal imaging technique does not require extensive modifications to the hoppers internally and might predict the source of concern with relative ease [5]-[7].

Work Carried Out

Measurements

Infrared thermal images were captured using thermo-graphic camera. Settings in camera for distance, temperature colour filters, and emissivity values were set accordingly. A digital thermometer along with a thermo couple probe was used to calibrate emissivity values of the hopper surfaces corresponding to the actual temperatures. For comprehensive thermal mapping, ESP hopper temperatures are captured at locations as shown in Fig 1.

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1. Hopper manhole door
2. Aluminium cladding door level
3. Thermostat location (Location1)
4. Anvil
5. Hopper elevation 1(3m)
6. Hopper elevation 2(4m)
7. Hopper elevation 3(5m)
8. Ash Poke hole
9. Thermostat location (Location2)

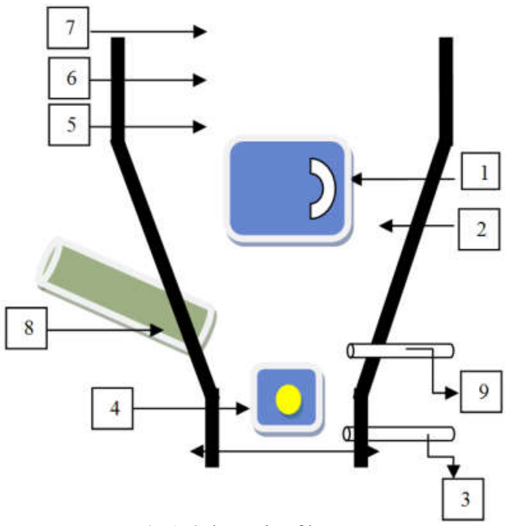


Fig.1. Schematic of hopper

Temperature profiles at nine locations for each of these 108 hoppers in Unit #1, Unit #2 and Unit# 3were taken. To have an overall understanding of temperature distribution, ESP casing temperatures were also logged.

Analysis

Data recorded revealed an inconsistency in temperature distribution. Areas away from heating modules displayed 33% higher temperature than design value. Heating supposed to happen in the hopper compartments at different elevations was absent. This may be due to dissipation of heat from the heater to outside the compartments. As per design, different heater modules should heat the inner surface of hopper, at different elevations separately, without diffusing heat outside. Probability of air ingress did not seem to cause the issue as the aluminium cladding was compact and properly done.ESP control room panel current (Ampere) readings were consistent with design values. Hence the probability of module heater malfunction was ruled out. The possibility of improper insulation lining was to be checked.

Rectification

To verify precision of the insulation erected, one of the ESP hoppers of Unit #3 was selected. Hopper was stripped of cladding sheet on one side, from gate valve upwards by a 3m stretch. A section of the exposed insulation was then cut open and inspected. On investigation, it was observed that there was a gap of 4 inches between the channel (stiffeners) and the surface of insulation wool, as shown in Fig 2.It was also found that the insulation was laid as a blanket sheet from top to bottom onto the hopper surface instead of packing separately in compartments over different heating panel modules.

Fig.2 Space between stiffeners, insulation

Air gap extending from top to bottom throughout the slant portion of the ESP hoppers is the cause for heat dissipation to outside locations. To repair the defective insulation, heating panels were first turned off and the surface was allowed to cool. Insulation was then entirely removed from hopper surface as shown in Fig 3.

Fig.3 Stripped Insulation from a hopper

Fresh insulation material was brought and properly laid onto the stiffeners without leaving any gaps, as shown in Fig 4. The heating modules were subsequently isolated (compartmentalized) by insulation at different elevations.

Fig.4. Laying of fresh insulation

After completion of the exercise and relaying of cladding, panel heaters were turned on and the thermostat was set at trip value. It was observed that the hopper tripped at the set value within 3 hours of heating by a single panel heater. Before rectification, it was not reaching even 75%

of the set value even after 24 hours heating, with both panel heaters.

CONCLUSIONS

Performance of heaters was studied and the following conclusions are drawn:

1. Technique of thermal imagery is utilized in diagnosing the cause for lower hopper surface temperature.
2. Root cause for higher hopper auxiliary power consumption is identified as improper erection of insulation. Repairs have reduced power loss of about 82% over design value for the three units.
3. Thermal Imaging is an important tool that can be implemented in other areas of power plants to diagnose faults.
4. The thermo graphic data collected can be utilized for optimizing insulation thickness.
5. The average scaled data of hopper temperatures, at each of the locations captured, is presented vis-à-vis the design temperature in Fig 5.

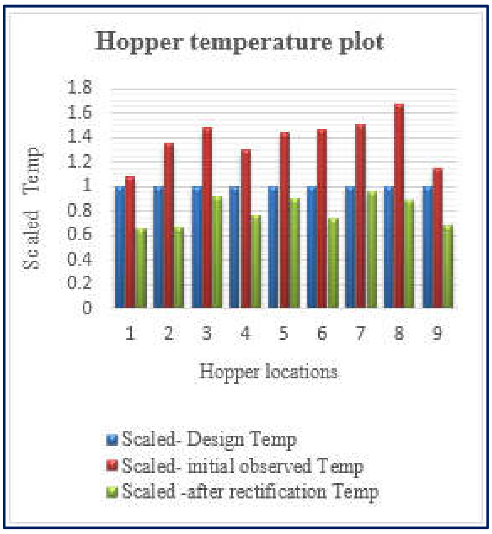
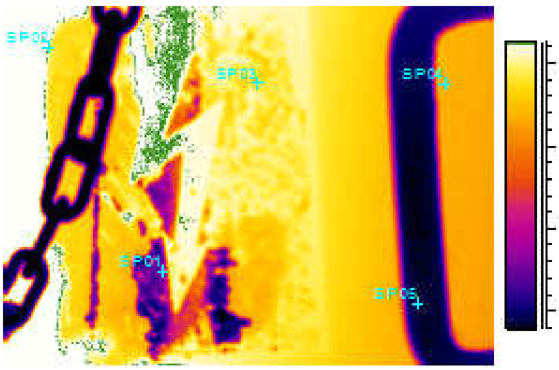
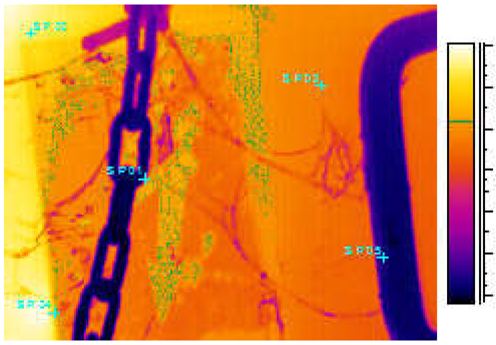


Fig.5 Scaled average hopper temperatures

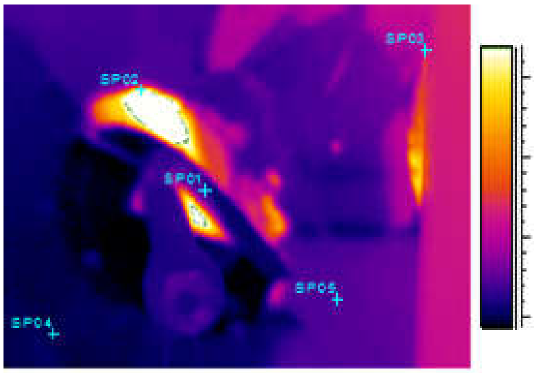
Normalized thermal image sets for a typical hopper in Unit#3 are appended in Annexure-1. Malfunctioning due to improper insulation can be seen with regard to images at different locations, after and before rectification, to comprehend the impact of rectifying the thermal insulation.

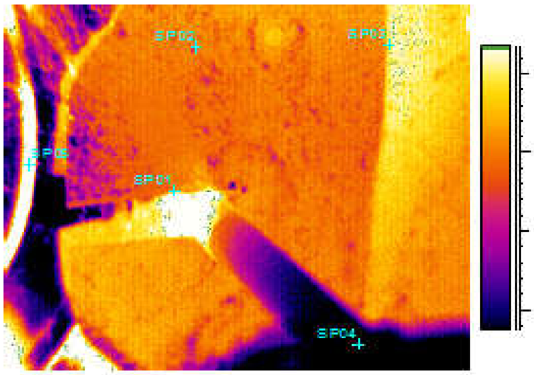
Annexure-1



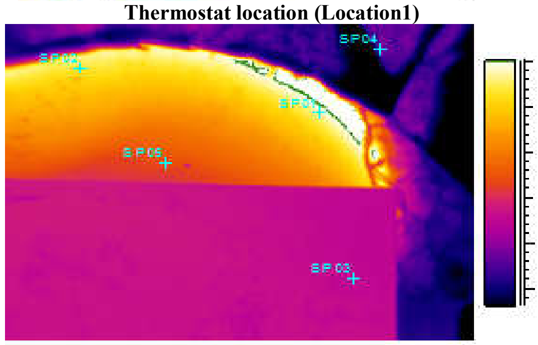


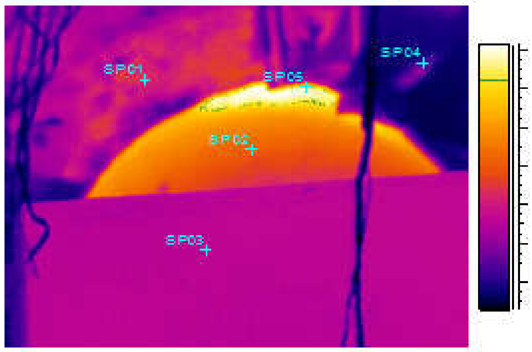
Hopper manhole door



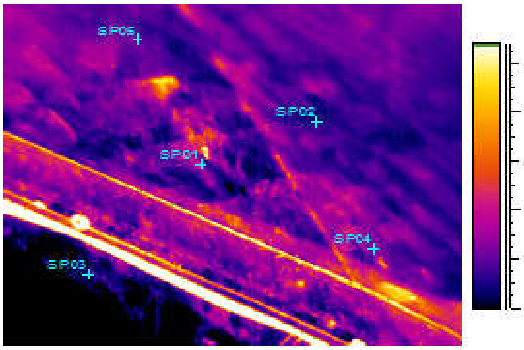


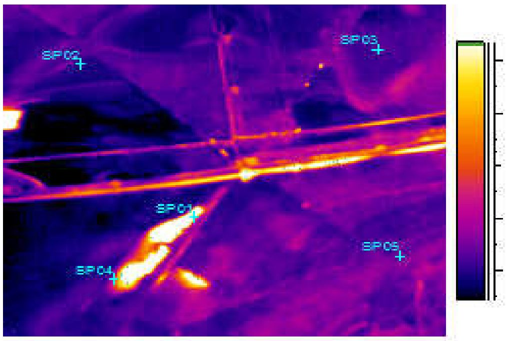
Thermostat location (Location1)



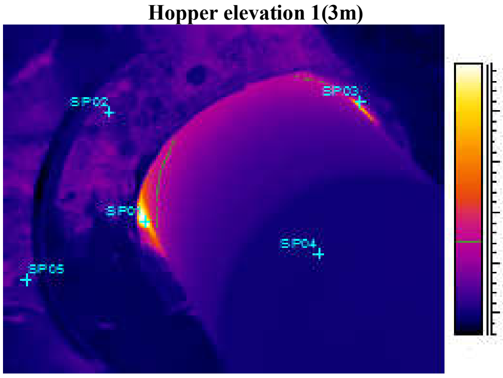


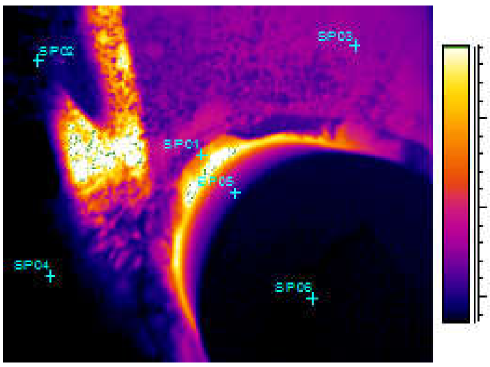
Anvil



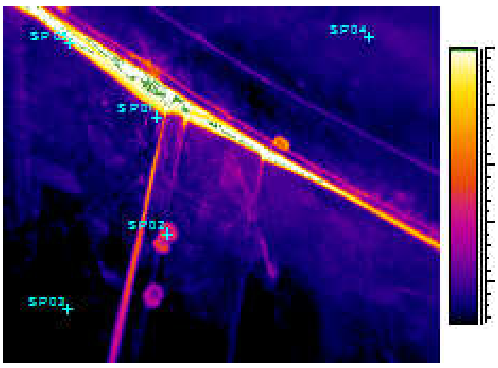


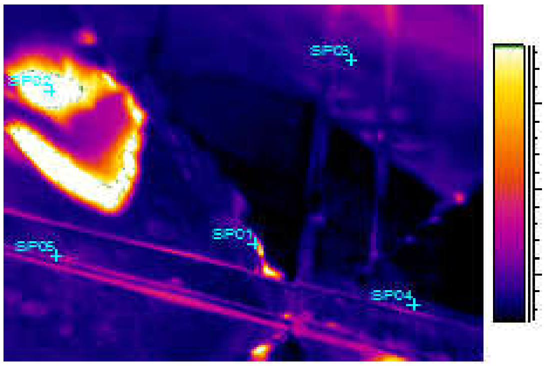
Hopper elevation 1(3m)



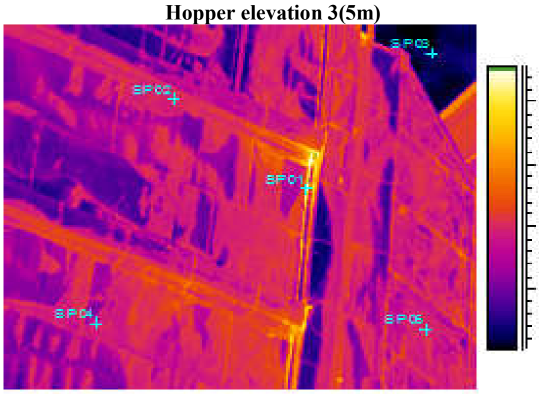


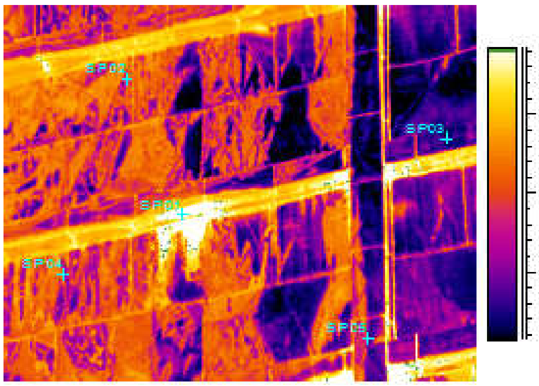
Ash Poke-hole





Hopper elevation 3(5m)





ESP casing (Flue gas path housing)

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