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DESIGN AND OPERATION OF AIR PREHEATER (APH) DE-CHOKING DEVICE

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Abstract
The accumulation of fly ash in air preheater (APH) tubes is a common challenge faced by power plants, leading to decreased efficiency and increased downtime for maintenance. While water washing is commonly used to remove fly ash, it can cause corrosion and reduce the life of the tubes. To address this issue, an APH de-choking device was developed using a 24 V dc motor and service air. This article presents the design and operation of the device and evaluates its effectiveness in removing fly ash without causing corrosion. The device was successfully implemented in a JSW Energy Ltd Barmer, Rajasthan power plant.

Keywords: Air Pre-heater, Fly Ash, De-choking Tool, Power Plant, APH.

I. Introduction

Power plants play a critical role in meeting the energy needs of modern society. However, maintaining their efficiency and reliability can be challenging, particularly with the accumulation of fly ash in APH tubes. A biomass steam generator unit (with the capacity of 40 tonne/hour of saturated team 15 bar) was taken as case study to investigate the effect of corrosion in the economizer and air preheater [1].

To enhance the efficiency of power plants with sustainable or environment consideration circulating fluidized bed combustion (CFBC) technology might be helpful to meet future energy requirement [2-3]. [4] introduced an S-TEN 1 corrosion resistant steel with Cu and Sb coating to avoid corrosion due to sulfuric acids. Which were widely used in air preheaters, smoke stacks and ducts, etc.; in these equipment's deal with flue gases. [5] discussed about the alloy steel and copper alloy pipe bending method, such as hot pipe bending, high frequency induction heating pipe bending. The dew point of acid gas temperature and dealing method was discussed [6-7] to understand the condensation problems in economizers and air preheaters.

Flameless oxidation was reported by Wunning and Wunning [8]; that was a special form of combustion in which thermal NO-formation suppressed / reduced by flame cooling in the form of water or steam injection; air staging; exhaust gas recirculation; reburning; etc.

Corrosion protection methods were discussed by [9] with its advantages (electric energy generation in battery, cathodic protection of structures) and disadvantages (environment pollution, and corrosion damages products).

The conventional design of thermal power plant was proposed by [10] that might be used in regenerative feed water heating to enhance the overall efficiency of power plant using integrated steam-air preheater and flue gas dryer. [11] developed fluidized-bed gasification process by KEDA clean energy corporation limited to produce industrial fuel gas.

Fly ash build-up can reduce the heat transfer efficiency of the tubes and increase resistance to the flow of air, resulting in decreased power output and increased downtime for maintenance. Although water washing is a common method used to remove fly ash, it can cause corrosion and reduce the life of the tubes. In this article, we present a novel solution to this problem in the form of an APH de-choking device.

II. Previously Available Technology

Several technologies are available for removing fly ash build-up from APH tubes, including water washing, steam soot blowing, mechanical soot blowing, ultrasonic cleaning, and pneumatic cleaning. While water washing and steam soot blowing are the most commonly used methods, they have limitations that can reduce their effectiveness. Mechanical soot blowing and ultrasonic cleaning are alternatives but may cause damage to the tubes. Pneumatic cleaning is similar to the APH de-choking device, but it may not be as efficient or effective.

III. What is Air Pre Heater (APH)

It is a device used in thermal power plants to improve the efficiency of the boiler by preheating the combustion air. The air preheater extracts heat from the flue gas exiting from the boiler and transfers it to the incoming combustion air, which increases the temperature of the air entering the furnace. This results in improved combustion efficiency and reduced fuel consumption, as less energy is required to raise the temperature of the incoming air. The air preheater typically consists of a series of metal tubes through which the air flows and which are heated by the flue gas, inside view of air pre-heated is shown in **Fig. 1**.

Fig.1 Air Pre-heater Inside view

(i) Water washing:

This is the most commonly used method for removing fly ash from APH tubes. It involves spraying water onto the tubes at high pressure to loosen the fly ash and flush it out. However, water washing cause corrosion and reduce the life of the tubes. White marked air preheater tube damaged due to corrosion is shown in **Fig. 2**.

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Fig. 2. Air preheater inside damaged tube (White marked)

(ii) Pneumatic cleaning:

This method involves using compressed air to blow the fly ash off the tubes. It is similar to the APH de-choking device as mentioned in this article, but may not be as efficient or effective in removing fly ash from the tubes as it does not have rotating brush. In this a metallic hollo rod being use as presented in **Fig. 3**.

Fig. 3. Pneumatic APH cleaner

IV How damaged APH tube affect boiler efficiency?

The damage to Air Pre-heater (APH) tubes has a significant impact on boiler efficiency in power plants. When these tubes are damaged, a portion of the fresh air intended for combustion leaks from the damaged tubes and mixes with the flue gas. This leakage disrupts the proper distribution of air, resulting in reduced combustion efficiency.

The leakage of fresh air through damaged APH tubes causes an increase in auxiliary power consumption. The fans responsible for supplying air to the combustion process have to work harder to compensate for the air leakage. This increased power consumption by the fans is substantial, often measured in megawatts (MW), and significantly impacts the overall energy efficiency of the power plant.

Therefore, it is crucial to address and mitigate APH tube damage promptly to ensure efficient combustion and minimize auxiliary power consumption. The development and implementation of an effective APH de-choking device, as discussed in this research article, can play a vital role in maintaining the integrity of APH tubes and optimizing boiler efficiency in power plants.

By emphasizing the consequences of damaged APH tubes and the subsequent impact on boiler efficiency, this information will provide valuable insights to readers and highlight the importance of addressing tube damage in power plant operations.

The formula for calculating net power output is:

Net Power Output = Gross Power Output - Auxiliary Power

Where:

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- Gross Power Output refers to the total power generated by the power plant, including both the useful power output and the power consumed by auxiliary equipment. It is typically measured in kilowatts (kW) or megawatts (MW).
- Auxiliary Power represents the power consumed by auxiliary equipment in the power plant, such as fans, pumps, and other supporting systems. It is typically measured in kilowatts (kW) or megawatts (MW).

By subtracting the auxiliary power from the gross power output, we obtain the net power output, which represents the actual electrical power available for distribution or utilization. The net power output reflects the efficiency of the power plant in converting fuel or energy input into useful electrical power output.

The formula for calculating the efficiency of a power plant is:

$$\text{Power Plant Efficiency} = (\text{Net Power Output} / \text{Fuel Power Input}) \times 100\%$$

Where:

- Net Power Output is the actual electrical power output of the power plant, typically measured in kilowatts (kW) or megawatts (MW).
- Fuel Power Input refers to the energy content of the fuel consumed by the power plant, typically measured in joules (J), British thermal units (BTU), or kilowatt-hours (kWh).

V Methodolo5gy

(i) Construction

The APH de-choking device consists of a nozzle for spraying air, a flexible tube, a 24 V dc motor, a detachable rod, and a detachable brush as shows in **Fig. 4** (a). The nozzle is designed to spray air onto the APH tubes with sufficient force to loosen the fly ash deposit as shown in **Fig. 4 (b).** The flexible tube connects the nozzle to the motor and allows for easy manoeuvring of the device between the two APH tubes. The 24 V dc motor is coupled with a detachable rod that allows for easy attachment and removal of the brush. The detachable brush is connected to the motor shaft and is designed to effectively loosen the fly ash from the APH tubes. The construction of the device took into account the strength of the APH tubes to ensure that they are not damaged during de-choking process. The detachable brush is designed to be adjustable according to the hardness of the fly ash deposit, allowing for optimal removal of the fly ash without damaging the tubes.

(a)

(b)

Fig. 4. (a) De-choking Device (b) Air spreading Nozzle

(ii) Working Principle

The methodology used to design the APH de-choking device involves skilled workers inserting the device in between two parallel APH tubes. The device is motorized and operates a brush that effectively loosens the hard fly ash that gets stuck in between the tubes. Once the ash is loosened, pressurized air is used to remove it and wash it away.

To begin the process, skilled workers carefully insert the device in between the parallel APH tubes. The device is then turned on, and the brush begins to loosen the hard fly ash deposits that have accumulated in between the tubes. The brush is designed to be strong enough to remove the ash but gentle enough to avoid damaging the tubes.

Once the ash is loosened, pressurized air is used to remove it from the area. Additionally, the air flow helps to wash away any residual ash, leaving the tubes clean and clear for the hot flue gas to transfer heat effectively.

(iii) Benefits of APH De-choking Device

The APH de-choking device provides a more efficient and less damaging method to remove fly ash build-up in APH tubes. It is an effective and efficient device; will be very useful for removing fly ash without causing corrosion, enhance the life of the tubes, leading to increase downtime for maintenance. The device has been successfully installed in a power plant, and it has the potential to improve the efficiency and sustainability of power plant operations.

(iv) Economic feasibility

DC Motor 12-24 V – 1150 INR
Flexible Pipe – 1000 INR Brush – 300 INR
Labour Cost - 500 INR

The total cost for the construction of the APH de-choking device is 2950 INR.

VI Conclusion

The APH de-choking device has been proven to be an effective and safe solution for the issue of fly ash build-up in-between two APH tubes in power plants. Its unique design takes into account the hardness of fly ash deposits and the strength of the tubes, resulting in positive results during testing in a power plant setting. By avoiding the need for water washing, which can cause corrosion and reduce tube life, the device has the potential to save significant downtime and maintenance costs.

VII Future Scope

The APH de-choking device is a step in the right direction, but there is still scope for further research and development. Future research could focus on optimizing the design and construction of the device to make it even more effective and reliable. Additionally, the device could be adapted for use in other applications, such as coal feeder de-choking, where it could offer similar benefits. The development of the APH de-choking device highlights the importance of investing in innovative solutions that can improve the efficiency and reliability of power plants by using maintenance tool.

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