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ORIGINAL

Tempvision 1000: A Portable Temperature Measurement and Monitoring System for Boiler Combustion.

Tempvision 1000: un sistema portátil de medición y control de temperatura para la combustión de calderas.

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ABSTRACT

This research investigates the operational and maintenance strategies aimed at improving boiler combustion efficiency at PT Indonesia Power UJP Banten 1 Suralaya, with an emphasis on the integration of the Portable Temperature Measurement System (PTMS) and the Distributed Control System (DCS). The objectives encompass comprehending the workflow of power plant systems, the role of PTMS in monitoring boiler combustion temperatures, maintenance facilitated by PTMS, and tackling challenges such as slagging and temperature deviations. Data were collected through direct observation of PTMS operations and analyzed using Rodin III PTMS software, employing a quantitative methodology. Parameters including Distributed Control System (DCS) data, specific fuel consumption (SFC), coal flow, air flow, steam flow and pressure, superheater (SH) and reheater (RH) temperatures, and air ratio served as benchmarks. Measurements from the boiler layers (TOP, LT8, SOFA, CCOFA, G, EF, CD, and AB) offered insights into the temperature distribution. The findings demonstrate that the integration of PTMS and DCS improves monitoring accuracy, facilitating precise adjustments to enhance combustion efficiency. Adjustments to the secondary air damper minimized temperature variations, addressed slagging problems, and reinstated sighthole functionality, as observed at CCOFA5, facilitating thorough data collection. Regular maintenance of components such as pulverizers and analysis of combustion byproducts ensured uniform fuel distribution and operational reliability. This integrated approach enhances efficiency, decreases emissions, and mitigates environmental impact. This study highlights the significance of advanced monitoring tools and proactive maintenance for sustainable and reliable power generation, providing a framework for analogous systems aiming for improved performance and energy sustainability.

Keywords: Boiler combustión; tempvision; PTMS.

RESUMEN

Esta investigación investiga las estrategias operativas y de mantenimiento destinadas a mejorar la eficiencia de combustión de la caldera en PT Indonesia Power UJP Banten 1 Suralaya, con énfasis en la integración del Sistema de medición de temperatura portátil (PTMS) y el Sistema de control distribuido (DCS). Los objetivos abarcan la comprensión del flujo de trabajo de los sistemas de la planta de energía, el papel del PTMS en el monitoreo de las temperaturas de combustión de la caldera, el mantenimiento facilitado por el PTMS y el abordaje de desafíos como la escoria y las desviaciones de temperatura. Los datos se recopilaron a través de la observación directa de las operaciones del PTMS y se analizaron utilizando el software Rodin III PTMS, empleando una metodología cuantitativa. Los parámetros que incluyen datos del Sistema de control distribuido (DCS), consumo específico de combustible (SFC), flujo de carbón, flujo de aire, flujo y presión de vapor, temperaturas del sobrecalentador (SH) y del recalentador (RH) y la relación aire sirvieron como puntos de referencia. Las mediciones de las capas de la caldera (TOP, LT8, SOFA, CCOFA, G, EF, CD y AB) ofrecieron información sobre la distribución de la temperatura. Los resultados demuestran que la integración de PTMS y DCS mejora la precisión del monitoreo, facilitando ajustes precisos para mejorar la eficiencia de la combustión. Los ajustes al regulador de aire secundario minimizaron las variaciones de temperatura, solucionaron problemas de escoria y restablecieron la funcionalidad del orificio de inspección, como se observó en CCOFA5, lo que facilitó la recopilación exhaustiva de datos. El mantenimiento regular de componentes como los pulverizadores y el análisis de los subproductos de la combustión garantizaron una distribución uniforme del combustible y la confiabilidad operativa. Este enfoque integrado mejora la eficiencia, reduce las emisiones y mitiga el impacto ambiental. Este estudio destaca la importancia de las herramientas de monitoreo avanzadas y el mantenimiento proactivo para la generación de energía sustentable y confiable, proporcionando un marco para sistemas análogos que apuntan a un mejor desempeño y sostenibilidad energética.

Palabras clave: Combustión de calderas; tempvision; PTMS.

INTRODUCTION

The thermal efficiency of power generation systems is a crucial determinant of operational reliability and economic feasibility. Recent performance assessments at PT Indonesia Power UJP Banten 1 Suralaya have indicated a troubling escalation in heat rate, with specific energy consumption increasing from 2657.8 Kcal/kWh to 2879.42 Kcal/kWh. This notable spike signifies a deterioration in generator reliability, with boiler conditions recognized as a principal contributing factor. Structural deficiencies, including localized leaks in the boiler system, have caused uneven heat distribution, resulting in heat losses and overheating in certain sections (1–4).

The combustion process in the boiler is crucial to the overall efficiency of coal-fired power plants. The combustion of coal produces heat that transforms water into steam, which propels turbines and provides electricity. The efficiency of this process directly affects both generation capacity and operational expenses. Ensuring optimal combustion efficiency necessitates effective monitoring systems to identify and rectify imbalances in flame distribution throughout the boiler's combustion zones. In boilers with numerous combustion layers, it is crucial to maintain temperature homogeneity at the four corners of each layer (5–8). Discrepancies in combustion temperature can markedly diminish boiler efficiency, exacerbate component wear, and heighten operating dangers.

To tackle these issues, the deployment of sophisticated monitoring instruments, such as the Portable Temperature Measurement System (PTMS), is important. The PTMS facilitates real-time mapping of combustion temperature profiles and offers a comprehensive investigation of flame temperature distribution throughout various layers and corners of the boiler. This device aids in identifying inefficiencies and assists engineers in optimizing combustion processes by offering actionable insights on temperature discrepancies (9–11).

This study seeks to assess the impact of PTMS on the efficiency and reliability of coal-fired power station operations. The objectives are: 1) to analyze the workflow of the power plant system with an emphasis on boiler combustion monitoring, 2) to comprehend the operational principles of PTMS in temperature monitoring, 3) to evaluate the effects of PTMS implementation on boiler maintenance practices, 4) to identify challenges and assess the results of PTMS-based monitoring, and 5) to enhance generator efficiency at PT Indonesia Power UJP Banten 1 Suralaya. This project aims to deliver practical insights for enhancing thermal efficiency and reliability in power generation systems.

LITERATURE REVIEW

Steam generator

Steam generators are essential components in coal-fired power plants, commonly known as fossil fuel-based power generation systems. They function as the principal energy source in these facilities, generating high-pressure superheated steam, generally between 2400 and 3500 psia (165–240 bar). This high-pressure steam is crucial for operating turbines in the Rankine cycle, a thermodynamic process integral to power generation [5,12-14]. In contrast, pressurized water reactor (PWR) steam generators function at relatively lower pressures, approximately 1000 psia (70 bar), which aligns with the specific demands of nuclear power systems.

Steam produced by boilers has diverse applications, supporting numerous industrial operations such as mechanical drive systems and heating. The effective and dependable functioning of boilers is regulated by compliance with predefined operational standards, often defined by both the boiler operator and the equipment manufacturer. Adherence to these standards guarantees safe operation, optimizes system reliability, and enhances operational efficiency, hence decreasing total costs (13). These requirements are essential for enhancing the efficiency of steam generators while guaranteeing long-term sustainability and safety in industrial applications.

Boiler efficiency

Boiler efficiency, characterized as the ratio of useful energy production to total energy intake, is an essential parameter for enhancing the technical and economic performance of boiler systems. Enhanced efficiency not only decreases fuel use but also mitigates operational expenses and environmental repercussions. To attain optimal boiler efficiency, it is essential to mitigate energy losses, which may arise from several mechanisms, such as heat dissipation through flue gases, radiation losses to the environment, energy expenditure for evaporating moisture in fuel, and incomplete combustion resulting in unburned fuel. Thermal efficiency is often assessed using two approaches: the Input-Output Method and the Heat-Loss Method.

This method compares the energy derived from the working fluid (water and steam) with the energy content of the fuel. It is straightforward as it only requires measurement of the output (steam) and input (fuel energy) for calculation. The efficiency is computed using the following formulas:

$$\eta = \frac{\text{Heat Output}}{\text{Heat Input}} \times 100\%$$

$$\eta = \frac{Q \times (h_g - h_f)}{q \times \text{GCV}} \times 100\%$$

Where:

- Q: Amount of steam produced per hour (kg/hour).
- q: Amount of fuel consumed per hour (kg/hour).
- h_g: Enthalpy of steam at working pressure and temperature (kcal/kg).

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- h_f: Enthalpy of feed water at its inlet temperature (kcal/kg).
- GCV: Gross calorific value of the fuel (kcal/kg).

Parameters Monitored in the Input-Output Method:

- Steam generation rate per hour (Q) in kg/hour.
- Fuel consumption rate per hour (q) in kg/hour.
- Operating pressure (kg/cm^2 gauge) and superheat temperature (°C), if applicable.
- Feed water temperature (°C)

The Input-Output Method, referred to as the direct method, assesses efficiency by juxtaposing the energy obtained from the working fluid (water and steam) with the energy content of the fuel. This method entails direct measurements of steam generation and fuel consumption rates, as well as characteristics such as steam pressure, superheat temperature, and feed water temperature. The efficiency of this process is quantified by calculations that account for the enthalpy of steam and feed water, in addition to the gross calorific value of the fuel [15].

The Heat-Loss Method, as per the ASME PTC-4-1 (1970) standard, evaluates efficiency by examining the disparity between energy input and the associated losses, including flue gas, radiation, moisture, and unburned fuel losses. This method is widely employed in Operation & Maintenance practices to assess the outcomes of boiler overhauls and to identify components that impede performance. Collectively, these methodologies establish a thorough framework for assessing and improving boiler efficiency, guaranteeing dependable and economical operation of power plant systems [16-18].

Fuel and Combustion

Biomass and coal are two distinct solid fuels characterized by unique physical and chemical properties that affect their combustion behavior and applications. Coal is defined by its elevated carbon content, substantial calorific value, moderate ash content, and low levels of volatile compounds. Biomass is characterized by a high proportion of volatile compounds and a lower carbon content. The ash content of biomass is contingent upon the specific type, while its calorific value is typically moderate. The elevated volatile compound content in biomass promotes easier combustion initiation at reduced temperatures [5,6,19-21].

Combustion processes are categorized into three main types: fixed bed combustion, pulverized coal combustion (PCC), and fluidized bed combustion (FBC). Each method employs unique boiler designs and operational principles that are specifically adapted to the characteristics of the fuel [22-25].

Fixed Bed Combustion

Fixed bed combustion utilizes a stoker boiler to regulate the combustion process. This method is appropriate for coal characterized by moderate ash content and particle sizes up to 30 mm. Minimizing fine coal particles is essential for optimizing combustion efficiency. Fuel is introduced into the combustion chamber through manual means or via a conveyor system. Fixed bed combustion represents a conventional and straightforward approach, rendering it appropriate for small-scale applications and particular fuel types [26].

Pulverized Coal Combustion (PCC)

Pulverized coal combustion represents the predominant method for large-scale power generation, especially in coal-fired power plants[22,27]. It is acknowledged for its dependability and superior performance. This method involves pulverizing coal into fine particles, mixing it with air, and injecting the mixture into the combustion chamber. Advancements in PCC systems have markedly enhanced efficiency via innovations in steam generation, evolving from subcritical to supercritical and ultimately to ultra-supercritical (USC) steam conditions. The advancements seek to elevate the temperature and pressure of the produced steam, thereby improving the thermal efficiency and performance of power plants.

Fluidized Bed Combustion (FBC)

The fluidized bed combustion technique requires the crushing of coal into particles smaller than 25 mm prior to combustion. Fluidized bed combustion (FBC) differs from fixed bed combustion, which employs a stationary layer of coal, and from pulverized coal combustion (PCC), which involves the spraying of coal and air[22–25]. FBC keeps coal particles in a fluidized, suspended state. This is accomplished by introducing air from below the combustion chamber at designated velocities. The equilibrium between upward aerodynamic forces and gravitational forces maintains the suspension of coal particles, resulting in a dynamic, fluid-like layer. This environment facilitates complete combustion by ensuring continuous particle movement, which enhances air circulation and improves combustion efficiency.

Pulverizer

The pulverizer is an essential component in coal-fired power plants, engineered to crush and grind coal lumps into fine particles measuring 200 mesh (74 μm), as outlined in Pulverizer Maintenance. Finely ground coal particles are transported by high-pressure hot air into the combustion chamber of the boiler. The main objective of coal refinement is to improve its combustibility, facilitating more efficient and complete combustion within the boiler[28,29]. The pulverizer not only refines the coal but also aids in its drying, thereby enhancing the grinding process and its preparedness for combustion. The pulverizer also serves to classify and filter the coal, ensuring that only adequately ground, soft particles are supplied to the boiler. The multi-functional operation of refining, drying, and classifying coal enhances the combustion process, increases efficiency, and lowers emissions in coal-fired power generation systems.

Coal Feeder

The coal feeder is a critical element in controlling the quantity of coal delivered to the pulverizer, thereby ensuring that the fuel input aligns with the load demands of the generating unit [30,31]. The amount of coal fed into the pulverizer fluctuates in response to power demand, enabling the system to adapt effectively to variations in load conditions. Two primary methods are employed to achieve precise regulation of coal feed. The first method utilizes an adjustable-speed drive motor, allowing for modifications in the motor's rotation based on operational requirements. This facilitates precise regulation of the coal feed rate, ensuring conformity with the system's specifications. The second method employs a fixed-speed motor paired with a variable speed drive (VSD). In this configuration, the motor maintains a constant rotational speed, while the variable speed drive (VSD) modulates the output to regulate the feeder speed, thereby offering flexibility in controlling the coal flow rate. This method integrates the dependability of a fixed-speed motor with the flexibility of variable speed control. Coal feeders employ these mechanisms to maintain a consistent and optimal coal supply to the pulverizer, thereby promoting stable combustion processes and enhancing energy generation efficiency in coal-fired power plants.

PTMS (Portable Temperature Monitoring System)

The Portable Temperature Measurement System (PTMS) is an advanced monitoring and measurement system that employs dual-spectrum imaging technology, specifically the TempVision system, to assess boiler temperatures via sight holes [10]. This system provides high precision in temperature measurement, rendering it an essential instrument for effective boiler management. PTMS, referred to as TempVision 1000, concurrently monitors temperatures and automatically adjusts for changes in emissivity resulting

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from soot or slag accumulation in the target area. This capability is essential for accurate temperature measurement in coal-fired boiler settings.

The TempVision 1000 Safe-Fire system records and presents real-time temperature profiles for individual flames, offering precise and prompt data. The PTMS enables technicians to accurately map combustion profiles in boilers through any accessible aperture at various temperature levels, with a maximum measurement capacity of 3,632°F (2,000°C). This capability positions PTMS as a critical instrument for optimizing flame temperature distribution, leading to decreased fuel costs, lower NOx and CO emissions, and enhanced overall boiler efficiency. PTMS can correlate the influence of flame temperature distribution on burner performance across various coal types, rendering it essential for ensuring operational flexibility and environmental compliance in coal-fired power plants.

METHODS

This research utilizes a quantitative methodology, featuring a systematic approach to data collection and analysis. The initial step entails direct observation via the monitoring of the Portable Temperature Measurement System (PTMS). This facilitates immediate analysis and understanding of PTMS operations and temperature measurement functions. The Rodin III PTMS software is utilized for data collection, establishing initial parameters that include Distributed Control System (DCS) data, specific fuel consumption (SFC), coal flow, air flow, steam flow and pressure, spray superheater (SH) and reheater (RH) temperatures, and air ratio as reference benchmarks. PTMS data is collected from specific boiler layers and corners, namely the TOP, LT8, SOFA, CCOFA, G, EF, CD, and AB layers. The measurements offer a detailed analysis of temperature distribution throughout the boiler.

A literature review is conducted to support the preparation of the industrial practice report. References pertinent to the study are collected from libraries, journals, and books that align with its focus. This step reinforces the theoretical framework and substantiates the empirical evidence. The study integrates observational data, advanced software tools, and comprehensive literature reviews to produce a thorough analysis and a well-documented report that meets international research quality standards.

RESULTS AND DISCUSSION

Table 1 displays data obtained from multiple established parameters utilized as comparative references in the analysis of boiler combustion monitoring via the Portable Temperature Measurements System (PTMS). The comparative data include analogous and directly comparable entities pertinent to the measurement object, thereby ensuring the precision and relevance of the analysis. The parameters were obtained from the Distributed Control System (DCS) monitor.

Throughout the measurement period, a decrease in load was noted, primarily attributed to the standby status of multiple mills, including Mill F and Mill G, leading to a reduction in output of 500 MW. The operational capacity of the boiler is directly affected by the number of active mills, as the coal flow rate has a significant impact on the load. Under optimal conditions, with all mills functioning, the boiler can attain a maximum load of 625 MW. Lignite, a low-grade coal, was utilized, possessing a calorific value of approximately 4,200 kcal/kg. Alongside the load and coal type, several critical parameters were monitored, including Specific Fuel Consumption (SFC), coal flow, air flow, steam flow and pressure, spray superheater (SH) and reheater (RH) temperatures, and the air ratio. SFC is an essential efficiency metric that quantifies the ratio of fuel consumption to electrical power generation, providing insights into the efficiency of the power plant and the calorific value of the coal utilized. The total specific fuel consumption (SFC) recorded during the measurement period was 0.53 kg/kWh, accompanied by a total coal flow of 263 T/h.

Air flow, an essential element of the combustion process, constitutes a component of the fire triangle within the boiler system. The total air flow measured 2,153 T/h, consisting of a primary air flow of 661 T/h and a secondary air flow of 1,492 T/h. Steam flow, reflecting the boiler's steam production capacity, was recorded at 1,791 T/h, with an associated steam pressure of 14.07 MPa. The spray SH temperature and spray RH temperature were measured at 386°C and 317°C, respectively. Finally, the air ratio, indicating the proportion of air to fuel as a volumetric or weight-based ratio, was recorded at 8.19. The parameters elucidate the combustion process, yielding essential insights into the efficiency and performance of the boiler system across diverse operational conditions. This data is essential for enhancing boiler performance and minimizing emissions while maintaining dependable power generation.

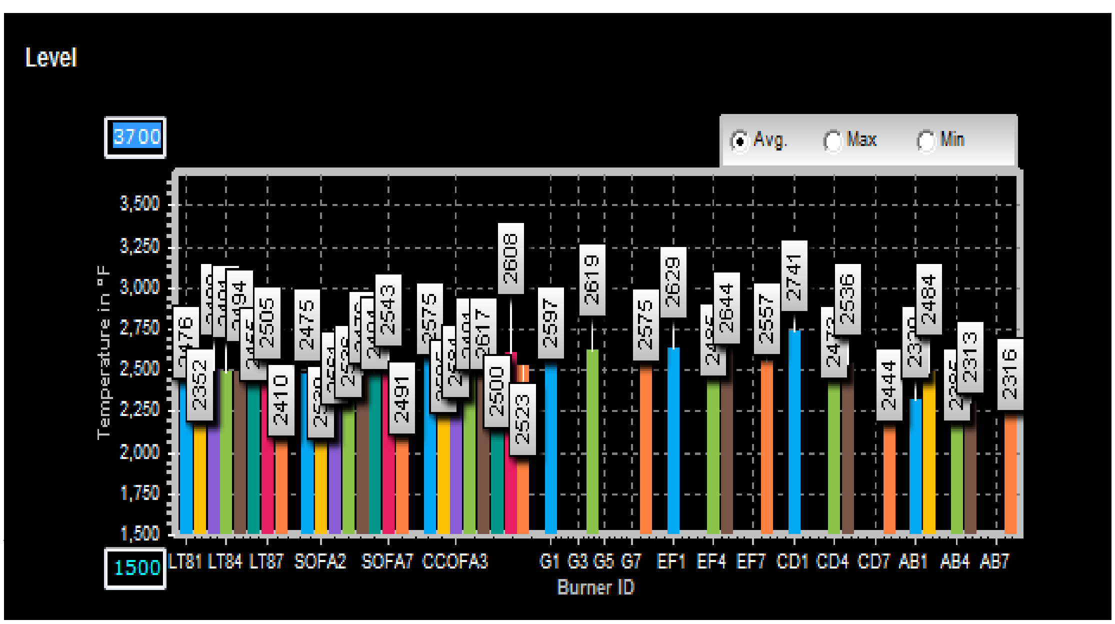
Table 1. Measurement Parameters.

No.	Parameters		
1.	Measurement Load	500	MW
2.	Maximum load	625	MW
3.	Coal type	Lignite	
4.	Calorific Value of Coal	4200	Kcal/kg
5.	SFC	0.53	
6.	Ash Deformation Temperature		degC
7.	Total Coal Flow	263	T/H
8.	Mill in Operation	A/B/C/D/E	
9.	Mill in Standby	F	
10.	Burner Tilting		
11.	A Side O2	2,7	%
12.	B Side O2	3,3	%
13	Total Air Flow	2153	T/H
14.	Primary Air Flow	661	T/H
15.	Secondary Air Flow	1492	T/H
16.	Steam Flow	1791	T/H
17.	Steam Pressure	14,07	Mpa
18.	Spray SH Temperature	386	degC
19.	Spray RH Temperature	317	degC
20.	Air Ratio	8.19	

Source: Own elaboration.

The results of the boiler temperature measurements consisting of each corner layer on each floor of the boiler can be seen in Figure 1 and Table 2.

Figure 1. Boiler temperature measurement result.



Source: Own elaboration.

Table 2. Boiler Temperature Measurement in ˚C Based on the boiler.

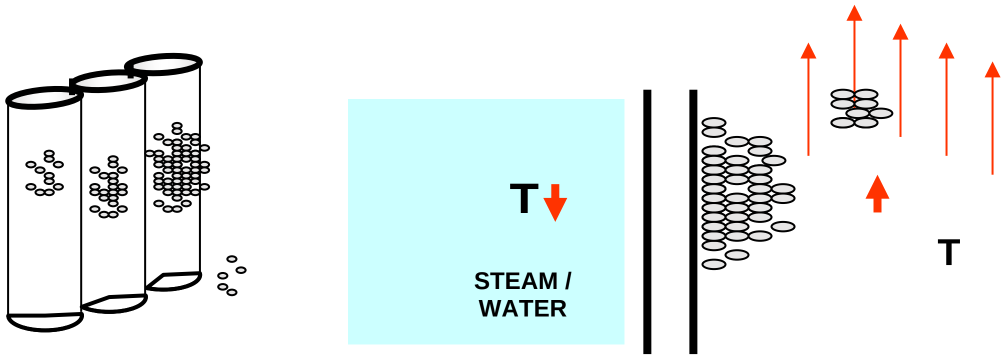
Corner Layer	1		2		3		4		Max	Min	Dev
	1	2	3	4	5	6	7	8			
TOP	1358	1289	1370	1366	1368	1346	1374	1321	1374	1289	85
LT8	1357	1393	1384	1391	1358	1368	1395	1366	1395	1357	38
SOFA	1413	1374	1418	1366	1436	1371	1431	1384	1436	1366	70
CCOFA	1425	F	F	1437	X	F	F	1413	1437	1413	24
G	1443			1424	1410			1403	1443	1403	40
EF	1505			1363	1451			1340	1505	1340	165
CD	1367			1356	1391			1341	1391	1341	50
AB	1271			1307	1267			1269	1307	1267	40
MAX	1505	1393	1418	1437	1451	1371	1431	1413			
MIN	1357	1289	1370	1356	1358	1346	1374	1321			
DEV	148	104	48	81	93	25	57	92			

Source: Own elaboration.

temperature measurements in Table 2, several corner layers were identified as inoperable due to the inability to open the sighthole or inspection port for measurements. Additionally, some corner layers were found to be affected by slagging, a common issue in high-temperature boiler environments, can be seen in Figure 2. Slagging formation occurs through a complex mechanism influenced by various factors. The deposits can exist in liquid, plastic, or solid states, depending on the temperature and duration of their formation. Typically, slagging develops on furnace walls and areas exposed to radiant heat, but it can also occur in convective zones if the temperature is not adequately reduced. While slagging can form on clean pipe surfaces, it is more likely to develop on rough or dirty surfaces, where ash particles adhere more easily. Fine ash particles that attach to a pipe surface tend to capture additional particles, leading to the progressive thickening of slagging deposits.

Temperature gradients also play a significant role in slagging formation. Cooler pipe surfaces are more prone to fouling, which can exacerbate the problem. When the heat transfer to water or steam in the pipes is insufficient, the gas temperature can rise to the ash melting point, making the ash particles plastic and more likely to trap additional particles, thus forming new slagging layers. Furthermore, if a slagging cluster detaches, it can be transported by gas flow and redeposit on other pipe surfaces, spreading the issue to new areas. This cyclical process not only diminishes boiler efficiency but also poses significant challenges to maintenance and operational stability. A comprehensive understanding of slagging mechanisms is essential for implementing effective prevention and mitigation strategies, such as optimizing combustion conditions, applying anti-slagging coatings, and scheduling proactive cleaning measures to minimize operational disruptions.

Figure 2. Slagging Formation Mechanism.

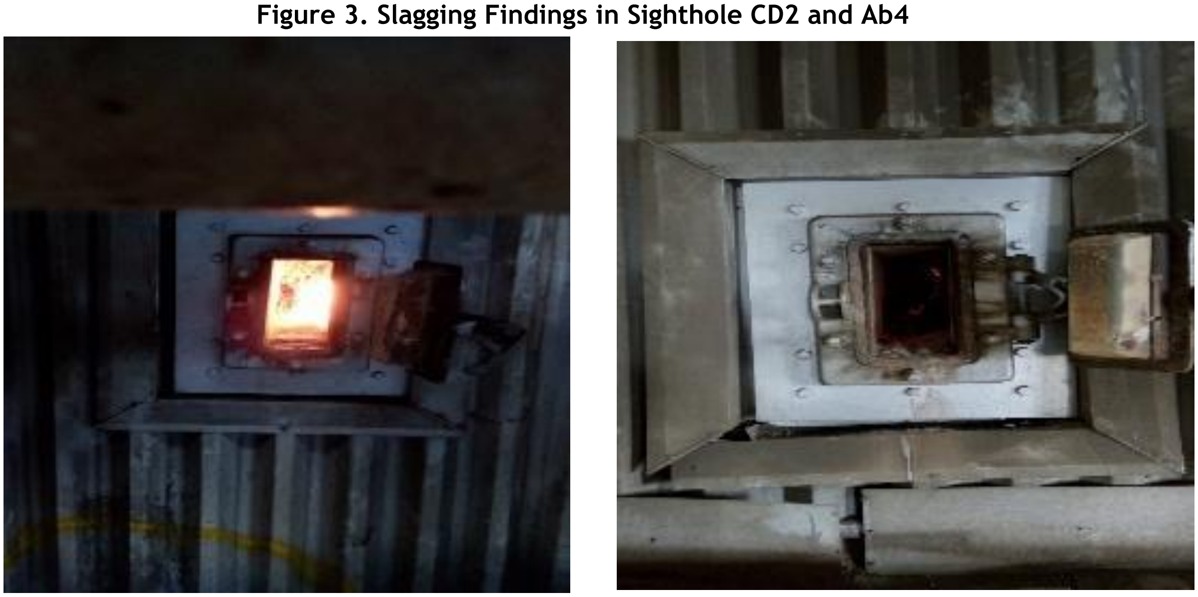


Source: Own elaboration.

Slagging in Corners CD2 and AB4

Slagging deposits were detected in corners CD2 and AB4. This problem occurs when the combustion temperature surpasses the ash fusion temperature (AFT) of the coal, resulting in ash particles softening and adhering to boiler surfaces. These deposits diminish heat transfer efficiency and, if not rectified, may result in significant operational inefficiencies and heightened maintenance demands. The primary cause of this issue is likely a discrepancy between the combustion temperature and the AFT values of the coal utilized, maybe aggravated by variations in coal quality or incorrect combustion settings. To address this issue, it is advisable to modify the combustion temperature to correspond with the AFT values specified in the Coal Analysis Report (COA). Consistent monitoring and maintenance are essential to avert the reoccurrence of slagging and to guarantee optimal boiler operation. Slagging in Sighthole CD2 and AB4 can be seen in Figure 3.

Figure 3. Slagging Findings in Sighthole CD2 and Ab4



Source: Own elaboration.

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The observed slagging is likely due to a misalignment in combustion parameters, specifically a failure to synchronize the combustion temperature with the coal's Ash Fusion Temperature (AFT), as shown in the Coal Analysis Report (COA). The variability in coal characteristics, especially with lignite or lower-grade coal, intensifies this problem due to its elevated moisture and volatile content, which affects combustion behavior.

To mitigate slagging, it is essential to adjust the combustion temperature to correspond with the AFT. Advanced control systems, including automated temperature regulation connected to coal property sensors, should be utilized to ensure accurate combustion parameters. Routine soot-blowing procedures must be performed to reduce the accumulation of slag deposits. Furthermore, regular examinations of boiler surfaces, particularly corners susceptible to slag accumulation, ought to be incorporated into the maintenance schedule. Implementing anti-slagging coatings on boiler walls and employing predictive maintenance techniques with thermal imaging tools can further reduce slagging concerns.

Inoperable Sighthole in Corner CCOFA5

The sighthole at corner CCOFA5 was found to be inoperable, likely due to mechanical damage or obstruction. The sighthole at corner CCOFA5 was discovered to be nonfunctional, restricting the capacity to observe flame patterns and temperature profiles in this region. Sightholes play a crucial role in the real-time assessment of combustion conditions, and their failure to operate can lead to undetected problems that may develop into significant inefficiencies. The blockage or impairment of the sighthole underscores a deficiency in regular maintenance procedures. Prompt action should include filing a damage report with the maintenance department to ensure repairs are prioritized. Regular inspection and cleaning of all sightholes, along with the installation of automated cleaning systems like air or steam purging mechanisms, should be part of preventative measures to ensure their functionality. Integrating functionality checks into regular maintenance procedures will guarantee that sightholes stay operational, improving the dependability of monitoring systems.

A damage report must be promptly created and submitted to the maintenance crew for rapid correction. Future preventative efforts must encompass routine inspection and maintenance of all sightholes to avert obstructions. Implementing automated cleaning methods, such as air or steam purging mechanisms for sightholes, can ensure their functionality without operator intervention. Furthermore, securing extra parts for the swift repair of sightholes and including their functioning assessments into boiler start-up procedures can reduce operating interruptions.

Temperature Deviation in Layer EF

A notable temperature discrepancy of 165°C was recorded in layer EF, signifying a combustion state imbalance. This discrepancy is likely due to incorrect configurations of the secondary air dampers, resulting in uneven air distribution in the combustion zone. This disparity may lead to incomplete combustion, localized warming, and diminished efficiency. To address this issue, it is advisable to modify the secondary air damper settings, raising the aperture to exceed 30% to improve air distribution. A subsequent measurement is planned for July 5, to assess the efficacy of these modifications. Furthermore, the routine calibration of air dampers and the implementation of real-time monitoring systems are essential to guarantee uniform air distribution and reduce temperature fluctuations in the future. Temperature trend for each corner layer EF can be seen in Figure 4.

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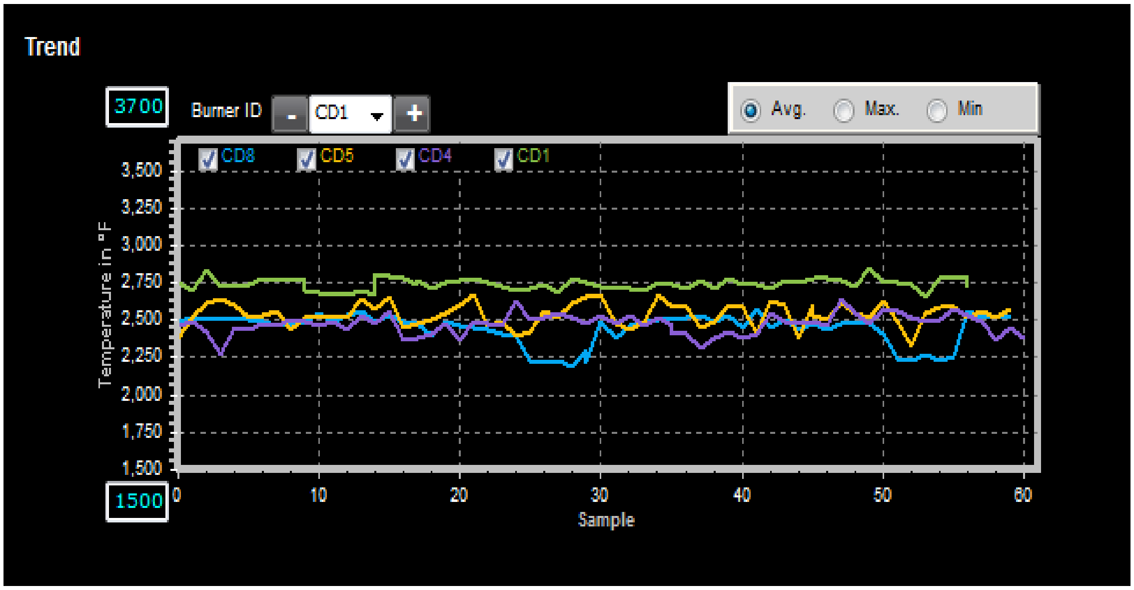
Figure 4. Temperature trend for each corner layer EF



Source: Own elaboration.

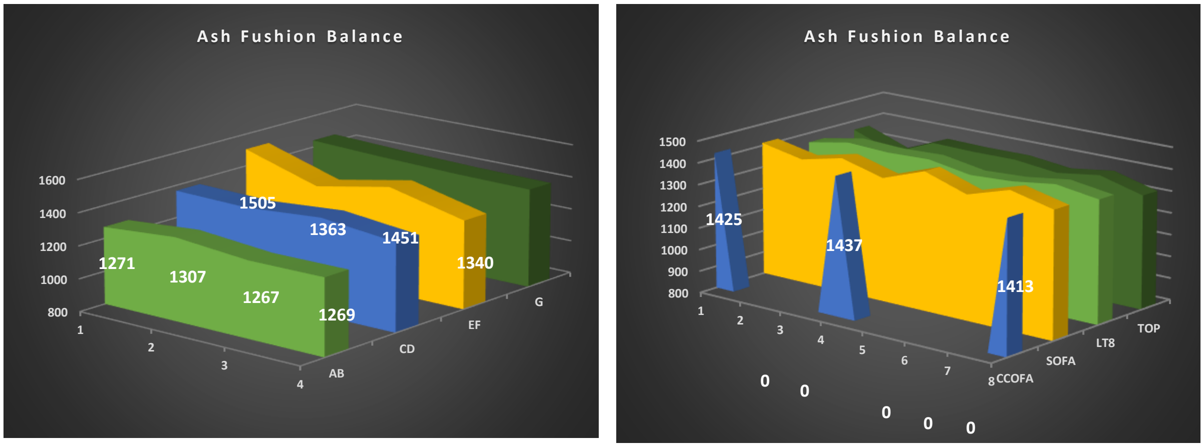
To prevent future deviations, the implementation of real-time airflow monitoring systems, periodic calibration of dampers, and the use of computational fluid dynamics (CFD) simulations to optimize airflow patterns are highly recommended. Automated damper controls linked to operational parameters such as boiler load and coal flow can also ensure consistent and efficient combustion.

Addressing these findings requires immediate corrective actions alongside long-term strategies to enhance boiler efficiency and reliability. Aligning combustion temperatures with the coal's AFT will mitigate slagging, ensuring all sightholes are operational will enhance monitoring capabilities, and optimizing secondary air damper settings will improve combustion balance and reduce temperature deviations. Integrating advanced monitoring and control technologies can further support these efforts, fostering sustainable operations and reducing costs and emissions.

Ash Fushion Balance

The investigation of ash fusion balance before modifying the secondary air dampers indicates considerable fluctuations in temperature and ash accumulation throughout various boiler layers. The layers AB, CD, EF, and G (shown on the left in Figure 5) and CCOFA, SOFA, LT8, and TOP (illustrated on the right) demonstrate imbalances in combustion conditions, with certain regions reaching or surpassing the ash fusion temperature (AFT) of the coal. These imbalances lead to the development of slag deposits, especially in areas with elevated temperatures or inadequate ventilation. The irregular distribution diminishes heat transmission efficiency and increases the risk of equipment damage from localized overheating and slag buildup.

Figure 5. Ash fusion balance before setting secondary air damper (layers AB, CD, EF, and G in left and CCOFA, SOFA, LT8, and TOP in right).

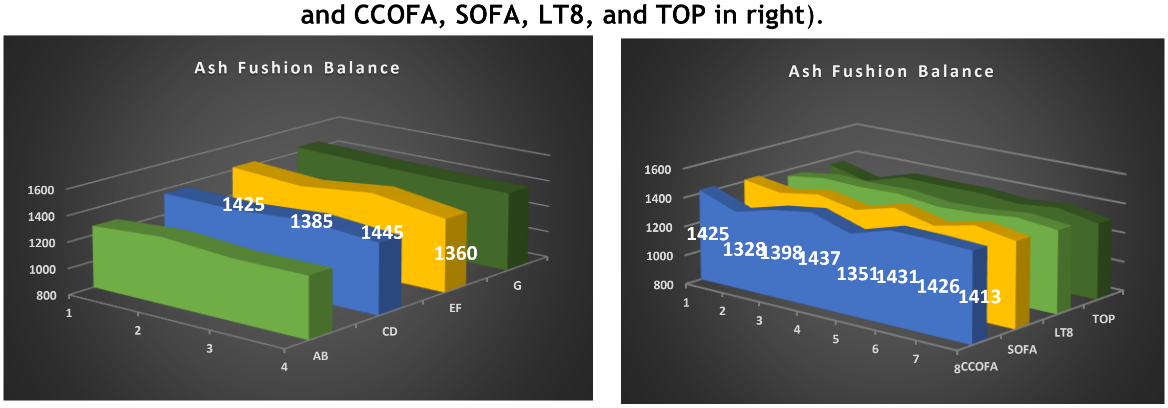


Source: Own elaboration.

The primary source of these imbalances is probably inadequate adjustments of the secondary air dampers, leading to unequal airflow distribution. Areas with inadequate air supply suffer fuel-rich situations, resulting in incomplete combustion and ash accumulation, whereas areas with excessive air encounter fuel-lean conditions that intensify temperature variations. To resolve this issue, it is advisable to modify the secondary air damper settings, raising the openings to exceed 30% to enhance airflow distribution and mitigate temperature fluctuations. A thorough reevaluation of temperature profiles across all layers should be performed post-adjustments to assess the efficacy of the modifications and inform subsequent enhancements.

Furthermore, ongoing surveillance of ash fusion parameters utilizing sophisticated instruments such as the Portable Temperature Measurement System (PTMS) is crucial for detecting developing discrepancies and implementing preemptive actions. Incorporating real-time monitoring and control systems to dynamically regulate secondary air dampers according to airflow and temperature patterns can enhance combustion conditions. These methods will augment combustion efficiency, reduce slagging, and guarantee consistent heat transfer throughout all layers, so enhancing the boiler's operating stability and performance.Figure 6 shows the ash fushion balance after setting the secondary air damper on each layer.

Figure 6. Ash fusion balance before setting secondary air damper (layers AB, CD, EF, and G in left and CCOFA, SOFA, LT8, and TOP in right).



Source: Own elaboration.

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Following the adjustment of the secondary air damper, notable enhancements in the temperature profiles throughout the boiler layers were observed. Figure 8 illustrates that the temperature deviation in layer EF, which exhibited the greatest variation, was significantly reduced, leading to a more uniform temperature distribution. This adjustment facilitated the operation of the sighthole at layer CCOFA5, which was previously inoperable, thereby enabling comprehensive temperature measurements in this area. The successful reopening of the CCOFA5 sighthole facilitated comprehensive data collection from this layer, yielding essential inputs for subsequent analysis.

The final results from the Portable Temperature Measurement System (PTMS) observations will be incorporated into the performance test data. The measurements are critical for assessing the reliability and efficiency of the UJP Banten 1 Suralaya power plant. The adjustment of secondary air dampers has improved combustion stability and enhanced the accuracy and completeness of boiler performance assessment by reducing temperature deviations and optimizing airflow distribution. The findings enhance the operational efficiency, mitigate risks, and bolster the reliability of the power plant.

Monitoring and measuring boiler combustion temperatures requires an understanding of several fundamental aspects. This encompasses the thermodynamic principles that regulate boiler operations, the primary and auxiliary components of the boiler, and the impact of input parameters on the temperature cycle. A technical understanding is crucial for assessing efficiency and diagnosing functional failures in the boiler. Coal properties and analysis are essential, as operational adjustments must take into account the specific type of coal utilized. PT Indonesia Power UJP Banten 1 Suralaya predominantly utilizes lignite, a coal with low calorific value, which considerably influences combustion dynamics and temperature control. Essential equipment, including the coal feeder that delivers fuel to the pulverizer or coal mill, is vital for transforming coal lumps into fine particles appropriate for combustion. The Portable Temperature Measurement System (PTMS) functions as the concluding analytical instrument for the measurement and monitoring of boiler temperatures.

The Portable Temperature Measurement System (PTMS), referred to as TempVision 1000, utilizes dual-spectrum imaging technology for the measurement and display of boiler temperatures via sightholes. PTMS demonstrates high precision in temperature measurements and possesses the capability to autonomously adjust for emissivity fluctuations induced by soot or slag accumulation in the target region. This capability is essential for accurate temperature measurements in coal-fired boiler settings, characterized by high temperatures and frequent slagging. PTMS functions as an essential instrument for optimizing boiler performance through the provision of real-time data for analysis and adjustment.

Effective boiler maintenance necessitates the incorporation of supplementary tools and parameters in addition to PTMS. The Distributed Control System (DCS) is critical for subsequent modifications and operational management. PTMS primarily emphasizes temperature measurement and monitoring, whereas DCS facilitates a more comprehensive regulation of combustion conditions, encompassing airflow and fuel flow. The integration of PTMS and DCS improves the optimization of boiler performance and the resolution of inefficiencies.

Monitoring of PTMS indicated temperature imbalances in multiple corner layers of the boiler, resulting in deviations that required modifications to the secondary air dampers. The adjustments significantly minimized temperature deviation in the most impacted layers, especially layer EF, and reestablished equilibrium throughout the boiler. Slagging deposits were identified as a significant challenge, obstructing sightholes like CCOFA5 and hindering accurate temperature measurements. After adjusting the secondary air damper, the slagging issue was reduced, enabling the reopening of the CCOFA5 sighthole and the completion of measurement data. These actions underscore the significance of prompt adjustments and maintenance in resolving operational challenges and ensuring temperature uniformity.

To ensure the power plant operates efficiently, it is essential to implement several key actions, such as making adjustments, configuring equipment settings, and conducting sample analyses. The adjustments,

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especially concerning the pulverizer or coal mill, are crucial for achieving uniform rotation of the orifice and ensuring balanced coal grinding throughout all areas. Imbalances in the pulverizer result in uneven fuel distribution and combustion inefficiencies. Consistent adjustment of orifice plates and oversight of grinding shaft alignment are essential to mitigate such problems. Sampling combustion byproducts, including fly ash, is essential for laboratory analysis to assess combustion completeness. These measures guarantee that operational adjustments are informed by data and significantly improve the plant's efficiency and reliability.

CONCLUSIONS

Monitoring and maintaining boiler combustion temperatures at PT Indonesia Power UJP Banten 1 Suralaya necessitate an integrated approach that includes thermodynamic principles, coal analysis, and the use of advanced tools such as the Portable Temperature Measurement System (PTMS) and Distributed Control System (DCS). PTMS delivers precise real-time temperature measurements and adjusts for emissivity fluctuations due to soot or slagging, whereas the DCS facilitates thorough modifications to maintain optimal combustion conditions. Challenges including slagging and temperature deviations identified during PTMS monitoring were mitigated by adjusting secondary air dampers, resulting in reduced temperature imbalances and the restoration of functionality to obstructed sightholes such as CCOFA5. Regular maintenance of essential components, such as pulverizers, including the alignment of grinding shafts and adjustment of orifice plates, is crucial for achieving uniform fuel distribution and efficient combustion. The examination of fly ash and other byproducts supports these initiatives by confirming combustion completeness, thereby facilitating data-driven decisions to improve efficiency and reliability. This integrated approach guarantees optimal performance of the power plant while reducing operational disruptions and environmental impact.

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