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Submission date: 29-Aug-2022 09:57AM (UTC+0700)
Submission ID: 1888535659
File name: Analysis_of_Clinker_Bottom.pdf (511.18K)
Word count: 2138
Character count: 10997

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 6, Issue 6, pp 47-50, June-2022

https://doi.org/10.47001/IRJIET/2022.606006

Analysis of Clinker Bottom Ash Hardness and NPHR Boiler against PC99 Corint Coal Additive Injection

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Abstract - **Steam Power Plant, Steam Power Plant is a power generation system with relatively low operating costs because the working medium uses air. Boiler is a device that functions to convert air into superheated steam which has high temperature and pressure. One of the obstacles that occur at Power Steam Plant itself is a decrease in boiler performance caused by the slagging phenomenon that forms on the walls of the boiler. This phenomenon arose because of the replacement of coal carried out by power steam plant. This practical work report describes the handling of the slagging phenomenon in the boiler by using additive coal injection in the boiler. The Coal Additive used is based on Magnesium, which is useful for increasing the AFT value, because it can weaken the inter-particles so that the particles that have reached AFT will turn into dry ash. There are two parameters taken for the successful use of Coal Additives, the first is clinker hardness which is the result of combustion in the boiler. Furthermore, for additional parameters, it is seen from the value of NPHR (Net Plant Heat Rate) which is an indicator of the reliability and efficiency of a thermal generator, especially power steam plant. The smaller the NPHR value, the more efficient it is.**

Keywords: Boiler, Coal Additive, Clinker.

I. INTRODUCTION

Steam Power Plant is a mainstay power plant and is a major need for industry in the world. The steam power plant is a generating system with relatively low operating costs because the working fluid uses water. The water heated in the pipes gets heat from the burning of coal that occurs in the boiler. So that the heat in the boiler is very important to maintain so that heat transfer from combustion can be more efficient.

Boiler is a closed vessel where the heat of combustion is flowed into water until hot water or steam is formed. Boilers function to convert water into superheated steam at high temperature and pressure. Boiler efficiency is the work performance or level of boiler performance obtained from the comparison between the energy provided (input) and the energy used (output) by burning fuel. Boiler efficiency is an important thing and is the main discussion in every power plant. Boiler efficiency can also be obtained by calculating heat losses, which consist of unburned carbon losses, heat losses carried by dry flue gases, fuel wetness losses, wetness losses due to hydrogen combustion, combustion air wetness losses, radiation and convection losses, which will affect the performance of the boiler and increase the consumption of coal fuel so that it will affect the cost of electricity production.

In general, boilers will experience a slagging phenomenon where coal ash particles, both solid and fused, stick to the surface of the heat conducting wall located in the high temperature combustion gas zone. Due to this phenomenon, the efficiency of the boiler decreases because the heat transfer is hampered by the slagging scale layer. To overcome this phenomenon, coal additive is injected to break down the crust layer for better heat transfer and increase boiler efficiency.

II. METHOD

The engineering department as one of the departments in the company is in charge of engineering the operation and maintenance of the power plant. In early 2022, the engineering department identified a decline in boiler efficiency. It is common in boilers that use coal because there is a decrease in heat transfer between the fire side to the water side which is hindered by the presence of scale (slagging & fouling) so that it is necessary to increase the amount of coal consumption to produce the expected steam. When obtained slagging on the wall tube and the data shows that the efficiency of the boiler decreases due to the absorption of heat that is not maximal by the wall tube this problem by using an additive (chemical super) based on Mg (Magnesia) mixed with coal. From this problem, the author wants to explore further whether the injection of coal additive is beneficial for boiler performance judging from the boiler NPHR parameters.

In the field study, the authors searched for primary data by means of question and answer and two-way discussions with field supervisors and field staff regarding the data needed to support the analysis carried out in practical work. At this stage, the authors also gain knowledge from the experiences of

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supervisors while working at there, and this knowledge can be used by the author in the data collection stage.

For data collection carried out in the analysis of the influence of coal additive injection on the parameters, the authors need supporting data, both primary and secondary data. These data were obtained from literature studies and field studies conducted by the author. Primary data includes coal additive specifications, causes of slagging, coal content, additive injection operations, and equipment needed for coal additive injection in boilers. There are also supporting data such as formulas and references that are used to support the calculations to be carried out. The data that has been collected will be processed using the formula that has been obtained, and the final result is the large influence of coal additive injection on the parameters that indicate the optimal return of the boiler performance.

III. RESULTS AND DISCUSSION

The author focuses on the results of the clinker (Bottom Ash) form before and after the application of Coal Additive PC 99 Corint injection. After knowing these results, the author will focus on calculating the NPHR for data supporting the success of Coal Additive to eliminate slagging in the boiler.

3.1 Case Data

Case : Boiler of Power Steam Plant
Location : Wall Tube
Starting Apear Problem : December 2021
Injection Coal Additive : : 4 – 17 January

Figure 1: Slagging In Boiler

Slagging on the wall tube boiler occurs because the calorific value of the coal used is lower, so it has a lower AFT. Therefore, lower AFT results in higher slagging potential.

The coal used in Power Steam Plant is subituminous coal with the following specifications:

Table 1: Coal Quality

Coal Content	Unit	IMM	KPC
Carbon	%	73.0	74.7
Hydrogen	%	5.18	5.47
Nitrogen	%	1.68	1.5
Oksigen	%	15.0	17.7
Sulfur	%	0.84	0.5
Ash	%	5.9	5.6
Moisture	%	11.8	11.9
Fix Carbon	%	42.0	42.8
Votalatile matter	%	40.3	49.7
Calori	%	5.820	5.584

Table 2: Ash Analysis

Chemical Elements	Unit	IMM	KPC
SiO2	%	47.42	45.61
Al2O3	%	19.18	21.08
Fe2O3	%	18.92	18.60
TiO2	%	0.92	5.30
CaO2	%	6.75	4.92
MgO	%	3.64	2.04
K2O	%	0.30	0.56
Na2O	%	0.23	0.24
P2O3	%	0.61	0.49
SO3	%	1.26	0.95

The following is the calculation of the acid base ratio method to determine the potential for slagging in the.
1.Indominco Coal (IMM)

$R = 0.5769$

If the R value is at the limit of 0.4 - 0.7 it will indicate a potential high slagging. Based on the calculation of the acid-base ratio, individually from each supplier of power plant, the potential for slagging is high.

3.2 Bottom Ash/Clinker Hardness Laboratory Test Results

Laboratory test results were carried out at the Energy and Environment Laboratory of the Ten December Institute of Technology DRPM.

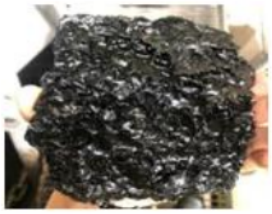

Figure 2: Bottom Ash/Clinker from Boiler

Table 3: Results Bottom Ash Hardness Test

Specimen	Test Type	Test Method	Results	Unit
Sebeluminjeksi coal additive	Micro hardness Vickers	IKA LEL – ITS MH	429,9	HV (Vickers hardness)
Sesudahinjeksi coal additive			218,4	

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In testing the hardness of the clinker sample using the Hardness Vicker method, the conditions before the application of coal additive at 5 different indentation points resulted in an average hardness of 429.9 HV, then the situation after the application of coal additive in indents at 4 different points resulted in an average hardness value of 218, 4 HV.

From the clinker hardness parameter, it can be seen that the coal additive used to remove slagging in the boiler becomes soft so that the soot blower can more easily clean the slagging that occurs in the boiler.

3.3 NPHR (Net Plant Heat Rate) Calculation

In calculating the NPHR, data are needed such as net power units, high heating value (HHV), and the amount of coal used. The following is the formula for calculating NPHR:

$$\text{Net Plant Heat Rate} = \frac{Total\ Coal\ Use\ x\ Value\ \ HHV}{Net\ Output}$$

1. NPHR value before injection (January 3, 2021) = 2275.58 Kcal/kwh
2. NPHR value after injection (16 January 2021) = 2368,487 Kcal/ kwh

Percentage Change = 0.92907 %

After calculating the percentage change, injection of coal additives made the NPHR value increase by 0.93% which indicates that the treatment had no significant impact. However, the parameter for the success of coal additive injection is not only from the NPHR value but also from the amount of crust that falls and the hard/soft scale that falls. According to these 2 parameters, the injection of coal additive succeeded in breaking down the scale and softening the crust attached to the wall tube.

IV. CONCLUSION

Based on the results of research conducted on boiler, the following conclusions can be obtained.

1. Based on the acid-base calculation method to indicate potential slagging, the coal used in power steam plant has a high potential for slagging because from the ash analysis calculation, the slagging index value is 0.4387.
2. Based on the analysis of the cause of slagging in the boiler power steam plant, a treatment action is taken in the form of injection of magnesium-based coal additive where based on the reaction, porosity is obtained so that the slag/crust can collapse.
3. Based on the hardness parameters of clinker/Bottom Ash, it is found that the hardness of clinker/Bottom Ash before injection of coal additive is 429.9 HV, and after injection of coal additive is worth 218.4. From this parameter, it can be seen that the coal additive is able to soften the clinker/Bottom Ash as a form of slagging so that it is easier to clean using a sootblower.
4. From the calculation of the NPHR value of unit boiler, it tends to increase which indicates the inefficiency of the power plant.

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ISSN (online): 2581-3048

Volume 6, Issue 6, pp 47-50, June-2022

https://doi.org/10.47001/IRJIET/2022.606006

Citation of this Article:

Yusuf Umardani, Bambang Yunianto, Sri Nugroho, Rizlan Riyadi, "Analysis of Clinker Bottom Ash Hardness and NPHR Boiler against PC99 Corint Coal Additive Injection" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 6, Issue 6, pp 47-50, June 2022. Article DOI https://doi.org/10.47001/IRJIET/2022.606006

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