Revamping of EAF Dedusting Plant to Optimize Off-Gas & Dust Control System in PT Krakatau Steel (Persero), Tbk.

Rio Arosyid Putra¹
Syafiq Hadi²

¹Senior Specialist of Techno-economy, Project Control of EAF Dedusting Plant Revamping. Division of Technology & Energy Development. PT Krakatau Steel (Persero) Tbk. Cigading Plant Site, Cilegon – 42435, Banten Province, Indonesia. (E-mail: rio.arosyid@krakatausteel.com)
²Superintendent Melting-2 of Slab Steel Plant, Head of Commissioning & Performance Test of EAF Dedusting Plant Revamping. Division of Slab Steel Plant. PT Krakatau Steel (Persero) Tbk. Cigading Plant Site, Cilegon – 42435, Banten Province, Indonesia. (E-mail: syafiq.hadi@krakatausteel.com)

ABSTRACT

PT Krakatau Steel (Persero) Tbk is currently building Blast Furnace Plant which produces hot metal to be fed into Electric Arc Furnace (EAF) and it will reduce the composition of solid material. The use of hot metal will impact to the operation of Dedusting Plant since it was designed only to process EAF off-gas (sponge iron based operation). This paper describes about revamping project of EAF Dedusting Plant which was finished under self-management of PT Krakatau Steel (Persero) Tbk including basic and detail design, manufacturing, procurement, installation and commissioning. The water cooled duct was reconditioned and extended to increase Dedusting Plant capability to absorb heat from larger volume of off-gas. In addition, Drop Out Box (DOB) was also installed to isolate larger duct particles and therefore it will minimize dust settlement in the duct. The results of this project were not only successful to modify optimized off-gas & dust control, but also significantly reduce the capital expenditure by 35% and also accelerate the project duration so that it can be finished in 18 months due to the efficiency and effectivity of the teams effort during engineering, fabrication, and commissioning phases. Moreover, this self-managed project was effectively helpful in accelerating transfer of knowledge and shortens the learning curve of the personnel.

Keywords: Dedusting Plant, Revamping, Dust, Off-Gas, Drop Out Box
I. INTRODUCTION

As an integrated steel company, PT Krakatau Steel (Persero) Tbk is currently developing its ironmaking production facility by building Blast Furnace Plant which will produce hot metal. Hot metal from Blast Furnace Plant will be fed into Electric Arc Furnace (EAF) and certainly will impact the operation of EAF Dedusting Plant since it was designed only to process EAF off-gas from a solid material based operation.

To avoid the impacts of EAF raw material transformation, revamping is necessary to be implemented. Revamping includes the installation of Drop Out Box and several modifications in Water Cooled duct and Uncooled Duct. Drop Out Box was installed to isolate larger duct particles and therefore it will minimize dust settlement in the duct. The Water Cooled Duct was reconditioned and extended to increase Dedusting Plant capability to absorb heat from larger volume of off-gas. The main background of revamping necessity was shown in this section. The main problem in Dedusting Plant in overcoming EAF raw material transformation was explained in Section II. Section III presented the new design of Dedusting Plant and the mechanism of project execution. The result of implementations was described and analyzed in Section IV. Section V provided the conclusions and future recommendations which should be followed up after this project was finished.

II. MAIN PROBLEM IN DEDUSTING PLANT

A. Overview Of Dedusting Plant

![Figure 1. Dedusting Plant of Electric Arc Furnace](image)

The dedusting system is designed with two duct systems consists of the primary duct (includes water cooled and uncooled duct) and the secondary duct (canopy duct) are both mixed in the mixer duct before the filter. Off gas or waste gas from the EAF consecutive sucked through some water cooling hot section of gas line, uncooled hot gas line, force draft cooler.
and filter by operation 2 ID fan (1 standby). Negative pressure inside the EAF is measured and controlled and regulated by the dilution Electric Control (DEC) damper.

![Figure 2. Dedusting Plant of Electric Arc Furnace (Top View)](image)

The temperature at the inlet filter is controlled by mixing chamber which is the equipment where the mixing temperature occur between the primary duct to the secondary duct canopy. While the water emergency damper acts to lower the temperature in the duct system in case of over temperature.

Filter bag in the filter plant is cleaned through the cleaning system by cooling air jet instrument, dust will descend into the filter hopper and passed continuously by a chain conveyor / rotary valve and bucket elevator to the silo and ends in an open container or truck.

**Water Cooled Hot Gas Line**

Water Cooled Hot Gas Line is made by using pipe boiler ST. 35.8.I. Water cooled hot gas line consists of furnace elbow, sliding sleeve, and water cooled duct section. To prevent overheating in hot gas line as a result of heat radiation or heat impact or due to lack of the flow of cooling water, water temperature sensor and flow meter measurement are installed to monitor each circuit water cooling line.

Furnace elbow or elbow is fixed to face each other with the elbow roof so that under normal conditions (sliding sleeve close) has a clearance of approximately 50 mm. The distance between the elbow with a fixed roof can be adjusted via a mechanism elbow sleeve sliding back and forth with the motor electric drive system (open and close). The main function of the sliding sleeve is for additional input from atmospheric oxygen so that the exothermic reaction CO can take place completely in the hot gas line. Under conditions of automatic, sliding movement of the sleeve is set based mode operating conditions EAF is happening (see table below).
Un-cooled duct is made from high resistant material which is steel plate 16Mo3. For avoiding the over-heating in the un-cooled duct and controlling the inlet temperature of Force Draft Cooler (FDC), the system is equipped with emergency water dilution damper. Emergency water dilution damper is designed by using the motor driving system AUMA (open and close) with the set point temperature sensor at the inlet FDC 550°C so that the temperature un-cooled would be restrained.

**Force Draught Cooler**

Force draft cooler is designed to reduce the temperature of primary duct into 250°C. Hot gas from un-cooled duct enters the draft force cooler through the inlet header then distributed to the heat exchanger package casing (the casing has several chamber). Hot air from the inlet transfering heat to the walls of the chamber (heat exchange area), the walls of the chamber receiving heat from the inside is cooled by blowing air from the outside (outside force convection) through 9 pieces of axial cooling fan that works by setting the temperature of the temperature sensor placed in the outlet side of FDC.
B. Performance Obstacles: Off-gas & Dust Settlement Increase

![Process Flow of Dedusting Plant](image)

**Figure 5.** Process Flow of Dedusting Plant

Existing conditions described in this study is related to the operation of the process based on EAF data testing after Performance Test of new Oxy Fuel Burner. Based on that testing, EAF frequent trips / off time due to maximum limit of temperature in the primary duct (hot gas line) was more than 700°C (600°C design), as shown in the following figure.

![Dedusting System Trip Alarm](image)

**Figure 6.** Dedusting System Trip Alarm due to Over Heat

If temperature of the hot gas line more than 700°C, then the corresponding dedusting Trip Alarm System then the EAF will switch off (trip) and will be operated again after about 3 minutes when the temperature of the hot gas line has dropped to 625°C. This causes the power on time and tap to tap time of EAF increases resulting in lower productivity.

Therefore the condition of dedusting system that often causes trip in EAF, then the way is taken to reduce the utilization of Oxy Fuel Burner which is only using 2 lances (from a total of 3
units). This method is done to reduce the thermal load received Hot Gas Line and avoid the occurrence of electricity trip.

### III. DESIGN OF REVAMPED DEDUSTING PLANT

#### A. New Design Of Dedusting Plant

Carbon content in pig iron or hot metal varies considerably depending on the process source. Typically pig iron will contain between 3 and 4.5 %. It is easy to see that use of large amounts of high carbon materials must be balanced with oxygen availability in order that decarburization time is not extended. The maximum practical decarburization rate in the EAF is much less than in the BOF due to the shallow metal bath. Exceeding a rate of 0.1 % C per minute typically results in excessive metal splashing and increased fume losses to the offgas system.

\[
\sum E_s + \sum m_s + \int \frac{\partial E}{\partial t} \, dt = 0
\]

\[
\sum m_s + \sum m_{\text{ref}} + \int \frac{\partial m}{\partial t} \, dt = 0
\]

The term \(\partial E/\partial t\) denotes the internal energy change of the gas stream due to combustion reactions and evaporation of water spray in the gas phase. Post-combustion of CO and H\(_2\) bearing off-gasses with air occurs in the first plant unit (drop out box, post combustion chamber, hot gas duct)/ Combustion reaction of CO, H\(_2\), and natural gas (CH\(_4\)) from burners release energy to the off gas:

\[
\begin{align*}
\text{CO} + 0.5\text{O}_2 & \rightarrow \text{CO}_2 \\
\text{H}_2 + 0.5\text{O}_2 & \rightarrow \text{H}_2\text{O} \\
\text{CH}_4 + 2\text{O}_2 & \rightarrow 2\text{H}_2\text{O} + \text{CO}_2
\end{align*}
\]

\(\Delta H = 282.98 \text{ kJ/mol}\)

\(\Delta H = 241.81 \text{ kJ/mol}\)

\(\Delta H = 802.60 \text{ kJ/mol}\)

![Figure 7. Influence of water cooling system to the off-gas temperature](image)

**Figure 7.** Influence of water cooling system to the off-gas temperature
Figure 8. Measuring point at primary and secondary dedusting system

The position of the sampling lance ensures that the EAF off-gasses are measure before mixing with air. Off gas temperature and the velocity of the gas flow are also measured. The off-gas enthalpy is calculated on the basis of these measurements and yield about 15-25% of total energy input. The amount of infiltrated air in the furnace is determined with calculated N$_2$ volume flow rate at EAF elbow. Measured off-gas enthalpy and infiltrated air volume flow provide information about the tightness of the furnace and the possibility of decreasing the off-gas enthalpy in order to optimize the energy balance.

B. Project Schedule

The project was executed in six phases which was shown in Table I. Basic Design and Detail Design was the first and second phase. These were the very fundamental phases in which the new design and revamping mechanism were planned. The chosen design, which was shown in Figure 7, was followed up by manufacturing necessary equipment, erection, commissioning
and final acceptance.

**TABLE I**  
Project Schedule of Revamping of EAF Dedusting Plant

<table>
<thead>
<tr>
<th>No.</th>
<th>Project Phase</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>1</td>
<td>Basic Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Detail Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Manufacturing</td>
<td></td>
<td></td>
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<tr>
<td>4</td>
<td>Erection</td>
<td></td>
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<tr>
<td>5</td>
<td>Commissioning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Final Acceptance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

IV. RESULT & ANALYSIS

Individual test has been conducted to examine the function of all equipments which consist of Cooled Duct, Un-cooled Duct, Force Drought Cooler, Mixing Chamber, Filter System dan ID-Fan. The individual test result are as follow:

<table>
<thead>
<tr>
<th>SEGMENT</th>
<th>STANDARD (max)</th>
<th>RESULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Fix L1</td>
<td>188 m³/h</td>
<td>188 m³/h</td>
</tr>
<tr>
<td>Flow Fix L2</td>
<td>183 m³/h</td>
<td>166 m³/h</td>
</tr>
<tr>
<td>Section 1</td>
<td>143 m³/h</td>
<td>113 m³/h</td>
</tr>
<tr>
<td>Section 2</td>
<td>143 m³/h</td>
<td>120 m³/h</td>
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</table>

<table>
<thead>
<tr>
<th>NO</th>
<th>PERFORMANCE WARRANTIES</th>
<th>VALUE</th>
<th>HASIL PERFORMANCE TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inlet Force Draugh Cooler, Max (°C)</td>
<td>530</td>
<td>371</td>
</tr>
<tr>
<td>2</td>
<td>Inlet to filter chamber, Max (°C)</td>
<td>120</td>
<td>83</td>
</tr>
<tr>
<td>3</td>
<td>Dust Content, Max (mg/m³)</td>
<td>50</td>
<td>5</td>
</tr>
</tbody>
</table>

V. CONCLUSION

Based on the results of the implementations and analysis, some conclusions could be obtained as follows:

1) Revamping of EAF Dedusting Plant could eliminate the impact of raw material transformation in EAF (hot metal material based operation)
2) By doing the revamping, transfer of knowledge was rapidly accelerated and the learning time could be effectively shortened.

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