An automated system to enhance palm oil mill (POM) boiler performance was established and its reliability was tested on plant scale operation to evaluate its efficacy against fluctuated boiler condition that is unique to POM boiler operation. The fluctuation can vary from fluctuated boiler feed water flow (37.8 ± 28.4 m³/hr); fluctuated water chemistry such as pH (7.0 ± 0.3), total dissolved solid (175 ± 15 μmhos, represented as water conductivity), and hardness (32.7% above accepted limit); and fluctuated boiler operation such as fluctuated deaerator temperature (81.1 ± 19.5 °C) and on-off operation (61% off during 1 month monitoring). Using the system that established, the boiler performance was improved due to the ability to control critical boiler water chemistry that affected by the fluctuation. The system is designed to control boiler water alkalinity, phosphate level, dissolved oxygen concentration in feed water, and cycle of concentration (COC) that known as the key performance indicator (KPI) of boiler operation. The trial result indicated an improvement on internal boiler surface condition that showed more passivated metal and less scale precipitation. The automation system established in this study would be useful for minimizing the financial and safety risk from upset boiler operation and for further development on small boiler operation system.

Keywords: Automation, Boiler performance, fluctuated boiler condition, Palm oil mill boiler

I. INTRODUCTION

Palm oil mills have some of the most challenging boiler feed water systems yet boiler reliability is critical in mills operations. If a boiler is shut down unexpectedly, it can impact the availability of steam to generate electricity as well as the heat requirement from the palm oil processing unit (mashing and cooking).

One of the main problems faced with palm oil boiler operation is hardness leakage from softener. Hardness in boiler make-up/feed water that exceeds 0.3 ppm [1] will create a scaling layer in the boiler leading to loss of heat transfer efficiency and increased water and energy consumption [2]. Ideally, hardness leakage monitoring will prompt operators to conduct salt regeneration on the softener system and trigger additional scaling inhibitor dosage. But, without continuous monitoring, this hardness leakage is sometimes undetected.

The other critical problem requiring attention is oxygen corrosion. Dissolved oxygen can be very aggressive in boiler feed water systems. Oxygen corrosion dissolves the metal surfaces, often causing localized pitting. Localized pitting attack can be especially aggressive and quickly penetrate the metal, resulting in feed water system leaks and failures [1].

Equally concerning, corrosion sends the dissolved iron into the boiler, which can deposit onto boiler tubes and cause overheating and tube failure. Since oxygen is highly corrosive, it must be reduced to the lowest possible concentration by the de-aerator and then polished by oxygen scavenger chemical [3].

Boilers in a palm oil mill are usually not operated continuously. During boiler start-up, de-aerator temperature is not high enough to remove dissolved oxygen (DO) to below 7 ppb [4]. An excellent oxygen scavenger providing chemical control was required to eliminate the rest of dissolved oxygen.

With the fluctuation of boiler feed water hardness and non-continuous operation, the boilers in palm oil mills can’t meet operational best practices.

II. MATERIAL AND METHODS

A. Plant Survey

An Indonesian palm oil mill in Kalimantan, Indonesia experienced a boiler upset that cost them over $150K due to replacement of corroded tube, boiler cleaning to remove scale and lost production due to unexpected shutdown.

The plant uses a softener to provide softened water to as boiler feed water (BFW). They have a standby softener as well to provide a backup BFW if the main softener resin has been saturated. Even with this back up softener, the hardness still leakage due to manual mode of monitoring that have large gap between each hardness monitoring. The BFW from softeners is collected in BFW tank before it goes to deaerator (DA) so the oxygen can be stripped away before it goes to boiler mud drum.

The boiler performance is enhanced by chemical program which are:

1. PO4 based scale inhibitor to give protection against hardness scaling
2. Sulfite based oxygen scavenger to reduce dissolved oxygen level pH adjuster to provide enough alkalinity that help to prevent boiler from corrosion [5]
3. Polymer with TRASAR to increase deposit disperancy in boiler water so the deposit can be flushed away from boiler by boiler blowdown. The polymer was tagged using TRASAR as a fluorescent tracer so the residual polymer can be monitored easily.

B. Automation and Control

The automation that we proposed includes multiple online monitoring and controller logic to help boiler operation. The features of our automation and control system are:

- Conductivity and TRASAR based blowdown control for energy and water savings
- Optimized O2 scavenger dosage based on deaerator temperature alarm for corrosion control
- TRASAR based chemical dosage and monitoring for scale control
- Boiler water TRASAR, pH & conductivity monitoring
- Softener shifting logic using combine alarm of totalizer and hardness analyzer
- Extra chemical dose based on hardness alarm
- Avoid hardness leakage in boiler feed water with alarm system
- Web reporting & data management

C. Control Logic

Boiler blowdown optimization

Frequent boiler shutdown might cause huge iron corrosion products accumulated inside pipeline and the boiler itself. With proper blowdown operations could discharge these substances out of boiler. Thus, the automation that we proposed apply conductivity and TRASAR blowdown to control the blowdown operation. The automation can also help optimize and control boiler blowdown based on a fluorescent TRASAR in the internal treatment product, or a conductivity set point.

The expected outcome is increased heat efficiency, reduced energy requirements, increased water reuse, asset preservation, and improved utilization of fuel to heat the boiler.
Pre-boiler corrosion control
Feed water temperature sensor is installed on deaerator outlet to measure deaerator temperature. This sensor is connected to controller and will control the O\textsubscript{2} scavenger dosage based on these readings and configuration setting. The expected outcome is to prevent boiler corrosion during high DO level in BFW which is normally generated when temperature deaerator is low (boiler start-up period).

Boiler and scale deposit control
Boiler feed water quality is measured with hardness analyzer and total flow rate is measured with totalizer. Output signals are combined using control to generate alarm and to shift softener. The alarm will help local operator to start softener regeneration. During the time when the hardness leakage is still detected even after softener switching (if local operator failed to conserve standby softener at its regenerated condition), the automation will trigger scale prevention by increasing scale inhibitor dosage. The expected outcome is scale prevention in the boiler even at un-proper boiler operation.

D. Plant Trial
Before the automation and control system is fully implemented, we establish monitoring mode to get a baseline data. The monitoring period was conducted from April 1\textsuperscript{st}, 2015 to April 18\textsuperscript{th}, 2015. After the data gathered is acknowledge, the automation and control system is fully implemented (controlling mode). The plant lay out can be seen in Appendix.

III. RESULT AND DISCUSSION
During the monitoring and controlling mode, the automation system that established able to collect operational data such as hardness leakage, boiler water pH, and BFW temperature. The data that gathered are displayed in graph below:

It can be seen from the data that the softener is not well operated. As you can see, the hardness leakage reading was too erratic, that forced the automation system to dose more scale inhibitor by turning on the additional the extra pump. The scale inhibitor that we used during this trial is a combination of PO4 based scale inhibitor and TRASAR-polymer to ensure that we dose enough polymer to make sure CaPO\textsubscript{4} that formed by the reaction of scale inhibitor and hardness leakage during the upset condition will be stabilized and disperse in bulk water so it can be flushed away from the boiler using boiler blowdown.

During the even that BFW temperature is very low that normally occur during start up, the DO will be higher than acceptable DO level. The automation that installed, will trigger the extra pump of corrosion inhibitor to dose more corrosion inhibitor to counteract the upset condition.

We got the opportunity to have internal boiler condition before and after automation implementation. The result is consistent with the data gathered.

As you can see from the Figure 4 and 5, the internal boiler condition before the automation implementation is heavily corroded (red color metal). Meanwhile, after the implementation, the internal boiler condition is well passivated that showed by black color metal (magnetite).

IV. CONCLUSION
An automation control has been implemented for oxygen scavenger dosing, pH adjustment, scale inhibitor dosing and boiler water cycles. Figure 2 shows that the automation is able to adjust scale inhibitor dosage in order to minimize the scaling risk resulted by hardness leakage from softener. The platform also generates an alarm to alert operators when there is a hardness leakage incident.
Figure 3 shows similar benefits through consistent monitoring of de-aerator temperature and adjustment of corrosion inhibitor. As de-aerator temperature decreases, the dissolved oxygen concentration will increase. This triggers the system to dose more corrosion inhibitor to protect water side boiler metal surface from oxygen corrosion.

REFERENCES


