Fuel Induced Pitting Corrosion on Boiler Bottom Wall Tube of Steam Power Plant

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Abstract

Power generating unit like steam power plant plays the important role on the economic developing in Indonesia. Tube failures can cause the decreasing of power plant reliability so that they need further analysis to solve the problems. In one case, the leakages of bottom wall tubes of steam power plant boiler have been investigated. A sectional reducing was shown on the upper curve radius of these tubes. This indicates that there were some variables from the outer of tube system that react with the tube surface and then lost. Around the leakages, there was found some pitting with leak and without leak. Pitting without leak was caused by variable process from the outer of tube system only. While, pitting with leak was caused by variables combination, the outer and the inner of tube system. These variables affect each other and form the leakage. These both pits often accompanied by unevenness rust prior to leakages were found to be due to fuel drops from burner. Purging nozzles inside of the burner resulted in the drops of fuels. These fuels fall down onto the top of boiler bottom wall tube. The local corrosion and consequent lost of iron-oxide deposition at the sites of fuel drops attack produce hot spots, which is evident from the microstructure of those regions. Tubes were cut by dividing into three parts section area, the leakage itself, around the leakage, and no leakage, and then were examined by using optical microscope to determine the microstructure analysis. Both corrosion products, around the leakages and far away from the leakages, were examined by chemical analysis Atomic Absorbed Spectrometrie (AAS) to determine the composition. These results then were compared to the initial tube corrosion products. There were shown that the composition differences occured at each product. Increasing of 23% amount of Mn composition was found at corrosion product that around the leakages. It indicates that the composition addition of Mn come from the outer of bottom wall tube system. The excess content of Mn inside the fuels ensure the contribution of Mn to the leakages of bottom wall tube of boiler. Besides that microstructure result shows the failures of iron oxide at the certain area of leakages that determine the local destruction from the outer tube bottom wall system. The inner system contribution of bottom wall tubes such erosion corrosion become the dominant factor to arise the leakage due to serious attack from inner rather than outer tube system that confirm the pits without leak.

Keywords: steam power plant, bottom wall tube, leakage, pitting corrosion, erosion corrosion

I. Introduction

Boiler has an important role as a place to change water from liquid to vapor phase in steam power plant. Properties of feed water and process variable control (velocity, temperature, pressure, and flow rate of fluid) that are not appropriate with design will result the failure [1]. Failure of boiler tubes by corrosion attack has been a familiar phenomenon in power plants resulting in unscheduled plant shut down; in consequence, there are heavy losses in industrial production and disruptions to civil amenities such operational and electric transfer was stopped. The failure of boiler tubes appears in the form of bending, bulging, cracking, wearing or rupture, causing leakage of the tubes [2]. A comprehensive study will be reported in this discussion due to a leakage on bottom wall tubes occurred during overhaul in boiler steam power plant.

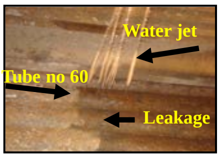
II. Experimental method

Tubes were divided into three samples, normal, pitting with leak, and pitting without leak sample. Physically analysis was done through macro and micro observation on the three samples of tubes. The microstructures were examined on optical microscope. Chemical composition analysis was observed to the product of the leakage (three samples of tubes) and media that contact with damaged tube at outer and inner surface tube. Some factors such variable process concerned with the leakage were also investigated.

III. Result and discussion

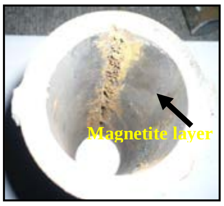
The leakage was found on the bottom wall tubes number 60 when hydrostatic test. Water jet passed through the pitting with leak as seen at Fig. 1(a). Damaged tube then was cut. The pitting with leaks were shown at Fig.

1(b). There was observed un-even rust around pitting with leaks in the outside tube. Groove were found exactly on the below the pitting with leak that cause the leakage as shown at Fig. 1(c).



(a)

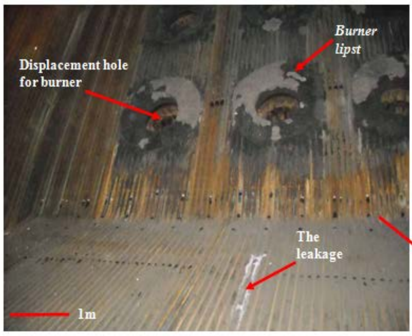
(b)



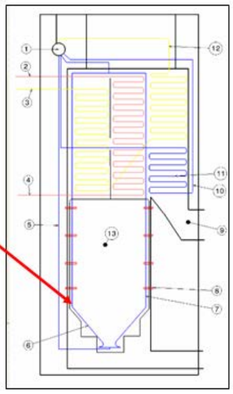
(c)

Fig. 1. (a) The leakage was found when hydrotest tubes (b) Un-even rust around pitting with leak (c) Groove were found exactly on the below the pitting with leaks

The leakage on the bottom wall tubes of boiler occurred at the exactly bottom of the displacement hole for burner as shown at Fig. 2(a) and side view at (b).



(a)



(b)

Fig. 2. (a) The leakage rear view truly (b) Side view

Fig. 3(a) shows the sectional deformation on the leakage tube. The pitting with leak formed the imperfect circle. Un-even rusts also were found around the leakage on the tube surfaces. There was found the change of diameter profile at the peak curve of tube as seen at Fig. 3(b).

(a)

(b)

Fig. 3. (a) The sectional deformation from side view (b) Top view

The protection layer was given on the outer surface tubes at the first operation. This may fail by time due to water jet cleaning process while the maintenance. When water jet cleaning was directed on to tube surfaces, the largest pressure will affect the peak curve of tube. This will cause the diameter deformation. Therefore the rust as the corrosion product was lost. Un-even pressure distribution may cause un-even rust on the tube surface. Continuously rust loss process occurred at the tube peak curve may cause the sectional deformation. The drops of electrolyte that contact on the naked tube surface were a local attack for the tube.

Table 1. Chemical composition of the corrosion product on the normal sample

Code	Parameter								
I	Fe%	Fe_2O_3 %	FeO%	Si%	SiO_2 %	C%	Mn%	MgO%	CaO%
	-	91,10	1,02	0,18	-	0,21	0,86	-	-

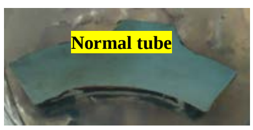
Table 2. Chemical composition of the corrosion product on the pitting without leak

ode	Parameter									
	Fe%	Fe_2O_3%	FeO%	Si%	SiO_2%	C%	Mn%	MgO%	CaO%	Al_2O3%
II	-	82,36	1,62	1,74	9,25	0,05	0,18	1,63	2,30	0,86

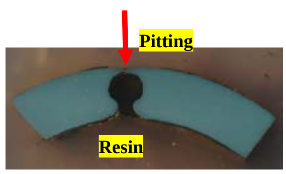
Table 3. Chemical composition of the corrosion product on the pitting with leak

Code	Parameter								
	Fe%	Fe_2O_3%	FeO%	Si%	SiO_2%	C%	Mn%	MgO%	CaO%
III	-	95,60	2,46	0,15	-	0,18	1,06	-	-

Chemical composition result of the corrosion product on the normal, pitting without leak, and pitting with leak were shown on the Table 1, 2, and 3. The decreasing of Mn content was found on the corrosion product of pitting without leak (Table 2) comparing with the corrosion product of normal tube (Table 1). Increasing of Mn content on the corrosion product of the pitting with leak (Table 3) comparing with the normal tube (Table 1) was observed as the result of the electrolyte drops (fuel from burner purging that burnt imperfectly). MgO, CaO, and SiO_2 content come from the seepage of mixture water and steam for filling the boiler when the failure undetectable. At the beginning of failure, pitting was unseen due to covered by the rust. It was shown the seepage on the top of tube surfaces. The leakage was just found when hydrostatic test tube occurred because of the loss of the rust. It indicated that there was no thickness left on the surface of tube.



(a)



(b)

Fig. 4. (a) Normal tube sample for microstructure observing (b) Pitting with leak sample (c) Pitting without leak sample

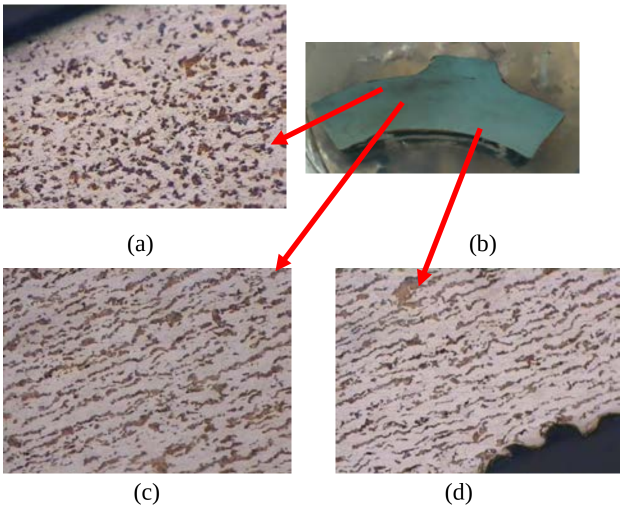


Fig. 5. (a) Top part microstructure view of normal tube (b) Normal tube sample (c) Middle part microstructure view of normal tube (d) Bottom part microstructure view of normal tube

Fig. 4 show the microstructure of normal tube which (a) top, (c) middle, and (d) bottom part view. These figures indicated that the grain unchanged because of plastic deformation or texture in spite of pressure and temperature. Microstructure texture shows flat grain shape due to forming process. Fig. 5(a) shows the beginning of failure magnetite layer which was marked by the surface roughness. The differences of grain shape between inside (Fig. 5(d)) and outside the tube (Fig. 5(a)) surface indicated that the force was received by inside tube has a tendency to be larger than outer surface tube.

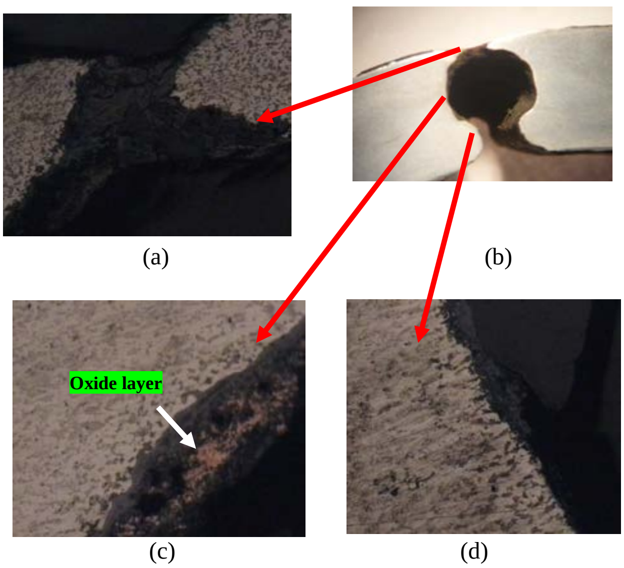


Fig. 6. (a) Top part microstructure view of pitting with leak tube (b) Pitting with leak tube sample (c) Middle part microstructure view of pitting with leak tube sample (d) Bottom part microstructure view of pitting with leak tube sample

Fig. 6 show the microstructure of pitting with leak tube sample which (a) top, (c) middle, and (d) bottom part view. These figures indicated that pure corrosion occured around the pitting and groove, considered the darker grains were compared with the grains that far away from the leakage. The corrosion progagated from one grains to other grains. The oxide layer was found on the unfail tube and it was lost on the fail tube which indicated local corrosion ooccured. At the beginning, there was formed oxidation layer because of general corrosion. Due to the roughness of the surface tube that arise fluid flow turbulence, the oxide layer was eroded and followed by fluid flow (Fig. 6(a)).

IV. Conclusions

Process parameters (pressure, temperature, pH, fluid flow speed, and corrosive media) that were inappropriate with the design become the reason of the failure of magnetite oxide. The pitting with no leak indicated that the dominant factor causing failure from the inside tube. Increasing Mn content as electrolyte from fuel induced pitting corrosion with the leak.

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