Effect of Prolong Aging to the Microstructure and Mechanical Properties of Boiler Tube

By:

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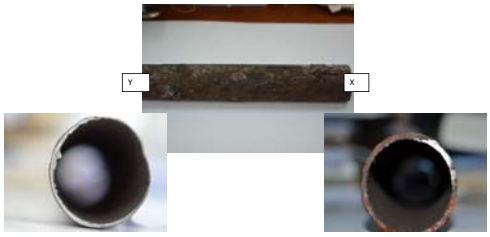
Introduction

- The major problems in all boilers with respect to availability are the failure of boiler tubes.
- From a life extension and safety point of view, the tubes that carry superheated steam to turbines, (main steam pipes and hot reheat pipes) are exposed to high temperature
- Consultation support for local biochemical plant such as Palm Oil Factory with database collected used during repair, replace and predict material life for safety and reliability of their components

Example of tube boiler where Steam/water flows in direction from X to Y. The section X is thicker than Y.



Material and Damage Mechanism

Table 1: The Chemical Composition of the BS3059-360, Standard for Boiler Structure Materials

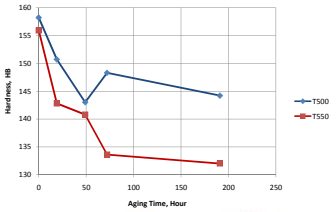
Elements	BS3059-360 (wt.%)
C	0.17 max
Mn	0.4-0.8
Si	0.35 max
S	0.045 max
P	0.045 max

Methodolgy

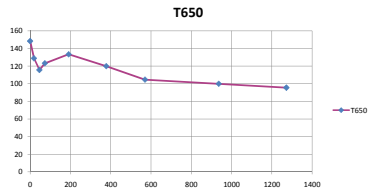
- Method - metallography experiment - including the microstructural analysis
  1. The BS3059 steel were cut for each temperature
  2. Hardness measurement by using Brinell hardness test
  3. The specimens will be heated with 500 °C and 550°C for 19, 49, 72 and 191 hours in a furnace
  4. Metallography/microstructural analysis
  5. viewed under Light Optical microscope for the microstructure imaging.
  6. viewed under Scanning Electron Microscope, Secondary Electron imaging to measure the oxide layer thickness as well as grain size determination

Results and Discussion/Insight

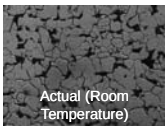
- Hardness Vs Aging Time @ 500 °C and 550°C

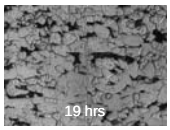


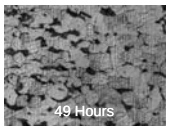
Result: Aging temperature @ 650°C

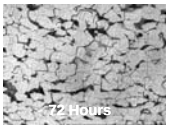


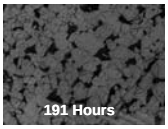
MICROSTRUCTURE ANALYSIS BY LIGHT OPTICAL MICROSCOPE IMAGING @500°C





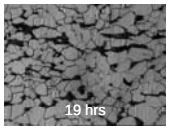


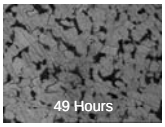


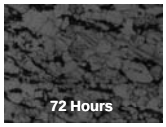


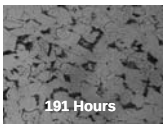
320x Magnification

MICROSTRUCTURE ANALYSIS BY LIGHT OPTICAL MICROSCOPE IMAGING @550°C



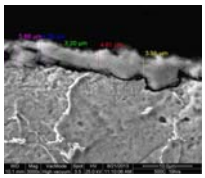




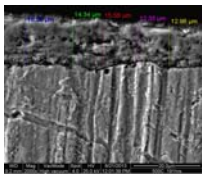


320x Magnification

Oxide Layer Thickness Measurement @500°C



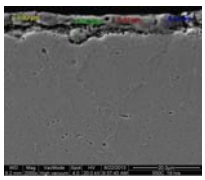
19 Hours: 3.20~5.66µm



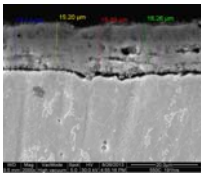
191 Hours: 12.33~16.58 µm

- The wall thickness the boiler tube is affected due to oxidation.
- The thickness was reduced with increasing of aging time
- More than 60% increase in the thickness of the oxidized layer

Oxide Layer Thickness Measurement @550°C



19 Hours: 6.02~8.42µm



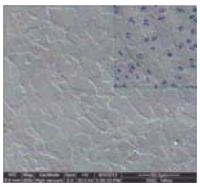
191 Hours: 14.14~16.26µm

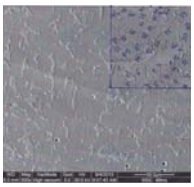
- About 50% or more increase in the thickness of the oxidized layer

Grain Size Measurement

Aging Hours	Number of Grains, (500°C)	Number of Grains, (550°C)
19 hours	77 grains	48 grains
49 hours	56 grains	40 grains
72 hours	48 grains	39 grains
191 hours	38 grains	38 grains

Images of Grain Size Count under 100 x 100 microns of Surface Area for 550°C 19 and 49 Hours Sample.





- The number of grains decreases as the aging hour increases.
- form of bigger grain due to the effect of heating through a certain of time

CONCLUSION AND RECOMMENDATION

- High temperature heating under air and ash environment after a series of boiler operation caused the oxidation and corrosion either at outer or inner surface of tube boiler.
- Considering the facts that the continuous heating of the steel specimen through a certain degree of temperature and over a period of time did affect the microstructure and mechanical properties of the material itself.
- Recommend - Further understanding mechanism of material deformation and failure of thermal plant materials shall be perform with analytical methods

The End

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