Leakage Failure Analysis in Super Heater Tubes In Sugar Industry
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Abstract:
Role of Super heater in steam generation industry has long been plagued by scale formation problem. Scale formation and leakage in tube is triggering factor of super heater problems. The objective of this research is to determine the leading super heater tube leakage problem at the bend section also due to poor welding of dissimilar metal at the bend section and due to scale formation inside the tubes, corrosion and erosion of the tubes due to deposition of fly ash gas. Scale formation influenced the tube geometry and heat transfer parameters such as steam temperature, pressure drop, mass flow rate, flue gas temperature, convection coefficient and relative temperature rise on outer surface of the tube. The outcomes of this research underscore the importance of reducing the scale formation, improving the material of super heater tube at bend section and by providing the shedding ring over the poor welding at the bend. Experimentation is carried out at Natural Sugar Industry, Unit no. 2, Gunj- Sawna, Mahagaon, Yavatmal, Maharashtra State.

INTRODUCTION

Thermal power plants contribute about 71% to all India installed capacity of electric power generating stations. Coal continues to be the dominant fuel source for fossil fuel steam generation in the Indian electric utility industry accounting almost 55% of the power generated. Coal available from various parts of Maharashtra which is used in thermal power plants has ash content about 30-40 %. Due to low quality coal, flue gases liberated from combustion of coal carries fly ash with it. Super heater failure is the prime reason of forced outages at coal fired thermal power plants. Whole world is facing problem due to crisis in energy sector. The production rate of energy is insufficient in proportion with the demand. Due to over-load the power stations are also facing many technical difficulties. One such major difficulty arises due to boiler tube leakage in the thermal power stations.

Super heater is an integral part of boiler and is placed in the path of hot flue gases from the furnace. The heat recovered from the flue gases is used in superheating the steam before entering into the turbine (i.e. prime mover).Its main purpose is to increase the temperature of saturated steam without raising its pressure. A super heater is a device used to convert saturated steam or wet steam into superheated steam or dry steam. Super heaters are used in steam engines or in processes, such as reforming.. The super heater can be treated as the heart of any boiler system, the main duty of which is to supply desired amount of steam regularly at rated temperature and pressure. Super heater is mainly a heat exchanger in which heat is transferred from furnace gas to the steam. Due to improper heat transfer between steam and furnace gas leads the reduce performance, repetitive failures.. Super heater tube failure is very common issue in boilers. The function of the super heater in the thermal power plant is to remove the last traces of moisture (1 to 2%) from the saturated steam coming out of boiler and to increase its temperature sufficiently above saturation temperature. The super-heating raises overall cycle efficiency as well as avoids too much condensation in the last stages of the turbine which avoids the erosion of blades.

Tube failure in the super heater is hazardous enough to shut down whole plant hence it is important to take remedial actions to avoid technical as well as economic losses. Proper distribution of furnace gas over entire super heater tubes and uniform steam flow in each tube is suggested for trouble free operation of super heater. Uneven heat transfer is a result of non-uniform gas flow or non-uniform steam distribution in super heater that is because of scale formation on super heater wall. The significant causes of failure in super heaters are localized prolonged heating, creep damage, thermal fatigue, excessive thermal stresses, water and erosion etc. The super heater can be treated as the heart of any boiler system.

PROBLEM DISCUSSION

In Natural Sugar Industry, Unit no. 2 , Gunj- Sawna, Mahagaon, Yavatmal , Maharashtra State the WIL boiler is used for the generation of 32 TPH of energy. After long running of boiler and super heater the failure occurs at the bend section, wide methodology is applied to find out the reason for tube failure in which Static Thermal Analysis is done on the ANSYS 16.0 ICEPAK to obtain the root cause for tube failure.

The result of the analysis are shown below and the root cause for the failure is found to be the scale deposition on the both sides of super heater tube and the poor welding quality.
Reynolds number for forced convection may be expressed as

\[ R_e = \frac{4Gh}{\pi D_i \mu_s} \]  \hspace{1cm} (1)

\[ R_e = 1.9491 \times 10^7 \]

Steam properties are at the mean bulk temperature of 320°C

\[ P_r = 2.4957 \]

Heat transfer in the super heater tube is considered as a forced convection, with turbulent flow.

\[ N_u = 22515.0069 \]

\[ h_s = 33298.2769 \text{ W/m}^2 \text{C} \]

Heat transfer outside the super heater tube is considered as forced convection due to cross flow of the hot flue gas over bare tubes. A conservative estimated convection coefficient of flue gas \( h_g \) on outer surface of bare tube in inline and staggered arrangements.

\[ Pr_g = \frac{\mu_x C_{pg}}{C_{pg}} \]  \hspace{1cm} (6)

\[ Pr_g = 0.771 \]

The corresponding Reynolds number \( Re_g \) may be expressed as

\[ Re_g = \frac{G D_o}{12 h_g} \]  \hspace{1cm} (7)

Where, \( G \) is gas mass velocity and may be expressed as

\[ G = \frac{12 \times W_g}{N_w \times L \times (S_i-D_o)} \]  \hspace{1cm} (8)

\[ Re_g = 5270.7947 \]

\[ h_g = 711.7369 \text{ W/m}^2 \text{C} \]

\[ Q = \frac{2\pi L (T_g - T_s)}{h_s (S_l-D_o) + \frac{h_i(T_i-T_g)}{\mu_x} + \frac{1}{h_g r_o}} \text{ Watt} \]  \hspace{1cm} (9)

\[ Q_{(without \ text{scale})} = 1407.319617 \text{ kW} \]
Fig: 3 Heat flux at super heater tube with shedding rings.

Shedding rings are provided over the welding joint and the heat flux is observed to be increased up to 21.34 %.

6. RESULT AND DISCUSSION

Table: Estimation of scale thickness and relative temperature rise

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Service time (hrs)</th>
<th>Scale thickness (mm)</th>
<th>Heat Flow (Watt)</th>
<th>Heat Loss (%)</th>
<th>Relative Temp. Rise (°C)</th>
<th>Heat Flux (Analytical) (W/m²)</th>
<th>Heat Flux (ANSYS)</th>
<th>Heat Flux With shedding ring (W/m²)</th>
<th>Deviation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1407319.61</td>
<td>0</td>
<td>0</td>
<td>348986.22</td>
<td>414009.2</td>
<td>493726.65</td>
<td>15.72</td>
</tr>
<tr>
<td>2</td>
<td>10,000</td>
<td>1.3912</td>
<td>1276617.35</td>
<td>13.98</td>
<td>46.37</td>
<td>317686.97</td>
<td>356712.3</td>
<td>453589.69</td>
<td>10.94</td>
</tr>
<tr>
<td>3</td>
<td>20,000</td>
<td>1.5263</td>
<td>1193221.9</td>
<td>15.21</td>
<td>50.87</td>
<td>314860.4</td>
<td>352894.4</td>
<td>446983.55</td>
<td>10.77</td>
</tr>
<tr>
<td>4</td>
<td>40,000</td>
<td>1.6746</td>
<td>1173786.2</td>
<td>16.59</td>
<td>55.82</td>
<td>311690.5</td>
<td>346988.9</td>
<td>441025.97</td>
<td>10.17</td>
</tr>
<tr>
<td>5</td>
<td>80,000</td>
<td>1.8373</td>
<td>1153610.8</td>
<td>18.02</td>
<td>61.24</td>
<td>308413.4</td>
<td>345695.6</td>
<td>437862.98</td>
<td>10.78</td>
</tr>
<tr>
<td>6</td>
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<td>2.0158</td>
<td>1131574.91</td>
<td>19.59</td>
<td>68.6</td>
<td>304851.30</td>
<td>341892.05</td>
<td>434692.58</td>
<td>10.82</td>
</tr>
</tbody>
</table>

CONCLUSIONS

The heat loss increases by the deposition of scale formation and improper welding in super heater tubes. The pressure drop is higher and also due to poor welding material resulting in leakages and rupture at bend section of the tube. From the analysis the thickness of scale increases over the time period and hence the inner diameter of the tube gets decreased. Scale formation influenced the tube geometry and heat transfer parameters such as steam temperature, pressure drop, mass flow rate, flue gas temperature, convection coefficient and relative temperature rise on outer surface of the tubes. By providing shedding ring over the welding reduces the chances of tube failure at the joint. It is concluded that 21.34 % reduction in leakage of the tube by providing the shedding ring over the joint.

REFERENCES


