Infrasound cleaning of smoke tube boilers

In heating plants up to 25 MW, a cost-efficient and compact way to recuperate the energy in the hot flue gas, is by means of a smoke tube boiler. As the name suggests in a smoke tube boiler, the flue gas passes inside tubes, surrounded by a water mantle cooling the smoke tubes. The boilers are normally mounted vertically and generally have three tube passes with between 300 and 800 tubes inside the boiler, ranging from hot in the center to cold in the outer parts.

On-line cleaning of smoke tube boilers is challenging and must be combined with manual cleaning as well. Traditional cleaning methods include compressed air blowing from the top of the boiler as well as manual cleaning of each individual tube. For the manual cleaning, the boiler must be taken offline and normally an oil-fired boiler is used to compensate the production loss. The manual cleaning is a dangerous work that can take up to one day and cost both man hours and oil consumption.

Most commonly, the fouling of a smoke tube boiler starts in the bottom turning chamber, where there is no automatic cleaning and where the compressed air blowing from the top does not reach. The fouling mechanism includes accumulation of so called “beard” at the inlet of the smoke tubes. As the beard grows, it is sucked into the tubes and eventually clog them. Since each tube constitute for 0.5 % of the heat transfer area of the pass, heat transfer is quickly deteriorated resulting in losses in thermal efficiency. Using long range infrasound, the smoke tubes are kept open in the bottom, avoiding said losses and prolonging the time between outages for manual cleaning. Figure 1 below show an example of “bearding” in a vertical smoke tube boiler.

Heat Management has developed a standard infrasound cleaner for this purpose, which does not require a full acoustic model and which has a generic design, for each installation. The result is the cost efficient supply of a powerful infrasound cleaner for all smoke tube boilers. The infrasound cleaner is operated with a 24 V DC solenoid valve and runs on compressed air (6-8 bar), for two seconds every four minutes and a sound pressure sensor gives the acoustic output of the infrasound cleaner, between 25 and 40 kPa. Air consumption ranges from 6 to 9 Nm3/h, depending on the size (MWth) of the boiler. A buffer tank of 500 liter must be installed close to the infrasound cleaner.
References

Heat Management has plenty of references and case studies for this boiler type. These references are for slow growing biofuels, such as wood chips. Fast growing fuels such as straw are more difficult due to higher alkali content in ash, creating stickier ash. Typical results for the references are reduced number of stops for manual cleaning, reduced average load on flue gas fan and reduced average flue gas outlet temperature.

Info for quotation

A quotation can be given based on the following information:

- Fuel
- Boiler capacity (MW)
- Approximate flue gas temperature in/out of smoke tube boiler
- Situation description (Other cleaning system installed? How often manually cleaned? Rising flue gas outlet temperature during the season?)
- Drawing showing the boiler and the number of smoke tubes and diameter of tubes

For smoke tube boilers it is quite easy to obtain high particle velocities. For a two-pass smoke tube boiler the reversal chamber is generally a good installation location. The following table gives a suitable size of sonic cleaner as a function of the total cross-section of the warmest tube pass.

<table>
<thead>
<tr>
<th>Smoke tube cross-section (m^2)</th>
<th>Sonic cleaner size</th>
<th>Attachment socket diameter (mm)</th>
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</thead>
<tbody>
<tr>
<td>0.05-0.15</td>
<td>APS15</td>
<td>273</td>
</tr>
<tr>
<td>0.15-0.4</td>
<td>APS70</td>
<td>324</td>
</tr>
<tr>
<td>0.4-1.0</td>
<td>APS150</td>
<td>406</td>
</tr>
<tr>
<td>1.0-</td>
<td>APS350</td>
<td>506</td>
</tr>
</tbody>
</table>

Examples:
52 tubes with diameter 65 mm => 0.17 m^2 cross-section => APS70
155 tubes with diameter 68 mm = 0.56 m^2 cross-section => APS150

Single tube pass boiler are more difficult to generate high particle velocity inside, so installation location etc must be based on the general design of boiler+ducts before/after.
Standard design of APS150. Shape can be changed to fit the surroundings

General installation of infrasound cleaner