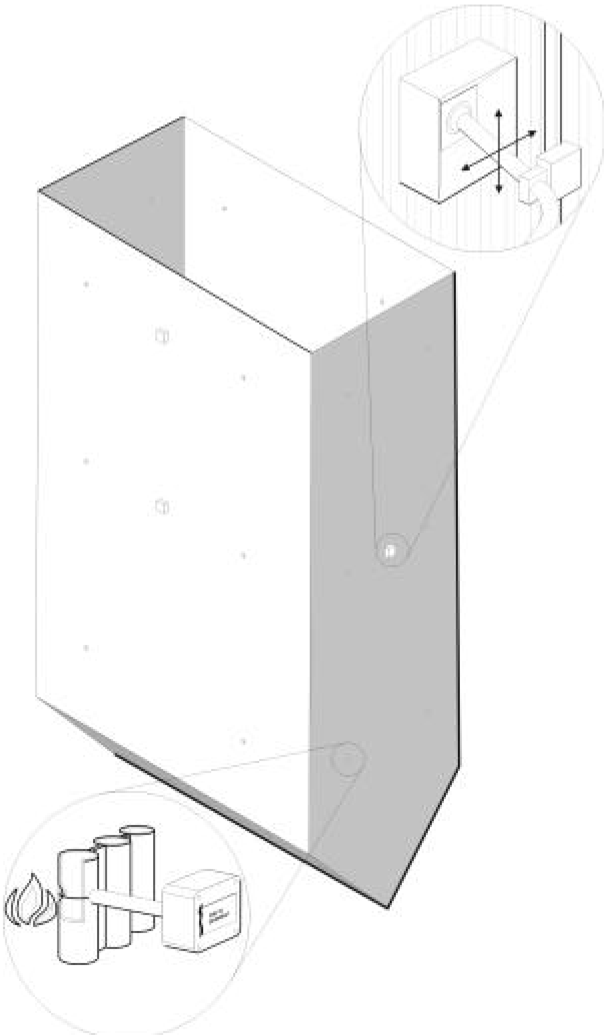
Boiler Heat Flux Sensors

Design considerations: structural integrity, pressure drop and tube temperature



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Introduction

Boiler heat flux sensors are becoming increasingly popular for supporting sootblower automation. The combination of sensor, software and sootblowers is known as “smart sootblowing”.
Clyde Bergemann is the leading supplier of smart sootblowing solutions.

The construction of a “boiler heat flux sensor” requires local dimpling of a boiler tube.
The dimpling process consists of local deformation of the tube, creating a concavity. The concavity is later filled up with the sensor, sensor wiring and welding material. The end result is a tube containing a sensor. The outside of the tube will be identical to that of a normal tube, on the inside however there will be a local indent.
The existence of this indent is a cause of concern. The main questions are:

1. Is the process of dimpling resulting in degradation of the structural integrity of the original tube material?
2. Is the indent creating any significant pressure drop?
3. Is the added welding material in the indent causing any higher than usual risk of failure by temperature rise?

These issues will be addressed in the following paragraphs.

(figure on the cover: boiler equipped with water cannons and heat flux sensor)

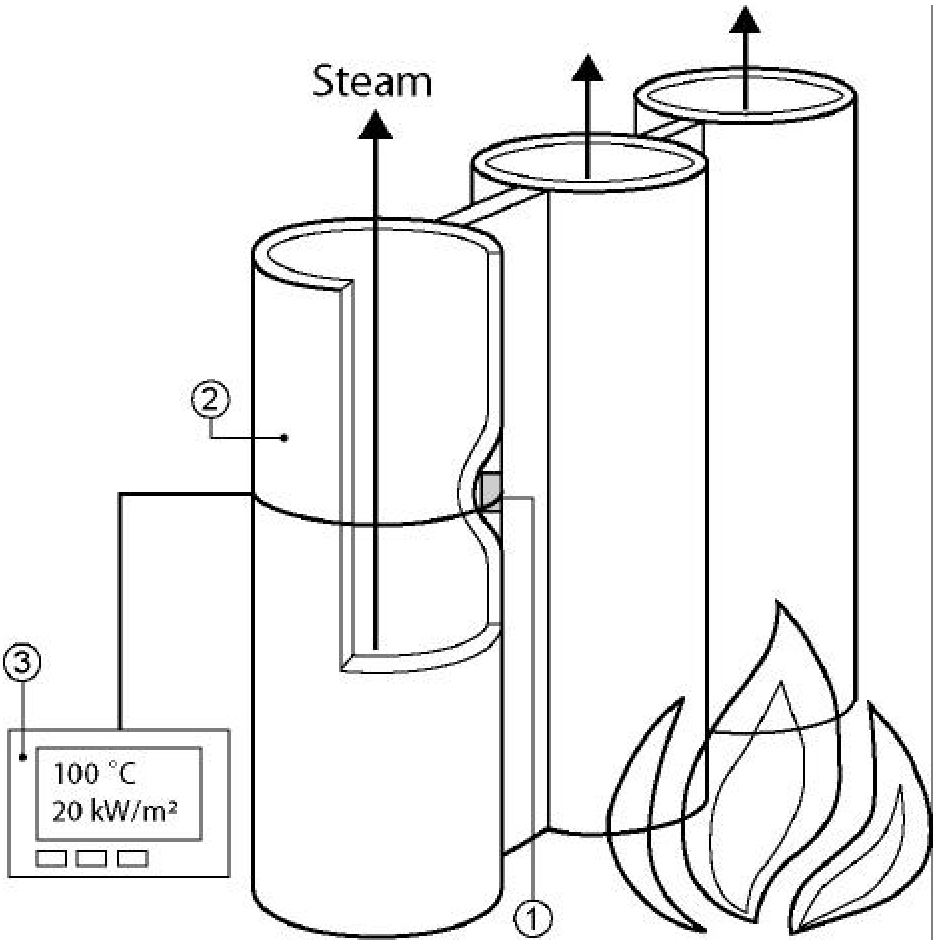

Figure 1: *Boiler heat flux sensor*

1 Structural integrity

The tube material is usually some heat resistant steel.
According to ASTM and ASME it is allowed to deform boiler pipes made out of these steel types. There are standards covering this deformation.
Clyde Bergemann' production procedures are complying with the relevant standards. Compliance is taken as sufficient assurance that structural integrity is maintained.

2 Pressure drop and tube surface temperature

2.1 General remarks, patenting by Clyde Bergemann

In general one can say that the size of any indent should be as small as possible. A larger size results in larger pressure drops, higher surface temperatures at the location of the sensor, and increased danger of local disturbance of the flow pattern (resulting in lesser heat transfer between fluid and tube).
The creation of a smaller dimpling than the present size is not feasible because it will lead to a loss of sensor signal below detectable limits.

Clyde Bergemann is claiming that the indent in its boiler heat flux sensors is considerably less than that of earlier designs.
Clyde Bergemann is presently patenting the construction and the method of dimpling. Without going into details, it can be stated that the indent volume is reduced by about 20 to 30% compared to earlier designs.

2.2 Pressure drop

The pressure drop has been calculated and tested on the eighties at the Central Electricity Research Laboratories in the United Kingdom. A summary of the results is that even in worst case conditions (supercritical steam, 19 mm inner tube diameter) the pressure drop is negligible (in that case equivalent to 114 mm additional pipe length).

2.3 Heat transfer / tube surface temperature

The most important factor in heat transfer in boiler tubes usually is the transfer between tube inner surface and steam.
During production of heat flux sensors it is taken into consideration that the indent should be as streamlined as possible. Also the patented design (see above) will keep any disturbance limited to a minimum.
Local increase of material thickness is typically leading to no more than 20 degrees C temperature increase. This is not significant.

3 Existing installations

Boiler heat flux sensors have been used since the eighties in scientific research applications. The first installations as well as pressure drop have been done in conventional subcritical boilers with relatively small tube diameters (inner diameter less than 1 inch).
Meanwhile boiler heat flux sensors have been installed for sootblowing related applications by Clyde Bergemann in more than 40 boilers.
In about half of these installations the installations these were supercritical boilers involving rifled tubes.
So far, more than 3 years after the first installations, no problems have arisen that can be related to pressure drops, structural integrity or degradation of heat transfer.