HFC Monitor Laboratory Demonstration

Water Cannon Thermal Shock Simulation

Introduction

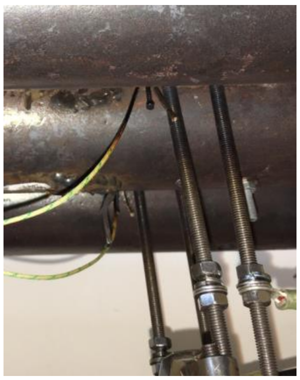
Water, sprayed onto tube walls to reduce the build-up of surface deposits, can unintentionally cause a sudden drop in surface metal temperature, resulting in unwanted stresses. Repeated cycling of this thermal 'shock' from water cannon activity can ultimately degrade the tube metal, causing possible surface cracking. By monitoring and analysing these transients, as they occur, it allows cleaning operations to be fine-tuned to help avoid a scenario where tube damage could occur.

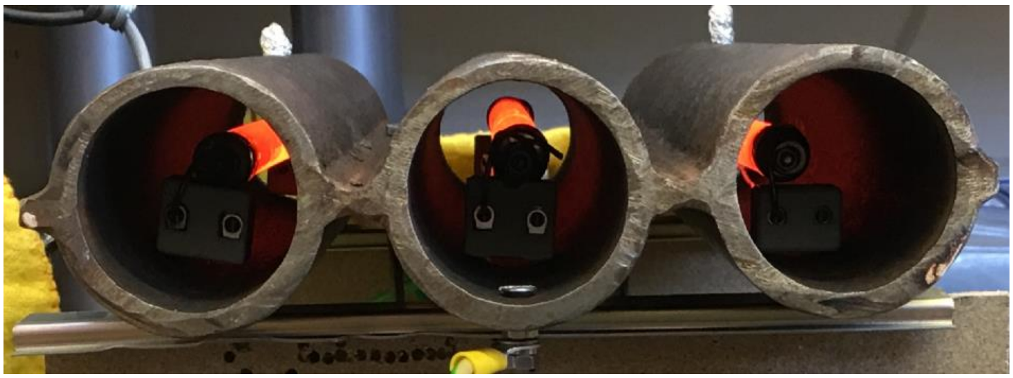
The laboratory simulation described below is designed to demonstrate the ability of the HFC electronics to capture and characterise temperature transients on the fireside crown of membrane tube walls caused by water cannon cleaning operations.

Simulation Method and Results

The demonstration was performed using an array of three 400mm (1.5 foot) long subcritical boiler tubes mounted in a horizontal position. A HFC sensor/electrode configuration was temporarily attached to the underside of the array across the central tube (see photo) - the underside simulating the external (cold) side of the tube array when installed on a boiler wall. During the tests, the tube's electrical and thermal characteristics were monitored using the latest version of HFC electronics and software, which was configured to log data at a rate of around 7 samples per second.

A 1kWatt heating element was installed in each of the three tubes (see photo) and the tube array temperature was allowed to reach equilibrium, stabilising at around 400^{0}C (~750^{0}F).





Underside Electrode Connections and Internal 1 kWatt Heating Elements

Having stabilised in temperature, the heating was switched off and a small amount of cool water (around 40cc or 1.5 fluid ounces) was rapidly poured over the tubes in the vicinity of the HFC sensors.

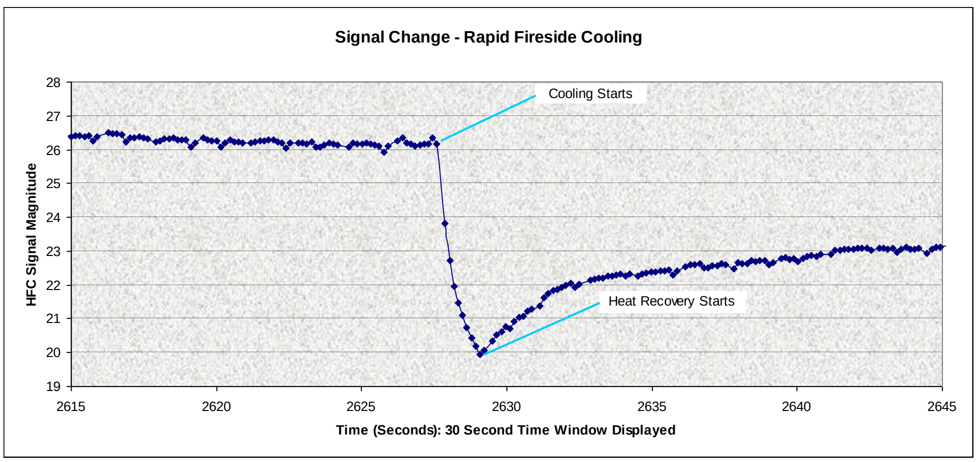
A typical cooling event was captured using 'high speed' photography, below. The water is seen to immediately boil on contact with the tube surface:

0 Seconds

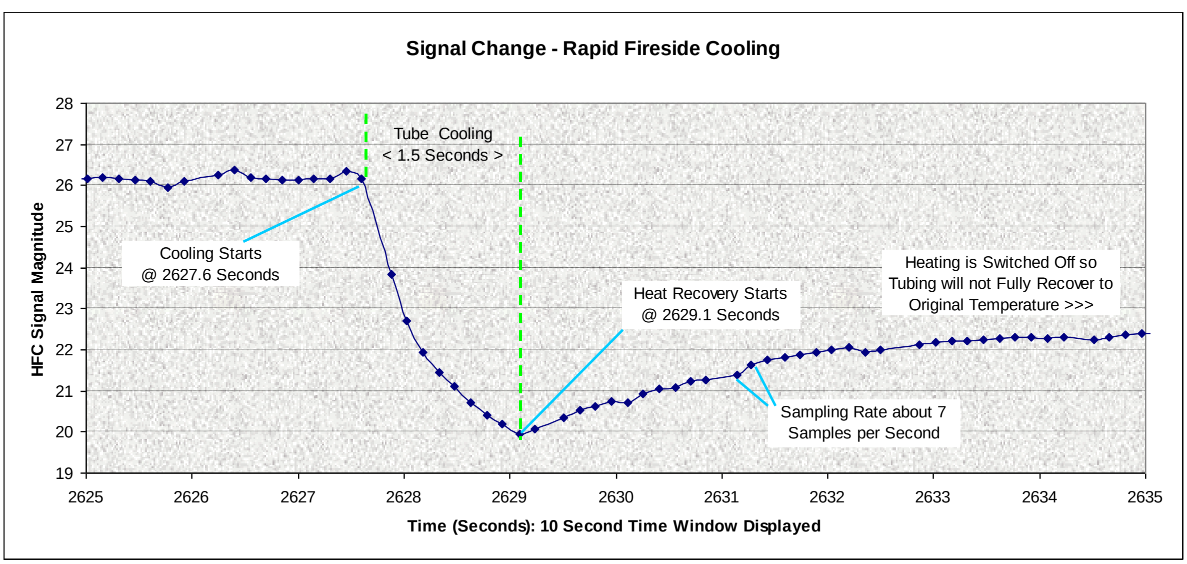
0.5 Seconds

1 Second

The effect of a typical cooling event, above, on measured HFC signals, is shown below:



Change in Signal due to Rapid Cooling: 30 sec. Window (Above) and 10 Second Window (Below)



Discussion

During the HFC measurement process, signals pass around both sides of the tube wall (both cold-side and fireside). As soon as the fireside tube surface is cooled, it immediately influences the tube's inherent electrical characteristics: the sudden cooling results in an immediate drop in signal.

By sampling the HFC signal multiple times per second, the profile of the thermal shock transient can be characterised in terms of speed and magnitude, enabling resulting metal stress to be quantified.

The fireside surface temperature dropped by around 100^{0}C (~180^{0}F) during this demonstration and this change may well be greater than those typically experienced on a tube wall during water cleaning. However, the purpose of the demonstration is to demonstrate the ability of the HFC monitors to capture and characterise these thermal shock events.

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