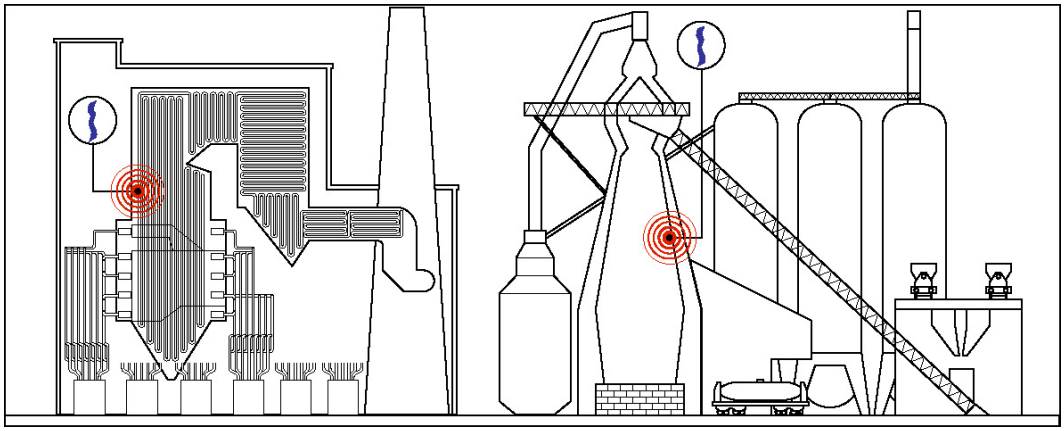
HEAT FLUX

Industrial Applications of Heat Flux Measurement



REPORT

Industrial heat flux measurement v0507

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Introduction

This report serves to introduce a new generation of heat flux sensors. Having a wide temperature range, these sensors can be used in industrial measurement and control systems.

Use of heat flux sensors can lead to:
1 improvements in efficiency
2 better system safety
3 automated detection of fouling and need for servicing.

Examples of applications are detection of fouling (Boiler Fouling Sensor),monitoring of furnaces (Blast Furnace Monitoring / General Furnace Monitoring) and flare monitoring.

Hukseflux is the world market leader for the above mentioned applications. Sensors can be manufactured in accordance with industry standards. In case of questions the reader is invited to contact Hukseflux Engineering, preferably by e-mail at info@hukseflux.com.

1 A New Generation of Heat Flux Sensors

Heat flux sensors measure the flow of energy to or from a certain object. Heat flux is expressed in watts per meter square. The use of these sensors has long been restriced to scientific research. In response to customer questions Hukseflux has recently modified the design to allow use of heat flux sensors in harsh industrial environments.

Examples of applications are given below. At Hukseflux sensors are now manufactured for use up to 1000 degrees C. Products can be manufactured following quality standards ISO 9000, and several industrial standards like ITS90, ANSI, DIN and BS. Also sensors for hazardous area's can be manufactured according to safety standards like Eexi, ATEX / Cenelec and NAMUR can be.

2 Applications

In the following paragraphs examples of four different applications are given.

2.1 Application 1: Boiler Fouling Sensor

In many boilers, the furnace walls suffer from fouling (also called slagging). In many cases it is possible to put heat flux sensors on the waterwall piping. By monitoring the heat flux from the boiler to the steam / water mixture in the piping, the process of fouling can be detected. An added thermocouple can also be used for estimating tube surface temperature (so-called chordal thermocouple).
The total system leads to:

- Automation of the process of sootblowing. (so-called intelligent sootblowing)
- Better system efficiency
- Savings on servicing.
- Optimal estimation of tube lifetime
- Extension of tube lifetime

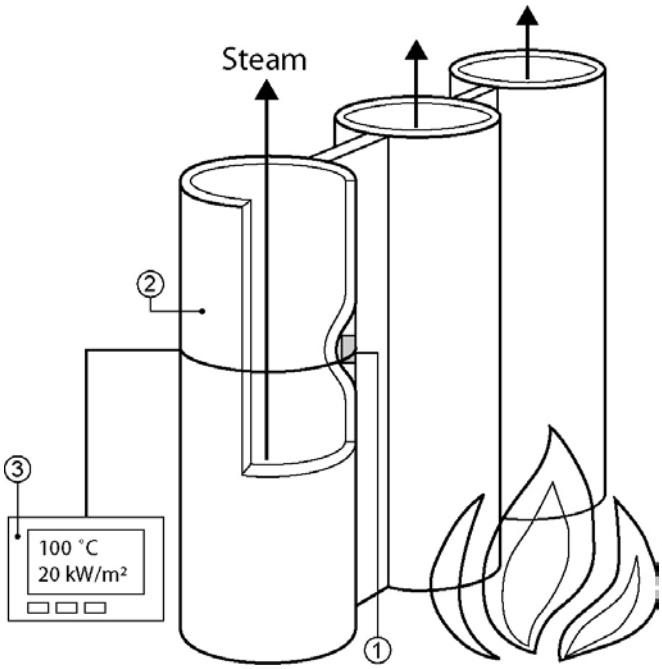

Figure 2.1.1 *Boiler waterwall (2) with incorporated heat flux & temperature sensor (2). The sensor is connected to an external readout (3).*

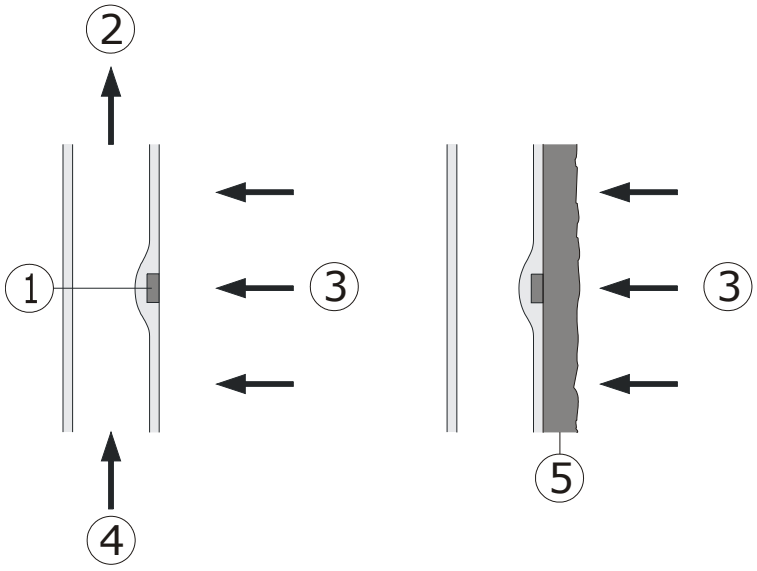

Figure 2.1.2 Cross section of the tube in figure 2.1.1. On the left hand side, the clean tube, exposed to the heat of the oven, on the right, the same tube, now covered with soot.

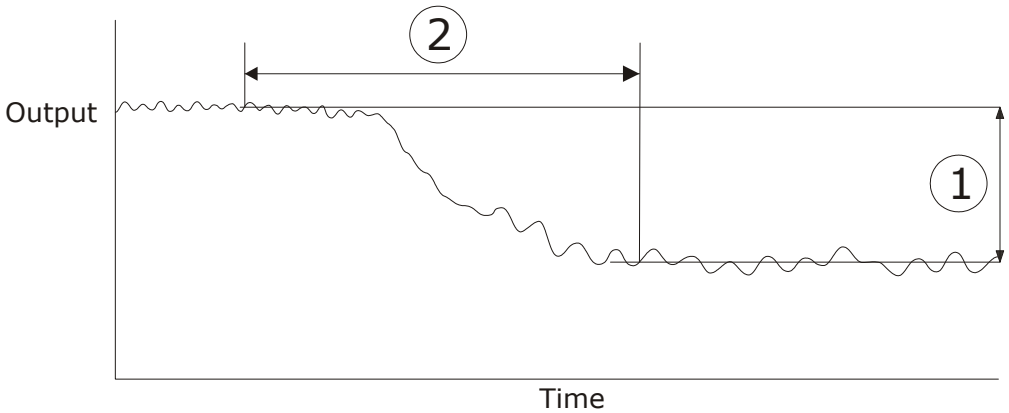

Figure 2.1.3 The heat flux signal, starting with a clean tube that gradually foules. (from left to right in figure 2.1.2)
There is a change in heat flux level, and at the same time, the spectral content of the signal changes; the fast changes are damped by the added heat capacity of the soot.

2.2 Application 2: Oven / Furnace Monitoring

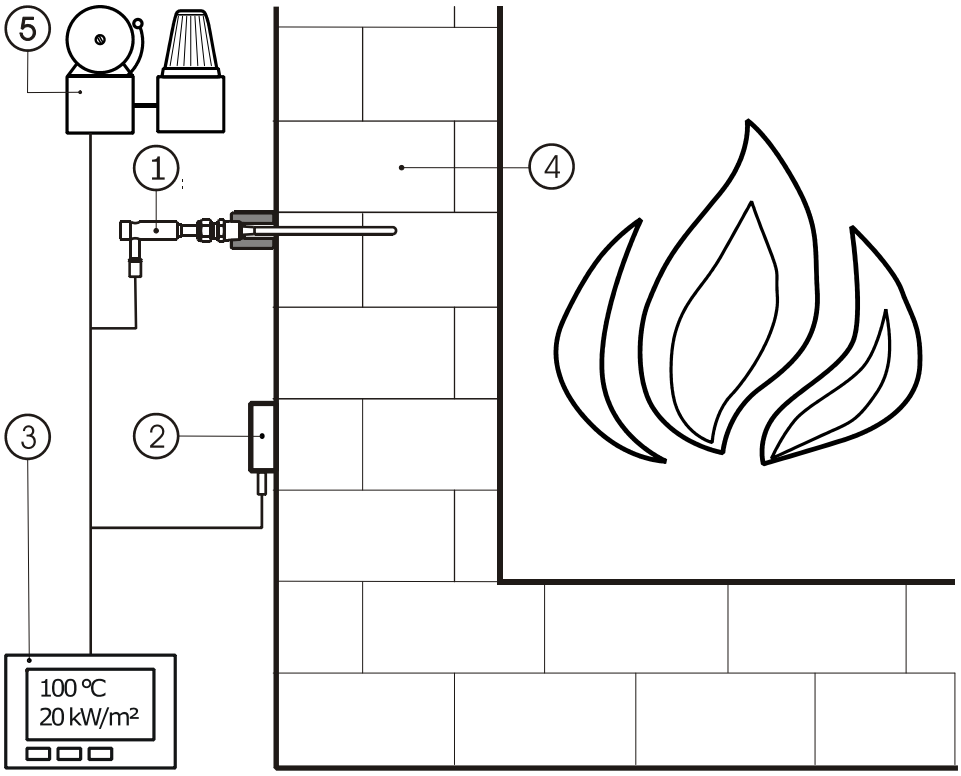

Figure 2.2.1 *The monitoring of furnaces and ovens. needle type heat flux & temperature sensor (1), plate type (removable) heat flux & temperature sensor (2), readout unit (3), brick (4), alarm/warning system (5).*

1. Improved system safety
2. Detection of wear of the mortar and brick material
3. Improved system modelling

2.3 Application 3: Blast Furnace Monitoring

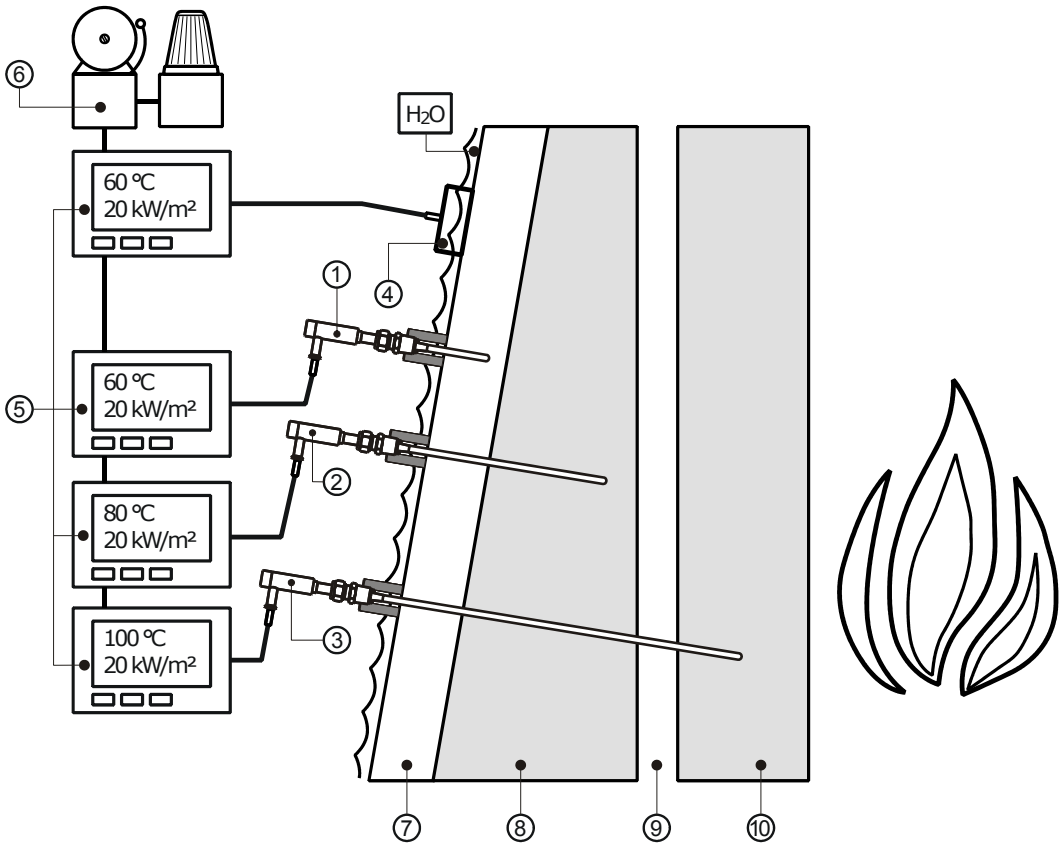

Figure 2.3.1 *Needle type Heat flux and Temperature sensors for monitoring of blast furnace conditions (1), (2), and (3):Removable temperature and heat flux sensor (4), measurement and control system (5), alarm /warning system (6), steel shell (water cooled) (7), graphite (8), mortar (9), semi-graphite (10).*

Condition	Shell Temp	Graphite Temp	Heat Flux
Normal conditions	0	0	0
Cooling system malfunction	++	+	0
High heat development (Danger)	++	++	++
Disturbed Thermal Contact	0	++	0

Table 2.3.1. *Furnace safety system / diagnosis: examples of furnace conditions. 0 indicates normal, + is an increased value, ++ is strongly increased. Column 1 showing various possible conditions: normal, cooling system malfunction, high heat development possibly caused by water in the furnace, disturbed thermal contact caused by cracks. Columns 2, 3 and 4 show resulting signals (T in the shell and the graphite and accompanying heat fluxes).*

2.4 Application 4: Flare Monitoring

Heat Flux sensors can be used as a sensor in alarm systems in case of possible high thermal radiation exposure. A typical application is close to flares. The heat flux level for a safe environment for personnel must not exceed 5 kW/m^2 (or 1500 BTU/hr ft2), or otherwise an alarm is activated.

The below design, HF02, is certified for use in an explosive environment, and can cope with radiation levels up to 15.000 W/m2.

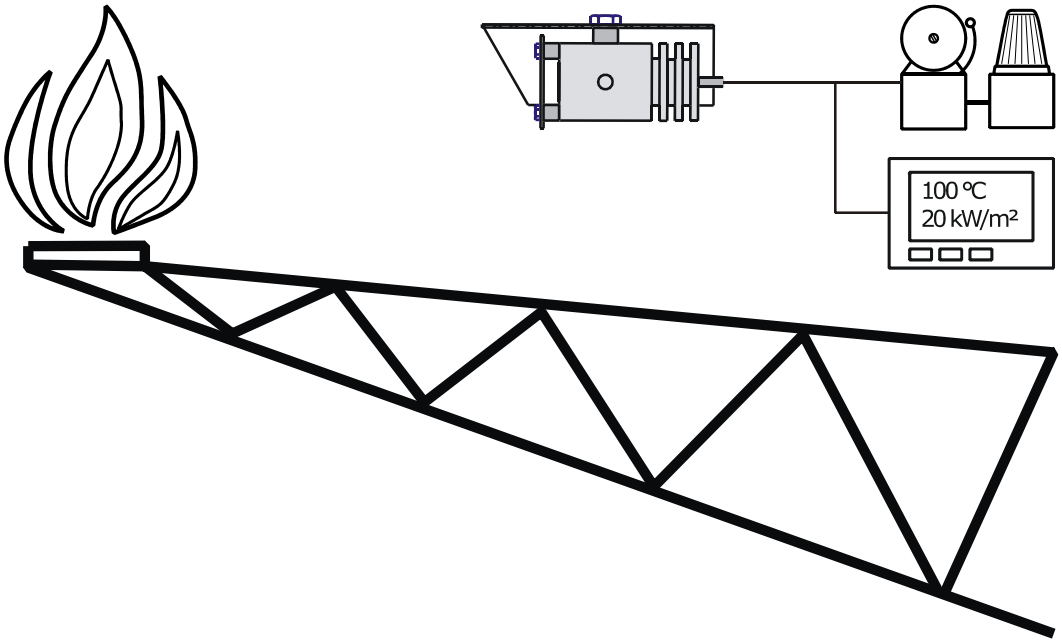

Figure 2.4.1 *Sensor HF02 used to monitor the radiation from a flare, coupled to a warning system.*

2.5 Application 4: Coker Control & Fouling

Many fluidised beds, cokers and distillation colums have problems with internal deposition of solid materials.
During maintenance the materials are typically removed. (de-scaling of de-coking).
Monitoring of heat flux can lead to:
1 improvements in process control (through better understanding of the process)
2 reduction of overall scaling
3 improved prediction of work to be expected by de-scaling crews.

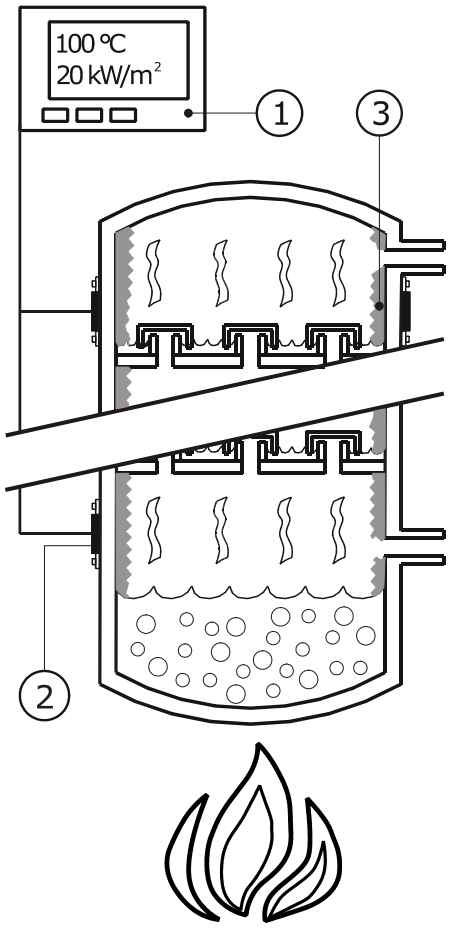

Figure 2.5.1. *Sensors of type HF01 monitoring the heat flux from a distillation column or coker.*

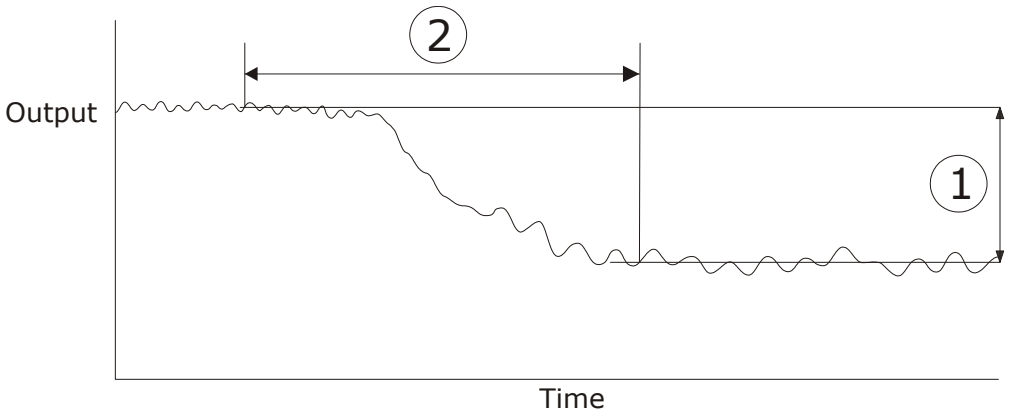

Figure 2.5.2 The heat flux signal, starting with a clean surface that gradually scales.
There is a change in heat flux level, and at the same time, the spectral content of the signal changes; the fast changes are damped by the added heat capacity of the soot. Typically the total process is monitored several weeks to average out local climatological effects.

2.6 References

Customer	Application	Purpose
Ticor South Africa	Titanium furnace monitoring	Safety, process monitoring
Corus	Steel blast furnace monitoring	Safety, process montoring
RWE	Coal fired electrical power plant	Process improvement, slagging detection
Corus Ceramics Research Centre	Aluminum furnaces	Study and optimisation
Alcan	Aluminum furnaces	Study and optimisation
VTT process	Coal fired electrical power plant	Study, fouling detection
Energie Centrum Nederland	Experimental boiler for biomass co-firing	Study, fouling detection

Table 2.6.1 *Reference users of Hukseflux heat flux sensors in industrial applications.*