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Temperature Measurement of Combustion Processes Using Radiation Pyrometers

The Subject

The subject of thermal waste disposal is determined, to an increasing extent, by environmental issues. Impositions of tight restrictions by legal authorities, especially the provisions of waste incineration, entail strict procedures for supervision and limitation of emissions into the atmosphere. This has become manifested, for instance, in regulations like the 13th and 17th BImSchV¹ and TA Luft² in Germany.

Apart from the responsibility for environment protection, there is a cross-industry economical interest by the users of incineration plants for suitable measurement and regulation techniques for process optimization, especially for a precise and reliable sensing of the measurement reading temperature.

The Solution

By the non-contact temperature measurement using **HEITRONICS** radiation pyrometers, a novel measuring technique is applied that offers some significant advantages to conventional temperature probes.

A comparison with conventional temperature measurement techniques clearly demonstrates the economical benefits of radiation pyrometers in practice. Thermocouples are exposed to high static, dynamic and corrosive loads and thus have to be replaced after a relatively short period of time.

However, radiation pyrometers measure temperatures by being introduced into the furnace and incineration chamber from outside without making contact to any surfaces. They virtually exhibit no wear at all and thus require a minimum of maintenance. Deviations from measured values, as are common for thermocouples are virtually unknown for contact-less temperature measurement. The radiation pyrometers are not subject to any thermodynamic aging.

The performance features of **HEITRONICS** radiation pyrometers are convincing:

- High measuring accuracy;
- high long-time stability;
- nearly unlimited service life;
- low operating costs;
- suitable for equipment meeting 13th and 17th BImSchV and TA Luft;
- for temporary averaging, adjustment periods up to 600 seconds are possible.

¹ Federal Immission Protection Directive of Germany by law

² Technical Procedure AIR – German law

Approval for 13th and 17th SImSchV and TA Luft

Comparative measurements with thermocouples and the suitability tests of TÜV Southern Germany have revealed that combustion gas temperatures from 500°C upward can be measured reliably and with good reproducibility using the **HEITRON-ICS** radiation pyrometers KT19.69 and KT15.69.

The suitability test were carried out between July 1999 and July 2000.

Both measurement systems were classified as suitable by the

Federal Ministry for Environment, Preservation of Nature and Reactor Safety (BMU)

and published under the heading

Uniform practice for the supervision of emissions and immissions

in the

*BMU Bulletin dated 10-11-2000 * IG I 3-51134/2*

Section II: Suitability for measuring equipment for continuous measurement of reference values / operational values

Chapter 3: Minimum temperature.

Measurement Principle

The principle of pyrometric temperature measurement is based on optical radiation density measurement of a thermal radiation emitted from a measured object. If the object-specific features are known, the temperature may be determined directly by such measurement. In those cases, the radiation density is mostly not determined throughout the total electro-magnetic spectrum, but withing a rather small spectral range adapted to the measuring task concerned.

The **HEITRONICS** radiation pyrometers KT19.69 and KT15.69 have been conceived specifically for temperature measurement in hot combustion gases, like e.g. incineration plants, garbage pyrolysis plants or rotary kilns furnace. They operate in a spectral range where hot carbon dioxide (CO₂) shows a high degree of emission, but cold CO₂ is largely transparent. This measurement principle enables a correct valuation of the detected heat radiation of the hot gas body without any reading displacement by absorptions in colder gas layers between the real target measuring volume and the pyrometer (see Fig. 1).

2 = cold gas layer
1 = hot gas layer

Fig. 1 *Measurement of the temperature of a hot gas body through a cold gas body*

CO₂ is particularly suitable for pyrometric detection because this molecule is represented in the mentioned applications in sufficient concentrations and, additionally, exhibits strong IR emission bands in wave length regions for which there are sufficiently high radiation density values are expected at the usual process temperatures, according to the *Planck's* distribution.

Applications

HEITRONICS radiation pyrometers KT19.69 and KT15.69 are used in fuel engineering and large-size fuel engineering plants, more and more replacing the thermocouples used before.

Typical applications are, for instance, in household waste or special waste incineration plants, but also for various purposes in the steel and cement industries. The different measuring tasks are versatile and numerous:

- Fire chamber final temperature measurement;
- SNCR control;
- heating output regulation;
- trimming of burners;
- minimum temperature supervision according to 17th BImSchV;
- grating control.

The versatility of applications can be demonstrated by the example of a waste incineration plant:

a) Measurement of gas temperature in the combustion chamber

The temperature of the combustion gas is determined in the combustion chamber. For these purposes, KT19.69 are mostly used.

Instruments of the KT19.69 and KT15.69 types are available as special versions with adjusting periods up to 600 seconds. The long adjusting periods are needed to realize comparability to the very slow thermocouples.

In view of the redundancy, only two instruments are required in contrast to measurements with thermocouples.

b) Measurement of minimum temperatures

According to the 17th BImSchV, a minimum temperature of 850°C and 1,100°C, respectively, is prescribed for the incineration of halogenized organic compounds with a chlorine content higher than 1%. By this requirement, it is ensured that all organic ingredients of the waste gas, particularly the highly toxic, partly cancerogenic and mutagenic pollutants such as dioxines, furanes, polychlorinated bi-phenyles (PCB) or polycyclic aromatic hydrocarbons (PAH) are transferred to more harmless compounds.

The **HEITRONICS** radiation pyrometers KT19.69 and KT15.69 are the only type-tested measuring equipment approved for the supervision of minimum temperatures according to the 17th BImSchV, apart from thermocouples.

The thermocouples currently used are not tested for suitability because they are classified as capable of being calibrated anyway.

c) Measurement of waste gas temperature for control of NOx reduction

For the reduction of nitric oxides (NOx), ammonia is introduced to the flue gas through nozzles. Here again temperature is a major criterion of process control. The temperature should be measured relatively quickly and online. For this reason, radiation pyrometers KT19.69 and KT15.69 are preferred with adjusting periods of 1 and 3 seconds, respectively.

The benefits of suitability-tested **HEITRONICS** radiation pyrometers KT19.69 and KT15.69 are convincing from a measuring viewpoint:

- No influence on the readings by “radiation errors”. These are radiation proportions caused by the system that might lead to severe measuring errors when measuring using thermocouples.
- No-wear measurement by non-contact methods. The **HEITRONICS** radiation pyrometers are installed outside of the combustion chamber and thus will neither corrode nor be distorted. No baking effect will occur as is usual for thermocouples.
- Drift-free measurement. **HEITRONICS** radiation pyrometers operate in a wide ambient temperature range free from any drift, for many months and years.
- Integral and rapid measurement with variable response times. The measurements can be realized very quickly from 30 ms. Depending on the type of application, the response time can be extended up to 10 minutes. For measuring the minimum temperature we recommend an adjustment period of 240 seconds.
- Virtually maintenance-free. **HEITRONICS** radiation pyrometers are maintenance-free when applied properly. For this purpose, especially the gage opening into the combustion chamber must be kept free. **HEITRONICS** offers adequate air-operated auxiliary equipment.
- Price worthiness. Due to the low maintenance effort and the freedom from wear, the purchase cost will amortize within 1 – 3 years.
- Flexibility of configuration possibilities.
- 4–20 mA and RS-232/422 interfaces.
- Operational software for start-up, reading display and system monitoring based on *Windows*[™].
- Approved technology highly available.
- Safe automatic operation.

Success in the field

The measuring systems are successfully used since 1992. In Europe, Asia and North America are more than 500 instruments in Combustion plants installs. The instruments work reliably and have very small maintenance costs. Equipment manufacturers have procedures patented, which are based on the measurement with these instruments.

Fig. 2a and 2b shows typical installations wit KT19.69.

Measuring Systems and Sets

For installation of **HEITRONICS** radiation pyrometers, an adequate gage opening shall exist in the furnace wall, for example a steel pipe of 50 mm minimum inner diameter and a flange DIN 2573 NW65. Using the adapter B4 or B5 and the quick-acting coupling B2, the **HEITRONICS** radiation pyrometer can be coupled directly to the flange.

As a preventive protection measure the use of the window adapter B7 is recommended. This adapter is provided with a sapphire window, which is particularly scratch-proof, temperature-resistant and easy to clean.

To guarantee smooth functioning of the measuring systems, any potential clogging of the gage opening shall be avoided. This is particularly true for installation in zones where the temperatures are above the slag or dust softening point. Therefore, it is recommended to use a pulsed-air flushing system by which any deposits can be blown out of the steel pipe once or twice a day.

Components

KT19.69

1. Radiation pyrometer KT19.69
2. Adapter set
 - 2.1 Adapter B4
 - 2.2 Adapter B7
 - 2.3 Adapter B2
3. Transformer T24 DC
4. Free-blowing set
Erpulsor 5 set with adapter pipe Erpulsor 5

KT15.69

1. Radiation pyrometer KT15.69
2. Adapter set
 - 2.1 Adapter B5
 - 2.2 Adapter B7
 - 2.3 Adapter B2
3. Transformer T24 DC

The following illustrations show the typical gage sets with the **HEITRONICS** radiation auxiliaries described above (fig 3. KT19.69, fig 4. KT15.69).

Gage Set with KT19.69

- Infrared radiation pyrometer KT19.69
- with viewing aperture
 - integrated temperature display
 - operating keyboard
- quick-relaese holder A2

protective window
air accumulator and booster

Gage Set with KT15.69

Infrared radiation pyrometer KT15.69
– with protective and cooling housing WK200L
quick-release holder A2
protective window
air accumulator and booster

Specifications

Basic Data KT19.69

Output:	0–20 mA, 4-20 mA, 0–1 V, 0–10 V
Adjusting period:	30 ms to 10 s or 1 to 600 s
Operating voltages:	22 – 30 VDC or 24 VAC $\pm 10\%$, 48 – 400 Hz
Power consumption:	≤ 700 mA at 24 VDC
Ambient temperature tolerance:	-20°C to +60°C, in HP version –20°C to 150°C
Protection class:	IP 65
Connection:	1 or 2 PVC or PTFE cables, 7 and 12 pole via plugs
Weight:	1.2 kg, in HD-version 1.5 kg
Options:	viewing aperture cooling housing (HD-version) for ambient temperature $> +60^\circ\text{C}$ serial interface RS232
Accessories:	air accumulator quick-release holder B2 protective window adapter B7

Basic Data KT15.69

Output:	0–20 mA, 4-20 mA, 0–1 V, 0–10 V
Adjusting period:	30 ms to 10 s or 1 to 600 s
Operating voltages:	22 – 30 VDC or 24 VAC $\pm 10\%$, 48 – 400 Hz
Power consumption:	≤ 370 mA at 24 VDC
Ambient temperature tolerance:	-20°C to +60°C, in HP version –20°C to 320°C
Protection class:	IP 65
Connection:	1 or 2 PVC or PTFE cables, 7 and 12 pole via plugs
Weight:	0.55 kg, with cooling housing WK200L 2.5 kg
Options:	cooling housing WK200L for ambient temperature $> +60^\circ\text{C}$ serial interface RS232
Accessories:	air accumulator quick-release holder B2 protective window adapter B7

