CO Control

the better alternative of
O_2 control for gas-fired furnaces

Optimisation of combustion plants:

Problem:	Incomplete combustion
	➤ Diminished efficiency
	➤ High emissions of CO, NO_X, particulates
Existing technology:	O_2 control
Future technology:	Empirical control method on the basis of the by-products (CO, H_2)
Objective:	Permanent monitoring and reduction of the emissions from all furnaces through the use of modern, **self-optimising** control technology

Sensors and Systems
for Combustion Engineering

LAMTEC

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The better alternative of O_2 control for gas-fired furnaces

A new type of empirical burner control method, based on a modified zirconium dioxide probe and using the by-products of combustion (CO/H_2), has been developed as an alternative to the existing O_2 control technology.
The aim was to achieve a dynamic, self-optimising control technology that could further reduce the flue-gas losses from industrial furnaces.
Monitoring and control of combustion processes is absolutely essential for energy-saving and for preventing damage to the environment and property, and to human health. Measurement of the oxygen content in flue gases does not itself provide any information about the completeness of combustion. This is why it is particularly important to measure and reduce the proportions of unburned components contained in the flue gas. These unburned components include carbon monoxide (CO) and hydrogen (H_2). If combustion is incomplete, there is always a combined hydrogen and carbon monoxide emission in the flue gas.
With the Combi Probe KS1 it is now possible, for the first time ever, for unburned components in flue gases from gaseous fuels to be rapidly detected in situ, with no maintenance requirement. The firing process can then be regulated accordingly.

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Measurement principle of the Combi Probe KS 1

The Combi Probe KS1 has a structure similar to that of a potentiometric oxygen probe.

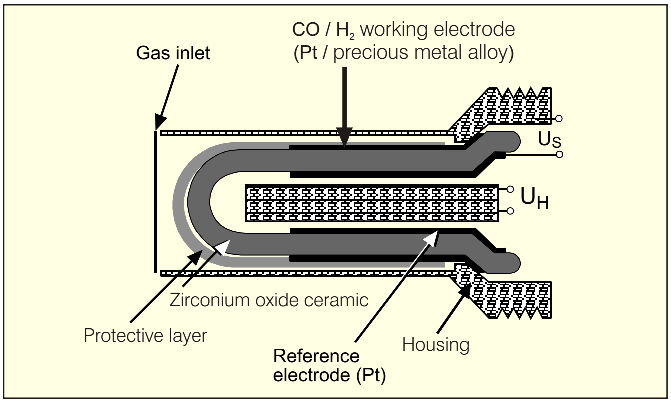

Figure 1: Schematic structure: Combi Probe KS1

Unlike an oxygen probe, which has a working electrode with a high catalytic activity, in the Combi Probe KS1 the catalytic activity of the CO/H_2 selective electrode has been deliberately reduced. This has the effect of impeding the catalytically supported reaction of oxidizable gas components, such as CO, H_2, etc., with O_2 on the electrode surface.

The sensor voltage obtained is a mixed potential, consisting of a component that is dependent on the O_2 reaction, and a component due to the reaction with oxidizable gas. The mixed potential is a function of the partial pressure ratio of the oxidizable components to the oxygen, thus

$$U = (CO/O_2) \text{ bzw. } U = (H_2/O_2)$$

Even with low concentrations of oxidizable gases, such as H_2 or CO, the mixed potential is markedly higher than the signal of the simple O_2 probe. The mixed potential develops very rapidly, attaining times of t_{60} in under 2 seconds.

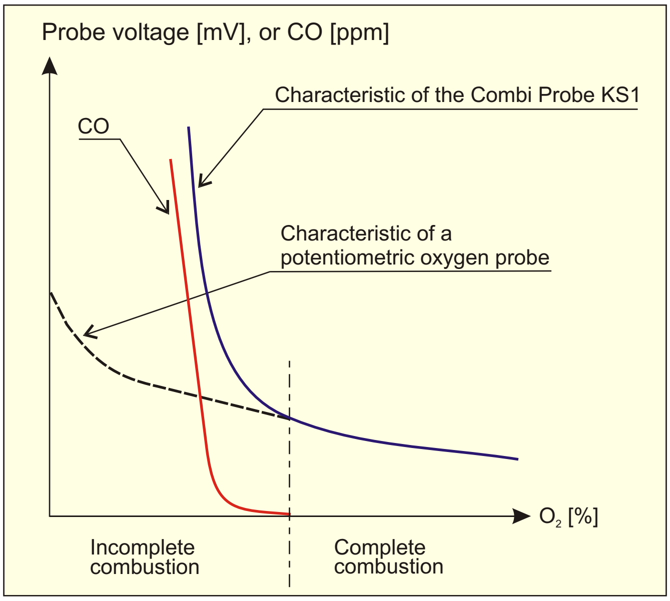

Figure 2: Sensor characteristic U (O_2) of the Combi Probe KS1 and of a potentiometric O_2 probe (Lambda Probe) on a gas-fired furnace, characterized by the burner characteristic CO (O_2).

Advantages of CO control over O_2 control

- Up to 0.5 % greater energy saving through continuous self-optimisation in each load point
- Improved control behaviour due to substantially reduced response lag
- Independent of secondary air
- Fail-safe
- Highly dependable
- Robust
- Maintenance-free

A further advantage is the steep signal rise in the range < 500 ppm CO, as shown in Figure 3.
An additional indicator of unburned (CO/H_2) is the dynamic response of the sensor signal (U_S). The dynamic response increases as the unburned component content increases.

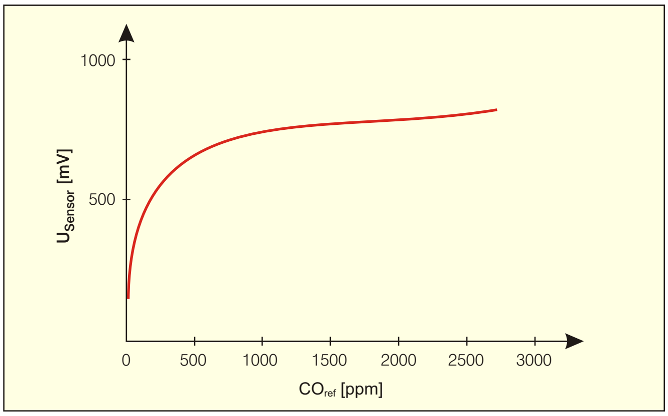

Figure 3: Sensor characteristic Us = f (CO) of the Combi Probe KS1 measured in flue gas of a gas-fired furnace with O_2 concentrations < 2 vol. %

This is achieved by dynamically varying the fuel/air ratio towards a lesser Lambda value (less air, more fuel), without influencing the output regulator, until a sharp signal rise of the Combi Probe KS1 and its dynamic response indicate the onset of incomplete incineration (Fig. 2 / Fig. 4). From this point onwards, the fuel/air mixture is again varied slightly, but towards a greater Lambda value (more air, less fuel), until the optimum operating point is found. The operating points found thus are subjected to a plausibility check. Any that are found to be implausible are rejected and redetermined.

Figure 4 shows the signal course as a function of the O_2 value, measured on an 18 MW reference plant (gas-fired forced-draught burner).

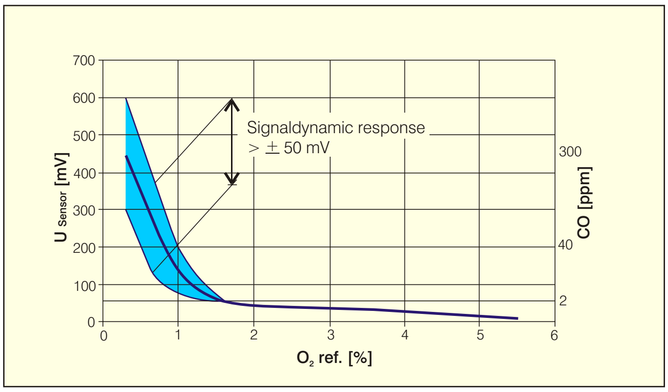

Figure 4: Dynamic response of the sensor signal in the case of incomplete combustion

Control principle:

Ascertain the optimum operating point of the firing operation close to the emission boundary; then set, maintain and, if necessary, further optimize and monitor this operating point. This process is repeated cyclically, so that the optimum operating points are always maintained, even in unfavourable weather and plant conditions.
If the Combi Probe KS1 detects unburned (CO/H_2), e.g. due to unmodified plant-specific conditions, the operating point is immediately shifted towards a higher Lambda value (more air, less fuel).

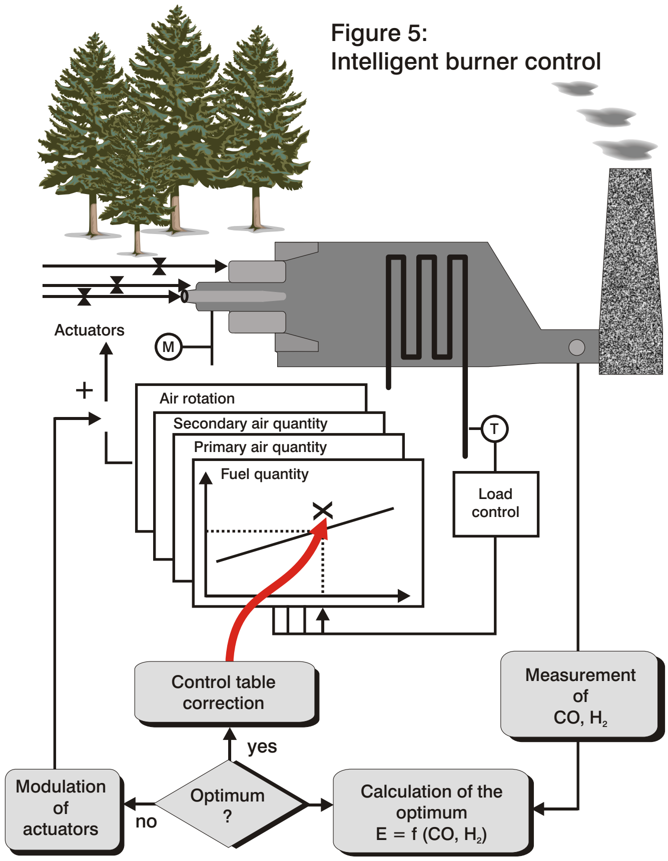

Figure 5: Intelligent burner control

Plant engineering:

CO control has been integrated, as a software tool, into the proven ETAMATIC/VMS/FMS electronic combined fuel / air control.

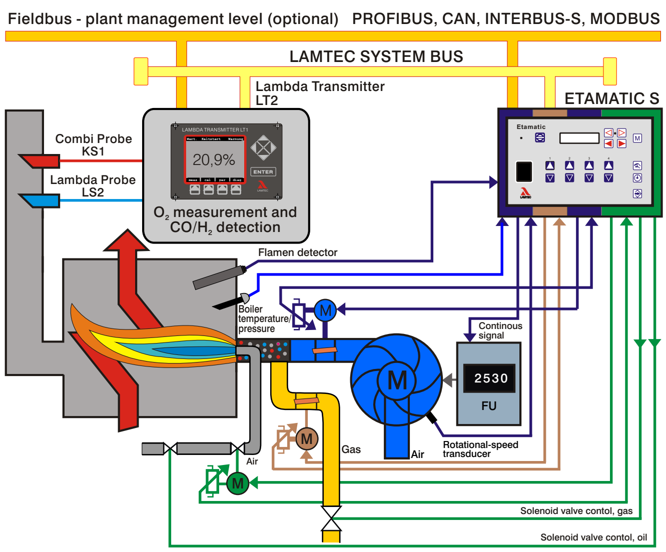

Figure 6: ETAMATIC S with integral CO control

The simultaneously measured O_2 value is not required for the actual CO control. It is used only for monitoring and visualization purposes. If, for combustion process reasons, it is not possible to go to the CO boundary over the entire load range, there is the option of switching progressively from CO control to O_2 control in dependence on load. With multi-fuel burners, it is possible to select, according to the specific fuel, whether the CO control or the O_2 control is active.

References:

The first CO control was activated in December 2001.
Until today more than 300 CO controls are operating. The new, adaptive controlling strategy ensures en operation of the combustion plant close to the energetic optimum, independent from extraneous influences and with a minimum of pollutant emission.

Figure 7: Bayerische Julius-Maximilians-Universität Würzburg

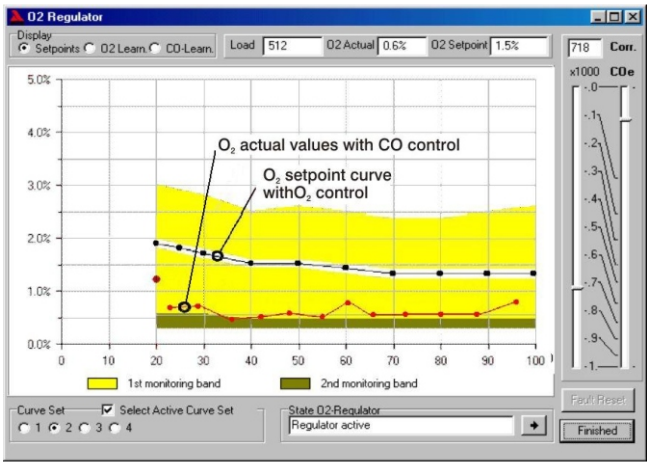

Figure 8: plant characteristic

The CO control is designed failsafe. The CO control is tested and approved for continuous operation by TÜV-Bavaria This means that, compared with the O_2 control, it was possible to improve combustion efficiency by a further 0.3 - 0.5 %, corresponding to a fuel saving equal to average-capacity combustion processes.

The future:

The Combi Probe KS1D has been specially developed for the "CO control" of average-capacity combustion processes. With the KS1D it is possible, for the first time ever, to perform selective but simultaneous measurement of oxygen (O_2) and combustible gases (CO/H_2) with a single sensor. The Combi Probe KS1D has 2 separate elec-trodes on the test-gas side, i.e., one electrode for oxygen (O_2) and the other for combustible gases (CO/H_2) .

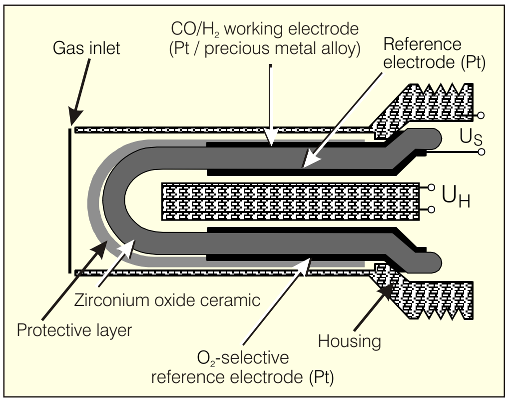

Figure 9: Schematic structure of the Combi Probe KS1D

Use of the intelligent CO control has not been limited to medium and large-scale industrial furnaces. With the CarboSen1.000 (Figure 10), a sensor is now available which also enables the control concept to be applied in domestic combustion installations. As well as being suitable for all types of gas-fired furnaces, the so-called "blue-burners" are also highly suitable for CO control.

Figure 10: CarboSen1.000, miniaturized sensor for detecting unburned (CO/H_2) in furnace flue gases

LAMTEC

LAMTEC Meß- und Regeltechnik für Feuerungen GmbH & Co. KG
Wiesenstraße 6
D-69190 Walldorf
Telefon (+49) 06227 / 6052-0
Telefax (+49) 06227 / 6052-57
Internet: http://www.lamtec.de
e-mail: info@lamtec.de

LAMTEC Leipzig GmbH & Co. KG
Schlesierstraße 55
D-04299 Leipzig
Telefon (+49) 0341 / 863294-00
Telefax (+49) 0341 / 863294-10

Author: Dipl. Ing. (FH) Harald Weber
Managing Partner
LAMTEC Meß- und Regeltechnik für Feuerungen GmbH & Co KG
Tel.: 06227 / 6052 41
E-Mail: weber@lamtec.de
Internet: www.lamtec.de

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