

Description

CO/O₂-Measurement Explained Simply
or
How Does My KS1/KS1D Work



**Sensors and Systems
for Combustion Engineering**



1 General

Below the complex procedures which are necessary to describe the function of the KS1 and the KS1D are explained as simply as possible. Many technical details are intentionally omitted in order to ensure general comprehensibility.

The principle of the LAMTEC probes KS1 and KS1D is based on the principle of solid-state electrolysis discovered by Walter H. Nernst. This principle is the same as the principle of electrolysis in liquids. As the name indicates however, solid bodies are used as electrolytes here. As a rule, these are made of zirconium oxide (ZrO_2 - ceramic) mixed with foreign atoms.

For the process of solid-state electrolysis to work, the probe or electrolyte must be heated to a temperature of several hundred degrees Celcius. In this way it receives the energy necessary for the transport of ions. Typical sensor temperatures are between 600°C and 800°C.

2 Sensor structure

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The electrolyte, in our case a unilaterally sealed cylinder, separates the sample gas from a reference gas (ambient air). For a sample signal to be generated, at least one electrode with lead is necessary on both sides. These electrodes are made of pure platinum in the case of an oxygen sensor.

The voltage between the electrodes can now be measured via an appropriate circuit.

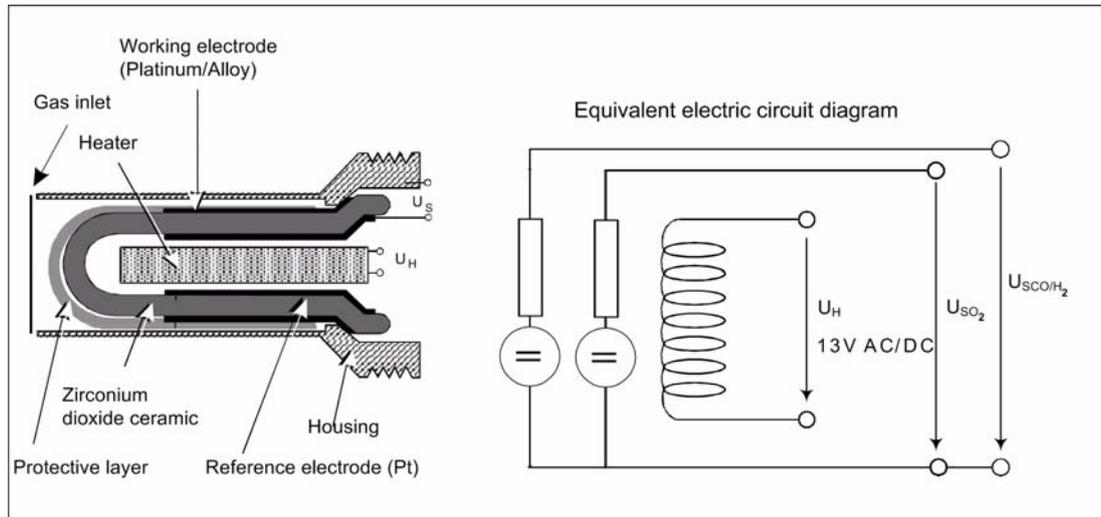


Fig. 2-1 Fundamental sensor structure

3 Operating principle of oxygen measurement

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The principle of oxygen measurement is really simple and was already described by W. H. Nernst at the end of the 19th century. The voltage U between the two electrodes is composed of a constant offset voltage U_0 and a variable voltage which on the one hand depends on the sensor temperature and on the other hand, on the ratio of oxygen content to the reference and measurement side.

$$U = U_0 + k * T * \ln \left(\frac{P_{O_2, \text{mess}}}{P_{O_2, \text{ref}}} \right)$$

k is a natural constant. This formula (Nernst formula) explains that the larger the difference between the oxygen fractions in the sample gas and in the reference gas, the greater the sensor voltage is. .

The offset voltage generally arises as a result of temperature differences between the reference electrode and the electrode in the sample gas.

On both electrodes the conversion of oxygen to ions takes place ($O_2 + 4e \rightarrow 2O^{2-}$). The back reaction takes place to the same degree in the chemical balance. The difference in the concentration of oxygen on both sides, however, results in more oxygen being converted than on the sample side when all the framework conditions are met on the reference side. This results in different potentials on both sides. The potential difference produces the measured voltage depending on the oxygen fraction in the sample gas (the reference side is always constant).

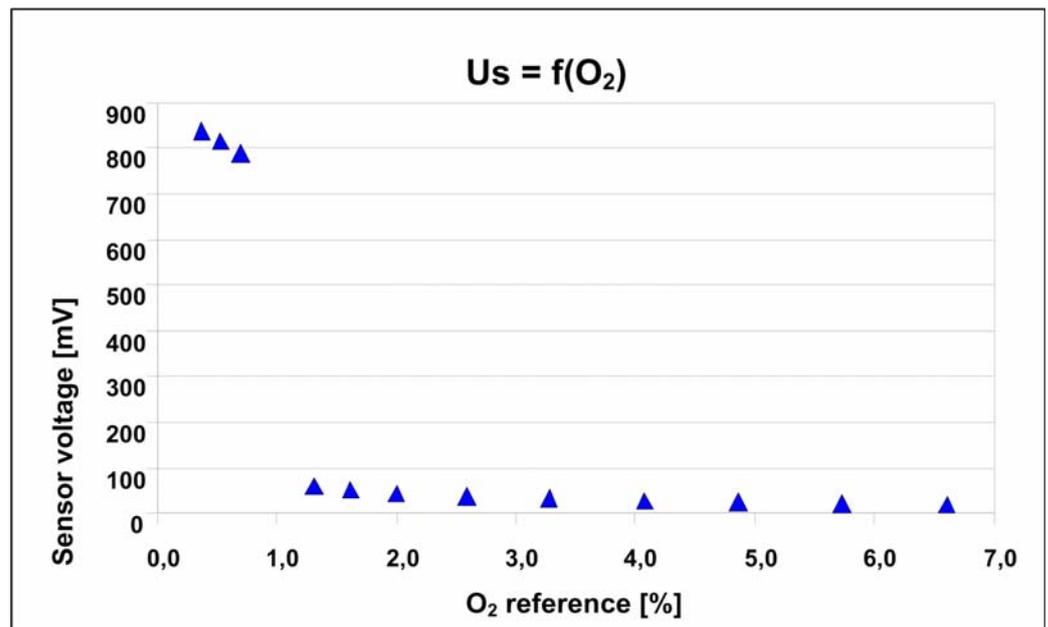


Fig. 3-1 Oxygen characteristic of KS1D

4 Operating principle of CO_e measurement

If the sample gas does not comprise pure air or nitrogen and oxygen, but also contains a fraction of combustible gases (CO, H₂, CH₄, etc. → CO_e), several effects are responsible for the occurrence of the measured voltage.

The first fraction is the same as in oxygen measurement. The difference between the oxygen fractions also exists in this case. The second voltage fraction is the so-called CO_e-voltage. This is added together with the voltage from the oxygen difference to the overall voltage measured between the electrodes U.

$$U = U_{O_2} + U_{CO_e}$$

The mechanisms which contribute to the formation of the U_{CO_e} voltage are far more complex than the operation of oxygen measurement. Therefore only the most important points should be mentioned here in brief..

- The sensor. To measure CO_e it is necessary to alter the material of the sensing electrode as a pure platinum electrode does not respond to CO_e as desired. As a rule, in CO_e-sensors the sensing electrode is "contaminated" with other metals.
- Platinum has the property of binding many gases including O₂ and CO_e to the surface in an active state. The CO_e bound to the surface reacts spontaneously with the bound oxygen as platinum is a very good catalyst.
- Gold does not have this property of platinum described. However, it binds CO_e molecules to its surface very well. Oxygen, which was there previously, is therefore displaced. In the end this results in no more oxygen being present anywhere where there is gold is on the surface. Therefore the desired balance of the oxygen fractions between both electrodes (see oxygen measurement) is shifted further towards an imbalance..

The catalytic reactions, the oxygen imbalance and additional processes not described here altogether form the sensor voltage which is determined when measuring CO_e.

If the known fraction of oxygen is deducted from this total voltage, the pure voltage which arises as a result of the CO_e processes is obtained. In the case of KS1, on account of the sensor structure in the available CO_e O₂ cannot be measured directly. For this reason in the area free of CO_e, a measurement point for calculation of the Nernst characteristic is consulted (comparison). This characteristic is then subtracted from the total voltage in order to obtain the corrected CO_e characteristic..

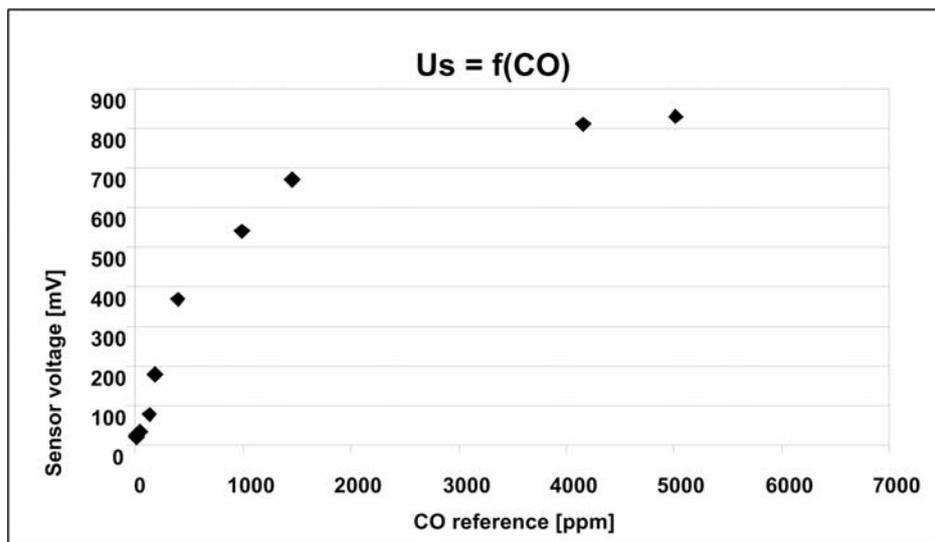


Fig. 4-1 CO_e characteristic of KS1 and KS1D



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