

O₂ and CO Reduction at Combustion Plants

CO/O₂ Control

O₂- and CO-reduction at combustion plants

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Due to economic, environmental and technical reasons, it's necessary to operate combustion plants by means of minimizing energy losses. Essentially, the energy losses of a boiler plant occur by loss of energy through incomplete combustion, through the heat in the exhaust gas, through radiation and through cooling down. This article considers the room for possibilities to improve combustions and discusses how to reduce losses of energy in the exhaust gas. At the established boiler plant of Leiber GmbH in Bramsche, Germany, an existing burner was modified to an effect where the existing O₂ trim was retrofitted into a CO control with VSD-control of the air blower.

The private, family-owned company Leiber GmbH is always first in line when it comes to saving resources. Implementing energy-saving measures is a key focus across the entire company, second only to the core business areas in the feedstuff and food industries. Relevant projects are carried through to completion in a responsible way by everyone from management through to production personnel. Leiber GmbH has already won multiple awards in the field

of efficient energy use. On the occasion of a network meeting on energy efficiency at Leiber GmbH, reports were given on the possibilities for O₂ and CO optimization. The company management subsequently contacted the maintenance firm of the 10 MW gas burner and high pressure steam boiler to obtain a quotation for the relevant equipment. The maintenance company declined the implementation of this measure. Leiber GmbH, on the recommendation of a participant in the network meeting, then contacted Hamburg-based company eNeG Vertrieb- und Servicegesellschaft mbH.

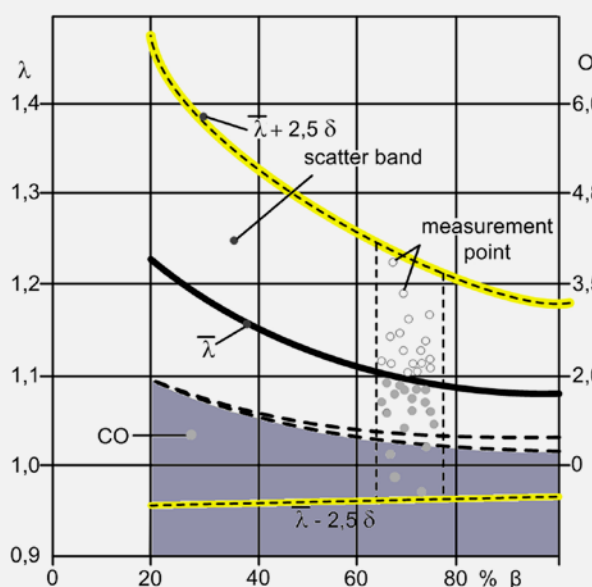


Fig. 1: Disruption of combustion by disturbance variables

THE PRINCIPLE

The significance of an O₂ trim with CO infeed for energy-efficient operation of a boiler plant with a gas burning system is described below. The energy loss due to incomplete combustion is determined by the proportion of non-burned carbon component in the flue gas. This means it is essential to ensure that the CO proportion is equal to "0" in the flue gas. This is determined primarily by the quality of the mixing equipment in the burner. In addition, the fuel/air ratio should be such that no CO is formed due to external influences at any operating point. The energy loss due to free heat in the flue gas is determined by the level of the flue gas temperature and the quality of the combustion. The level of the flue gas temperature is affected primarily by the boiler construction and only after this by the combustion quality (Fig. 1).

It is desirable that the air requirement of a combustion process comes as close as possible to stoichiometric combustion. For example, for the combustion of 1 m³ of

natural gas with a high of 10.0 kWh/m³, an air quantity of 9.47 m³ is required in the normal status condition. If more air than is necessary is fed into the corresponding fuel quantity, the oxygen contained in the air is no longer included in the combustion process, and the air must be heated up as ballast material. The heat flow due to free heat in the flue gas volume rises, the flue gas temperature also rises, and the flue gas losses therefore increase.

The following disturbance variables occur during combustion:

- Air (temperature, pressure, humidity),
- Fuel (calorific value, temperature),
- Contamination (burner, fan, boiler),
- Flue draught (as a consequence of wind and temperature),
- Mechanics (play and hysteresis in the drives and rods).

The objective in optimising furnace plants is the compensation of all disturbance variables acting on the combustion process (**Fig. 2**).

The furnace can therefore be operated close to the combustion optimum. Simultaneously, a reduction in emissions is achieved in addition to lowering the flue-gas losses. The former state-of-the-art technology in this range is the O₂ trim. The O₂ value measured is compared to a burner firing rate dependent setpoint calculated in advance and the fuel/air ratio is corrected accordingly, for example via a frequency inverter acting on the combustion air fan. For the measurement of the residual oxygen content of the flue gases, zirconium oxide measurement probe (ZrO₂) have now become the norm in-situ (in the flue gas). Various ZrO₂ O₂ probes are available today, both for assembly onto the end of the boiler and in the front reversing chamber of a three-pass boiler (**Fig. 3**). In comparison to the O₂ measurement, the detection of non-burned flue gas components has the advantage of a direct correlation to the quality of the combustion process. With an O₂ trim this would result in infiltrated air that enters the flue gas chimneys in front of the measuring point, and falsifies the O₂ actual value, which in turn would result in too little air in the fuel air ratio. This discovery resulted in an improved version of the ZrO₂ voltage probe being developed for the detection of non-burned flue gas components (CO/H₂) (**Fig. 4**).

THE MEASURE IMPLEMENTED

Initially the procedural stages from the submission of tenders through to acceptance of the services were agreed together with the user.

- Recording of the current technical combustion measurement values,
- Recording of the operating times at the various firing rate levels,
- Calculation of the potential savings by starting up the technical combustion limit values,
- Calculation of the amortisation time,

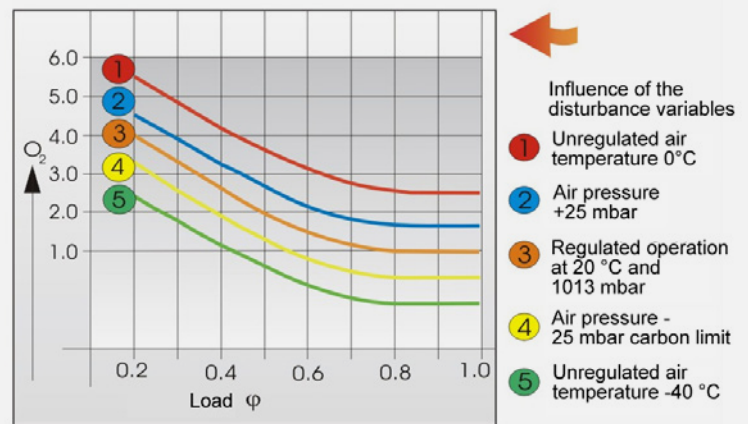


Fig. 2: The influence of air temperature and air pressure on combustion

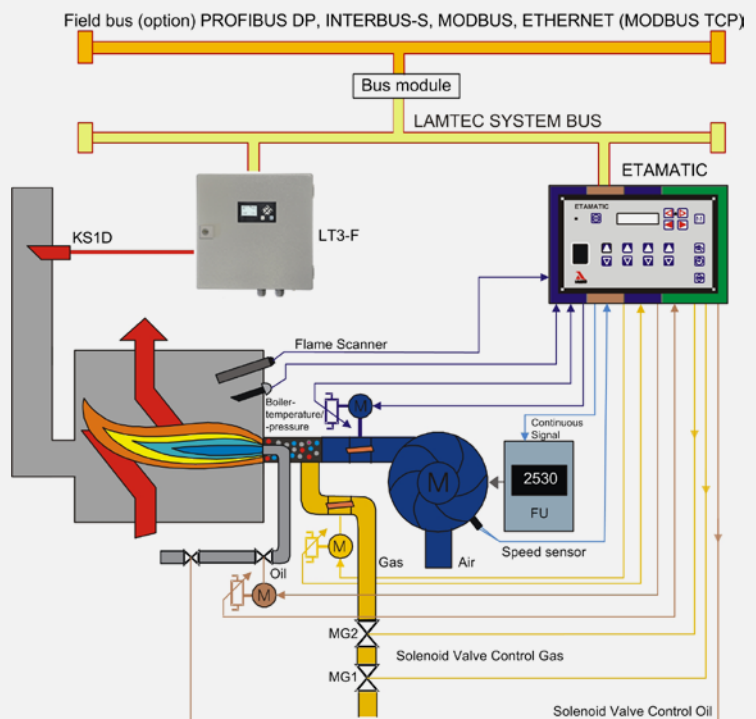


Fig. 3: Combined O₂ measurement LT3-F with the detection of unburned residues

- Submission of the tender,
- Contract awarded,
- Determination of the implementation time,
- Initiation of approval procedures,
- Implementation of conversion measures with commissioning,
- Completion of acceptance by the expert,
- Provision of evidence of the energy savings.

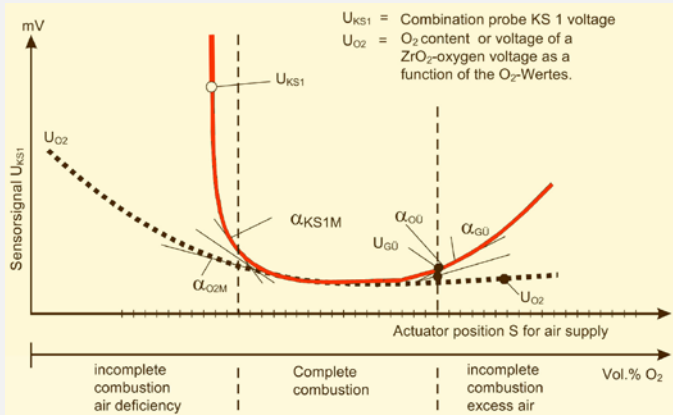
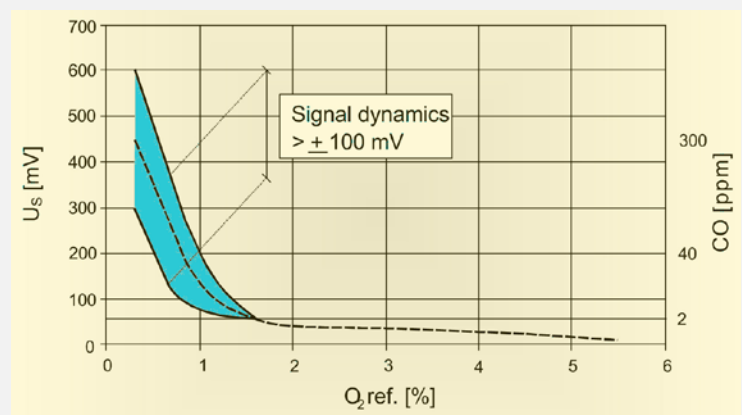


Fig. 4: Detection of the CO edge



Technical combustion measurements were carried out in the various firing rate status conditions that enable conclusions to be drawn on the current technical combustion efficiency of the boiler. The combustion has a different efficiency level depending on the burner firing rate. To calculate the energy saving, it is necessary to either calculate or determine experientially the time of the different firing rate conditions. In the steam boiler plant at Leiber, there were recordings of the steam consumption that were evaluated via graphs.

Based on this data, it was agreed that an efficiency improvement of 1.39 % would form part of the contract. The complete measure paid for itself in 12 months, according to these calculations. Around three months passed between measuring the basic principles and the implementation process, for this reason these measurements were repeated immediately before the conversion. As the calorific value of the gas could have changed in the meantime, the measurement was extended so that a calorific value change would also be detected.

THE APPROVAL

The change in control system represented a considerable intervention in the approval of the burner. In accordance with sections 10.1; 13.1 and 14.2 of the operational safety ordinance, the modification is legally subject to a test in advance of the modification, approval following the test and a test before commissioning by the approved institutions. The test principles are derived from the technical rules on operational safety (Technische Regeln zur Betriebssicherheit; TRBS) and the technical rules for steam boilers (Technische Regeln Dampfkessel; TRD), where still applicable in

this case. This procedure was completed very quickly by all participants in accordance with TÜV.

THE CONVERSION

The centrepieces of the control and safety technology of the burner, such as the burner control, valve leak check device and combustion control system were dismantled. The gas/air assembly rod was disassembled. The gas damper and both air dampers were given appropriate new actuators.

The frequency inverter for the 30 KW combustion air fan was assembled and a suitable Namur transmitter was installed on the motor of the combustion air fan to monitor the speed. The conversion process was completed in 3 days, including the electrical installation work (Fig. 5).

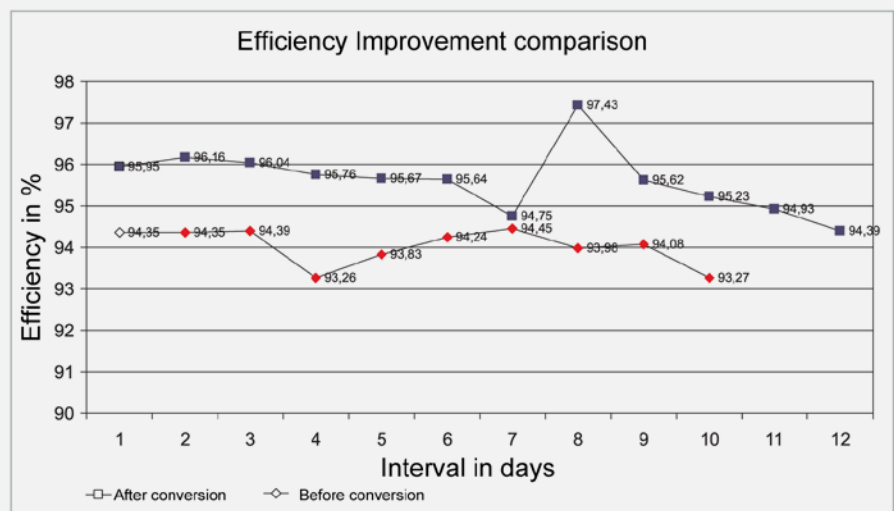


Fig. 5: Improvement of efficiency

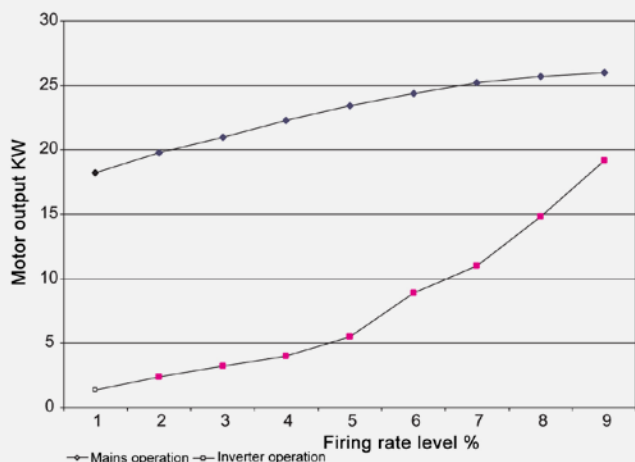


Fig. 6: Power-energy savings

THE RESULT

It was agreed that the improvement in efficiency would be tested using two procedures; the direct method using the gas quantity taking account of the gas parameters and the steam quantity output and using Siegert's formula. The direct method without all theoretically required, calibrated measuring equipment and an adequate inertia run, can only be regarded as approximate. A calculation based solely on the Siegert's formula would not produce a 100 % result either without taking into account the boiler and firing rate parameters. However, both procedures for the efficiency calculation are entirely adequate for practical requirements. The following efficiency improvements were measured:

- Small firing rate: 0.9 %
- Medium firing rate: 1.1 %
- Full firing rate: 2.5 %

The firing rate distribution graph produced the following values:

- Small firing rate: 7 %
- Medium firing rate: 64 %
- Full firing rate: 29 %

The total improvement in efficiency according to this method resulted in an average value of 1.5 %. The calculation according to the direct method was carried out over a period of 10 days and accordingly resulted in a value of 1.6 % efficiency improvement. This was used to calculate an energy saving of approx. 1,000,000 kW/a resulting in an amortisation period of < 1 year. Equipping the combustion air fan with a frequency inverter produced additional savings of 125,000 kW/a (**Fig. 6**). As a pleasing side-effect, Dr. Schmitz noticed the lower noise emissions of the combustion air fan.

LITERATURE

- [1] Documentation on the lecture by LAMTEC Kesselbetriebs-technik 2008

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