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(54) Benævnelse: **Fremgangsmåde til at justere luft-/brændstofforholdet for en brændgasdrevet brænder**

(56) Fremdragne publikationer:

**EP-A1- 1 176 364**
**EP-A2- 1 331 444**
**DE-A1- 19 839 160**
**US-A- 4 118 172**
**US-A- 5 971 745**
**US-A1- 2006 257 805**

The invention relates to a method for adjusting the fuel gas-air ratio of a gas-fired burner.

It is known from the prior art that the fuel gas-air ratio of a fuel-gas operated burner can be adjusted by measuring the ionisation voltage or the ionisation current at a monitoring electrode. EP 770 824 B1 describes a method in which, on the basis of an over-stoichiometric burner operation, excess air is reduced until there is a slightly under-stoichiometric combustion. In this case the ionisation voltage is measured between an ionisation electrode and the burner. In stoichiometric combustion ($\lambda = 1.0$) the ionisation voltage is at a maximum. As a result the ionisation voltage increases firstly, on the basis of over- stoichiometric combustion, with the reduction of excess air in order to reach a maximum during stoichiometric combustion. If the ionisation voltage drops with a further reduction of the air content, this is an indication that the combustion is under-stoichiometric. In the method known from EP 770 824 B1, on the basis of the air content available with the maximum ionisation voltage, the air content is increased by a defined amount so that the desired air content is reached. Thus can be achieved for example in that the speed of a combustion air fan is increased by 25% on the basis of the stoichiometric combustion.

Configurations of this control method are also known from DE 40 27 090 C2, DE 196 18 573 C1 and US 5 971 745 A.

US 5 971 745 A discloses a method for adjusting the fuel gas-air ratio by monitoring the ionisation flow. A characteristic feature of this method is that on the basis of an operating point with excess air the fuel gas-air ratio is firstly enriched. As soon as an extreme value (maximum) has been determined the enrichment is ended. This can be established for example in that after the increase in the ionisation flow a decrease is recorded. Alternatively, said “peak”, i.e. extreme value/maximum, can be established when the gradient of the signal is zero. When the maximum has been found the mixture is thinned out again.

DE 20 2004 017 850 U1 shows a gas burner in which the flame temperature is measured by means of a thermoelement. The temperature behaves in a similar way to the ionisation flow according to EP 770 824 B1 . It is enriched to calibrate the mixture and the flame temperature is measured. If a maximum is measured the mixture is then thinned out in a defined manner.

US 4 118 172 A discloses a calibration method in which a temperature measurement is used to detect a maximum in stoichiometry.

The disadvantage of such a method is that it is always necessary to start up with stoichiometric or slightly under-stoichiometric combustion. In this case considerable amounts of carbon monoxide and nitrogen oxide are emitted.

From DE 102 00 128 B4 and EP 833 106 B1 methods are known for adjusting the fuel gas-air ratio, in which a fuel gas-air ratio is thinned out until the flame is extinguished. From this point the burner is then operated using a specifically richer mixture. It is also a disadvantage in such a method that an increased amount of harmful emissions are produced by extinguishing the flame and then restarting it. Furthermore, the method cannot be integrated into normal operation.

From EP 1 176 364 A1 it is known that methods using maximum stoichiometry have the disadvantage that the burner is operated temporarily at high level of harmful emissions. In the method known from EP 1 176 364 A1 the ionisation signal is measured when starting up, then the fuel gas ratio is changed and the ionisation signal is measured again. The composition of the fuel gas is inferred from the evaluation of the signal difference and the fuel gas choke is adjusted accordingly.

The underlying objective of the invention is to provide a method for adjusting the fuel gas-air ratio in gas-fired burners by measuring the ionisation current, which does not creates polluting combustion conditions.

The objective is achieved according to the invention in that during the operation of the burner the fuel gas-air ratio is thinned out and the ionisation signal is measured continually. A gradient is formed from the ionisation signal with the change. If the gradient exceeds a specific gradient or the gradient increases overproportionally compared to its previous course, the thinning is ended and the fuel gas-air mixture is enriched in a defined manner.

The measurement signal is heavily dependent on deposits on the electrode and the position of the electrode. Therefore, it is not expedient to consider exceeding a specific absolute value or falling below the latter as a relevant event. A significant increase in the gradient however is a sure indication of the imminent lifting of the flame with a further increase in the air content.

Advantageous embodiments are provided according to the features of the dependent claims. Thus the gradient can be determined by dividing the differential signal of the ionisation electrode by the differential speed of the fan motor. Alternatively to this, the differential signal of the ionisation electrode can be divided by the differential position of the actuating drive of a gas valve or a differential time unit.

The signal of the ionisation electrode can be determined in that a constant voltage source is connected in series with the flame of the burner and a resistor and the drop in voltage is measured at the resistor.

The invention is now explained in detail with reference to the Figures. In the latter:

Figure 1 shows a structure for performing the method according to the invention and

Figure 2 shows the course of the ionisation signal in the method according to the invention.

Figure 1 shows a burner 1 with a fan 8 having a fan motor 9 in an air inlet 12. A gas line 13 runs into the air inlet 12, in which line a gas valve 10 with an actuator 11 is located. The fan motor 9 and the actuator 11 are connected to a control device 7. On the burner 1 there is a flame 2, into which an ionisation electrode 3 projects. The ionisation electrode 3 is connected to a voltage source 4. The latter is connected with its second electrode to a resistor 5 which is connected in turn to the burner 1. Parallel to the resistor 5 is a voltmeter 6 which is connected to the control device 7.

When operating the burner the fan 8 suctions combustion air through the air inlet 12. The speed n of the fan 8 can be adjusted continually in this case. By means of the gas valve 10 the supplied amount of fuel gas, which flows in via the gas line 13, can be varied continually; in this way the step number $n_S$ of the actuator 11 is detected. In the fan 8 the fuel gas and air are mixed together and ignited at the output of the burner 1 so that a flame 2 is formed. As the ions of the flame 2 are electrically conductive a current can flow between the ionisation electrode 3 and the burner 1. As a result the electric voltage $U_{flame}$ is available. The ion flow through the flame 2 ensures that the electric circuit (burner 1, ionisation electrode 3, voltage source 4, resistor 5) is closed.

Figure 2 shows the path of the voltage U measured at the resistor 5 by means of the air ratio λ and the fan speed n. $U_0$ is the voltage of the voltage source 4. Thus:

$$U = U_0 - U_{flame}$$

It should be noted that the voltage U measured at the resistor 5 is minimal with stoichiometric combustion (λ = 1.0). By increasing the excess air the voltage U increases continually. At an air ratio of about 1.6 the voltage U increases much more significantly than before. With an air excess of about λ = 1.7 the flame lifts up. It is no longer possible to measure an ionisation signal; a not shown safety valve locks the fuel gas supply.

In the control method according to the invention firstly the burner 1 runs with a previously unknown amount of excess air. With a continually open gas valve 10 the speed n of the fan 8 is increased. In this way the air ratio λ increases. The voltage drop U at the resistor 5 is measured continually over period t and transmitted to the control device 7. In the control device 7 the gradient $\Delta U/\Delta n$ is calculated, whereby n is the speed of the fan 8. If the gradient $\Delta U/\Delta n$ increases excessively from a specific point, this is an indication of the fact that flame is about to lift and thus break away. The air ratio λ is then about 1.6. From this point on the speed n of the fan is then reduced specifically so that the air ratio becomes λ ≈ 1.25). As an alternative to determining the gradient by means of a quotient of the differential signal to the differential speed $\Delta U/\Delta n$ a gradient can also be formed from a differential voltage $\Delta U$ to the differential position of the actuating drive $\Delta n_S$, if the amount of fuel gas is reduced instead of increasing the fan speed. In a further variant, by continual thinning out a gradient can also be formed from the period ($\Delta U$).

The operating state in which the lifting is about to occur can be determined in that the current gradient is compared with at least one earlier gradient and if the current gradient exceeds the comparison value or values by a specific percentage the expected state exists. For example the smallest measured gradient can be used as a comparison value. Alternatively, an absolute value can be provided.

In order to eliminate the effect of signal noise (fluctuation of the measurement signal by a trend line), the time differential or speed differential cannot be selected to be too small.

Instead of the voltage drop U at the resistor 5 the voltage of the flame $U_{flame}$ can also be measured directly. In this case the however the ionisation voltage is at the maximum with stoichiometric combustion and the ionisation voltage signal drops with an increase in the air ratio.

Instead of a constant voltage $U_0$ also a constant current source with a constant current $I_0$ can be connected to the series circuit of the resistor 5 with the flame 2. Depending on the flame resistance a specific voltage is adjusted.

**Patentkrav**

**1.** Fremgangsmåde til at justere brændstofgas-luft-forholdet for en brændgasdrevet brænder (1), der overvåges ved hjælp af en ioniseringselektrode (3), hvor signalet af ioniseringselektroden (3) måles direkte eller indirekte, **kendetegnet ved at** under driften af brænderen (1) udtyndes brændstofgas-luft-blandingen og signalet af ioniseringselektroden (3) måles kontinuerligt, hvorved gradienten af signalet af ioniseringselektroden (3) dannes, når en specifik gradient overskrides eller når en overproportional stigning i gradienten af udtyndingen af brændstofgas-luft-blandingen stoppes og brændstofgas-luft-blandingen beriges på en defineret måde.

**2.** Fremgangsmåde til at justere brændstofgas-luft-forholdet for en brændgasdrevet brænder ifølge krav 1, **kendetegnet ved at** luften fremføres af en blæser (8) med en blæsermotor (9) og gradienten af signalet af ioniseringselektroden (3) bestemmes fra inddelingen af differenssignalet af ioniseringselektroden (3) med differenshastigheden af blæsermotoren (9).

**3.** Fremgangsmåde til at justere brændstofgas-luft-forholdet for en brændgasdrevet brænder ifølge krav 1, **kendetegnet ved at** brændgassen ledes via en gasventil (10) med en aktuator (11) og gradienten af signalet af ioniseringselektroden (3) bestemmes fra inddelingen af differenssignalet af ioniseringselektroden (3) af differensjusteringspositionen af aktuatoren (11).

**4.** Fremgangsmåde til at justere brændstofgas-luft-forholdet for en brændgasdrevet brænder ifølge krav 1, **kendetegnet ved at** gradienten af signalet af ioniseringselektroden (3) bestemmes fra inddelingen af differenssignalet af ioniseringselektroden (3) af tidsdifferensen.

**5.** Fremgangsmåde til at justere brændstofgas-luft-forholdet for en brændgasdrevet brænder ifølge et hvilket som helst af kravene 1 til 4,

**kendetegnet ved at** en konstant spændingskilde (4) eller konstant strømkilde serieforbindes med flammen (2) af brænderen (1) og en modstand (5) og spændingsfaldet ved modstanden (5) måles som et signal af ioniseringselektroden (3).

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Fig. 1

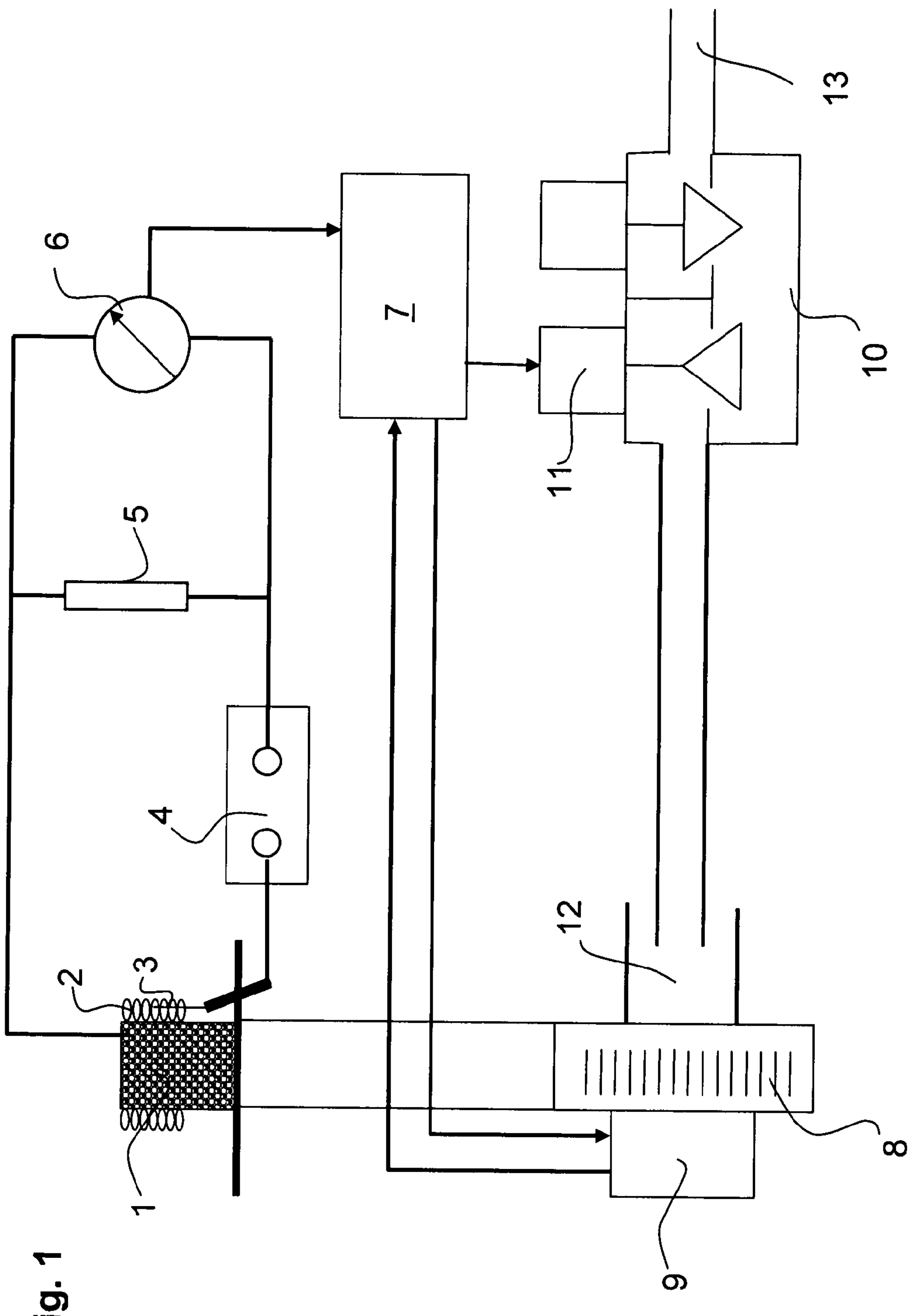
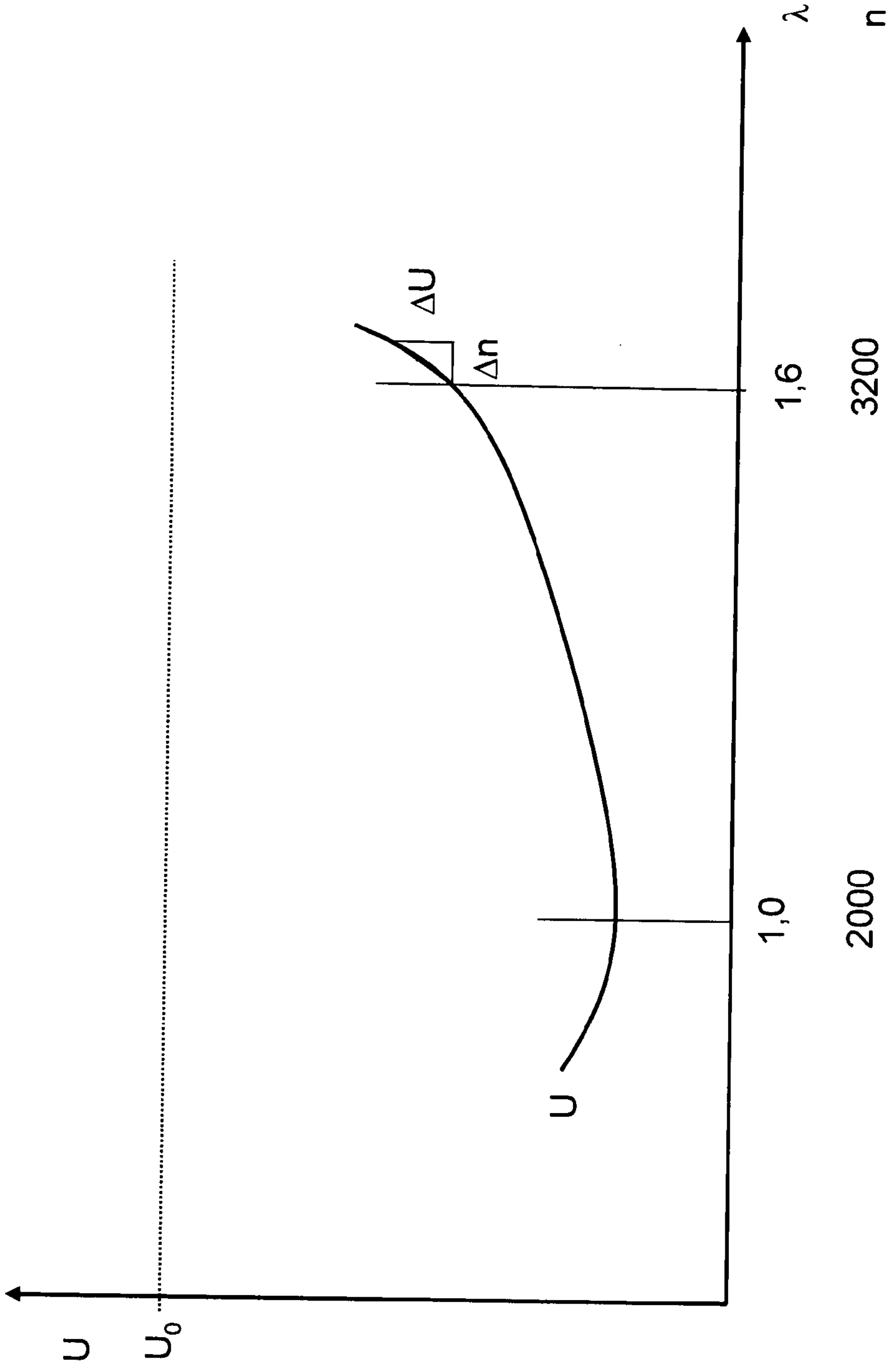


Fig. 2

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