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Description

Background

The present disclosure deals with the detection of gas types in a combustion device. In particular the present disclosure is concerned with the detection of gas types of combustible gases in respect of emissions to be avoided.

Common gas types in combustion devices are those from the E gas group (in accordance with EN 437:2009-09) and also gases from the B/P gas group (in accordance with EN 437:2009-09). Gases from the E gas group, like almost all gases from the second gas family (in accordance with EN 437:2009-09) contain methane as their main component. Gases from the B/P group, like almost all gases from the third gas family (in accordance with EN 437:2009-09) are based on propane gas. The mixtures based on methane gas or propane gas ultimately represent mixtures from different gas sources with which the combustion device can be supplied.

As a rule characteristic curves, which will be selected on site during commissioning, are provided for different gas types according to the gas group present. The setting is made for example by selecting one or more curves held in the memory of a control unit. Each of these curves reflects the course of the amount of fuel fed to the burner in relation to the amount of air fed to it. In such cases, as well as the amount of fuel fed in or the setting signal of a valve in the fuel line, the target value of an ionisation sensor is plotted, with the aid of which, as well as with the measured ionisation signal as the actual value, the amount of fuel via the valve is adjusted. Also, instead of the amount of fuel the amount of air fed in, the speed of a fan in the air feed line of the burner can be applied. The setting or the setting signal of an air flap can also be considered as a measure for the air feed to the burner.

If incorrect characteristic curves are set on site, the possible consequences for the combustion in the combustion device are as follows:

- One or more characteristic curves for a gas of the B/P group are set on site, although a gas from the E group is present. The mixture of fuel and air is leaner at high power. At low burner power on the other hand the mixture is somewhat richer. Thus the emissions of the burner device increase somewhat compared to a system with a correctly set characteristic curve at low burner power, but remain non-critical.
- One or more characteristic curves for a gas of the E group are set on site, although a gas from the B/P group is present. This means that the mixture of fuel and air is richer at high power, while it is somewhat leaner at low power. In this case the emissions at low power remain non-critical in many cases, since the mixture is leaner compared to a system with a correctly set characteristic curve. At high power on the other hand undesired emissions occur. Thus there is interest in the detection and where necessary handling of the consequences of an incorrectly set gas type characteristic curve.

Through the inclusion of environmental influences such as for example changes in the air temperature, the air pressure, the air humidity, the gas temperature and/or the gas inlet pressure the characteristic curves widen out over the power of the gas actuators or alternatively air actuators to bands of characteristic curves. Thus the possible characteristic curve bands of the actuator settings approach each other and the distance between them reduces. A further blurring of the characteristic curve bands is produced by tolerances of mechanical components such as valves in the gas feed duct for example.

The aim of the present disclosure is the detection of gas types in a combustion device, in particular in respect of the avoidance of emissions and the optimised operation of the device. The document AT413440 B discloses the precharacterising clause of independent claim 1.

Summary

The present disclosure teaches a method for detection of gas types in a combustion device. The method is based on the ratio of air to fuel being regulated in a combustion device. In particular the ratio of air to fuel can be regulated with reference to what is referred to as a λ regulation. It is further assumed that at least one characteristic curve for at least one fuel is held in the (non-volatile) memory of a closed-loop and/or open-loop control device and/or monitoring device.

One of the two actuators for air or gas is defined as a measure for the burner power. For the λ regulation a required value is defined as a function of the burner power. Via the λ regulation the other actuator, for air or gas, is excluded from the regulation and the amount of fuel or an equivalent, such as the actuator position or activation value, is defined. The defined value is compared to the value that is stored for the actuator in the characteristic curve or in the characteristic curve band. In particular the situation in relation to a limit characteristic curve is established. If the adjusted characteristic curve point is located on the wrong side of the limit characteristic curve, it is deduced that there is an error

The said problems of gas type detection and error handling are addressed with reference to the main claims of the present invention. Particular forms of embodiment are dealt with in the dependent claims.

A related aim of the present invention is to provide a method for gas type detection that minimises costs for additional sensors and/or electronic modules. Ideally a method for gas type detection is provided that manages without additional sensors and/or processing units and/or storage media.

A further related aim of the present disclosure is to provide a method for gas type detection that makes it possible to recognise different types of gas even during operation over a long period of a combustion device, for example even over the service life of the combustion device. Advantageously changes in fuel by the gas supplier can also be recognised by the method provided.

Yet a further related aim of the present disclosure is to provide a method for gas type detection that automates the detection of different gas types. In particular it is an aim of the present disclosure to exclude errors due to human failings, such as for example incorrect settings, or at least to reduce them.

It is further another related aim of the present disclosure to provide a method for gas type detection that makes error handling possible. Advantageously the method provided makes possible the (preventive) switching off of a system for avoiding undesired emissions. Moreover the method provided advantageously makes it possible to output a notification when an error occurs.
A further related aim of the present disclosure, when an error occurs and with the possibility of uniquely assigning the fuel supplied to a group, is to switch over the combustion device to operation with a fuel from the uniquely assigned fuel group and to operate the combustion device with said fuel.
A further related aim of the present disclosure, when an error occurs and without the possibility of uniquely assigning the fuel supplied to a group, to switch over the combustion device to operating parameters that result in acceptable combustion values for all possible fuels from different fuel groups.
Above and beyond this it is an aim of the present invention to provide a combustion device with a closed-loop and/or open-loop control device and/or monitoring device with instructions in its memory for carrying out a method disclosed here.

It is also an aim of the present disclosure to provide a method for gas type detection that is used in a combustion device such as for example an industrial firing system and/or a heating system and/or an internal combustion engine (of an automobile).

Brief description of the figures

Various details will become available to the person skilled in the art with reference to the more detailed description. The individual forms of embodiment are not restrictive in such cases. The drawings, which are enclosed with the description, can be described as follows:

FIG. 1 shows a schematic of a combustion device with a closed-loop and/or open-loop control device and/or monitoring device.

FIG. 2 shows an example of characteristic curves of the course of the required ionisation current value plotted against the air feed for two gas groups or gas families.

FIG. 3 shows an example of characteristic curves of the course plotted against the fuel feed expanded to characteristic curve bands without any overlapping between the characteristic curve bands, for which a limit characteristic curve exists between the characteristic curve bands.

FIG. 4 shows examples of characteristic curves expanded to characteristic curve bands with overlapping between the characteristic curve bands for which a limit characteristic curve exists between the characteristic curve bands in the overlap-free area.

FIG. 5 shows examples of characteristic curves expanded to characteristic curve bands that do not overlap, in which the limit characteristic curves exist within the characteristic curve bands.

FIG. 6 shows an example of characteristic curves of course of an ionisation current plotted against the air feed for two gas groups or gas families, with a further characteristic curve with which a further characteristic curve can be switched to for increasing the air ratio λ.

More detailed description

FIG. 1 shows a burner 1. A flame of a heat generator burns in the combustion chamber 2 of the burner 1 during operation. The heat generator switches the heat energy of the hot combustion gases into another fluid, such as water for example. A hot water heating system is operated and/or drinking water is heated up with the heated water for example. In accordance with another form of embodiment a material can be heated up with the hot combustion gases in an industrial process for example. In accordance with another form of embodiment the heat generator is part of a system with power-heat coupling, for example a motor of such a system. In accordance with another form of embodiment the heat generator is a gas turbine. In accordance with yet another form of embodiment the heat generator heats up a fuel cell and/or battery and/or (lithium-metal) accumulator to the temperature required for its operation. The exhaust gases 8 are taken away from the combustion chamber 2 via a chimney for example.

The inlet air 4 for the combustion process is fed to the burner 1 via a (motor-) driven fan 3. Via the signal line 10 the closed-loop and/or open-loop control device and/or monitoring device 9 specifies to the fan the amount of inlet air that it is to convey. In this way the fan speed 11 is a measure for the amount of air conveyed.

In accordance with one form of embodiment the fan speed 11 is reported back to the closed-loop and/or open-loop control device and/or monitoring device 9 by the fan 3. If the amount of air 4 is set via an air flap and/or a valve, the flap and/or valve setting and/or the measured value obtained from the signal of a mass flow sensor and/or volume flow sensor can be used as a measure for the amount of air. The sensor is advantageously arranged in the duct for the air supply. Advantageously the sensor provides a signal, which is converted by a suitable signal processing unit into a measured flow value. A signal processing device ideally comprises at least one analogue/digital converter. In accordance with one form of embodiment the signal processing device, in particular the analogue/digital converter(s) is or are integrated into the closed-loop and/or open-loop control device and/or monitoring device 9.

The measured value of a pressure sensor and/or of a mass flow sensor in a bypass duct can also be used as a measure for the amount of air. The sensor establishes a signal that corresponds to the pressure value and/or the air flow (particle and/or mass flow) dependent on the air throughput in the bypass duct. Advantageously the sensor provides a signal that is converted into a measured value by a suitable signal processing device. In accordance with a further advantageous form of embodiment the signals of a number of sensors are converted into a common measured value. A suitable signal processing device ideally comprises at least one analogue/digital converter. In accordance with one form of embodiment the analogue/digital converter(s) is or are integrated into the closed-loop and/or open-loop control device and/or monitoring device 9.

Mass flow sensors allow measurements at great flow speeds specifically in conjunction with combustion devices during operation. Typical values of such flow speeds typically lie between 0.1 m/s and 5 m/s, 10 m/s, 15 m/s 20 m/s or even 100 m/s. Mass flow sensors that are suitable for the following disclosure are for example OMRON® D6F-W or SENSOR TECHNICS® type WBA sensors. The usable range of these sensors typically begins at speeds between 0.01 m/s and 0.1 m/s and ends at a speed of 5 m/s, 10 m/s, 15 m/s 20 m/s or even 100 m/s. In other words lower limits such as 0.1 m/s can be combined with upper limits such as 5 m/s, 10 m/s, 15 m/s 20 m/s or even 100 m/s.

The fuel throughput is set and/or adjusted by the closed-loop and/or open-loop control device and/or monitoring device 9 with the aid of an actuator and/or a (motor-) adjustable valve. In the version in FIG. 1 the fuel is a fuel gas. A device type can then be connected to different fuel gas sources, for example to sources with a high proportion of methane and/or to sources with a high proportion of propane. In FIG. 1 the amount of fuel gas 6 is set by a (motor-) adjustable gas valve 5 by the closed-loop and/or open-loop control device and/or monitoring device 9. The activation value 12, for example with a pulse-width modulated signal, of the gas valve in this case is a measure for the amount of fuel gas. The activation value 12 of the gas valve is a value for the supply of fuel 6. In accordance with a specific form of embodiment the gas valve 5 is set using a stepping motor. In any event the step setting of the stepping motor is a measure for the amount of fuel gas.

If a gas flap is used as the actuator, then the position of a flap can be used as the measure for the amount of fuel gas. As an alternative the measured value derived from the signal of a mass flow sensor can be used as a measure for the amount of fuel gas. That sensor is advantageously arranged in the feed duct for fuel. That sensor creates a signal, which is converted by a suitable signal processing device into a measured flow value (measured value of the particle and/or mass flow). A suitable signal processing device ideally comprises at least one analogue/digital converter. In accordance with one form of embodiment the signal processing device, in particular the analogue/digital converter or converters, is or are integrated into the closed-loop and/or open-loop control device and/or monitoring device 9.

The person skilled in the art recognises how the values given above can also be computed from a combination of values established by sensors. Those values are then measures of throughput (particle and/or mass flow) of fuel gas. The person skilled in the art furthermore recognises that the throughput of fuel of a liquid fuel can be established in a similar manner.

If the fuel throughput is selected as a measure for the current power of the combustion device, then the value of the fuel supply 6 can be used as the value of the burner power with which the actuator 5 will be activated. Since the fuel supply and the air throughput (air supply) are associated with one another via the pre-specified air ratio λ, the air supply can equally be seen as a measure for the current power of the combustion device. Thus the speed 11 is a representative value for the power of the combustion device.

A current flows through the ionisation electrode 7 when the burner is operating. KANTHAL®, e.g. APM® or A-1® is often used as the material of the ionisation electrode 7. Electrodes made of Nikrothal® will also be considered by the person skilled in the art.

The ionisation signal 13 is created from the current through the ionisation electrode 7. The signal 13 is read in by the closed-loop and/or open-loop control device and/or monitoring device 9 and suitably evaluated. With the aid of the ionisation signal 13 a pre-specified air ratio λ can be adjusted for the throughput of supplied air. In this case the measured throughput is adjusted to a pre-specified required value via the actuator in the fuel feed duct and/or via the actuator in the air feed duct.

FIG. 2 shows the required values 14 of the ionisation current for two different gas groups/families plotted against the fan speed. The person skilled in the art recognises that instead of the fan speed, another equivalent variable of the air throughput can be applied. The measured ionisation value 13 is regulated via the regulation circuit comprising control unit 9, setting signal 12, the gas amount actuator 5 setting the mixture ratio, the flame in the combustion chamber 2 and the current through the ionisation electrode 7 to the required value 14 of the ionisation current.

Via the required value 14 of the ionisation current, for each value of the air throughput that occurs, i.e. for each fan speed 11, the air ratio λ is set. Thus for example the required value 14 of the ionisation current is established, in that by way of example the desired air ratio λ is set at the combustion device as a function of the fan speed 11 via the gas amount actuator 5 and the value of the ionisation current measured subsequently is defined as the characteristic curve point of the characteristic curve 15, 16. Further sensors, with the aid of which the air ratio λ can be measured, are preferably used for the described establishment of the ionisation current required value characteristic curve 15, 16. The person skilled in the art is familiar in particular with the measurement of the O_2 value and/or of the CO_2 value. In this case the air ratio λ is able to be determined directly in each case from the measurement result. The characteristic curve 15, 16 established in this way is representative for all combustion devices that have the same assignment of ionisation current 14 via the air throughput and at the same time of the air ratio λ via the air throughput. The assignment of the acquired value of the ionisation current measured value 13 to the required ionisation value 14 and the adjustment of the acquired ionisation current measured value 13 to the required value 14 thus represents a processing to an air ratio measured value, which is equivalent to a direct measurement of the O_2 value in the exhaust gas for example and a direct calculation of the associated measured air ratio value, which is subsequently adjusted to a pre-specified required air ratio value.

The characteristic curve 15 shows the course of the required value, which can be used for a group of similar gas compositions. The E gas group, of which the main component is methane gas, can be cited here as an example. The characteristic curve 16 shows the course of the required value, which can be used for a second group of similar gas compositions. An example of this is the B/P gas group with mixtures of propane with propene or propane and butane.

The course of the ionisation current behaves differently for different gas groups over the burner power (and thus over the required supply of air) because of the different flame image. The person skilled in the art recognises that the course of characteristic curves as in FIG. 2 is not restricted to the said E gas and/or B/P gas groups.

Each gas group consists of gases, which for their part are mixed from the basic gas and other gases. In the E gas group for example these are mixtures of methane and propane, mixtures of methane and nitrogen but also mixtures of methane and hydrogen. The mixtures represent real mixtures from gas sources for the combustion device.

Basically for each pre-specified mixture of gases, but also for every other percentage gas composition right through to the limit mixtures, for a pre-specified λ, a characteristic curve of the fuel throughput 12 is defined via the air throughput 11, wherein the air throughput is selected as a measure of the burner power. In the present case the characteristic curve is represented by a position of a stepping motor plotted against a fan speed. Thus, within the limit mixtures, characteristic curve bands of the fuel supply 12 plotted against the air supply 11 are produced. These circumstances are illustrated in FIG. 3.

If there is now a desire to burn gases from the E gas group for example, then the characteristic curve 15 from FIG. 2 should be chosen as the required characteristic curve. If the gas supply is actually delivering a gas from the E gas group then the characteristic curve point of the gas currently adjusted for a power lies in the characteristic curve band 17.

If there is now a desire to burn gases from the B/P gas group, then the characteristic curve 16 should be selected (as a required value characteristic curve). If the gas supply is actually delivering a gas from the B/P gas group then the characteristic curve point of the gas currently adjusted lies in the characteristic curve band 18.

Normally an installer is responsible for the selection of the correct characteristic curve for the gas group on site. If the installer does this incorrectly or if they neglect to select a correct characteristic curve, the following further combinations are possible:

1. The installer selects the characteristic curve 16 for B/P gas, but has a gas from the E group in the network. Thus the mixture is leaner at high power (see FIG. 2). At low power the mixture is somewhat richer, but the emissions are not critical.
2. The installer selects the characteristic curve 15 for E gas, but has a gas from the B/P group in the network. Thus the mixture is richer at high power. At low power the mixture is somewhat leaner. At low power the emissions are frequently not critical, since the mixture is leaner (see FIG. 2). At high power on the other hand the mixture is richer, so that critical emissions can arise. That state should therefore be detected. Moreover that state should be transferred to a non-critical state.

The list of possible combinations given above does not claim to be complete.

The two gas groups E gas and B/P gas have a sufficient spacing from one another of the minimum air requirement L_{min} for their respective gases. Therefore the characteristic curves from FIG. 3 do not overlap. Consequently a limit characteristic curve 19 can be defined between the two characteristic curve bands. The limit characteristic curve 19 advantageously runs as an arithmetic mean between the upper and lower boundaries of the characteristic curve bands 18 and 17 from FIG. 3.

With the correct choice of the characteristic curve for the gas group used the adjusted characteristic curve point for gases of the E gas group lies above limit characteristic curve 19. For gases of the B/P gas group the adjusted characteristic curve point for a correct choice of the characteristic curve lies below the limit characteristic curve 19.

If on the other hand the wrong characteristic curve is selected for a gas used, then the adjusted characteristic curve point does not lie in all cases in the characteristic curve band of the group of gases on the other side of the limit characteristic curve 19. However the adjusted characteristic curve point lies on the other side of the limit characteristic curve 19. Thus, in the case of a gas from the E gas group with an incorrect characteristic curve, the adjusted characteristic curve point lies below the limit characteristic curve 19. For a gas from the B/P group the adjusted characteristic curve point lies above the limit characteristic curve 19. The location of the adjusted characteristic curve point in relation to the limit characteristic curve 19 thus allows the detection of the incorrect choice of a characteristic curve for fuel.

Environmental influences such as changes of air temperature, of air pressure, of the pressure at the gas inlet and/or of the air humidity frequently have effects on the accuracy of the value of air throughput or fuel throughput. This applies in particular when these influences are not already compensated for in the detection of various signals by a mass flow sensor for example. With uncompensated values for air throughflow and/or gas throughflow this has an effect in the characteristic curve diagram depicted in FIG. 3 as a widening-out of the characteristic curve bands 17 and/or 18. The characteristic curve bands 17 and/or 18, despite such influences, frequently do not (yet) overlap in practice. The person skilled in the art recognises that the air throughflow and throughflow of fuel can advantageously be represented by the fan speed 11 and the position of the stepping motor of a gas valve 5.

If there are additional tolerances included, in particular (mechanical) tolerances of the gas valve 5, then it can occur that the characteristic curve bands 17 and 18 (partly) overlap. Such a state of affairs is shown in FIG. 4. In accordance with a specific form of embodiment at least 2 percent of the surfaces of the characteristic curve bands 17 and 18 overlap, furthermore at least 5 percent overlapping of the surfaces of the characteristic curve bands 17 and 18 is possible. Moreover there are cases with at least 20 percent or at least 60 percent overlapping of the surfaces of the characteristic curve bands 17 and 18.

Overlaps of the characteristic curve bands occur above all in practice in the low power range (i.e. at low fan speeds). In that range the characteristic curve bands 17 and 18 are close to one another. In accordance with one form of embodiment the overlaps occur in the lower 60% of the power range, in accordance with a specific form of embodiment in the lower 40% or 10% of the power range.

However rather non-critical emissions frequently tend to occur in the lower power range. Thus it can be sensible to carry out the check for the correct gas group only in the upper power range. In that range the characteristic curve bands 17 and 18 do not overlap. There the limit characteristic curve 19 can be uniquely defined between the characteristic curve bands. For this case too for example the limit characteristic curve 19 can be defined as the arithmetic mean between the upper and lower limits of the characteristic curve bands 17 and 18.

The limit characteristic curve 19 will then only be defined from the maximum power (corresponding to the maximum air throughput and/or the maximum fan speed) up to a defined limit 20. Preferably the defined limit 20 lies above the power range in which the characteristic curve bands 17 and 18 overlap. In accordance with a further preferred form of embodiment the defined limit 20 lies at least 5% of the maximum power, furthermore preferably at least 10% of the maximum power, likewise preferably at least 20% of the maximum power, above the first overlap (starting at the maximum power) between the characteristic curve bands 17 and 18. In the case of characteristic curves held as tables the limit 20 can also be the value (starting at the maximum power) of the last overlap-free value stored of characteristic curve held in the table.

The check as to whether the adjusted characteristic curve point is located on the correct side of the limit characteristic curve 19 is only undertaken in the area between the limit 20 and the maximum power.

If it is detected that the adjusted characteristic curve point is located on the incorrect side of the limit characteristic curve 19, there should be a reaction. Associated therewith is the aim of (largely) avoiding (critical) emissions. Possible reactions are

- (Output of a signal to) switch off the burner device,
- (Output of a signal to) put the burner device into a fault setting,
- (Output of a signal to) display a warning message on a display of the burner device,
- Notification to a mobile terminal of a user and/or a specialist,
- Switchover to the correct characteristic curve (in operation) and continuation of operation.

The person skilled in the art recognises that combinations of the aforesaid reactions are possible. The list given above of possible reactions does not claim to be complete.

Incorrectly set characteristic curves mostly occur during installation or during a switchover of gas supply. In accordance with a specific form of embodiment the detection of an incorrectly set characteristic curve is therefore limited to the first hours of operation and/or the first days of operation. In particular the detection of an incorrectly set characteristic curve can be limited to the first 5 hours of operation and/or to the first 50 hours of operation and/or to the first 500 hours of operation. The person skilled in the art recognises that the time limit on the detection of an incorrectly set characteristic curve can depend on the network (gas supply network). The time limit on the detection of an incorrectly set characteristic curve is of advantage because an incorrect detection as a result of extreme environmental influences can thus (largely) be excluded. Such extreme environmental influences are for example a covering of the exhaust gas path during the service life of the combustion device.

With an incorrect choice of a required value characteristic curve 15 or 16 with the consequence of an incorrect gas group for the selected characteristic curve as fuel gas 6, the limit characteristic curve 19 can also shift into the bands 17 and/or 18. This case is shown in FIG. 5. Because of the different required value characteristic curves 15 or 16, two limit characteristic curves 21 and 22 are now obtained. For correct operation with E gas the location is in band 17. Above the limit characteristic curve 21 the fuel gas 6 is certain to be E gas. But below the limit characteristic curve 21 the fuel gas is either E gas or also B/P gas. In this case it cannot be detected below the limit characteristic curve 21 whether the fuel gas is E gas or B/P gas.

For correct operation with B/P gas the location is in band 18. Below the limit characteristic curve 22 the fuel gas 6 is certain to be B/P gas. But above the limit characteristic curve 21 the fuel gas is either B/P gas or also E gas. In this case it cannot be detected above the limit characteristic curve 22 whether the device is being supplied with B/P gas or E gas.

The person skilled in the art recognises that at least one of the two limit characteristic curves 21, 22 can also lie between the bands 17, 18. If a gas group is selected and if only one of the limit characteristic curves for the incorrect gas group 21 or 22 is within the band 17 or 18 assigned to the gas group, then operation with the incorrect gas group beyond all tolerances cannot be discovered. The person skilled in the art also recognises this as such for the case in which both limit characteristic curves 21, 22 lie inside the band 17 or 18 that is assigned to the respective gas group. This case is outlined in FIG. 5.

When both characteristic curve bands 17, 18 overlap completely, a similar case is obtained. Above and below the overlap area the gas group is recognised with certainty. The upper and lower limit lines of the overlap area then form the two limit characteristic curves 21 and 22.

If both limit characteristic curves 21 and 22 lie outside the respective assigned band 17, 18, then a common limit characteristic curve can be found, which completely fulfils the function of the two limit characteristic curves 21, 22.

For the case in which at least one of the two limit characteristic curves 21, 22 for a gas group is located within the assigned band 17 or 18, there is no question of a switch-off reaction if this characteristic curve 17 or 18 is exceeded, since the correct fuel gas could be located in the supply line. For the said case falling below the characteristic curve 21 is still detected. To be sure that no critical emissions can occur in the supply line in the case of the incorrect gas group B/P, the λ value will be increased when the value falls below the characteristic curve 21, in order to obtain a sufficiently large safety margin with respect to the λ limit value at which, in the case of the incorrect gas group B/P as fuel gas 6, critical emissions occur.

FIG. 6 shows the measure with which the increase in the λ value is achieved. If the setting of the fuel valve 5 is adjusted so that it lies above the limit characteristic curve 21, then the required value of the ionisation current over the entire power range is specified via the pre-specified required value characteristic curve 15. This is possible since it is ensured above the limit characteristic curve 21 that there is only E gas located in the inlet line as fuel gas 6. If the value falls below the limit characteristic curve 21, the B/P gas can also be located in the inlet line as fuel gas 6. In this case a required value characteristic curve 23 is specified, which adjusts the device to greater λ value. This ensures that even in the event of B/P gas as the fuel gas 6 in the supply line no critical emissions can occur. The person skilled in the art recognises that the reduction of the required value characteristic curve to the characteristic curve 23 is only carried out where critical emissions can also occur. This is established by trials with the incorrect gas group for a selected characteristic curve 15. The reduction in the λ value is then carried out as from an air amount point 24 corresponding to the associated burner power point as from which, with B/P gas as fuel gas 6, critical emission occur. In a particular embodiment the characteristic curve 23 can be defined as a straight line, which is defined by its end point and the point 24. Thus the characteristic curve 23 can be stored easily (and without requiring much storage) in the closed-loop, open-loop control device and monitoring device 9.

Through this measure the λ value is changed for the case of correct operation with E gas only in the edge area of the band 18, i.e. for limit patterns of the fuel valve 5 and/or in the area of limit-value environmental conditions. Thus a slightly lower level of efficiency, which has to be taken into account, occurs only for these cases.

The person skilled in the art recognises that a similar type of process can be carried out for the limit characteristic curve 22. This is not absolutely necessary however, since normally critical emission do not occur here.

The limit characteristic curve 19 and also the limit characteristic curves 21, 22 are held in accordance with one form of embodiment in the form of a table in the (non-volatile) memory of the closed-loop and/or open-loop control device and/or monitoring device 9. Intermediate values between the points held in the tables are obtained by linear interpolation for example. As an alternative intermediate values are interpolated between the points defined by the table by a polynomial covering a number of neighbouring values and/or via (cubic) splines. The person skilled in the art recognises that further forms of interpolation are also able to be implemented.

In accordance with another form of embodiment the limit characteristic curve 19 or the limit characteristic curves 21, 22 are also computed from other setting characteristic curves from the characteristic curve bands, for example limit characteristic curves and/or reference characteristic curves of representative actuators with defined environmental conditions. In particular the limit characteristic curve 19 can have a defined spacing ratio in relation to the two reference characteristic curves in the overall power range. In accordance with yet another form of embodiment the limit characteristic curves 19, 21, 22 are stored on the basis of (sectionally defined) functions such as for example straight lines and/or polynomials.

Parts of the control unit and/or of a method in accordance with the present disclosure can be implemented as hardware, as a software module that is executed by a processing unit, or on the basis of a cloud computer, or on the basis of a combination of the aforementioned options. The software might comprise firmware, a hardware driver that is executed within an operating system, or an application program. The present disclosure thus also relates to a computer program product, which contains the features of this disclosure or carries out the required steps. For implementation as software the described functions can be stored as one or more commands on a computer-readable medium. A few examples of computer-readable media include random access memory (RAM), magnetic random access memory (MRAM), read-only memory (ROM), flash memory, electronically programmable read-only memory (EPROM), electronically erasable programmable read-only memory (EEPROM), registers of a processing unit, a hard disk, a removable hard disk, an optical memory or any suitable medium to which access is possible by a computer or by other IT facilities and applications.

In other words the present disclosure teaches a method for burning a fuel 6 from a predetermined fuel group originating from a connection of a burner device to a supply source, taking into account a value of a required power 11 of the burner device, the burner device comprising at least one sensor 7, a signal processing unit 9 and a monitoring unit 9 with a memory, in which at least one error range of characteristic values is held for the predetermined fuel group, wherein the at least one error range of characteristic values exclusively comprises those characteristic values of which the occurrence is to be avoided and/or is excluded for a (correctly regulated) combustion of a fuel 6 from the predetermined fuel group by the burner device, the method comprising the steps:

- Acquisition of at least one signal 13 of the at least one sensor 7,
- Transfer of the at least one signal 13 to the signal processing unit 9,
- Processing of the at least one signal 13 to a measured air ratio value,
- Transfer of the measured air ratio value to the monitoring unit 9
- Assignment of the at least one measured air ratio value and the required power 11 of the burner device to a pair of values for the fuel 6 comprising a value of a fuel feed 12 to the burner device and the value of the required power of the burner device 11,
- Comparison of the assigned pair of values with the at least one error range of characteristic values held in the memory of the monitoring unit 9,
- Detection that the assigned pair of values lies outside a range for a safe presence of the fuel 6 from the predetermined fuel group (at the connection of the burner device), if as a result of the comparison the established position of the assigned pair of values lies in the at least one error range of characteristic values held in the memory of the monitoring unit 9.
- Creation of an error signal, if the assigned pair of values lies outside the range for a safe presence of the fuel 6 of the predetermined fuel group (at the connection of the burner device), wherein a first characteristic curve band 17 with at least two limit curves for a first fuel group and a second characteristic curve band 18 with at least two limit curves for a second fuel group are additionally held in the memory of the monitoring unit 9, the method additionally comprising the steps:
- Determining a limit characteristic curve 19, 21, 22, which runs between neighbouring limit curves of the first and the second characteristic curve band 17 – 18, - wherein the neighbouring limit curves below the at least two limit curves of the first characteristic curve band 17 and below the at least two limit curves of the second characteristic curve band 18 are those limit curves that, for each given power 11 of the burner device, have the smallest distance from one another,

- Storage of the limit characteristic curve 19, 21, 22 determined in the memory of the monitoring unit 9.

In accordance with a specific form of embodiment the supply source is a supply network, in particular a gas supply network.

The present disclosure likewise teaches one of the aforesaid methods, wherein the at least one sensor of the burner device is an ionisation electrode 7.

The present disclosure likewise teaches one of the aforesaid methods, wherein the memory of the monitoring unit 9 is non-volatile.

The present disclosure likewise teaches one of the aforesaid methods, wherein the signal processing unit 9 comprises at least one analogue/digital converter.

The present disclosure likewise teaches one of the aforesaid methods, wherein the signal processing unit 9 is integrated into the monitoring unit 9.

The present disclosure likewise teaches one of the aforesaid methods, the burner device comprising a fuel feed duct 25 with at least one actuator 5, the method additionally comprising the steps

Transfer of the error signal to the at least one actuator of the fuel feed duct 25 of the burner device if the assigned pair of values lies outside the range for a safe presence of the fuel 6 of the predetermined fuel group,

Switching the at least one actuator 5 of the fuel supply duct 25 into the error position on arrival of the error signal at the actuator 5 of the fuel supply feed 25 (so that, in the error position, the burner device is switched off and the burner device cannot put a combustion process in train by itself).

The fuel feed duct 25 preferably has a fluid connection to the combustion chamber 2.

The present disclosure likewise teaches the aforesaid method, wherein the at least one actuator of the fuel feed duct 25 is a fuel valve 5, wherein the fuel valve is embodied to close on arrival of the error signal and the fuel feed duct 25 is embodied to be interrupted as a result of the closure of the fuel feed duct 25,

wherein the step of switching the at least one actuator 5 of the fuel feed duct 25 into the error position comprises the step of closing the gas valve 5, so that the fuel feed duct 25 is interrupted.

In accordance with a specific form of embodiment the fuel valve 5 is a gas valve 5.

The present disclosure likewise teaches one of the aforesaid methods, the burner device additionally comprising a display embodied for output of a warning message and a control unit for the display, the method additionally comprising the steps:

Transfer of the error signal to the control unit for the display if the assigned pair of values lies outside the range for a safe presence of the fuel 6 of the predetermined fuel group,

Output of a warning message to the display of the burner device on arrival of the error signal at the control device.

The present disclosure likewise teaches one of the aforesaid methods, the burner device additionally comprising a communication unit embodied for sending a warning message to a mobile terminal of a user and/or a specialist, the method additionally comprising the steps:

Transfer of the error signal to the communication unit if the assigned pair of values lies outside the range for a safe presence of the fuel 6 of the predetermined fuel group,

Sending of a warning message to a mobile terminal of a user and/or a specialist on arrival of the error signal at the communication unit of the burner device.

The present disclosure likewise teaches one of the aforesaid methods, the burner device additionally comprising a control unit 9 with a (non-volatile) memory wherein a first characteristic curve 15 (for a first fuel group) and a second characteristic curve 16 (for a second fuel group) are held in the memory of the control unit 9 (wherein the first characteristic curve 15 is different from the second characteristic curve 16) and the control unit 9 is embodied to regulate the burner device on the basis of either the first characteristic curve 15 or the second characteristic curve 16, the method additionally comprising the steps:

Transfer of the error signal to the control unit 9 if the assigned pair of values lies outside the range for a safe presence of the fuel 6 of the predetermined fuel group,

On arrival of the error signal at the control unit 9, determination of the stored characteristic curve 15 – 16, on the basis of which the control unit is (currently) controlling the burner device, and

Regulation of the burner device on the basis of a characteristic curve 16 – 15 other than the characteristic curve 15 – 16 determined.

The present disclosure likewise teaches one of the aforesaid methods, the burner device additionally comprising a control unit 9 with a (non-volatile) memory, wherein a first characteristic curve 15 (for a first fuel group) and a second characteristic curve 16 (for a second fuel group) are held in the memory of the control unit 9 for a predetermined fuel group and a further characteristic curve 23 (different from the at least one characteristic curve 15 – 16) (and preferably a critical burner power 24) are held in the memory and the control unit is embodied to regulate the burner device on the basis of either the at least one characteristic curve 15 – 16 or the further characteristic curve 23, the method further comprising the steps:

Transfer of the error signal to the control unit 9 if the assigned pair of values lies outside the range for a safe presence of the fuel 6 of the predetermined fuel group, On arrival of the error signal at the control unit 9, determination of the stored characteristic curve 15 – 16, on the basis of which the control unit is (currently) controlling the burner device, and

Regulation (preferably for required powers 11 of the burner device greater than the stored critical burner power 24) of the burner device on the basis of the further characteristic curve 23.

The further characteristic curve 23 of the aforesaid method is preferably a fallback characteristic curve 23, wherein the control unit is embodied to regulate the burner device on the basis of the fallback characteristic curve 23 and in doing so, independently of the predetermined fuel group, to avoid emissions that are critical and/or legally forbidden (by standards and/or laws).

In accordance with a preferred form of embodiment the control unit 9 is integrated into the monitoring unit 9.

The present disclosure likewise teaches one of the aforesaid methods, wherein a fuel group is assigned and an index is held additionally for each of the stored characteristic curve bands 17 - 18 in the memory of the monitoring device 9, the method additionally comprising the steps:

Reading of an index that corresponds to one of the stored characteristic curve bands from the memory of the monitoring device 9,

Selection of that characteristic curve band 17 – 18 that corresponds to the index read in,

Establishing a side of the limit characteristic curve 19, 21, 22 on which exclusively fuel 6 from the fuel group assigned to the selected characteristic curve band 17 – 18 can be burned and/or establishing a side of the limit characteristic curve 19, 21, 22 which is facing towards the selected characteristic curve band 17 – 18,

Determining a range of characteristic values, wherein the range determined lies opposite the established side of the limit characteristic curve 19, 21, 22, Storing the range of characteristic values determined as at least one error range of characteristic values for the predetermined fuel group in the memory of the monitoring device 9.

The above fuel group preferably comprises at least one fuel.

A non-volatile computer-readable medium, which stores a set of commands for execution by at least one processor, which, when it is executed by a processor, carries out one of the aforesaid methods.

What has been stated above relates to individual forms of embodiment of the disclosure. Various changes can be made to the forms of embodiment without deviating from the underlying idea and without departing from the framework of this disclosure. The subject matter of the present disclosure is defined via its claims. A very wide range of changes can be made without departing from the scope of protection of the following claims.

Reference characters

1 Burner

2 Combustion chamber

3 (Motor-driven) fan

4 Inlet air

5 Gas amount actuator (motor-adjustable valve)

6 Fuel, in particular fuel gas

7 Ionisation electrode

8 Exhaust gases

9 Closed-loop, open-loop and/or monitoring device (with non-volatile memory)

10 Signal line for specifying the air feed (air throughput) to the fan

11 (Signal line for transmitting the) fan speed

12 Signal line for specifying the fuel feed (fuel throughput) to the gas amount actuator

13 Signal line for ionisation signal

14 Required value of the ionisation current

15 Characteristic curve for example for gases of the E gas group

16 Characteristic curve for example for gases of the B/P gas group

17 Characteristic curve band for example for gases of the E gas group

18 Characteristic curve band for example for gases of the B/P gas group

19 Limit characteristic curve

20 Limit of the power value from which the limit characteristic curve is defined

21, 22 Limit characteristic curves

23 Characteristic curve for increased air ratio λ

24 Limit of the power value, from which there can be switchover to the characteristic curve for increased air ratio λ

25 Fuel feed duct

Patentkrav

1. Fremgangsmåde til forbrænding af et brændstof (6) fra en forudbestemt brændstofgruppe, der stammer fra en tilslutning af en brænderindretning til en forsyningskilde under hensyntagen til en værdi af en påkrævet effekt (11) af brænderindretningen, hvor brænderindretningen omfatter mindst en sensor (7), en signalbearbejdningsenhed (9) og en overvågningsenhed (9) med en hukommelse, hvori mindst et fejlområde af karakteristiske værdier er gemt til den forudbestemte brændstofgruppe, hvor det mindst ene fejlområde af karakteristiske værdier udelukkende omfatter sådanne karakteristiske værdier, hvis forekomst skal forhindres ved en forbrænding af den forudbestemte brændstofgruppe af brænderindretningen, hvilken fremgangsmåde omfatter trinnene:

at registrere mindst et signal (13) af den mindst ene sensor (7);

at overføre det mindst ene signal (13) til signalbearbejdningsenheden (9);

at bearbejde det mindst ene signal (13) til en lufttalmåleværdi;

at overføre lufttalmåleværdien til overvågningsenheden (9);

at tilordne den mindst ene lufttalmåleværdi og den påkrævede effekt (11) af brænderindretningen til et værdipar til brændstoffet (6) omfattende en værdi (12) af en brændstoftilførsel til brænderindretningen og værdien af den påkrævede effekt af brænderindretningen (11);

at generere et fejlsignal, hvis det tilordnede værdipar ligger uden for området til sikker forekomst af brændstoffet (6) fra den forudbestemte brændstofgruppe;

kendetegnet ved, at fremgangsmåden omfatter:

at sammenligne det tilordnede værdipar med det mindst ene fejlområde af karakteristiske værdier, der er gemt i overvågningsenhedens (9) hukommelse; og

at påvise, at det tilordnede værdipar ligger uden for et område til en sikker forekomst af brændstoffet (6) fra den forudbestemte brændstofgruppe, hvis den fastslåede position af det tilordnede værdipar som resultat af sammenligningen ligger i det mindst ene fejlområde af karakteristiske værdier, der er gemt i overvågningsenhedens (9) hukommelse;

hvor der i overvågningsindretningens (9) hukommelse endvidere er gemt et første karakteristikbånd (17) med mindst to begrænsningskurver til en første

brændstofgruppe og et andet karakteristikbånd (18) med mindst to begrænsningskurver til en anden brændstofgruppe, hvilken fremgangsmåde endvidere omfatter trinnene:
at bestemme en grænsekarakteristik (19, 21, 22), der forløber mellem naboliggende begrænsningskurver af det første og andet karakteristikbånd (17 - 18);
hvor de naboliggende begrænsningskurver under de mindst to begrænsningskurver af det første karakteristikbånd (17) og under de mindst to begrænsningskurver af det andet karakteristikbånd (18) er de begrænsningskurver, der for hver givet effekt (11) af brænderindretningen har den mindste afstand til hinanden; og
at gemme den bestemte grænsekarakteristik (19, 21, 22) i overvågningsindretningens (9) hukommelse.

2. Fremgangsmåde ifølge krav 1, hvor den mindst ene sensor af brænderindretningen er en ioniseringselektrode (7).

3. Fremgangsmåde ifølge et af kravene 1 til 2, hvor overvågningsindretningens (9) hukommelse er ikke-flygtig.

4. Fremgangsmåde ifølge et af kravene 1 til 3, hvor signalbearbejdningsenheden (9) omfatter mindst en analog-digital-konverter.

5. Fremgangsmåde ifølge et af kravene 1 til 4, hvor signalbearbejdningsenheden (9) er integreret i overvågningsenheden (9).

6. Fremgangsmåde ifølge krav 1, hvor der yderligere for hvert af de gemte karakteristikbånd (17 - 18) i overvågningsindretningens (9) hukommelse er tilordnet en brændstofgruppe og gemt et indeks, hvilken fremgangsmåde endvidere omfatter trinnene:
at indlæse et indeks, der svarer til et af de gemte karakteristikbånd (17 - 18), fra overvågningsindretningens (9) hukommelse;
at vælge det karakteristikbånd (17 - 18), som det indlæste indeks svarer til;
at fastslå en side af grænsekarakteristikken (19, 21, 22), hvorpå der udelukkende kan forbrændes brændstof (6) fra den brændstofgruppe, der er tilordnet til det valgte karakteristikbånd (17 - 18);

at bestemme et område af karakteristiske værdier, hvor det bestemte område ligger over for den fastslåede side af grænsekarakteristikken (19, 21, 22); og at gemme det bestemte område af karakteristiske værdier som mindst et fejlområde af karakteristiske værdier til den forudbestemte brændstofgruppe i overvågningsindretningens (9) hukommelse.

7. Fremgangsmåde ifølge et af kravene 1 til 6, hvor brænderindretningen omfatter en brændstoftilførselskanal (25) med mindst en aktuator (5), hvilken fremgangsmåde endvidere omfatter trinnene
at overføre fejlsignalet til den mindst ene aktuator (5) af brændstoftilførselskanalen (25) af brænderindretningen, hvis det tilordnede værdipar ligger uden for området til en sikker forekomst af brændstoffet (6) fra den forudbestemte brændstofgruppe; og
at overføre den mindst ene aktuator (5) af brændstoftilførselskanalen (25) til fejlstilling, når fejlsignalet kommer ind ved brændstoftilførselskanalens (25) aktuator (5).

8. Fremgangsmåde ifølge krav 7, hvor den mindst ene aktuator af brændstoftilførselskanalen (25) er en gasventil (5), hvor gasventilen (5) er udformet til at lukke, når fejlsignalet kommer ind, og brændstoftilførselskanalen (25) er udformet til at blive afbrudt som følge af, at gasventilen (5) lukkes,
hvor trinnet til overføring af den mindst ene aktuator (5) af brændstoftilførselskanalen (25) til fejlstilling omfatter trinnet med at lukke gasventilen (5), således at brændstoftilførselskanalen (25) afbrydes.

9. Fremgangsmåde ifølge et af kravene 1 til 8, hvor brænderindretningen endvidere omfatter et display, der er udformet til at afgive en advarselsmeddelelse, og en styreenhed til displayet, hvilken fremgangsmåde endvidere omfatter trinnene:
at overføre fejlsignalet til styreenheden til displayet, hvis det tilordnede værdipar ligger uden for området til sikker forekomst af brændstoffet (6) fra den forudbestemte brændstofgruppe; og
at afgive en advarselsmeddelelse til brænderindretningens display, når fejlsignalet kommer ind ved styreenheden.

10. Fremgangsmåde ifølge et af kravene 1 til 9, hvor brænderindretningen endvidere omfatter en kommunikationsenhed, der er udformet til at sende en advarselsmeddelelse til en brugers og/eller en specialists mobile terminal, hvilken fremgangsmåde endvidere omfatter trinnene:
at overføre fejlsignalet til kommunikationsenheden, hvis det tilordnede værdipar ligger uden for området til sikker forekomst af brændstoffet (6) fra den forudbestemte brændstofgruppe; og
at sende en advarselsmeddelelse til en brugers og/eller en specialists mobile terminal, når fejlsignalet kommer ind ved brænderindretningens kommunikationsenhed.

11. Fremgangsmåde ifølge et af kravene 1 til 10, hvor brænderindretningen endvidere omfatter en reguleringsenhed med en hukommelse (9), hvor en første karakteristik (15) og en anden karakteristik (16) er gemt i reguleringsenhedens (9) hukommelse, og reguleringsenheden 9 er udformet til at regulere brænderindretningen ved hjælp af enten den første karakteristik 15 eller den anden karakteristik 16, hvilken fremgangsmåde endvidere omfatter trinnene:
at overføre fejlsignalet til reguleringsenheden (9), hvis det tilordnede værdipar ligger uden for området til sikker forekomst af brændstoffet (6) fra den forudbestemte brændstofgruppe;
når fejlsignalet kommer ind ved reguleringsenheden (9), at bestemme den gemte karakteristik (15 - 16), ved hjælp af hvilken reguleringsenheden (9) regulerer brænderindretningen; og
at regulere brænderindretningen ved hjælp af en anden karakteristik (16 - 15) end den bestemte karakteristik (15 - 16).

12. Fremgangsmåde ifølge et af kravene 1 til 10, hvor brænderindretningen endvidere omfatter en reguleringsenhed med en hukommelse (9), hvor mindst en karakteristik (15 - 16) til en forudbestemt brændstofgruppe og en yderligere karakteristik (23), der adskiller sig fra den mindst ene karakteristik (15 - 16), er gemt i reguleringsenhedens (9) hukommelse, og reguleringsenheden (9) er udformet til at regulere brænderindretningen ved hjælp af enten den mindst ene karakteristik (15 - 16) eller den yderligere karakteristik (23), hvilken fremgangsmåde endvidere omfatter trinnene:

at overføre fejlsignalet til reguleringsenheden (9), hvis det tilordnede værdipar ligger uden for området til sikker forekomst af brændstoffet (6) fra den forudbestemte brændstofgruppe;
når fejlsignalet kommer ind ved reguleringsenheden (9), at bestemme den gemte karakteristik (15 - 16), ved hjælp af hvilken reguleringsenheden (9) regulerer brænderindretningen; og
at regulere brænderindretningen ved hjælp af den yderligere karakteristik (23).

13. Fremgangsmåde ifølge et af kravene 1 til 10, hvor brænderindretningen endvidere omfatter en reguleringsenhed med en hukommelse (9), hvor mindst en karakteristik (15 - 16) til en forudbestemt brændstofgruppe og en yderligere karakteristik (23), der adskiller sig fra den mindst ene karakteristik (15 - 16), og en kritisk brændereffekt (24) er gemt i reguleringsenhedens (9) hukommelse, og reguleringsenheden (9) er udformet til at regulere brænderindretningen ved hjælp af enten den mindst ene karakteristik (15 - 16) eller den yderligere karakteristik (23), hvilken fremgangsmåde endvidere omfatter trinnene:
at overføre fejlsignalet til reguleringsenheden (9), hvis det tilordnede værdipar ligger uden for området til sikker forekomst af brændstoffet (6) fra den forudbestemte brændstofgruppe;
når fejlsignalet kommer ind ved reguleringsenheden (9), at bestemme den gemte karakteristik (15 - 16), ved hjælp af hvilken reguleringsenheden (9) regulerer brænderindretningen; og
at regulere til de påkrævede effekter (11) af brænderindretningen, der er større end den gemte kritiske brændereffekt (24) af brænderindretningen ved hjælp af den yderligere karakteristik (23).

14. Ikke-flygtigt computerlæsbart hukommelsesmedium, der gemmer et kommandosæt til udførelse ved hjælp af mindst en processor, der, når den udføres ved hjælp af en processor, udfører en fremgangsmåde med trinnene ifølge et af kravene 1 til 13.

FIG 1

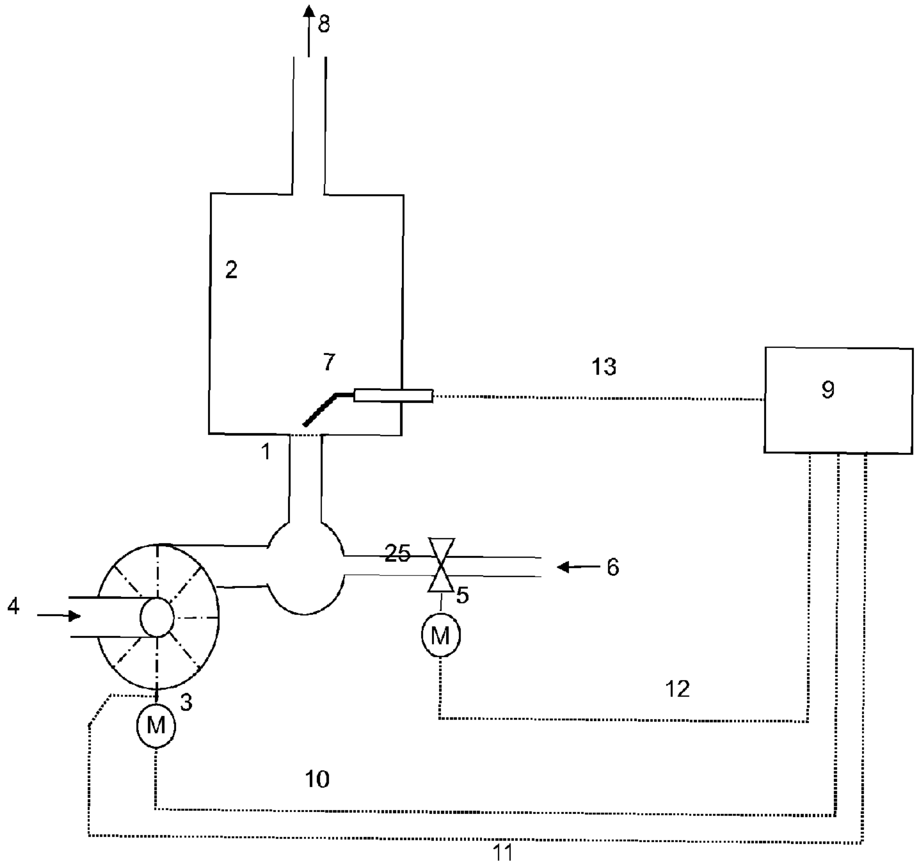

FIG 2

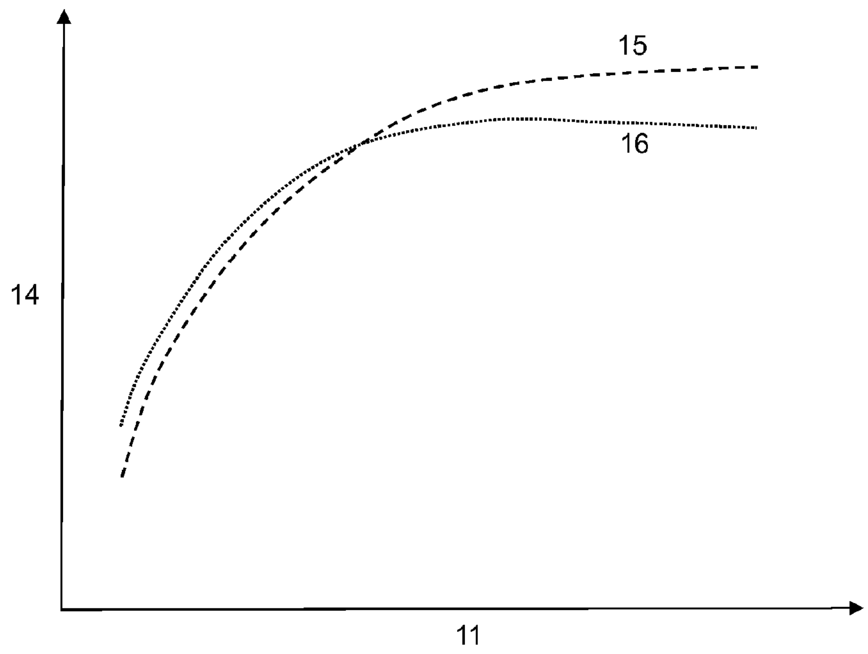

FIG 3

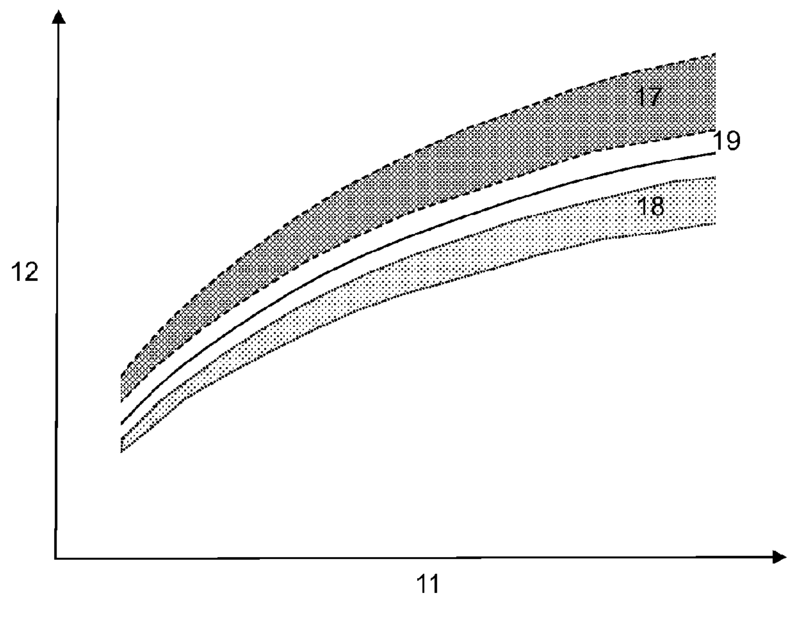

FIG 4

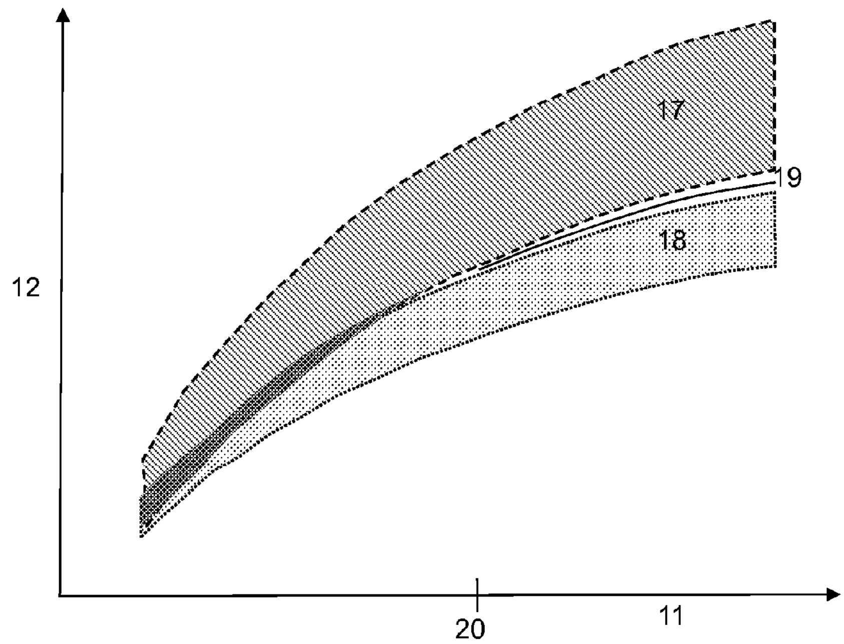

FIG 5

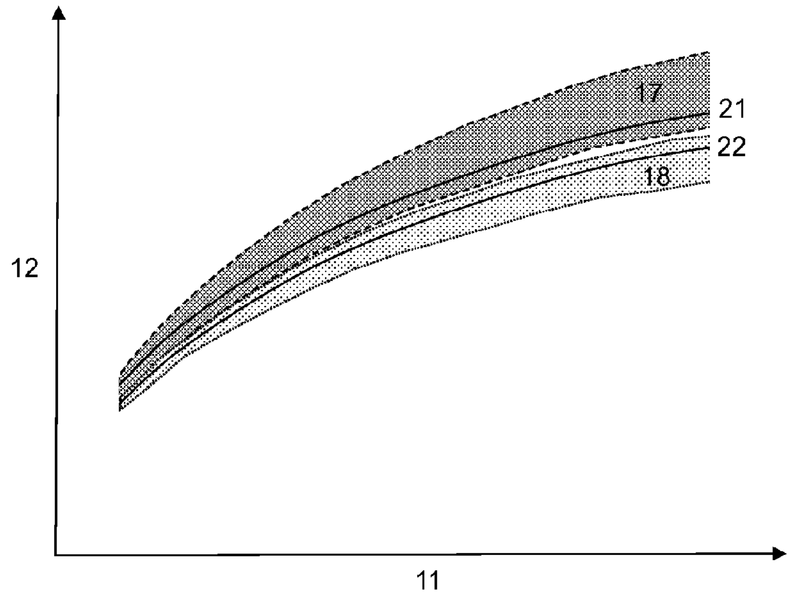

FIG 6