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(54) Benævnelse: **Fremgangsmåde til kemisk omsætning af et brændstof med oxygenholdig gas ved hjælp af en præ-mix brænder**

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Description

The invention relates to a method for the chemical reaction of a fuel with an oxygen-containing gas by means of an externally mixing burner, the fuel being fed via the burner and being reacted with a first stream, surrounding the fuel stream, of an oxygen-containing gas.

When a fuel gas is combusted with an oxygen-containing gas in externally mixing burners, i.e. in burners in which the fuel gas and the oxygen-containing gas are not pre-mixed, but are separately conducted into a mixing zone and ignited there, it is important to achieve an intensive mixing of the oxygen-containing gas and the fuel gas, in order to accelerate the chemical combustion reaction between these gases and obtain a stable flame. This is particularly important when low-calorific fuels are used.

Problems with flame stability and burn-off loss, i.e. complete combustion, of the fuel frequently occur as a result of this with burners which run on solid or liquid fuels. The flame becomes detached or is unstable and does not therefore allow reliable operation. The flame characteristics vary greatly, depending on the method of operation. A reliable flame adjustment is scarcely possible with different burner outputs and burner fuels.

The problem addressed by the invention is therefore that of developing a method for the chemical reaction of gases, wherein the aforementioned problems in relation to flame stability and burn-off loss are avoided as far as possible.

This problem is solved by a method according to Claim 1.

An oxygen-containing gas, preferably air, oxygen-enriched air, a mixture of oxygen and carbon dioxide or a mixture of oxygen, carbon dioxide and air, is used as the oxidant. In one embodiment of the invention, a carbon dioxide stream is combined with oxygen as the oxidant, so that the oxygen content thereof is between 15% by vol. and 25% by vol.

The method according to the invention takes on particularly significance, in that the oxygen content can be simply adjusted to the changed fuel conditions (calorific value, composition, moisture).

The burner is suitable for fuels of all kinds - solid, liquid or gaseous fuels. The burner is particularly suitable for the combustion of low-calorific fuels, particularly solids, such as lignite, anthracite, wood or wood chips, and fuels and biofuels obtained from biomass, such as vegetable oil, biodiesel, bioethanol or biomethane, for example. The burner may also be run on mixtures of the aforementioned fuels, for example on coal and wood. In this case, the fuel may be fed as a mixture both via a first fuel feed and also via a second fuel feed. It is equally possible for one type of fuel to be provided via the one fuel feed and for another type of fuel to be provided via the other fuel feed.

"Low-calorific fuels" are understood to be fuels with a lower calorific value than natural gas. Examples of low-calorific fuels are gaseous fuels with a calorific value below 10 kWh/m^3, below 8 kWh/m^3 or below 5 kWh/m^3 or solid or liquid fuels with a calorific value below 30 MJ/kg.

Means of supplying an oxygen-containing gas, particularly pure oxygen, air, carbon dioxide or a mixture of two or more of these substances, are connected to a first and second oxidant supply. Means of supplying a fuel, either in gaseous, liquid or solid form, are attached to the first and second fuel feed. The oxygen lances are connected to an oxygen source, which supplies a gas with an oxygen content of over 21% by vol., a gas with an oxygen content of over 75% by vol., a gas with an oxygen content of over 90% by vol. or technically pure oxygen.

According to the invention, the fuel feed is divided into two.

One part of the fuel leaves the burner via the outlet port of the first fuel supply arranged centrally in the burner head. A second part of the fuel is fed via a second fuel feed, the outlet port of which surrounds the outlet port of the first fuel feed annularly. The fuel is divided between the two fuel feeds, such that more fuel is supplied via the first fuel feed than via the second fuel feed. Particularly preferably, the ratio of the amount of fuel fed via the first fuel feed to the amount of fuel fed via the second fuel feed is between 4:1 and 1.3:1, particularly preferably between 2.5:1 and 1.5:1.

Between the outlet ports of the two fuel feeds is located the likewise annular outlet port of a first oxidant feed, via which an oxidant which reacts with the fuel and converts it chemically is supplied. A second oxidant feed surrounds the second fuel feed. The outlet port of the second oxidant feed is arranged annularly around the outlet port of the second fuel feed. More oxidant is advantageously supplied via the second oxidant feed than via the first oxidant feed, particularly preferably 1.2 to 2 times the amount of oxidant supplied via the first oxidant feed.

The first and second fuel feed and also the first and second oxidant feed are preferably arranged coaxially to one another. Instead of the parallel feed of the fuel and oxidant streams, the fuel and oxidant may also be combined at a given angle, in order to improve the mixing of the streams.

In addition, a plurality of oxygen lances is provided, the outlet ports of which are at a shorter radial distance from the burner centre than the outlet port of the second fuel feed. The oxygen lances are arranged in the area within the wall delimiting the second fuel feed inwards radially. The oxygen lances are preferably located within the ring conduit forming the first oxidant feed and particularly preferably at the radially inner edge thereof or at the radially outer edge thereof. The oxygen lances may, however, also be provided within the first central fuel feed, preferably on the outer edge thereof.

The oxygen lances are advantageously aligned parallel to the first oxidant supply. Oxygen fed via the oxygen lances preferably flows parallel to the fuel emerging from the first fuel feed.

An oxygen-containing gas, preferably with an oxygen content of over 90% by vol., particularly preferably of over 95% by vol., particularly preferably of technically pure oxygen, is fed via the oxygen lances.

The splitting into two of the fuel feed according to the invention and the division of the oxidant feed into two streams and the possibility of feeding additional oxygen via the oxygen lances means that the combustion control and flame stability are significantly improved. Additional oxygen may be added via the oxygen lances as required. If, for example, a mixture of oxygen and carbon dioxide having a high carbon dioxide content and a low proportion of oxygen of under 20% by vol., for example, is fed via the first oxidant feed, technically pure oxygen is advantageously injected via the oxygen lances, in order to provide the total amount of oxygen required for fuel combustion.

Through the division of the fuel into two separate feeds and the division of the oxidant into two feeds and the additional injection of oxygen, the burner allows different flame geometries and flame lengths to be set for different burner outputs. The heat distribution in the burner flame may be systematically chosen.

The second fuel feed and/or the second oxidant feed and/or the oxygen lances advantageously exhibit means for generating a swirl. A swirl flow may thereby be imposed on a fuel flowing through the second fuel feed or else a gas flowing through the second oxidant feed. It is likewise possible for the oxygen fed via the oxygen lances to be swirled.

The additional swirling of the fuel fed and/or of the oxidant or oxygen fed leads to an intensive radial mass exchange between the swirled stream and the streams adjacent thereto. This strong interaction between the streams causes quick, intensive mixing and therefore an accelerated reaction.

The swirling of the second fuel stream and of the second oxidant stream may take place such that the two swirl flows are aligned codirectionally or counterdirectionally.

Counterdirectional swirling, in other words swirling in which the swirl flows of the two streams move in the opposite direction to one another in the contact area of the two streams, has the advantage that the streams are very well mixed with one another. The chemical reaction is accelerated, in other words there is a quick, early ignition and combustion of the fuel. The swirling of the combined stream produced after the gas streams have been combined is relatively limited, as the two original swirl flows are partially cancelled out by the counterdirectional swirling of the reaction streams. The resulting flame is thereby expanded to a relatively limited extent.

It may also be favourable, however, for the two swirl streams to be aligned such that they are codirectional. In this case, the swirl flows become stronger in the contact area of the two streams, so that a relatively high total swirl rate is achieved. This leads to a greater expansion of the flame. The velocity along the stream axis diminishes in the burning zone and the dwell time of the reaction partners increases in the reaction space.

In addition, if there is a suitable swirl strength, a backflow may be generated relatively far away from the burner tip. This leads to a circulation flow, which means that the gases spend more time in the reaction space and are therefore better converted. Particularly during the combustion of relatively low-calorific fuels, i.e. where there is a slow-running chemical reaction, complete conversion of the fuel with the oxidant is thereby achieved.

The flame topology can be particularly effectively adjusted in the case of codirectional swirling. The axial length and radial expansion of the flame can be selected and adapted to the reaction conditions. In addition, the mixing of the two gas streams in the proximity of the burner tip is not as intensive as with a counterdirectional swirling of the streams, so that the thermal load on the burner tip is reduced.

Moreover, codirectional swirling has the advantage that where there is a desired total swirl rate of the swirl, one of the two streams may be selected lower than is possible with counterdirectional swirling. When a stream swirls, it inevitably undergoes a certain pressure loss. This pressure loss must be kept as low as possible, particularly when the stream concerned is only available at low pressure. Under these circum-stances it is advantageous for the stream at a lower pressure to be swirled less and, conversely, for the stream at a higher pressure to be swirled more. Through the codirectional swirling of the two streams, it is nevertheless possible for the desired total swirl rate to be achieved.

It is favourable if the means for generating a swirl exhibit flow conduits in the second fuel feed and/or in the second oxidant feed, said flow conduits being inclined tangentially against the flow direction. An embodiment of this kind of the means for generating a swirl is easy to produce. The swirling of the stream can easily be defined by the angle of the flow conduits. The swirling may also generated in the second fuel feed or in the second oxidant feed by means of correspondingly aligned deflector plates or guide vanes. This embodiment is particularly preferable when the pressure loss produced by swirling is to be minimized.

The means for generating a swirl in the second fuel feed and/or in the second oxidant feed are preferably adjustable, such that swirl flows of different strengths can be generated. By selecting a suitable swirl rate, i.e. swirling strength, the gas streams involved can be adjusted to the combustion reaction taking place.

It has proved favourable for a third oxidant feed to be provided, which is configured as a ring conduit, the outlet port of which surrounds the second oxidant feed annularly. The same oxidant is preferably fed via the third oxidant feed as via the first and second oxidant feed. This is advantageously oxygen, air, oxygen-enriched air, a mixture of oxygen and carbon dioxide, a mixture of air and carbon dioxide or a mixture of oxygen, air and carbon dioxide.

The operationally reliable control range of the burner is further enlarged by the third oxidant supply. In addition, the improved combustion control enables the burner emissions, particularly CO and NO_x, to be influenced more systematically. The amount of oxidant fed via the third oxidant feed is for example 1.5 to 8 times that fed via the first oxidant feed.

It is moreover advantageous to provide a plurality of oxygen lances in the third oxidant feed too. The oxygen lances are arranged within the annular gap acting as the third oxidant feed, preferably on the inner or outer edge thereof. Oxygen, preferably with a purity of over 90% by vol., particularly preferably over 95% by vol., particularly preferably technically pure oxygen, is fed via the oxygen lances.

As mentioned above, it is favourable in practice for the first, the second and the third oxidant feed to be fed the same oxidant in each case. For the improved and more systematic control of the combustion reaction, it may also be advantageous, however, if not all oxidant feeds are supplied with the same oxidant, but at least in some cases oxidants with a different composition are used. Hence, for example, a greater oxygen content may be selected for the oxidant flowing through the first oxidant feed than for the oxidant flowing through the other two oxidant feeds.

The burner is suitable for the combustion of solid, liquid and gaseous fuels. When using liquid fuels, it has proved successful for the first fuel feed and/or the second fuel feed to be provided with means for atomizing a liquid fuel. The atomization of the fuel increases the surface thereof and therefore accelerates and intensifies the reaction of the fuel with the oxidant.

The flow velocity of the second oxygen-containing stream fed via the second oxidant feed preferably exceeds flow velocity of the second fuel stream fed via the second fuel feed by more than 50%, preferably by more than 75%, the flow velocity of the second oxygen-containing stream is particularly preferably between 90% and 120% of the flow velocity of the second fuel stream. The flow velocity of the second oxygen-containing stream is 1.5 to 2.5 times the flow velocity of the second fuel stream, preferably approximately twice the flow velocity of the second fuel stream. Shear forces between the two adjacent streams are generated by the different flow velocities, said shear forces resulting in improved mixing of the fuel with the oxidant.

The absolute flow velocity of the second fuel stream is preferably between 20 and 50 m/s, while the flow velocity of the second oxygen-containing stream is preferably between 20 and 70 m/s.

The invention and further details thereof are described in greater detail below with the help of the exemplary embodiment depicted in the drawing. In this

Fig. 1 shows a cross-section through a burner head in schematic form and

Fig. 2 shows a variant of the burner head depicted in Figure 1.

The burner depicted in Figure 1 is used for the combustion of low-calorific fuels, for example a mixture of wood and coal. The burner has a plurality of pipes of different diameters arranged coaxially to one another, the central pipe 1 and the annular gaps 2, 3, 4, 5 created between the pipes are used as fuel or oxidant feeds. The pipes are aligned parallel to one another, such that the streams fed in each case also emerge from the pipe 1 or the annular gaps 2, 3, 4, 5 parallel to one another.

Pipe 1 and the annular gap 3 are used for the fuel feed. A fuel source is connected to the central pipe 1 and to the ring conduit 3, from which the pipe 1 acting as the first fuel feed and the annular gap 3 acting as the second fuel feed are supplied with fuel. Means for generating a swirl flow are provided in the annular gap 3. Flow conduits which are inclined tangentially against the main flow direction, i.e. against the axial extension of the burner or the pipe 1 and the annular gaps 2, 3, 4, 5, are fitted in the annular gap 3 for this purpose. In this way, a rotational movement component 8 is imposed on the second fuel stream flowing through the annular gap 3, said component causing the second fuel stream to flow on a helical path.

An oxidant is fed via the annular gaps 2, 4, 5. Air with oxygen or a mixture of oxygen and carbon dioxide is used as the oxidant. The composition of the oxidant may be varied depending on the desired burner output and the flame geometry.

In a similar way to the swirling of the second fuel stream, suitable means for swirling the oxidant stream are also provided in the annular gap 4. The oxidant stream is displaced in a rotational movement 9 by corresponding fittings, such as flow conduits, guide vanes or deflector plates, for example, said rotational movement preferably exhibiting the same rotational direction as the rotational movement 8 of the second fuel stream.

In the annular gap 2, oxygen lances 7 are located evenly distributed over the outer periphery of the pipe 1. Likewise, twelve further oxygen lances 6 are arranged equidistantly along the inner periphery of the outer annular gap 5. All oxygen lances 6, 7 are connected to an oxygen source, via which the oxygen lances 6, 7 are supplied with oxygen having a purity of over 98% by vol.

The fuel supply according to the invention is split into two: A first part of the fuel is fed via the central pipe 1. The remaining fuel is conducted via the annular gap 3 and swirled there, i.e. provided with an additional rotational component. The ratio of the amounts of fuel fed via the central pipe 1 and via the annular gap 3 is preferably 2 to 1.

A mixture of oxygen and carbon dioxide is used as the oxidant, for example. For this purpose, enough oxygen is advantageously added to the carbon dioxide for the carbon dioxide stream to exhibit an oxygen content of 15 to 25% by vol. The oxidant feed is distributed over the three annular gaps 2, 4, 5, wherein, as explained above, the oxidant stream flowing through the annular gap 4 is exposed to swirling. The splitting of the total oxidant between the annular gaps 2, 4, 5 preferably takes place in a ratio of 2 to 3 to 5. In addition, oxygen is injected via the oxygen lances 6, 7. These oxygen streams are likewise advantageously swirled, in other words, an additional rotational movement component is imparted to the oxygen streams.

The splitting of the fuel and oxidant feed according to the invention between a plurality of separate feeds, the central pipe 1, the annular gaps 2, 3, 4, 5 and the oxygen lances 6, 7, and also the swirling of the second fuel stream 3, of the oxidant stream 4 and of the injected oxygen streams 6, 7 allows an optimum combustion performance. The flame characteristics may be set and optimized independently of the burner output at the time. The flame stability is significantly improved.

A particularly thorough mixing of the streams 3, 4, 6, 7 is achieved through the swirling of these streams 3, 4, 6, 7 with the adjacent streams 1, 2, 5. The reaction conditions are thereby improved overall. Additional oxygen may be supplied as the oxidant via the inner oxygen lances 7, if for example the proportion of oxygen in the oxidant fed via the annular gap 2 is too small to guarantee uniform, stable combustion.

The embodiment according to Figure 2 differs from that according to Figure 1 solely in that the oxygen lances 7 arranged in the ring conduit 2 are not provided on the inner edge thereof, but on the outer edge of the ring conduit 2.

Patentkrav

1. Fremgangsmåde til kemisk omsætning af et brændstof med en oxygenholdig gas ved hjælp af en præ-mix brænder, idet brændstoffet tilføres via brænderen og omsættes med en første strøm (2) af en oxygenholdig gas, som omgiver brændstofstrømmen (1), kendetegnet ved, at der er tilvejebragt en anden brændstofstrøm (3), som omgiver den første oxygenholdige strøm (2) som omgivende strøm, og at der er tilvejebragt en anden oxygenholdig strøm (4), som omgiver den anden brændstofstrøm (3) som omgivende strøm, og idet der via dyser ledes to eller flere oxygenstrømme (7), som leverer gas med et oxygenindhold på mere end 21 vol-%, ind i den første oxygenholdige strøm (2).

2. Fremgangsmåde ifølge krav 1, kendetegnet ved, at der påtrykkes en spiralstrømning (8, 9) på den anden oxygenholdige strøm (4), den anden brændstofstrøm (3) og/eller de yderligere oxygenstrømme (7).

3. Fremgangsmåde ifølge et af kravene 1 eller 2, kendetegnet ved, at de spiralstrømninger (8, 9), der er påtrykt på den anden oxygenholdige strøm (4) og på den anden brændstofstrøm (3), har samme omdrejningsretning.

4. Fremgangsmåde ifølge et af kravene 1 til 3, kendetegnet ved, at strømningshastigheden for den anden oxygenholdige strøm (4) overstiger strømningshastigheden for den anden brændstofstrøm (3) med mere end 50%, fortrinsvis med mere end 75%, særligt foretrukket er mellem 90% og 120% af strømningshastigheden for den anden brændstofstrøm (3).

5. Fremgangsmåde ifølge et af kravene 1 til 4, kendetegnet ved, at der omsættes et flydende eller fast brændstof, navnlig kul, brunkul eller træ.

6. Fremgangsmåde ifølge et af kravene 1 til 5, kendetegnet ved, at den første (2) og/eller den anden oxygenholdige strøm

(4) indeholder en blanding af oxygen og kuldioxid, navnlig består af en blanding af oxygen og kuldioxid.

Fig. 1

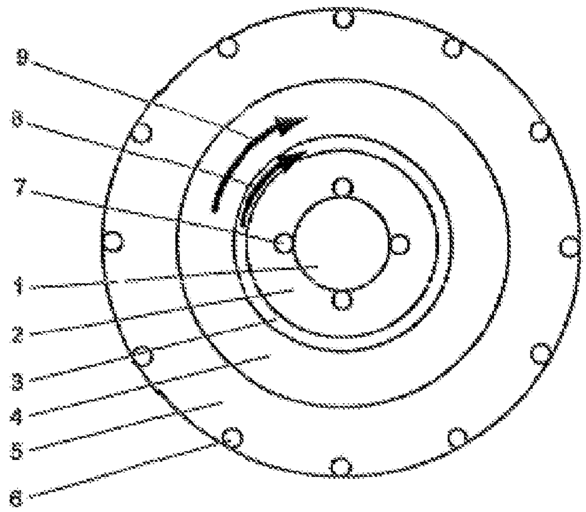

Fig. 2