

Burner for the production of synthesis gas

The present invention relates to a burner for the production of synthesis gas, by partial oxidation of carbon-containing fuels, having improved properties.

- 5 The production of synthesis gas is conventionally carried out by partial oxidation of carbon-containing materials with oxygen or an oxygen-containing gas, for example air at elevated pressure and relatively high temperatures from 1000 to 1600°C. The carbon-containing materials used
10 are hydrocarbons, slurries of solid carbon-containing fuels in hydrocarbons or slurries of solid carbon-containing fuels in water such as coal/water suspensions.

- EP 0 095 103 B1 describes a process and a burner for the production of synthesis gas. The process is carried out
15 with the aid of a burner system composed of three concentrically arranged tubes, three mass streams being fed to the reaction. The mass stream containing the oxygen or the oxygen-containing gas is conducted through the inner and the outer zone of the burner and the carbon-containing material, that is a coal/water suspension, is
20 passed through the annular space formed by the inner and middle tube. 1 to 20% of the total oxygen amount required for the partial oxidation is allotted to the inner mass flow, the remaining oxygen requirement is covered by the
25 outer mass flow, which passes into the reaction through the annular space formed by the middle and outer tube.

The burner has three concentrically arranged tubes, each of which has a conically tapering end, and a cooling chamber in the region of the burner outlet.

- 30 The coal/water suspension forming the middle mass stream is fed to the reactor at a pressure of 1 to 20 MPa at a velocity of 1 to 25, in particular 2 to 15 m/second, while the inner and outer gas streams are passed into the reaction zone with a velocity of 50 to 300, in particular
35 80 to 200 m/second.

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As a result of the conical tapers of the concentrically arranged tubes, the three mass streams meet each other at an acute angle. As a result of this, the coal/water suspension stream, after leaving the end of the conical taper, is forced or torn apart by the inner gas stream. The suspension stream is thus subjected to a horizontal deflection and does not pass into the reaction zone under free fall. As a consequence, the mean residence time of the individual coal/water droplets is increased and the degree of conversion is increased.

At the same time, the outer gas stream impacts the coal/water suspension broadened by the inner gas stream and produces a further mixing of gas and suspension, so that a zone of uniform distribution of gas or oxygen and very fine suspension droplets is produced. This is an essential precondition for reacting the coal/water suspension to the greatest possible extent.

It has been shown that for the use of hydrocarbon-containing fuels, similar conditions, as described above in more detail in connection with coal/water suspensions, are advantageous.

The partial oxidation of the carbon-containing fuel, in particular a hydrocarbon, leads to a chemically highly aggressive mixture which contains about 30 to 50% by weight of carbon monoxide, about 30 to 50% by weight of hydrogen, about 3 to 20% by weight of CO₂ and unreacted steam and, in smaller quantities, in addition to other materials also contains sulfur, iron, vanadium, nickel, sodium, chlorine and calcium.

The material composition and the ash contents of the resulting gasification product are dependent on the one hand on the type of fuel, and on the other hand on the

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process conditions, such as the amount of oxygen, the temperature established and the pressure. The partial oxidation of hydrocarbon-containing fuels is conventionally carried out at about 1000 to 1600, in particular at 1200 to 1600°C, and at pressures of 1.0 to 15.0, in particular 2.0 to 10, preferably 3.0 to 5.0 MPa. The hydrogen contained in the synthesis gas results from the reaction of water which is fed to the partial oxidation in the liquid state and/or in the form of steam. The water required for the reaction can be passed for use as a separate mass stream or as a mixture with other mass streams, for example mixed with the hydrocarbon, the oxygen or the oxygen-containing gas stream. It is also possible to distribute, both in the liquid state and in the form of steam, the water among a plurality of mass streams.

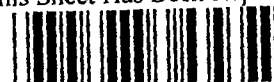
The same applies to the supply of the hydrocarbon-containing fuel and the mass stream containing the oxygen or an oxygen-containing gas mixture. These mass streams can also be fed to the reaction either as a separate stream or distributed among a plurality of streams.

As a consequence of the conditions prevailing in the partial oxidation, the burner is subjected to a considerable extent to a series of physical and chemical stresses.

As a result of the high exit velocity of the mass streams, in particular the gas streams, vibrations occur which cause a high mechanical load on the burner.

As a result of the composition of the highly reactive gas mixture resulting from the partial oxidation, in connection with the high temperatures, the burner is also exposed to a great extent to a chemical attack. In addition, slag particles, which for example are deposited in the molten state on the burner, lead, as a result of

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chemical reactions and erosion, to stress of the burner, in particular in the region of the end of the burner.

In addition, the burner is especially exposed to a thermal stress, which is caused by the high intensity of the thermal radiation occurring in the gasification. This thermal stress is higher in the gasification of fuels containing hydrocarbons than in the corresponding reaction of a coal/water suspension. The higher gasification temperature on the one hand and the shorter distance between the burner and the gasification zone on the other are responsible for this. The higher temperature is a consequence of the easier flammability of the hydrocarbon and the reduced distance results from an earlier ignition of the hydrocarbon, as a result of its lower ignition temperature in comparison to a coal/water suspension.

In continuous operation, the burner is subjected not only to vibrations and a chemical attack by the highly reactive synthesis gas, but is also subjected to erosion by slag particles and to high thermal stress. Although high-grade materials, in particular high alloy special steels such as Incoloy and Hastelloy are used for the part of the burner projecting into the gasification reactor, the burner has only a highly restricted life expectancy of about three to four months. This is a considerable disadvantage for the operation of a modern plant for the production of synthesis gas, since the burner can only be changed when the plant is shut down. However, shutting down the synthesis gas plant has as a consequence the cooling and depressurizing of the apparatus under pressure. After the defective burner has been replaced by a new one, the plant must first be heated up again and pressurized before the production of synthesis gas can be resumed.

The object, therefore, was to produce a burner having considerably increased life expectancy.

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- This object was achieved by a burner for the production of synthesis gas by partial oxidation of carbon-containing fuels, containing three or more tubes arranged concentrically to each other, which may have a conical tapering at the burner outlet, and a cooling chamber, surrounding the burner outlet, arranged in the end of the burner. The end facing the partial oxidation zone is clad with a layer composed of individual, adjacently arranged ceramic platelets.
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- 10 The burner according to the invention contains at least three, in particular three to six, preferably three to four, particularly preferably three tubes arranged concentrically to each other. The conical tapers of the tubes arranged concentrically to each other, which tapers
- 15 may be present at the burner outlet, form the outlet orifices for the individual mass streams, the innermost tube forming a cross-shaped outlet orifice and the remaining tubes concentrically arranged to each other forming corresponding annular outlet orifices.
- 20 The burner according to the invention is suitable for the partial oxidation both of coal/water suspensions and of hydrocarbons or hydrocarbon-containing fuels. The burner has proved to be of worth particularly in the production of synthesis gas by partial oxidation of hydrocarbons or
- 25 hydrocarbon-containing fuels.

- The end of the burner facing the gasification zone is clad with individual ceramic platelets, which are arranged adjacent to each other in a surface-covering manner, in the manner of a mosaic. The individual ceramic
- 30 platelets are bonded both to each other and to the end of the burner by a ceramic adhesive. The ceramic adhesive forms a layer on the end of the burner in which layer the individual ceramic platelets are embedded.



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According to a particular embodiment, the individual ceramic platelets have one or more bulges and the end of the burner has corresponding recesses to receive the bulges. By introducing the bulges located on the lower side of the ceramic platelets into the recesses of matching shape, an additional bonding of ceramic platelets and end is created and the mechanical strength is simultaneously increased. It has proven to be particularly expedient to design the bulges and recesses in a dovetail shape, but other shapes such as pins or knobs are also suitable.

It is possible to distribute the ceramic platelets next to each other in any desired arrangement on the end of the burner in a surface-covering manner. It is particularly expedient to arrange the individual ceramic platelets in such a manner that they form the shape of a ring in each case. A plurality of such rings concentrically surrounding each other cover the end of the burner.

The ceramic platelets of the individual rings are expediently arranged displaced with respect to each other. By this means is avoided the formation of long continuous joints, which could have disadvantageous effects on the mechanical stability of the cladding.

The individual ceramic platelets can have any desired shape. They can be round, square, rectangular, rhomboid, triangular, quadrangular or have the shape of a regular or irregular polygon. Ceramic platelets of identical or different shape can be arranged adjacently.

Ceramic platelets having the shape of a trapezium or of a ring segment are particularly suitable. This type of shape facilitates the arrangement of the individual ceramic platelets to form a ring.

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The individual ceramic platelets are to have a layer thickness of 1 to 10, in particular 2 to 5 mm, calculated in each case without the bulge serving as the anchor in the end of the burner. The sides of the individual ceramic platelets should not be selected to be too long. A length of the individual sides up to 50 mm should be of sufficient size. In most cases, it is recommended to use ceramic platelets each side of which has a length of 5 to 35, in particular 6 to 30, preferably 8 to 20 mm.

- 10 The individual ceramic platelets are composed of a ceramic resistant to the conditions occurring in the gasification reaction. Suitable materials are oxide ceramics, which, for example, contain Al_2O_3 , Cr_2O_3 , MgO , ZrO_2 and/or SiO_2 , or non-oxide ceramics, which, for example, include carbides and nitrides of boron, of aluminum or of silicon. Silicon nitride is particularly suitable.

- 20 The ceramic adhesive must also be resistant to the conditions occurring in the gasification reaction and assure a lasting, elastic bond between the individual ceramic platelets and the end of the burner.

A ceramic adhesive based on an aluminosilicate, which is matched to the thermal expansion behavior of the ceramic platelets, has proved to be particularly expedient.

- 25 The drawings below describe the present invention in more detail without restricting it.

- 30 Figure 1 shows a longitudinal section through the lower part, facing the gasification zone, of the burner according to the invention. The burner is composed of an outer jacketed tube 1, which has a conical taper 1a and an inserted tube 2 for feeding a coolant, and a plurality of inner tubes 3, 4 and 5 arranged concentrically to each other, which have corresponding conical tapers 3a, 4a and

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- 5a. The individual mass streams pass through the intermediate spaces, which are formed firstly by the jacketed tube 1 and the inner tube 3, secondly by the inner tube 3 and the tube 4 lying further in and thirdly by the tube 4 lying further in and the tube 5 arranged in the middle of the burner. A further mass stream is conducted through the tube 5. The mass streams exit at the annular orifices formed by the conical tapers 1a, 3a, 4a and 5a and through the conical taper 5a of the tube 5.
- 10 The jacketed tube 1 is closed at the end of its conical taper 1a. This closed part forms the end 6 of the burner, which is clad with a layer 7 composed of individual, adjacently arranged ceramic platelets. The coolant, preferably water, is introduced through the tube 2
- 15 inserted into the jacketed tube 1. As a result, the jacketed tube 1, in particular in the region of its conical taper 1a, functions as a cooling chamber.

- Figure 1a shows a detail of the burner in longitudinal section, in enlargement. In this, 1a represents the conical taper of the jacketed tube 1, which, together with the tube 2 conducting the coolant, forms a cooling chamber, and 6 represents the end clad with the ceramic platelets 7a possessing the dovetail-shaped bulge. The ceramic platelets are bonded both to each other and to
- 20 the end 6 of the burner by means of a layer 8 of a ceramic adhesive.

- Figure 2 shows a top view of the end 6 of the burner covered in part with ceramic platelets 7a. To simplify the representation, the inner tubes 3, 4 and 5 are not
- 30 included in the drawing.

The annular end 6 has three dovetail-shaped annular grooves 7b to receive the dovetail-shaped bulges of the ceramic platelets 7a. Each annular groove 7b has an expanded opening 7c, which serves for inserting the



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- dovetail-shaped bulges of the ceramic platelets 7a. By sliding the ceramic platelet, its dovetail-shaped bulge is introduced into the annular groove 7b. By sequentially ordering the individual ceramic platelets, a corresponding ring is formed. The dovetail-shaped bulge of the ceramic platelet introduced last is first inserted into the expanded opening 7c, the whole ring formed by the individual ceramic platelets then being displaced by half the length of the expanded opening 7c. By this means it is ensured that the two ceramic platelets neighboring the expanded opening 7c are located at least partly with their dovetail-shaped bulge 7a in the annular groove 7b. Between the individual ceramic platelets, there is a joint filled with a layer 8 of the ceramic adhesive.
- Figure 2a shows a top view of the end 6 of the burner completely covered with individual, adjacently arranged ceramic platelets 7a.

The ceramic platelets 7a have the shape of a trapezoid and are sequentially ordered in such a manner that three concentrically arranged annular surfaces result. Between the individual ceramic platelets, there is a joint filled with the layer 8 of the ceramic adhesive.

As in Figure 2, to simplify the representation, the inner tubes 3, 4 and 5 are not included in the drawing.

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Patent claims

1. A burner for the production of synthesis gas by partial oxidation of carbon-containing fuels, containing three or more tubes arranged concentrically to each other, which may have a conical tapering at the burner outlet, and a cooling chamber, surrounding the burner outlet, arranged in the end of the burner, in which the end facing the partial oxidation zone is clad with a layer composed of individual, adjacently arranged ceramic platelets.
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2. The burner as claimed in claim 1, wherein the individual ceramic platelets are bonded to each other and to the end of the burner by a ceramic adhesive.
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3. The burner as claimed in claim 1 or 2, wherein the individual ceramic platelets have one or more bulges and the end of the burner has corresponding recesses to receive the bulges.
- 20 4. The burner as claimed in one or more of claims 1 to 3, wherein the bulge and the corresponding recess are dovetail-shaped.
5. The burner as claimed in one or more of claims 1 to 4, wherein the individual ceramic platelets are arranged next to each other forming the shape of a ring.
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6. The burner as claimed in one or more of claims 1 to 5, wherein the individual ceramic platelet has the shape of cross, a trapezoid or a ring segment, in particular a trapezoid or ring segment.
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7. The burner as claimed in one or more of claims 1 to 6, wherein the individual ceramic platelet has a layer thickness of 1 to 10, in particular 2 to 5 mm.
- 5 8. The burner as claimed in one or more of claims 1 to 7, wherein the individual ceramic platelet has a length on each side of 5 to 35, in particular 6 to 30, preferably 8 to 20 mm.
- 10 9. The burner as claimed in one or more of claims 1 to 8, wherein the individual ceramic platelet is composed of a ceramic based on an oxide ceramic, which contains Al_2O_3 , Cr_2O_3 , MgO , ZrO_2 and/or SiO_2 , or is based on a non-oxide ceramic, which contains a carbide or nitride of boron, of aluminum or of silicon, in particular silicon nitride.
- 15 10. The burner as claimed in one or more of claims 1 to 9, wherein the ceramic adhesive contains a high temperature-resistant aluminosilicate.



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