Process and burner for the partial combustion of finely divided solid fuel.

A core of finely divided solid fuel, surrounded by oxygen or oxygen-containing gas and an annulus of finely divided solid fuel around the oxygen or oxygen-containing gas are introduced into a reactor space via a burner. The solid fuel is centrally (10) introduced into the burner, whereas oxygen or oxygen-containing gas is separately introduced into the burner outside (14) the central solid fuel channel (10). In the burner the oxygen or oxygen-containing gas is caused to flow inwardly (16) into the central channel (10) for supplying the oxygen or oxygen-containing gas into the reactor space between the core and the annulus of solid fuel.
The invention relates to a process for the partial combustion of finely divided solid fuel, such as pulverized coal, in which the latter is introduced together with oxygen or oxygen-containing gas via a burner into a reactor space. The invention further relates to a burner for use in such a process for the partial combustion of finely divided solid fuel.

Partial combustion, also known as gasification, of a solid fuel is obtained by reaction of the solid fuel with oxygen. The fuel contains as useful components mainly carbon and hydrogen, which react with the supplied oxygen - and possibly with steam and carbon dioxide - to form carbon monoxide and hydrogen. Depending on the temperature, the formation of methane is also possible. Whilst the invention is described primarily with reference to pulverized coal the process and burner according to the invention are also suitable for other finely divided solid fuels which can be partially combusted, such as lignite, pulverized wood, bitumen, soot and petroleum coke. In the gasification process pure oxygen or an oxygen-containing gas, such as air or a mixture of air and oxygen, can be used.

There are in principle two different processes for the partial combustion of solid fuel. In the first process, solid fuel in particulate form is contacted with oxygen or oxygen-containing gas in a reactor in a fixed or fluidized bed at temperatures below 1000°C. A drawback of this method is that not all types of solid fuel can be partially combusted in this manner, which limits the flexibility of the method. High swelling coal, for example, is unsuitable since particles of such a coal type easily sinter with the risk of clogging of the reactor. In some cases the high yield of methane obtained with this type of process is a disadvantage.
In a more advantageous process finely divided solid fuel is passed into a reactor at a relatively high velocity. In the reactor a flame is maintained in which the fuel reacts with oxygen or oxygen-containing gas at temperatures above 1000°C. Contrary to the first gasification method, the residence time of the fuel in the reactor is in this method relatively short, in any way short enough to prevent sintering of the solid fuel. The last-mentioned method is therefore suitable for the gasification of a relatively wide range of solid fuels.

In the latter process the solid fuel is usually passed in a carrier gas to the reactor via a burner, while oxygen or oxygen-containing gas is also passed via the burner to the reactor. Since solid fuel, even when it is finely divided, is usually less reactive than atomized liquid fuel or gaseous fuel, great care must be taken in the manner in which the fuel and oxygen are mixed. If the mixing is insufficient, zones of underheating are generated in the reactor next to zones of overheating caused by the fact that part of the solid fuel does not receive sufficient oxygen and an other part of the fuel receives too much oxygen. In zones of underheating the fuel is not completely gasified, while in zones of overheating the fuel is completely converted into less valuable products, viz. carbon dioxide and water vapour. Local high temperatures in the reactor have a further drawback in that damage is caused to the refractory lining which is normally arranged at the inner surface of the reactor wall.

A primary requirement for obtaining a sufficient mixing of the solid fuel with oxygen throughout the gasification process is a stable supply of solid fuel to the burner fuel outlet. The supply of solid fuel should moreover be uniformly distributed over the total fuel outlet, whereas the oxygen or oxygen-containing gas should be supplied uniformly to the flow of solid fuel, to generate an intimate and uniform contact of oxygen with the solid fuel.
Further care should be taken to prevent damage to the burner front caused by the heat load during the gasification process. To protect the burner front from overheating it is necessary to prevent premature contact near the burner front of the supplied oxygen with already formed carbon monoxide and hydrogen in the reactor, which contact would result in a hot flame front at the burner front.

An object of the present invention is to provide a process for the partial combustion of a finely divided solid fuel, wherein the solid fuel is supplied via a burner to the reactor in such a manner that a sufficient mixing of the solid fuel with oxygen is obtained to guarantee an optimal partial combustion of solid fuel, and wherein overheating of the burner front by premature mixing of oxygen with the gas mixture already formed in the reactor is prevented.

A further object of the present invention is to provide a burner for the partial combustion of finely divided solid fuel with which the above objectives can be obtained.

The process for the partial combustion of a finely divided solid fuel thereto comprises according to the invention introducing a core of a finely divided solid fuel into a reactor space, supplying oxygen or oxygen-containing gas around the core and supplying an annulus of the finely divided solid fuel around the core of solid fuel and the oxygen or oxygen-containing gas, the finely divided solid fuel and the oxygen or oxygen-containing gas being introduced into the reactor space via a burner, wherein the finely divided solid fuel is introduced into a central channel of the burner, and the oxygen or oxygen-containing gas is separately introduced into the burner outside the central channel and wherein in the burner the oxygen or oxygen-containing gas is caused to flow from outside the channel in a direction at least partly inclined with respect to the solid fuel flow into the central channel for supplying the oxygen or oxygen-containing gas into the reactor space between the core of solid fuel and the annulus of solid fuel.
To meet the aforementioned objectives the burner for the partial combustion of a finely divided solid fuel according to the invention comprises an outlet and a central channel communicating therewith for a finely divided solid fuel, at least one outlet and a channel communicating therewith and arranged outside the central channel for oxygen or oxygen-containing gas, wherein the outlet for oxygen or oxygen-containing gas divides the outlet for the solid fuel into a first centrally arranged zone and a second substantially concentrical annular zone and wherein the channel for oxygen or oxygen-containing gas is in communication with the outlet for oxygen or oxygen-containing gas via at least one connecting channel being at least partly inclined with respect to the flow direction in the central channel.

In the process and burner according to the invention the flow of solid fuel through the burner is hardly disturbed by the flow of oxygen or oxygen-containing gas, so that the core and annulus of solid fuel entering the reactor space will be substantially uniform. The annulus of solid fuel around the oxygen or oxygen-containing gas forms a shield preventing premature mixing of the oxygen or oxygen-containing gas with the gas mixture already formed in the reactor space and thereby preventing the burner front from becoming overheated.

The invention will now be described in more detail by way of example only with reference to the accompanying drawings, wherein

Figure 1 shows a longitudinal section of the front part of a burner according to the invention;
Figure 2 shows front view II-II of Figure 1;
Figure 3 shows cross-section III-III of Figure 1;
Figure 4 shows a longitudinal section of the front part of a first alternative of the burner shown in Figure 1;
Figure 5 shows front view V-V of Figure 4;
Figure 6 shows cross-section VI-VI of Figure 4;
Figure 7 shows a longitudinal section of the front part of a second alternative of the burner shown in Figure 1; Figure 8 shows front view VIII-VIII of Figure 7, and Figure 9 shows cross-section IX-IX of Figure 7.

It should be noted that identical elements shown in the drawings have been indicated with the same reference numeral.

Referring to Figures 1, 2 and 3, a burner, generally indicated with reference numeral 1, for the partial combustion of a finely divided solid fuel, such as pulverized coal, comprises a cylindrical hollow wall member 2 having an enlarged end part forming a front face 3 which is normal to the longitudinal axis 4 of the burner. The hollow wall member 2 is interiorly provided with a concentric wall 5 having an enlarged end part 6 arranged close to the burner front face 3. The concentric wall 5 serves to divide the interior of the hollow wall member 2 into passages 7 and 8 and a transition passage 9 for cooling fluid supplied into and discharged from the interior of the wall member 2 via not shown conduit means. The hollow wall member 2 encloses a central channel 10 for finely divided solid fuel having a free end 11 forming an outlet for the solid fuel.

The burner 1 further comprises conduit means 12 for oxygen or oxygen-containing gas having free ends 13 forming an outlet for the oxygen or oxygen-containing gas. The conduit means 12 are composed of an annular channel 14 concentrically arranged around the central channel 10 and a plurality of connecting channels 15 forming a fluid communication between the annular channel 14 and the outlet 13. The connecting channels 15 which are uniformly distributed with respect to the annular channel 14 each have an inclined part 16 extending from a location outside the central channel 10 to a location inside said central channel. The angle of inclination of the inclined parts 16 of the connecting channels 15 should be so chosen that the flow of solids through the central channel 10 is hardly disturbed by the presence of said parts 16.
The free ends 13 of the conduit means 12, forming an outlet for oxygen or oxygen-containing gas, are uniformly distributed over the circumference of a circle having its centre positioned on the longitudinal burner axis 4, thereby dividing the outlet 11 for solid fuel into a first, central zone 17 and a second, concentrically disposed annular zone 18.

During operation of the above-described burner for the gasification of coal with air, pulverized coal suspended in a carrier fluid is passed through the central channel 10 to the outlet 11 for entering a reactor space arranged downstream of the burner. Simultaneously air is passed through the annular channel 14 and via the connecting channels 15 to the outlet 13, for contacting the solid fuel in the reactor space. The annulus of solid fuel entering the reactor space via the annular zone 18 of the outlet 11 forms a shield preventing the burner front face 3 from becoming overheated. The length of the central channel 10 downstream of the inclined parts 16 of the connecting channels 14 should be chosen sufficiently large for stabilization of the solid fuel in case disturbances are caused upon passing said inclined parts 16. Since the inclined parts 16 cross only a minor part of the solid flow, the disturbances in the coal flow will be only minor. The annulus of solid fuel leaving the burner 1 via the zone 18 should be sufficiently narrow for allowing contact of the oxygen-containing gas with all the solid fuel in the annulus. Care should, however, be taken that the annulus width is sufficiently large for maintaining a stable flow of solid fuel. A suitable width of the annulus for solid fuel is chosen within the range of 3 to 20 mm. An even more suitable width is in the range of 3 to 10 mm.

The flow stability of the solid fuel might be further improved by generating a swirling motion in the annular part of the central channel 10, for example by means of not shown baffles arranged in said central channel.
Reference is now made to Figures 4-6 showing a first alternative according to the invention of the above described burner.

In the second embodiment of the invention the central channel 10 for solid fuel of a burner generally indicated with reference number 20 has a relatively narrow section 21, a frustoconically shaped transition section 22 and an enlarged section 23 at the burner front face 3.

For directing the solids flow in the central channel 10 a bluff body 24 is centrally arranged within the transition section 22 by means of a plurality of spacers 25. The conduit means for oxygen or oxygen-containing gas are formed by a first annular channel 26, encompassing the relatively narrow section 21 of the central channel for the solid fuel, and a second annular channel 27 arranged within the enlarged section 23 of the solid fuel channel. The second annular channel 27 is provided with an open end forming an annular outlet 28 for oxygen or oxygen-containing gas within the outlet 11 for solid fuel. Fluid communication between the annular channels 26 and 27 is accomplished via a plurality of connecting channels 29 being inclined with respect to the flow direction of the solid fuel in the central channel 10. At the location of the transition section 22 the connecting channels 29 enter the central channel for solid fuel.

During operation of the burner shown in Figures 4-6, pulverized coal entering the transition section 22 via section 21 of the central channel 10 is forced to flow in lateral outward direction towards the enlarged section 23. The bluff body 24 promotes a distribution of the coal over the enlarged portion 23 of the central channel for the coal. Simultaneously air is transferred to the annular channel 27 and outlet 28 via the annular channel 26 and the connecting channels 29. The cross-sectional area of the enlarged portion 23 available for the solid fuel is suitably chosen substantially equal to the cross-sectional area of the part 21 of the central channel for solid fuel, so that the velocity and
the density of the coal flow are substantially constant over the central channel. By arranging the connecting channels 29 in such a manner that they enter the central channel 10 at its transition section 22, the coal flow which might be slightly disturbed upon passing the connecting channels 29 can be easily redistributed over the cross-section of the enlarged section 23.

Reference is now made to Figures 7-9 showing a further embodiment of the invention.

In this embodiment the central channel for solid fuel has the same shape as the solid fuel channel in the burner shown in the Figures 4-6.

In this further embodiment of the invention oxygen or oxygen-containing gas is transferred via the annular channel 26 and a plurality of partly inclined connecting channels 30 each forming a fluid communication between the annular channel 26 and having an open end forming an outlet 31 for the oxygen or oxygen-containing gas. As clearly shown in the drawings the channels 30 each have an end part 32 helically arranged with respect to the central channel 10 of the burner in order to supply the oxygen or oxygen-containing gas leaving the channels 30 with a tangential velocity component to the core 14 of solid fuel. A swirling motion of the oxygen or oxygen-containing gas is so generated, which promotes the mixing of said gas with the finely divided solid fuel. It will be understood that with the above arrangement of the channels 30 with end parts 32 the annulus 18 of solid fuel should be chosen relatively shallow to permit sufficient contact between the gas from the channels 30 and the solid fuel from said annulus.

In addition to the longitudinal and tangential velocity components of the oxygen or oxygen-containing gas an inward or outward radial velocity component may be imparted to the gas in order to preferentially promote the mixing with the core and the annulus of solid fuel respectively.
It should be noted that the invention is not restricted to particular means for controlling the heat load of the burner. Instead of the hollow wall member with internal cooling fluid passages, the burner may for example be provided with a suitable refractory lining applied onto the outer surface of the burner front wall for resisting the heat load during operation of the burner.

Further, it is noted that for high duty operations the channels and conduits for oxygen which are usually made of metal, are preferably internally coated with an oxidic coating, such as ZrO₂ or a ceramic, enabling the application of high oxygen velocities without the risk of metal combustion by the oxygen.

The invention is not restricted to a particular number of oxygen channels, provided that the channels are preferably substantially equally distributed with respect to the central channel for solid fuel.
1. Process for the partial combustion of finely divided solid fuel comprising introducing a core of a finely divided solid fuel into a reactor space, supplying oxygen or an oxygen-containing gas around the core, and supplying an annulus of the finely divided solid fuel around the core of solid fuel and the oxygen or oxygen-containing gas, the finely divided solid fuel and oxygen or oxygen-containing gas being introduced into the reactor space via a burner, wherein the finely divided solid fuel is introduced into a central channel of the burner, and the oxygen or oxygen-containing gas is separately introduced into the burner outside the central channel and wherein in the burner the oxygen or oxygen-containing gas is caused to flow from outside the central channel in a direction at least partly inclined with respect to the solid fuel flow into the central channel for supplying the oxygen or oxygen-containing gas into the reactor space between the core of solid fuel and the annulus of solid fuel.

2. Process as claimed in claim 1, wherein the oxygen or oxygen-containing gas is supplied into the reactor space as a substantial annulus between the core of solid fuel and the annulus of solid fuel.

3. Process as claimed in claim 1 or 2, wherein the oxygen or oxygen-containing gas is supplied with a tangential velocity component into the reactor space.

4. Process as claimed in any one of the claims 1-3, wherein a swirling motion is imparted to the solid fuel.

5. Burner for the partial combustion of a finely divided solid fuel comprising an outlet and a central channel communicating therewith for a finely divided solid fuel, at least one outlet and a channel communicating therewith and arranged outside the central channel for oxygen or oxygen-containing gas, wherein the outlet for oxygen or oxygen-containing gas divides the outlet for the solid fuel into a first centrally arranged zone and a second
substantially concentrical annular zone, and wherein the channel for oxygen or oxygen-containing gas is in communication with the outlet for oxygen or oxygen-containing gas via at least one connecting channel being at least partly inclined with respect to the flow direction in the central channel.

6. Burner as claimed in claim 5, wherein the channel for oxygen or oxygen-containing gas and the central channel have substantially coinciding longitudinal axes.

7. Burner as claimed in claim 5 or 6, wherein the outlet for oxygen or oxygen-containing gas is substantially annular and is substantially concentrically arranged in the outlet for the solid fuel.

8. Burner as claimed in any one of the claims 5-7, being provided with a plurality of inclined connecting channels being substantially uniformly distributed with respect to the central channel.

9. Burner as claimed in any one of the claim 5-8, wherein the outlet for oxygen or oxygen-containing gas is arranged to impart a tangential velocity component to the oxygen or oxygen-containing gas.

10. Burner as claimed in any one of the claims 5-9, further comprising swirling means for imparting a swirling motion to the solid fuel.
### DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<tr>
<th>Category</th>
<th>Citation of document with indication, where appropriate, of relevant passages</th>
<th>Relevant to claim</th>
<th>CLASSIFICATION OF THE APPLICATION (Int. Cl. *)</th>
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<tbody>
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### TECHNICAL FIELDS
SEARCHED (Int. Cl. *)

- F 23 D
- F 23 B

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The present search report has been drawn up for all claims.

**Place of search**

- VIENNA

**Date of completion of the search**

- 20-02-1984

**Examiner**

- TSCHÖLLITSCH

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**CATEGORY OF CITED DOCUMENTS**

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