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⑤④ **Process for the preparation of synthesis gas.**

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⑤⑥ References cited:
DE - C - 880 623
LU - A - 29 330
US - A - 541 376
US - A - 4 200 495

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Description

The application relates to a process for the preparation of synthesis gas by the partial combustion of finely divided carbon-containing fuel by supplying oxygen-containing gas axially into a vertically arranged reactor and feeding the fuel through one or more passages in the side wall of the reactor.

The synthesis gas thus prepared substantially consists of carbon monoxide and hydrogen and contains in addition, inter alia, minor quantities of carbon dioxide and methane. If the partial combustion is not carried out with pure oxygen but with air, the product of course also contains much nitrogen. By carbon-containing fuel is preferably meant coal and other solid fuels, such as brown coal, peat, lignite, waste wood etc., but liquid fuels such as oil optionally derived from tar sand, are suitable.

The reactor is preferably mainly cylindrical, but oval, conical or rectangular reactors are also suitable.

Such a process is known from the German Patent Specification No. 880,623. According to said patent specification oxygen is blown down in a narrowly de-limited jet through the top of a reactor, coal dust being blown from the side obliquely down into the oxygen jet, so that synthesis gas is formed centrally in the reactor. A problem not mentioned by said patent specification is that the hot synthesis gas formed must also be discharged from the reactor, just like the ash and slag formed. This is probably effected through the bottom which is unfavourable because the hot gas tends to ascend.

Further the yield per unit of space of such a reactor is not optimal, since reactions only take place in the middle of the reactor. Since the coal dust is blown obliquely down into the oxygen jet, the center of said jet has less chance to react with coal than its outer parts. Further, a rather high reactor is required to ensure that all coal particles are gasified before they reach the bottom of the reactor.

Said problems have now been solved by supplying the oxygen-containing gas into the bottom, feeding the fuel at an angle of $90^\circ (\pm 15^\circ)$ with the centre line of the reactor and discharging the resultant gas at the top.

In United States Patent Specification No. B 541,376 a fluidized bed process for the gasification of solid fuel is disclosed, in which process an oxygen-containing gas is supplied into a reactor axially through the bottom, the fuel is fed at an angle of 90° with the centre line of the reactor through one passage in the side wall, and the synthesis gas formed is discharged at the top of the reactor. In this process the gasification takes place by the reaction of carbon dioxide and/or steam with the fuel. The carbon dioxide and steam are the products of the complete combustion of carbon-containing ash and part of the fuel with the oxygen-containing gas. The gasification

must be carried out at temperatures below the melting point of the remaining ash particles.

It has now been found that a direct partial combustion of the fuel with the oxygen-containing gas may be carried out under conditions yielding liquid slag.

The present invention therefore relates to a process for the preparation of synthesis gas by the partial combustion of finely divided carbon-containing fuel by supplying oxygen-containing gas axially into a vertically arranged reactor through the bottom, feeding the fuel at an angle of $90^\circ (\pm 15^\circ)$ with the centre line of the reactor through one or more passages in the side wall of the reactor and discharging the synthesis gas formed at the top of the reactor, characterized in that the process is carried out at such temperatures that the non-combustible remainders of the fuel are in the molten stage.

Since the fuel is now fed in a thin layer more or less rectangularly with the stream of oxygen-containing gas, the chance of fuel particles also reaching the centre of said stream is most likely. In practice fuel will be advantageously fed by means of sprayers in such a pattern that the whole cross-section of the gas stream is equally charged with fuel. By means of all these provisions the reactor height can be limited.

In order to charge the whole cross-section of the gas stream or of the reactor equally with fuel, the orifice angle of the sprayer or sprayers must be 180° . The result, however, is that a large proportion of the finely divided fuel strikes against the reactor side wall before it has fully reacted, as a result of which erosion and overheating take place. Therefore, the orifice angle of the sprayer is made somewhat smaller. The greater the number of sprayers, the higher the temperature at which the fuel is divided over the cross-section of the reactor. It is assumed that the inside of the reactor has a circular cross-section. It is of course also possible to choose another shape that is adapted to the spraying pattern of the fuel inlets, such as a square or an ellipse with the sprayers at two or all four angular points or ends of the centre lines.

The synthesis gas formed rises in the reactor since it has a higher temperature than the oxygen-containing gas and it has a lower molecular weight. It is therefore advantageous that the discharge is fitted at the top of the reactor. This discharge may be designed as described in the Netherlands Patent Applications Nos. 7408036 and 7704399.

According to the invention the oxygen-containing gas is supplied at the bottom of the reactor, as a result of which it contacts the descending hot fuel and/or slag particles on its way up. This yields two important additional advantages: the oxygen is pre-heated whereas the slag is cooled; and the last remainders of the carbon-containing fuel are removed from the slag particles by partial or complete combustion, the oxygen being further heated by the

heat evolved. In cases where the slag is drained in liquid form it may happen that the slag cools off excessively and does not flow any more with the result that the discharge and the bottom will be blocked. In order to prevent this it may be useful to preheat the oxygen-containing gas in a higher degree and/or to locate the inlet(s) thereof at a higher level in the bottom of the reactor.

Most partial combustion reactions in the reactor take place at the level of the fuel inlet. Some not yet fully gasified fuel particles will be entrained upwards by the gas stream over a certain distance before they are fully gasified. Owing to the high concentration of synthesis gas and low concentration of oxygen, at the higher levels in the reactor the exothermic reaction with oxygen hardly takes place, but mainly the endothermic reaction with water and CO₂ with the formation of CO and H₂.

Consequently, three zones can now be distinguished in the reactor, from bottom to top: the preheating zone, the exothermic partial oxidation zone and the endothermic reduction zone.

The fuel is preferably fed through at least two passages in the side wall of the reactor, which are fitted at the same height and symmetrically in relation to the centre line of the reactor. The result is that a kind of flat disc of fuel particles is formed at said level in the reactor space. The fuel particles are introduced into the reactor at such a speed that they do not fall at once, but not at such a speed that they hit the opposite side wall. In the ideal case the upward pressure of the oxygen-containing gas balances the downward-acting gravity, so that the fuel particles remain at the same height in the reactor until they have fully reacted with the oxygen. However, this is not feasible in practice, since the fuel particles disintegrate during the partial combustion and the lighter particles are entrained more readily by the oxygen-containing gas. Said particles then react further in the endothermic zone. The heavier particles will descend a little against the gas stream, owing to which they will reach a zone with more oxygen and react rapidly and consequently disintegrate into pieces which are subsequently forced upwards by the gas stream.

The non-combustible remainders, such as silicate, are in the molten state owing to the high temperature and tend to agglomerate. The heaviest ash particles descend, exchanging heat with the stream of oxygen-containing gas, to the bottom of the reactor where they form the slag and ash, the lighter particles leaving the reactor through the discharge with the synthesis gas as fly ash. With the aid of known means it is possible to cool and remove the slag and ash from the reactor and the synthesis gas discharge, respectively. The slag is preferably discharged via the bottom of the reactor.

It is preferred to provide a horizontal slit for feeding fuel along the entire circumference of

the reactor, since an ideal spatial distribution of the fuel particles is ensured in this manner.

The reactor bottom is preferably shaped as a diffuser. This results in better utilization of the complete reactor space of the oxygen-containing gas and also in a decrease in the gas velocity. At a certain height the gas velocity has become so low that the injected fuel starts descending. The finely divided fuel is preferably fed at the height of this point, a kind of shield being formed in this manner between the oxidizing preheating zone and the endothermic reduction zone.

The diffuser shape will then not be allowed to go any further and consequently the reactor diameter is determined as a function of the oxygen supply rate and temperature. In other words, at this height the bottom of the reactor becomes the side wall. Briefly, the fuel is preferably fed to the reactor at the height of the place where the bottom becomes the side wall of the reactor.

In the process according to the invention the reaction temperature is approx. 1800°C, preferably between 1700 and 1900°C. The feed of carbon-containing fuel is about 0.6 kg/s/m³ of reactor space, the oxygen-containing gas being supplied to the reactor in such quantities that the carbon/oxygen weight ratio lies between 0.6 and 0.9.

The invention will now be illustrated with reference to the drawing. Fig. 1 is a diagrammatic longitudinal section of a reactor according to the invention, and Fig. 2 is a cross-section along the line II—II in Fig. 1. Cooling and insulation, valves, thermometers, etc., are not shown in the drawings.

A discharge 2 for synthesis gas and fly ash is provided in a top 1. In a side wall 3 are located passages 4 for fuel dust, for example coal dust that has been pressurized in some known device and can be blown into the reactor with an inert gas, for example synthesis gas, steam or nitrogen. A bottom 5 is conical downward and becomes a slag discharge 6 in the centre of which an oxygen supply line 7 is located. As appears from Fig. 2, the fuel passages 4 are located at regular intervals in the side wall 3. By way of example pour passages are drawn and the sprayers have an orifice angle of about 90°. The fuel dust is drawn as dots.

Example

A quantity of 40,000 kg/h of a finely ground coal dust and 133 kg of nitrogen at 40°C as carrier gas were blown through the passages 4 into a reactor having the above-mentioned shape and an internal volume of 18 cu.m. the coal dust had an average particle size of 50 μm and had the following composition on a dry ashless basis:

C	78.1% by wt
H	5.5% by wt
N	1.2% by wt

O	10.9% by wt
S	4.3% by wt

The ash content was 12.6% by weight and the moisture content was 2% by weight. The reactor had a pressure of 30 atm ($2.94 \cdot 10^6$ Pa). A quantity of 33,500 kg/h of gas of 200°C and of the following composition was introduced through the supply line 7:

O ₂	99% by wt
N ₂	0.3% by wt
Ar	0.7% by wt

A quantity of 9000 kg of moderator steam was added to this gas.

A quantity of 67,500 kg/h of synthesis gas of 1500°C and of the following composition was discharged through the outlet or discharge 2:

CO	64.0% by wt
H ₂	31.6% by wt
CO ₂	0.8% by wt
H ₂ S	1.3% by wt
H ₂ O	1.5% by wt
COS	0.1% by wt
CH ₄	—% by wt
N ₂	0.5% by wt
Ar	0.2% by wt

The synthesis gas formed was practically free from soot and contained 3% by weight of fly ash which was separated off in a cyclone. The remaining solids were discharged as molten slag through 6 and dropped in a water bath to be cooled. The cooled slag-water mixture was drained through a lock system, the high pressure in the reactor being maintained.

Claims

1. A process for the preparation of synthesis gas by the partial combustion of finely divided carbon-containing fuel by supplying oxygen-containing gas axially into a vertically arranged reactor through the bottom, feeding the fuel at an angle of 90° ($\pm 15^\circ$) with the centre line of the reactor through one or more passages in the side wall of the reactor and discharging the synthesis gas formed at the top of the reactor, characterized in that the process is carried out at such temperatures that the non-combustible remainders of the fuel are in the molten stage.

2. A process as claimed in claim 1, characterized in that the fuel is fed via at least two passages in the side wall of the reactor which are located at the same height and symmetrically in relation to the centre line of the reactor.

3. A process as claimed in claim 1, charac-

terized in that the fuel is supplied via a horizontal slit along the entire circumference of the reactor.

Revendications

1. Procédé de préparation de gaz de synthèse par combustion partielle de combustible contenant du carbone finement divisé par fourniture de gaz contenant de l'oxygène axialement dans un réacteur disposé verticalement par le bas, introduction du combustible à un angle de 90° ($\pm 15^\circ$) avec l'axe du réacteur à travers un ou plusieurs passages dans la paroi latérale du réacteur et déversement du gaz de synthèse formé au sommet du réacteur, caractérisé en ce que le procédé est conduit à des températures telles que les restes non combustibles du combustible sont à l'état fondu.

2. Procédé selon la revendication 1, caractérisé en ce que le combustible est introduit par au moins deux passages dans la paroi latérale du réacteur, qui sont situés à la même hauteur et symétriquement par rapport à l'axe du réacteur.

3. Procédé selon la revendication 1, caractérisé en ce que le combustible est fourni par une fente horizontale sur toute la circonférence du réacteur.

Patentansprüche

1. Ein Verfahren zur Herstellung von Synthesegas durch die teilweise Verbrennung eines fein verteilten Kohlenstoff enthaltenden Brennstoffes durch achsiale Einspeisung eines Sauerstoff enthaltenden Gases in einen vertikal angeordneten Reaktor durch den Reaktorboden, Einspeisung des Brennstoffes in einem Winkel von 90° ($\pm 15^\circ$) zur Mittellinie des Reaktors durch eine oder mehrere Durchlässe in der Seitenwand des Reaktors und Abführen des gebildeten Synthesegases am Kopf des Reaktors, dadurch gekennzeichnet, daß das Verfahren bei solchen Temperaturen durchgeführt wird, daß die nicht brennbaren Restbestandteile des Brennstoffes in der geschmolzenen Phase vorliegen.

2. Ein Verfahren wie in Anspruch 1 beansprucht, dadurch gekennzeichnet, daß der Brennstoff über mindestens 2 Durchlässe in der Seitenwand des Reaktors, welche sich auf gleicher Höhe befinden und symmetrisch in bezug auf die Mittellinie des Reaktors angeordnet sind, eingespeist wird.

3. Ein Verfahren wie in Anspruch 1 beansprucht, dadurch gekennzeichnet, daß der Brennstoff über einen horizontalen Spalt um den gesamten Reaktorumfang zugeführt wird.

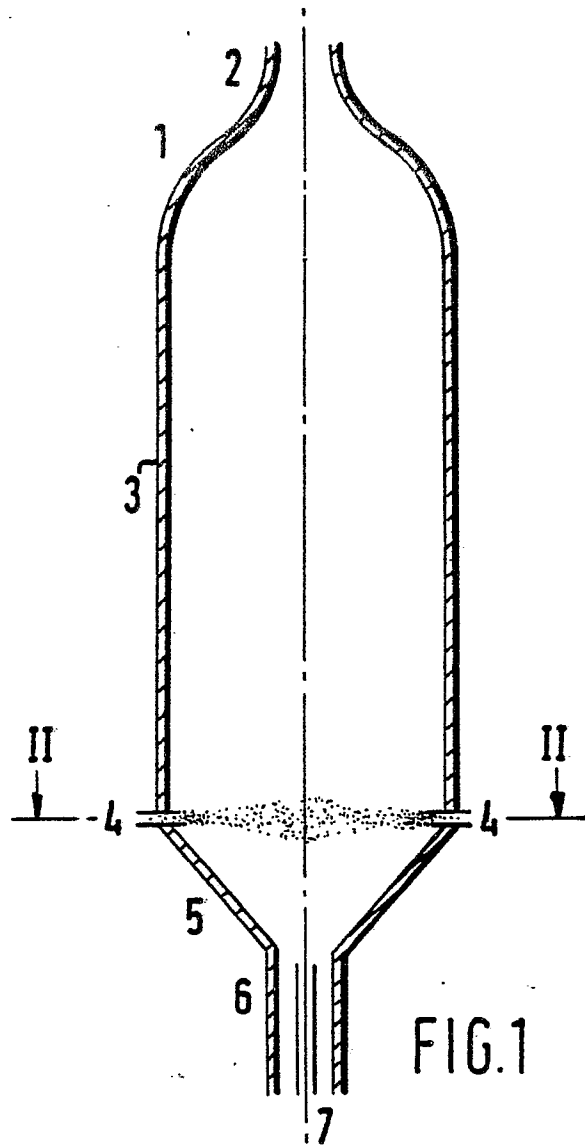


FIG. 1

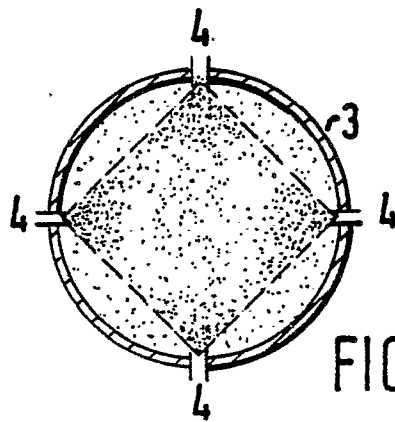


FIG. 2