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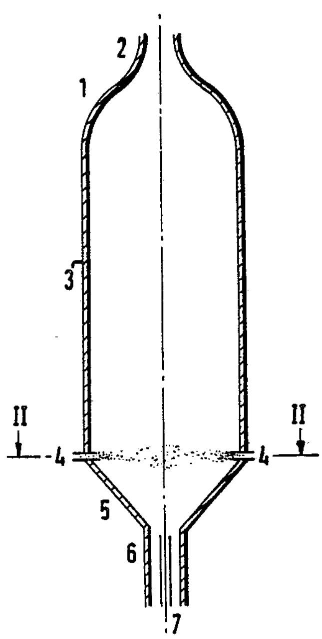
(54) **Process and reactor for the preparation of synthesis gas.**

(57) Gasifier wherein coal dust is introduced from at least one passage in its sidewall and oxygen-containing blast is introduced essentially perpendicular to the coal flow, preferably from below, so as to form a horizontal flat disc. The contact between the hot slag falling down in the bottom of the reactor and the oxygen causes a carbon-free slag and some preheating of the blast.

Since burners are not used in the present gasifier difficulties of flashback and flame impingement are obviated. Moreover, the coal gasification is more efficient, because carbon remained in the slag is completely combusted while falling down through the rising oxygen stream.



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PROCESS AND REACTOR FOR THE PREPARATION OF SYNTHESIS GAS

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 application also relates to a reactor suitable for carrying out the process.

The synthesis gas thus prepared substantially consists of carbon monoxide and hydrogen and contains in addition, inter alia, miner 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 and reactor are 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 centre 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° ($\pm$ 15°) with the centre line of the reactor and discharging the resultant synthesis gas at the top.

The 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 and feeding the fuel via one or more passages in the side wall of the reactor, characterized in that the oxygen-containing gas is supplied into the reactor bottom, the fuel is fed at an angle of 90° ($\pm$ 15°) with the centre line of the reactor and that the synthesis gas formed is discharged at the top of the reactor.

In addition, the invention relates to a vertically arranged reactor for the preparation of synthesis gas by the partial combustion of a finely divided carbon-containing fuel, provided with an axial supply line for oxygen-containing gas and one or more passages in the side wall for feeding the fuel, characterized in that the supply line for oxygen-containing gas is fitted in the bottom of the reactor, that the passage(s) in the side wall is/are at an angle of 90° ($\pm$ 15°) with the centre line of the reactor, and that a discharge for synthesis gas is fitted at the top.

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 CO_2 with the formation of CO and H_2.

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/m^3 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 four 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 µ 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. 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_2S	1.3% by wt
H_2O	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 and feeding the fuel through one or more passages in the side wall of the reactor, characterized in that the oxygen-containing gas is supplied into the reactor bottom, the fuel is fed at an angle of 90° ($\pm$ 15°) with the centre line of the reactor and that the synthesis gas formed is discharged at the top of the reactor.

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

4. A process as claimed in any one or more of claims 1-3, characterized in that the bottom of the reactor is shaped as a diffuser.

5. A process as claimed in any one of claims 1-4, characterized in that the fuel is fed to the reactor at the height of the place where the bottom becomes the side wall of the reactor.

6. A process as claimed in any one or more of claims 1-5, characterized in that the slag formed is discharged via the bottom of the reactor.

7. A vertically arranged reactor for the preparation of synthesis gas by the partial combustion of finely divided carbon-containing fuel, provided with an axial supply line for oxygen-containing gas and one or more passages in the side wall for feeding the fuel, characterized in that the supply line for oxygen-containing gas is located in the bottom of the reactor, that the passage(s) in the side wall is/are at an angle of 90° ($\pm$ 15°) with the centre line of the reactor, and that a discharge for synthesis gas is provided at the top.

8. A reactor as claimed in claim 7, characterized in that at least two passages for feeding fuel are fitted in the side wall of the reactor at the same height and symmetrically in relation to the centre line of the reactor.

9. A reactor as claimed in claim 7, characterized in that a horizontal slit for feeding fuel is provided over the entire circumference of the reactor.

10. A reactor as claimed in any one or more of claims 7-9, characterized in that the bottom of the reactor is shaped as a diffuser.

11. A reactor as claimed in any one or more of claims 7-10, characterized in that the passages for feeding the fuel have been fitted at the height of the place where the bottom becomes the side wall of the reactor.

12. A reactor as claimed in any one or more of claims 7-11, characterized in that a discharge for slag is provided in the bottom of the reactor.

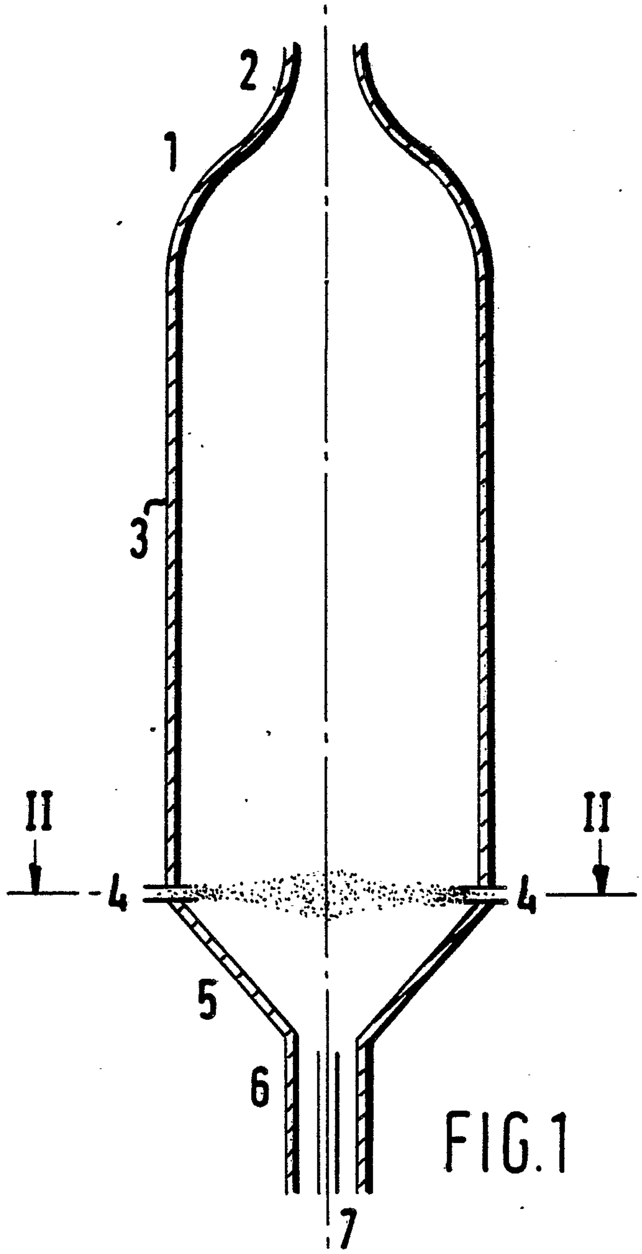

FIG.1

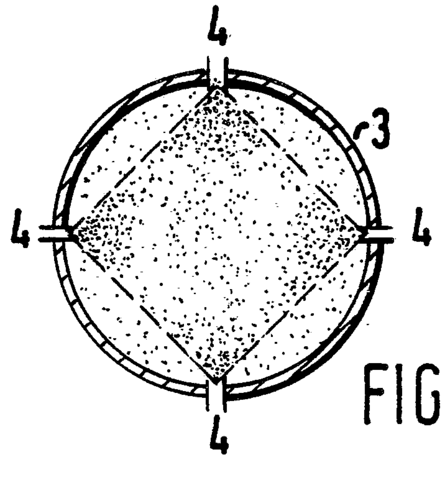

FIG.2

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EUROPEAN SEARCH REPORT

0040868

Application number
EP 81 20 0474

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	US - A - B541 376 (CHEN) * column 3, lines 40-62; column 4, lines 5-69; column 5, lines 1-27 * --	1,4-7, 10-12
	US - A - 4 200 495 (LISS) * column 14, lines 19-28; column 18, lines 50-54 * --	1,2,7, 8
A	LU - A - 29 330 (STAATSMIJNEN LIMBURG)	
D	DE - C - 880 623 (SCHMALFELDT) ------	

CLASSIFICATION OF THE APPLICATION (Int. Cl.3)

C 10 J 3/54
3/56
3/50

TECHNICAL FIELDS SEARCHED (Int. Cl.3)

C 10 J 3/54
3/56
3/50
B 01 J 8/00

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

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

Place of search	Date of completion of the search	Examiner
The Hague	28-08-1981	WENDLING