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(54) Method and installation for gasifying solid fuel

(57) The invention relates to a method for gasifying solid fuel such as carbon and heavy petroleum residue, comprising of:

- i) adding dry solid fuel to a gasifying unit;
- ii) gasifying the solid fuel at high temperature and pressure in the gasifying unit;
- iii) cooling a gas flow leaving the gasifying unit and containing gasified fuel with a watery slurry of the solid fuel;
- iv) separating dry solid fuel from the gas flow; and
- v) feeding back the separated dry solid fuel to the gasifying unit,

and to

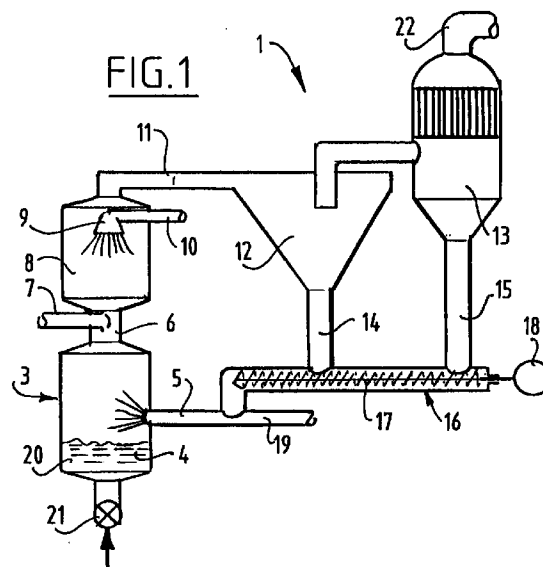
a gasification installation for gasifying solid fuel such as carbon and heavy petroleum residue, comprising:

a gasifying unit provided with an inlet for dry solid fuel and a gas flow outlet;

a cooling unit connecting onto the gasifying unit for cooling the gas flow with a watery slurry of the solid fuel;

a separating unit for separating dry solid fuel from the cooled gas flow; and

a feedback unit for feeding back to the gasifying unit the dry solid fuel separated out of the gas flow.



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Description

The present invention relates to a method and to an installation for gasifying solid fuel such as carbon and heavy petroleum residue.

Gasification of solid fuel is a very attractive method of generating electricity from carbon due to the high efficiency, the low emission of harmful substances and the modular construction of the installation. Gasification of carbon or heavy petroleum residues is also an attractive method of producing raw materials for the chemical industry. However, the cost of a gasification installation are unacceptably high. Costly components of a gasification installation are the unit for grinding, drying, pressurizing and feeding in the fuel for gasifying and (in the case of a KV steg) the synthesis gas cooler for generating current via the sensible heat.

While the use of a wet carbon mass instead of dry solid fuel has the advantage of simplicity and lower cost for the fuel supply unit, it results inherently in a substantial increase in the consumption of fuel and oxygen.

The gas leaving the gasifier must be cooled in order to cause the slag material present therein to solidify before the gas flow comes into contact with a cold surface. The slag material can adhere thereto and thus foul the "heat-exchanging" surfaces. Use can be made for cooling purposes of for instance a radiation cooler, a cooled recirculated gas or sprayed water. This latter is less complicated but the heat required to evaporate the water must be considered lost, whereby the installation efficiency is lower than in the case of recirculation with clean synthesis gas or cooling in a radiation cooler.

The invention has for its object to change the method and the installation for gasifying solid fuel such that the advantages of the use of a watery fuel flow are retained but the drawbacks associated therewith are avoided to the greatest possible extent.

This is achieved according to the invention with a method for gasifying solid fuel which comprises of:

- i) adding dry solid fuel to a gasifying unit;
- ii) gasifying the solid fuel at high temperature and pressure in the gasifying unit;
- iii) cooling a gas flow leaving the gasifying unit and containing gasified fuel with a watery slurry of the fuel;
- iv) separating dry solid fuel from the gas flow; and
- v) feeding back the separated dry solid fuel to the gasifying unit.

Using a fuel slurry as cooling agent provides the advantage that a unit for preheating and drying the carbon and pressurizing it via lock hoppers is no longer required. Once the watery fuel slurry has been carried in simple manner via for instance plunger pumps or other

pumps into the system operating at high temperature and pressure the fuel particles can, after separation from the gas flow, be supplied dry and in simple manner to the gasifier as dry solid fuel. The heat of the synthesis gas will dry the carbon particles and cause the excess water to evaporate.

The watery slurry of solid fuel generally contains 90-10% water, preferably 75-25%, more preferably 65-30% water. In a practical embodiment the watery slurry contains about 40% water.

The gas flow leaving the gasifier must be cooled to below 500°C in order to avoid so-called alkali transfer. In addition, the temperature of the gas flow must lie above about 250°C to avoid the forming of solid ammonium chloride. When the gas flow is cooled with the fuel slurry the problem may occur that tacky fuel particles and tar form on the carbon particles, whereby the separating unit located downstream for separating solids may be fouled. Tar formation in particular can be avoided by pre-cooling the gas flow with an (inert) gas such as nitrogen (or synthesis gas). Pre-cooling can take place for instance to a temperature wherein the fuel particles present in the fuel slurry do not become hotter than 300-350°C.

If separation of the dry solid fuel from the gas flow takes place at a level higher than the level of the gasifying unit, the fuel particles for feeding back will be under a slightly higher pressure in the standpipe than the pressure prevailing in the gasifier. This simplifies supply to the (dry) burners.

If fly ash is separated from the gas flow with the dry solid fuel and fed back to the gasifying unit, whereafter liquid slag is discharged from the gasifying unit, all fly ash is recirculated to the gasifier in this way and can there be agglomerated to glazed slags which are discharged from the gasifier. Thus is created a substantially fully scorifying process.

If gasifying is carried out in a gasifying unit comprising two successive gasifiers, not only is a considerably lower fuel and oxygen consumption achieved but tar and moisture forming is substantially absent, while there are substantially no limitations to the particle size distribution and the cake-forming properties of the fuel. The supply to the second gasifier can consist of extra fuel and/or partly converted fuel.

Another aspect of the present invention relates to a gasification installation for gasifying solid fuel such as carbon and heavy petroleum residue, comprising:

- a gasifying unit provided with an inlet for dry solid fuel and a gas flow outlet;
- a cooling unit connecting onto the gasifying unit for cooling the gas flow with a watery slurry of the solid fuel;
- a separating unit for separating dry solid fuel from the cooled gas flow; and
- a feedback unit for feeding back to the gasifying unit the dry solid fuel separated out of the gas flow.

Use of the method and installation according to the invention for gasifying solid fuel not only provides a considerably cheaper installation but also increases the total

efficiency to about 50%, while the oxygen consumption falls by about a third.

Mentioned and other features of the method and gasification installation according to the invention will be further elucidated hereinafter in the light of two embodiments which are only given by way of example while reference is made to the annexed drawing.

In the drawing:

figure 1 shows schematically a gasification installation according to the invention; and
figure 2 shows a flow diagram of another gasification installation according to the invention in which two gasifiers are applied.

Figure 1 shows a gasification installation 1 according to the invention. The installation 1 comprises a gasifying unit 3 with a gasifier 4 which is provided with an inlet 5 for dry solid fuel and an outlet 6 for a gas flow containing gasified fuel. This gas flow is pre-cooled using an (inert) gas (for example nitrogen) which is supplied via pipe 7. The gas coming from gasifier 4 is hereby cooled from about 1500°C to about 700°C. The pre-cooled gas subsequently enters a cooling unit 8 which comprises a spray unit 9 for spraying a watery slurry of solid fuel which is supplied via pipe 10. The watery slurry used consisted of 60% carbon and 40% water and had a temperature of 20°C.

Via the outlet 11 a two-phase flow leaves cooling unit 8 consisting of gas (about 500-600°C and 15-20% water vapour) and carbon/fly ash particles with a temperature of about 250-350°C.

Coarser carbon and fly ash particles are separated in the cyclone 12 following on from outlet 11. On the gas flow side a ceramic filter unit 13 for separating fine carbon and ash particles follows the cyclone 12. Via the standpipes 14, 15 respectively the collected dry solid fuel is carried into a feedback unit 16, for instance a worm conveyor comprising a rotatably mounted worm 17 which can be driven by a motor 18. Dry solid fuel is thus fed via inlet 5 to the gasifier 4 at 250-300°C, dosed at the pressure prevailing in the system (30-40 bar).

Supply of fuel can take place via pipe 19 with nitrogen/steam, whereby the level of the fuel in standpipes 14 and 15 can also be controlled.

The recirculated fly ash and the slags formed during gasification are cooled in a water bath 20, whereafter the slags are discharged via outlet 21.

The gas leaving the ceramic filter unit (synthesis gas; temperature 500°C) is finally supplied to the gas turbine after cleaning.

Figure 2 shows another gasification installation 2 according to the invention. In this case the gasifying unit 3 consists of a first gasifier 23 and a second gasifier 24. A carbon slurry 25 is supplied via the metering pump 26 to the cooling unit 27 in which is cooled the gas flow from the gasifier 24 which is pre-cooled with nitrogen 28 in the pre-cooling unit 29. The flow 30 of gas and dry fuel par-

ticles is separated in the separating unit 31 and the dry solid fuel is fed to the first gasifier 23 via the pipe 32.

In the air separation unit 33 air 34 is separated into nitrogen 28 which is supplied to the pre-cooling unit 29 and oxygen 34 which is supplied to the gasifier 23.

Slags coming from the gasifier 23 are cooled in the boiling water bath 35 and discharged via pipe 36. Formed steam 37 is added to the second gasifier 24 to which steam 38 which may be released from the installation is likewise supplied.

The synthesis gas 39 is then fed to the processing unit 40 and finally to the gas turbine.

Claims

1. Method for gasifying solid fuel such as carbon and heavy petroleum residue, comprising of:
 - i) adding dry solid fuel to a gasifying unit;
 - ii) gasifying the solid fuel at high temperature and pressure in the gasifying unit;
 - iii) cooling a gas flow leaving the gasifying unit and containing gasified fuel with a watery slurry of the solid fuel;
 - iv) separating dry solid fuel from the gas flow; and
 - v) feeding back the separated dry solid fuel to the gasifying unit.
2. Method as claimed in claim 1, wherein the watery slurry of solid fuel contains 90-10%, preferably 75-25%, more preferably 65-30% water.
3. Method as claimed in claim 1 or 2, wherein cooling takes place to a gas flow temperature of 250-500°C, preferably 300-400°C, more preferably 300-350°C.
4. Method as claimed in claims 1-3, wherein pre-cooling with an inert gas takes place prior to cooling with the watery slurry of solid fuel.
5. Method as claimed in claims 1-4, wherein separation of the dry solid fuel from the gas flow takes place at a level higher than the level of the gasifying unit.
6. Method as claimed in claims 1-5, wherein fly ash is separated from the gas flow with the dry solid fuel and fed back to the gasifying unit and fly ash slags are discharged from the gasifying unit.
7. Method as claimed in claims 1-6, wherein gasification is carried out in a gasifying unit comprising two successive gasifiers.

8. Gasification installation for gasifying solid fuel such as carbon and heavy petroleum residue, comprising:
- a gasifying unit provided with an inlet for dry solid fuel and a gas flow outlet; 5
 - a cooling unit connecting onto the gasifying unit for cooling the gas flow with a watery slurry of the solid fuel;
 - a separating unit for separating dry solid fuel from the cooled gas flow; and 10
 - a feedback unit for feeding back to the gasifying unit the dry solid fuel separated out of the gas flow.
9. Installation as claimed in claim 8, wherein the cooling unit comprises a pre-cooling unit for cooling the gas flow with an inert gas. 15
10. Installation as claimed in claim 8 or 9, wherein a separation unit for separating dry solid fuel from the gas flow is located at a higher level than the gasifying unit. 20
11. Installation as claimed in claims 8-10, wherein the gasifying unit comprises two successive gasifiers. 25

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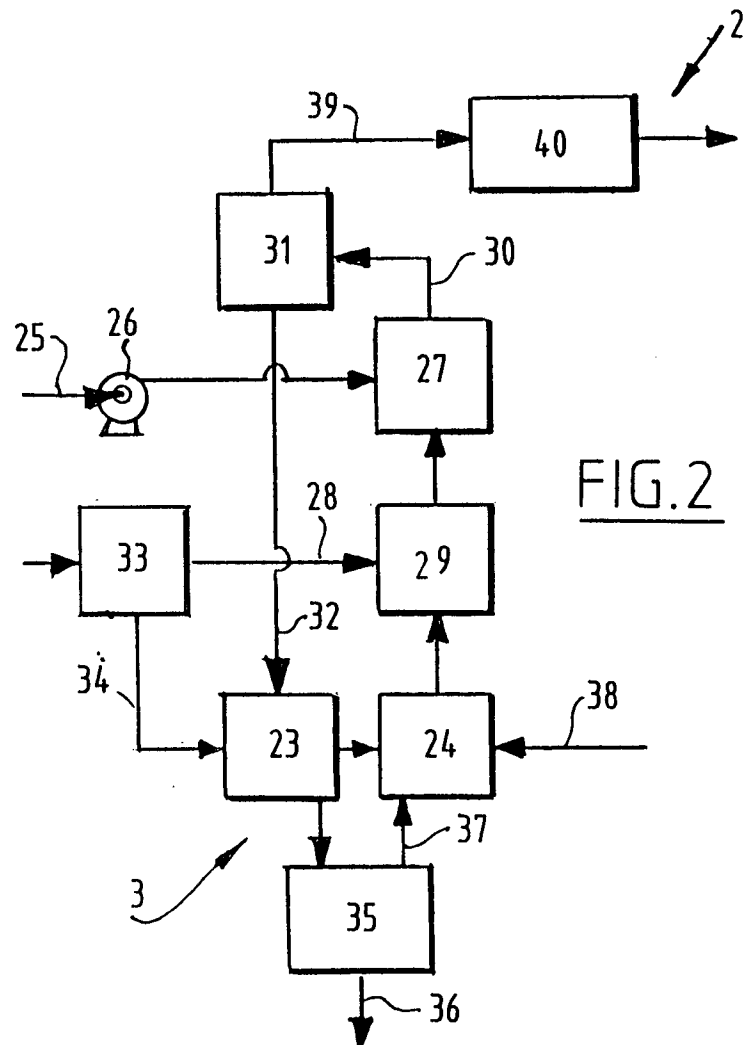
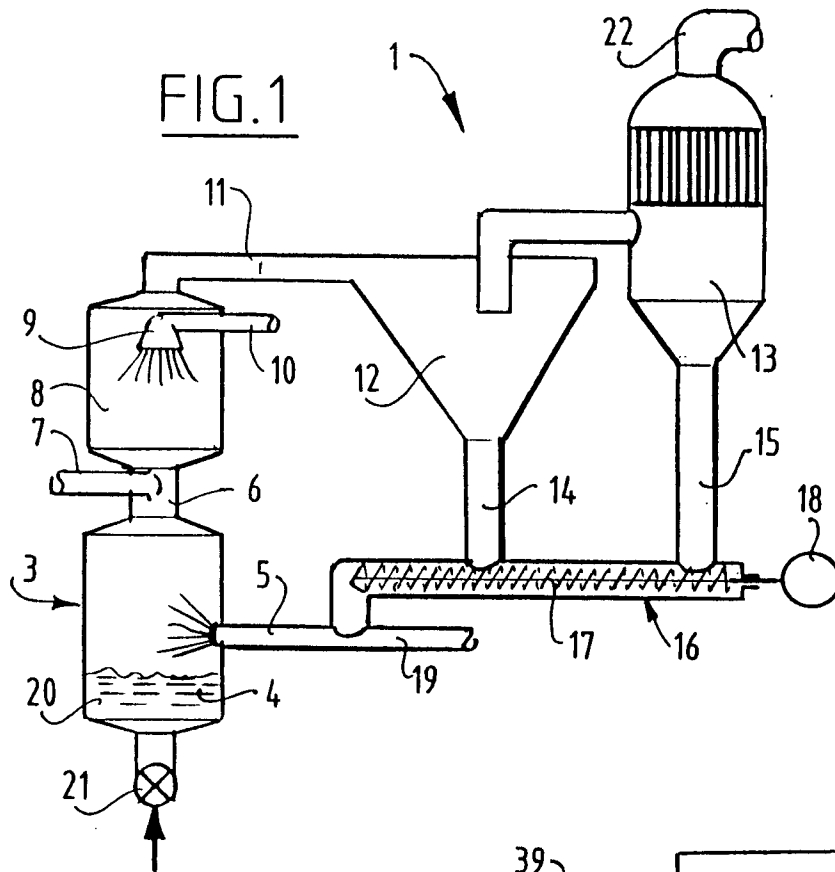
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EUROPEAN SEARCH REPORT

Application Number
EP 95 20 2805

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	EP-A-0 225 146 (THE DOW CHEMICAL CO.) 10 June 1987 * page 2, line 20 - page 12, line 3 *	1-3,5-8, 10,11	C10J3/46 C10J3/48
A	* page 15, line 2-6 * ---	4,9	
A	WO-A-93 23500 (STATE ELECTRICITY COMMISSION OF VICTORIA) 25 November 1993 * page 6, line 17 - page 16, line 24 *	1-3,8	
A	GB-A-1 370 410 (TEXACO) 16 October 1974 * page 6-8; example 1 *	1-3,8	
A	FR-A-2 177 089 (BITUMINOUS COAL RESEARCH) 2 November 1973 * page 10-13; claims 1-13 *	1,7,8,11	
A	US-A-2 633 416 (GORNOWSKI) 31 March 1953 * column 3, line 38 - column 5, line 75 *	1	
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A	US-A-4 166 802 (SLATER) 4 September 1979 ---		
A	US-A-4 153 427 (BISSET) 8 May 1979 -----		
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
THE HAGUE		7 February 1996	Wendling, J-P
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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