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(54) **Updraft gasifier with moisturization means**

(57) The invention relates to an updraft gasifier (4) for a biomass gasification system (2) to generate gasifier product gas to be burned in a combustion unit (6), which gasifier (4) comprises:

- a first inlet (9) for biomass in the upper area (12) of the gasifier (4), and
- a first outlet (11) for ash in the lower area (13) of the gasifier (4), and
- a second inlet (14) for a gasification agent in the lower area (13) of the gasifier (4), and
- a second outlet (15) for the gasifier product gas in the

upper area (12) of the gasifier (4),

wherein, the gasifier furthermore comprises:

- a temperature sensor (19) to measure the temperature of the gasifier product gas in the upper area (12) of the gasifier (4), and
- moisturization means (20) to moisture the biomass, and
- a control circuit (21) to activate the moisturization means (20) to moisture the biomass in case the temperature of the gasifier product gas exceeds a maximum temperature.

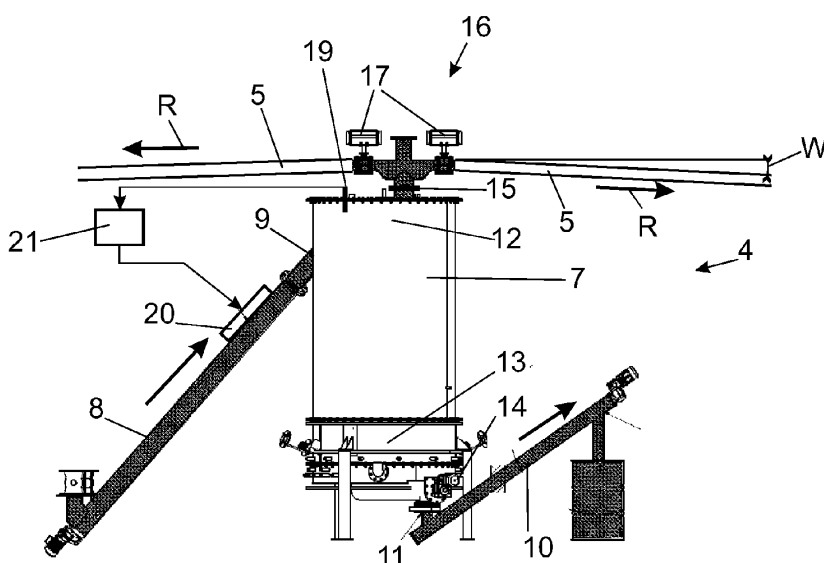


FIG.3

Description

[0001] The invention relates to an updraft gasifier for a biomass gasification system to generate gasifier product gas to be burned in a combustion unit, which gasifier comprises:

- a first inlet for biomass in the upper area of the gasifier, and
- a first outlet for ash in the lower area of the gasifier, and
- a second inlet for a gasification agent in the lower area of the gasifier, and
- a second outlet for the generated gasifier product gas in the upper area of the gasifier.

[0002] Document WO 2007/081296 discloses a cross draft gasifier for biomass that uses a downdraft and an updraft mode to produce gasifier product gas, which can be burned in a combustion unit. The disclosed gasifier comprises a first inlet for municipal waste in the upper area of the gasifier and a first outlet of the gasifier for the ash at the bottom of the gasifier. The gasifier furthermore comprises a second inlet for preheated air or oxygen in the lower area of the gasifier and a second outlet in the upper area of the gasifier for syngas as gasifier product gas generated in the gasifier. The gasifier product gas at the outlet of the gasifier comprises dust and tar residues, which need to be kept at a low percentage level of the gasifier product gas as they may result in damage at the internal combustion engine unit.

[0003] To achieve a low percentage level of tar in the gasifier product gas WO 2007/081296 discloses that a number of parameters need to be maintained within certain limits. These include: particle size distribution, moisture content, ash content, volatile matter content, heating value, bulk density and feedstock composition. The heating value is kept in a range by providing preheated air as needed. It is furthermore disclosed that the moisture content of the biomass needs to be kept in a 10% to 20% range to achieve this low level of tar in the gasifier product gas.

[0004] This known gasifier comprises the disadvantage that there is a need of a high number of sensors and control circuits to keep all these parameters in the preferred range and still the result is not satisfying as there is a high percentage of tar in the gasifier product gas. A biomass gasification system that uses this known cross draft gasifier therefore needs an expensive system to separate the tar and dust from the rest of the gasification product gas before burning in the combustion unit.

[0005] Thus in view of the foregoing it is desirable to have an improved biomass gasifier that provides a more effective way to cope with dust and tar residues from the gasifier product gas before burning.

[0006] The inventors realized that there is a need to keep the temperature of the generated gasifier product gas in the upper area of the gasifier below a maximum

temperature to ensure that the tar in the gasifier product gas is captured in moisture drops. The gasification product gas at the second outlet of the gasifier has to have a temperature in the range of about 70 to 80 degrees Celsius. This temperature and other process parameters enable equilibrium between vaporisation and condensation of water and tar in upper area of the updraft gasifier. The tar residues in the gasifier product gas are captured in moisture drops of nebular. This nebula consists of liquid tar dissolved in the water coming from the wood chips moisture. These moisture drops get in contact with pipes connected to the second outlet of the gasifier and condense on the inner walls of the pipes and run along the declined pipes towards the combustion unit. With the moisture drops, the tar from the gasifier product gas is flushed away towards the combustion unit where it is burned residue-free together with the gasification product gas.

[0007] Based on this knowledge a gasifier according to the invention is characterized in, that the gasifier furthermore comprises:

- a temperature sensor to measure the temperature of the gasifier product gas in the upper area of the gasifier, and
- moisturization means to moisture the biomass, and
- a control circuit to activate the moisturization means to moisture the biomass in case the temperature of the gasifier product gas exceeds a maximum temperature.

[0008] This updraft gasifier comprises the advantage that the tar and dust residues in the gasifier product are kept in a condition that enables an easy and cost effective way to separate and to keep them in the gasifier, convert them to ash and to take them out as grate ash from the gasifier. Consequently, the product gas and then after combustion the flue gas has a very low dust content. Further details and advantages of this updraft gasifier will become more apparent in the following description and the accompanying drawings.

Figure 1 is a perspective view of a Stirling plant with the preferred biomass gasifier of this invention.

Figure 2 is a side view of the Stirling plant of Figure 1.

Figure 3 is a side view of the gasifier of the Stirling plant of Figure 1.

[0009] Figure 1 is a perspective view and Figure 2 is a side view of a Stirling plant 1 to generate heat and electricity from biomass. The Stirling plant 1 comprises a biomass gasification system 2 to generate heat, which heat to some extent is transformed into electricity by four Stirling engines 3. The biomass gasification system 2 comprises an updraft gasifier 4, from which gasifier prod-

uct gas is transported through pipes 5 to four combustion units 6 where the gasifier product gas is burnt to heat up a transfer medium used to drive the Stirling engines 3.

[0010] Figure 3 is a side view of the gasifier 4 of the biomass gasification system 2. The gasifier 4 is built as updraft gasifier. In principle the updraft gasifier is a standing tubular reactor 7 which consists essentially out of cylindrical steel shell isolated and lined with bricks on the inner side. Additional the reactor 7 is isolated on the outer side as well, to avoid hot surfaces. The gasifier 4 comprises a wood chip conveyor 8 connected to a first inlet 9 of the gasifier 4 as fuel feed and an ash conveyer 10 connected to a first outlet 11 of the gasifier 4 as fuel discharge.

[0011] The wood chip conveyor 8 feeds the gasifier 4 through the lateral first inlet 9 which is arranged in the upper area of the gasifier 4. The feeding is monitored by a filling level indicator. The filling level indicator consists out of a rotating blade in the filling space mounted on a geared motor. The filling level is periodically checked and if necessary the fuel feed activated.

[0012] The gasification in the updraft gasifier 4 takes place in a counterflow principle, thereby the fuel passes the gasifier 4 from its upper area 12 to its lower area 13, while the gasification agent enters the gasifier 4 at a second inlet 14 at the bottom of the gasifier 4 and leaves the gasifier 4 as gasification product gas at a second outlet 15 in the upper area of the gasifier 4. Thereby different zones are formed in the gasifier 4. Basically four zones are formed, the drying zone, the pyrolysis zone, the reduction zone and the oxidation zone. As a gasification agent, a defined mixture of flue gas and air is used. The gasification agent is preheated in a gas pre-heater of the biomass gasification system 2 and afterwards fed at the second inlet 14 at the bottom of the gasifier 4.

[0013] The biomass gasification system 2 comprises a manifold system 16 to connect the second outlet 15 of the gasifier 4 with pipes 5 for the four combustion units 6 of the biomass gasification system 2. The biomass gasification system 2 is setup in such a way, that there is a route of transportation R of the gasifier product gas from the outlet 15 of the gasifier 4 through the manifold system 16 and the pipes 5 into inlets 18 of the combustion units 6. The highest or top points of these routes of transportation R is the manifold system 16 from where there is a decline W of the pipes 5 into the combustion units 6 in the direction of the route of transportation R and from where there is a decline through the manifold system 16 to the outlet 15 of the gasifier 4 towards the route of transportation R.

[0014] The gasifier 4 comprises a temperature sensor 19 to measure the temperature of the gasifier product gas in the upper area 12 of the gasifier 4. The gasifier 4 furthermore comprises moisturization means that are realized by a sprinkler system 20 arranged at the chip conveyor 8 to moisture the biomass in the chip conveyor 8. A control circuit 20 is connected to the temperature sensor 19 and the sprinkler system 20 and is arranged to

activate the sprinkler system 20 in case the measured temperature exceeds a maximum temperature stored in the control circuit 20. The appropriate maximum temperature to be stored in the control circuit might depend on different circumstances like for instance the kind of biomass fed into the gasifier or contents of the gasifier product gas allowed to be burned in the combustion unit.

[0015] During the gasification process in the gasifier 4 the moisture of the biomass (wood chips) is typically in a preferred range of 20-55%. The gasification product gas at the second outlet 15 of the gasifier 4 has to be kept in a temperature range of about 70 to 80 degrees Celsius. This temperature and other process parameters enable equilibrium between vaporisation and condensation of water and tar in the upper area of the updraft gasifier 4. The tar residues in the gasifier product gas are captured in moisture drops of nebular. This nebula consists of liquid tar dissolved in the water coming from the wood chips moisture. These moisture drops get in contact with the pipes 5 and condense on the inner walls of the pipes 5 and run along the pipes 5 towards the combustion units 6. With the moisture drops, the tar from the gasifier product gas is flushed away towards the combustion units 6 where it is burned residue-free together with the gasification product gas. The pipes 5 are insulated to avoid that too much of the moisture drops condensate on the inner walls of the pipes 5. This keeps the amount of condensate in a preferred range.

[0016] In case the temperature of the gasifier product gas exceeds the maximum temperature defined within the range of 75-100 degrees Celsius, the control circuit 21 activates the sprinkler system 20. As a result the sprinkler system 20 moistures the biomass in the chip conveyor 8 with steam or water droplets. This biomass with an increased moisture content is transported by the chip conveyor 8 into the gasifier 4 what increases the moisture content in the gasification process what reduces the temperature of the gasifier product gas by the cold due to evaporation.

[0017] As a result the advantage is achieved, that tar and dust residues in the gasifier product gas are kept in a status of nebula during the whole process what enables, that the amount of dust in the gasifier product gas that enters the combustion units 6 is reduced dramatically. This helps to reduce the dust in the emissions of the biomass gasification system 2. The biomass gasification system 2 therefore is characterized by a very low amount of dust in the emission which can be less than 20mg/m³ or even less than 10mg/m³. This makes the use of the biomass gasification system 2 outstanding environment-friendly.

[0018] The control circuit 21 deactivates the sprinkler system 20, in case a deactivation criteria is met. As this process to reduce the temperature of the gasifier product gas by the cold due to evaporation takes some time it has proven to be advantageous to use fixed time duration as deactivation criteria. As an example, the sprinkler system 20 could moisture the biomass in the chip conveyor

8 for a given time duration of e.g. 120 seconds or 5 minutes, while the chip conveyor transports the moistured chips into the gasifier 4. An alternative deactivation criteria would be, that the temperature of the gasifier product gas fell below a minimum temperature of e.g. 60 or 75 degrees Celsius.

[0019] A further deactivation criteria would be, that a moisture sensor attached to the gasifier to measure the moisture of the chips in the gasifier 4 exceeds a maximum moisture limit. The control circuit 21 could use only one of these deactivation criteria or two or more of these deactivation criteria to decide about when to deactivate the sprinkler system 20.

[0020] In another embodiment of the invention, the sprinkler system is mounted at the ceiling of the gasifier to moisten the biomass already in the gasifier. This solution has the advantage that the steam or water droplets from the sprinkler system immediately increase the humidity of gasifier product gas and the biomass in the gasifier. Apart from this additional advantage the same advantages are achieved with a gasifier of this embodiment as explained for the gasifier 4.

[0021] Furthermore it has proven to be advantageous to supply the water through the mechanical leveler of the gasifier.

[0022] The biomass gasification system 2 with the combustion units 6 may be used in the Stirling plant 1, but could be used in a heating system of a building as well. In both embodiments the combustion units 6 heat up a transfer medium (e.g. water or air). In the Stirling plant 1 this transfer medium is used to drive the Stirling engine 3 and in a heating system the transfer medium would be used to heat the radiators in one or more buildings. Combined systems may be used as well.

[0023] In a biomass gasification system where tar would be accumulated in the gasifier, the gasification process would be hampered or even stopped. It is therefore essential that the tar residues in the gasification product gas are not accumulated within the gasifier 4. Based on the fact that the pipes 5 that transport the gasification product gas from the valves 17 to the combustion units 6 are declined towards the combustion units 6, the tar residues are flushed away from the gasifier 4 towards the combustion units 6 and burned there. This avoids any maintenance work to remove accumulated tar from the biomass gasification system 2 as the tar is not accumulated in the system.

[0024] Without departing from the gist of the invention, the preferred temperature range could be in a different range of e.g. 60 to 100 degrees Celsius with maximum and minimum temperatures adapted to it

[0025] It has to be stated that instead of the conveyor 8, the gasifier could comprise a hydraulic piston or other means to transport the biomass through the first inlet into the gasifier.

Claims

1. Updraft gasifier (4) for a biomass gasification system (2) to generate gasifier product gas to be burned in a combustion unit (6), which gasifier (4) comprises:

- a first inlet (9) for biomass in the upper area (12) of the gasifier (4), and
- a first outlet (11) for ash in the lower area (13) of the gasifier (4), and
- a second inlet (14) for a gasification agent in the lower area (13) of the gasifier (4), and
- a second outlet (15) for the gasifier product gas in the upper area (12) of the gasifier (4),

characterized in, that the gasifier furthermore comprises:

- a temperature sensor (19) to measure the temperature of the gasifier product gas in the upper area (12) of the gasifier (4), and
- moisturization means (20) to moisten the biomass, and
- a control circuit (21) to activate the moisturization means (20) to moisten the biomass in case the temperature of the gasifier product gas exceeds a maximum temperature.

2. Updraft gasifier (4) of claim 1 **characterized in, that** the gasifier (4) comprises a conveyor (8) to transport the biomass through the first inlet (9) into the gasifier (4) and that the moisturization means (20) are arranged to moisten the biomass in the conveyor (8).

3. Updraft gasifier (4) of claim 1 **characterized in, that** the moisturization means (20) are arranged in the upper area (12) of the gasifier (4) to moisten the biomass in the gasifier (4).

4. Updraft gasifier (4) according to any of the preceding claims **characterized in, that** the control circuit (21) deactivates the moisturization means (20), if one or more of the following deactivation criteria are met:

- moisturization time limit reached;
- temperature of the generated gasifier product gas falls below a minimum temperature;
- moisture in the generated gasifier product gas exceeds a maximum moisture limit.

5. Updraft gasifier (4) of claim 4 **characterized in, that**

- the maximum temperature is about 100°C and preferred about 75°C;
- the minimum temperature is about 60°C and preferred about 75°C

6. Stirling plant (1) to generate heat and electricity from

biomass which plant (1) comprises at least one Stirling motor (3) to transform heat into electricity, **characterized in, that** the plant (1) furthermore comprises an updraft gasifier (4) in a biomass gasification system (2) to generate gasifier product gas to be burned in a combustion unit (6) according to any of the preceding claims to provide the heat to fuel the at least one Stirling motor (3). 5

7. Stirling plant (1) of claim 6 **characterized in, that** it comprises at least one pipe (5) to transport the gasifier product gas from the second outlet (15) of the gasifier (4) to an inlet (18) of the combustion unit (6), and that the at least one pipe (5) is declined (W) from the gasifier (4) to the combustion unit (6) to transport fractions of tar in the gasifier product gas towards the combustion unit (6), and preferred into the combustion unit (6). 10 15

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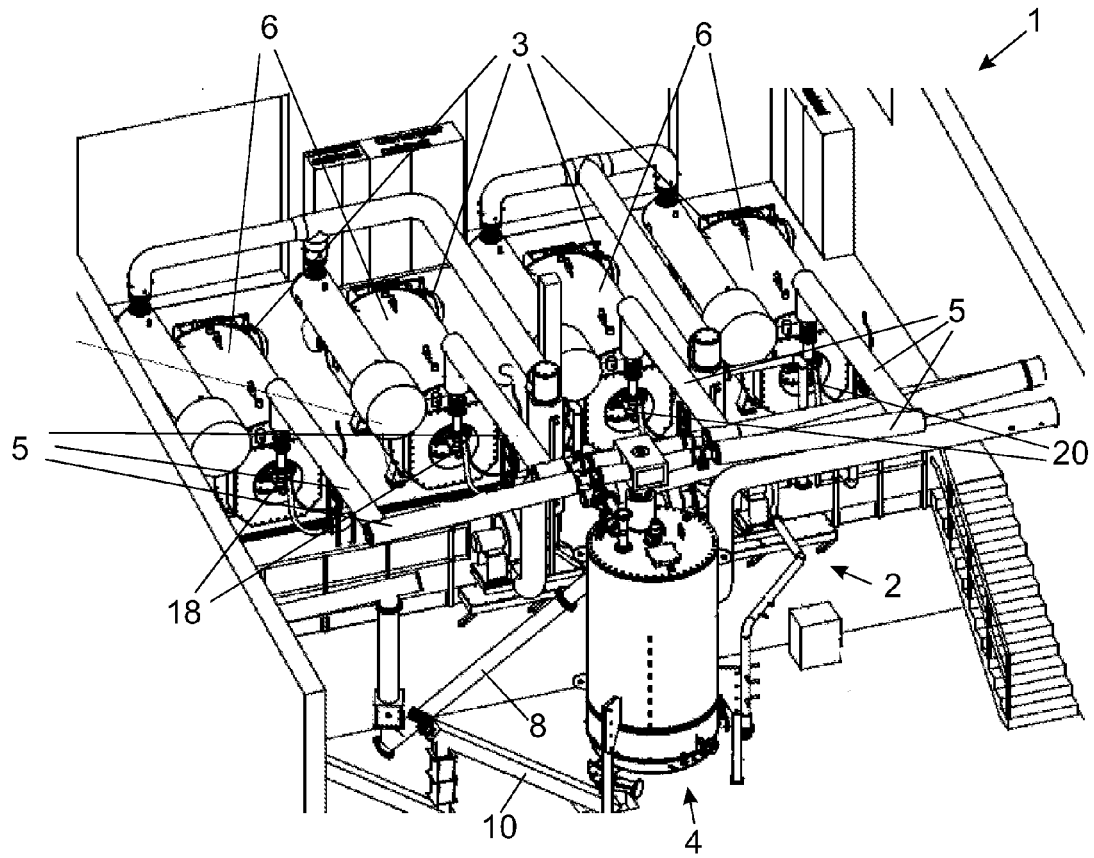


FIG.1

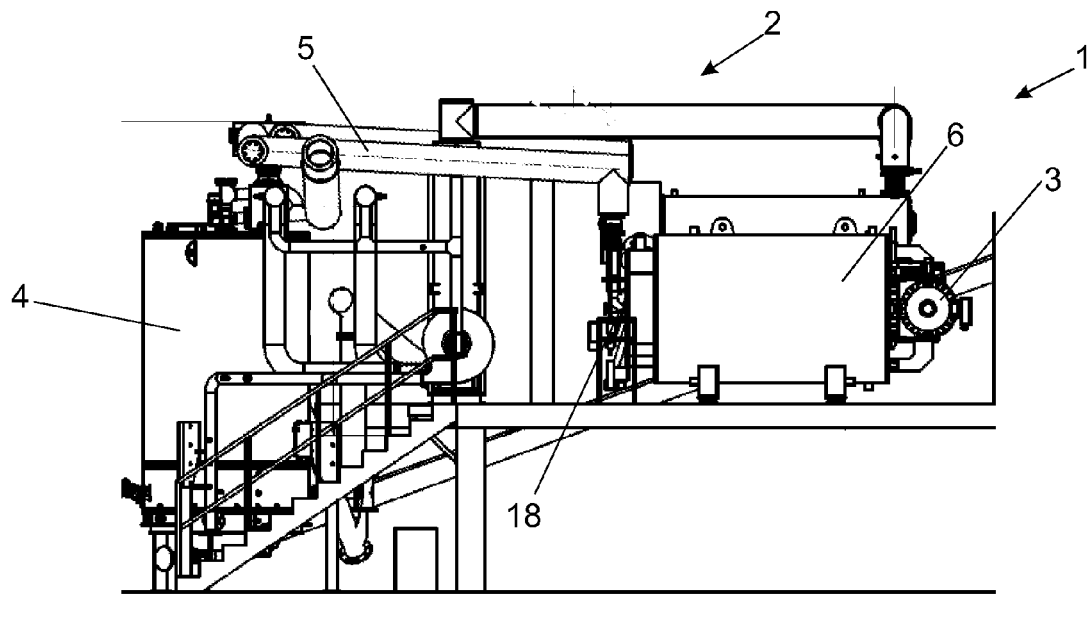


FIG.2

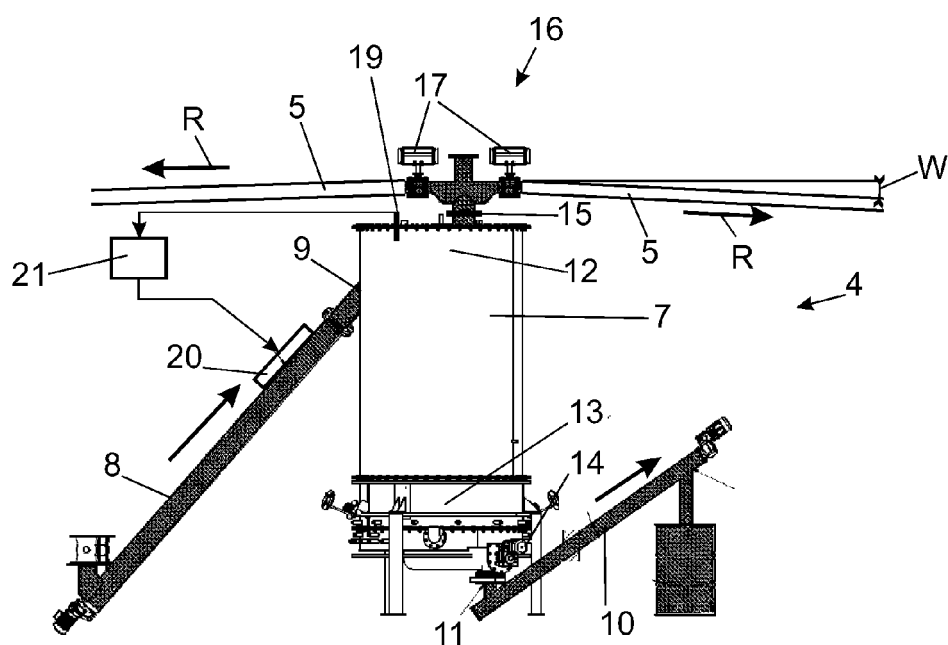


FIG.3



EUROPEAN SEARCH REPORT

Application Number
EP 11 17 0730

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
1 X	JP 2006 143983 A (MITSUI SHIPBUILDING ENG) 8 June 2006 (2006-06-08) * figures 1-14 * * abstract * * paragraphs [0002], [0032] - [0033] *	1,3-5 2	INV. C10J3/30
1 Y	WO 01/05910 A1 (NUOVA MECCANICA S R L [IT]; MORGANTINI GIAMPIERO [IT]; PELLEGRIN ROBER) 25 January 2001 (2001-01-25) * figure 2 * * claim 7 * * page 11, lines 1-10 *	2 1,3-5	
1 A	EP 0 137 461 A2 (FISCHER ERHARD) 17 April 1985 (1985-04-17) * figure 1 * * claims 1-8 * * page 3, lines 13-22 * * page 4, lines 17-27 *	1-5	
1 A	US 2006/112639 A1 (NICK PETER A [US] ET AL) 1 June 2006 (2006-06-01) * figures 1,2 *	1-5	
----- The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC) C10J
Place of search		Date of completion of the search	Examiner
Munich		28 October 2011	Lachmann, Richard
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			

EPO FORM 1503 03.02 (P04C01)



Application Number

EP 11 17 0730

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1-5

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).



**LACK OF UNITY OF INVENTION
SHEET B**

Application Number

EP 11 17 0730

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-5

Updraft gasifier having inlets and outlets for gases and solids entering and exiting the reactor further comprising a temperature control mechanism comprising a temperature sensor, moisturization means and a control circuit.

2. claims: 6, 7

Energy production plant comprising an updraft gasifier, a Stirling motor and a combustion unit.

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 11 17 0730

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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28-10-2011

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
JP 2006143983	A	08-06-2006	NONE	
WO 0105910	A1	25-01-2001	AU 4640699 A WO 0105910 A1	05-02-2001 25-01-2001
EP 0137461	A2	17-04-1985	NONE	
US 2006112639	A1	01-06-2006	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2007081296 A [0002] [0003]