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(54) Configuration for gasification and quenching

(57) Configuration (1) for gasification and quenching, comprising a vertical elongated gasification reactor (2) having a product gas outlet (3) at its upper end (4), fluidly connected to an upper end (5) of a vertically elongated quench vessel (6) by means of a duct (7), wherein the upper end (4) of the gasification reactor (2) is provided with a gas reversal chamber (8) having a gas outlet (9) connected to the duct (7) and wherein the duct (7) is connected with the upper end (5) of the quench vessel (6) at a lower elevation than the gas reversal chamber (8).

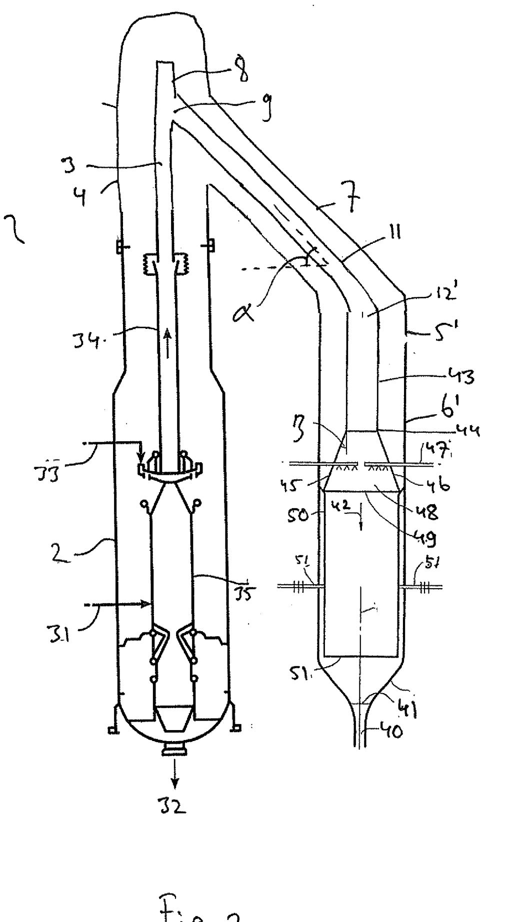

Fig. 2

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Description

Field of the invention

[0001] The invention relates to a configuration for gasification and quenching. The configuration comprises a vertical elongated gasification reactor having a product gas outlet at its upper end is fluidly connected to an upper end of a vertically elongated quench vessel by means of a duct.

Background of the invention

[0002] Such a configuration is known and described in WO-A-2007125046. This publication describes a gasification system having a gasification reactor and a synthesis gas cooling vessel. The gasification reactor has a pressure shell for maintaining a pressure higher than atmospheric pressure. Inside the pressure shell a gasification chamber is present wherein during operation the synthesis gas can be formed. Via a connecting conduit the gasification reactor is connected to the cooling vessel. In the cooling vessel the synthesis gas is cooled by contacting the gas with evaporating droplets of water. The connecting conduit as illustrated in the Figures of WO-A-2007125046 is either an upwardly straight conduit connecting the upper part of the gasification reactor with the cooling vessel or a bended conduit.

[0003] A disadvantage of the design of the connecting conduits is that the bended design of Figure 3 is constructively difficult to build due to the curved parts. The design of Figure 2 is disadvantageous because unwanted gas flowing regimes are found in the cooling vessel that negatively influences the cooling by the mist of water droplets.

[0004] It is an object of the present invention is to provide an improved configuration for gasification and quenching.

Summary of the invention

[0005] Configuration for gasification and quenching, comprising a vertical elongated gasification reactor having a product gas outlet at its upper end, fluidly connected to an upper end of a vertically elongated quench vessel by means of a duct, wherein the upper end of the gasification reactor is provided with a gas reversal chamber having a gas outlet connected to the duct and wherein the duct is connected with the upper end of the quench vessel at a lower elevation than the gas reversal chamber.

Brief description of the drawings

[0006]

Figure 1 shows a preferred embodiment for the configuration according to the present invention.

Figure 2 shows another preferred embodiment for the configuration according to the present invention.

Figure 3 illustrates how a configuration according to the state of the art will operate as calculated by means of Computational Fluid Dynamics.

Figure 4 illustrates how a configuration according to Figure 2 will operate as calculated by means of Computational Fluid Dynamics.

Detailed description of embodiments

[0007] The gasification reactor and the quench vessel are defined using terms in this description as upper, lower, downwardly and vertically. These terms relate to the orientation of the configuration according the invention when in use.

[0008] The gasification reactor is a vertical elongated gasification reactor having a product gas outlet at its upper end. An example of such a gasification reactor is described in the aforementioned WO-A-2007125046. Such gasification reactors are suited to gasify ash-containing feedstocks. In use a layer of molten slag will be present on the internal walls of the gasification reactor, wherein the molten slag slowly moves downwards to a lower slag outlet opening. The synthesis gas flows upwards to a higher gas outlet. The synthesis gas is thus separated from the slag before it is cooled. Thus gasification reactors are excluded which gave a quenching zone at their lower end in which quench zone synthesis gas and slag are reduced in temperature in the same cooling step.

[0009] In the gasification reactor a synthesis gas is obtained comprising for its majority of hydrogen and carbon monoxide. The feedstock is suitably an ash containing carbonaceous feedstock. Examples of such feedstocks are coal, coke from coal, coal liquefaction residues, petroleum coke, soot, biomass, and particulate solids derived from oil shale, tar sands and pitch. The coal may be of any type, including lignite, subbituminous, bituminous and anthracite.

[0010] In the gasification reactor gasification is carried out in a gasification chamber at a temperature in the range from 1200 to 1800 °C, preferably between 1400 and 1800 °C and at a pressure in the range from 1 to 200 bar, preferably between 20 and 100 bar, more preferably between 40 and 70 bar. Preferably the synthesis gas is partly cooled before it is fed to the quench vessel. The synthesis gas is preferably partly cooled by means of a gas or liquid quench as the gas leaves the gasification chamber. Preferably the synthesis gas entering the quench vessel has a temperature between 500 and 900 °C, more preferably between 600 and 900 °C. The synthesis gas will typically contain some residual ash particles, fly-ash, when an ash-containing feed is gasified.

[0011] In the quench vessel the synthesis gas is cooled from an elevated temperature to a lower temperature by contacting the synthesis gas with a suitable liquid quench medium. The temperature of the gas as it leaves the quench vessel is preferably between 200 and 600 °C and more preferably between 300 and 500 °C and even more preferably between 350 and 450 °C.

[0012] The quenching medium may be any liquid having the required cooling capacity. Non-limiting examples are a hydrocarbon liquid, a waste stream as obtained in a downstream process, which uses the synthesis gas as feedstock. Preferably the liquid comprises at least 50 wt% water. Most preferably the liquid is substantially comprised of water (i.e. > 95 vol%). In a preferred embodiment the wastewater, also referred to as black water, as obtained in a possible downstream synthesis gas scrubber is used as the quenching medium.

[0013] Contacting with the liquid quenching medium can be performed in different manners for which different types of quench vessels are preferably used. According to one method the synthesis gas is passed through a water bath via a diptube. According to another method droplets of liquid quench medium is injected into a stream of synthesis gas. Figures 1 and 2 will show suitable quench vessels for both methods.

[0014] When liquid quench medium is injected the temperature of said liquid is at most 50 °C below the bubble point at the prevailing pressure conditions at the point of injection, particularly at most 15 °C, even more preferably at most 10 °C below the bubble point. To this end, if the injected quenching medium is water, it usually has a temperature of above 90 °C, preferably above 150 °C, more preferably from 200 °C to 270 °C, for example 230 °C. The temperature will obviously depend on the operating pressure of the gasification reactor, i.e. the pressure of the raw synthesis gas as specified further below. Hereby a rapid vaporization of the injected quenching medium is obtained, while cold spots are avoided.

[0015] Further it is preferred that the quenching medium is injected in the form of a mist of fine liquid droplets. More preferably the mist comprises droplets having a diameter of from 50 to 200 μm, even more preferably from 50 to 150 μm. Preferably, at least 60 vol.% of the injected liquid is in the form of droplets having the indicated sizes.

[0016] To enhance quenching of the raw synthesis gas, the quenching medium is preferably injected with a mean velocity of between 10 and 60 m/s and more preferably between 20 and 50 m/s.

[0017] Injection is preferably performed by means of a nozzle or an arrangement of nozzles. More preferably an arrangement of more than one nozzles for atomisation and spraying liquid in a downwardly direction is used. With a downwardly direction is especially meant that the direction of the liquid as it is discharged from the nozzles is vertically downward. It is of course understood that the flow of quench medium as it is discharged from the nozzle will have a cone form and that the average direction of this cone will be the direction of the liquid as it is sprayed from the nozzle. The nozzle can be a hydraulic nozzle. Hydraulic nozzles require a high injection pressure of typically at least 40 bar above the pressure of the synthesis gas. This because when the pressure difference between the injection pressure and the pressure of the raw synthesis gas is lower, the droplets of in the injected mist may become too large. The latter may be at least partially offset by using a so-called twin fluid nozzle wherein an atomisation gas, which may e.g. be N_2, CO_2, steam or synthesis gas atomises the fluid into fine droplets. A preferred atomisation gas is synthesis gas as recycled from a downstream process step. Using atomisation gas has the advantage that the difference between injection pressure and the pressure of the raw synthesis gas may be reduced while achieving the same droplet size and velocity. Such twin-fluid nozzles are well known and can for example be obtained from Spraying Systems Co. Examples of suitable nozzles are described in US-A-5732885 and US-A-2004/0222317.

[0018] When the nozzle is a twin fluid nozzle it is preferred that the quenching medium is injected with an injection pressure of at least 5 bar above the pressure of the raw synthesis gas, preferably from at least 10 bar above the pressure of the raw synthesis gas and up to 20 bar above the pressure of the raw synthesis gas.

Detailed description of the Figures

[0019] Figure 1 shows a configuration (1) for gasification and quenching, comprising a vertical elongated gasification reactor (2) and a vertically elongated quench vessel (6). The gasification reactor (2) has a product gas outlet (3) at its upper end (4), fluidly connected to an upper end (5) of the quench vessel (6) by means of a duct (7). The upper end (4) of the gasification reactor (2) is provided with a gas reversal chamber (8) having a gas outlet (9) connected to the duct (7). The duct (7) is connected with the upper end (5) of the quench vessel (6) at a lower elevation than the gas reversal chamber (8). Preferably the duct (7) comprises a downwardly positioned straight tubular conduit (10). The straight tubular conduit (10) suitably comprises a co-axial inner conduit (11), wherein the inner conduit has a water-cooled wall, suitably a so-called membrane wall. The angle α between the horizon and the tubular conduit (10) is between 40 and 70°, and more preferably from 45 to 50°, lower angles are not advantageous because fly-ash may accumulate in conduit (11). Higher angles are not advantageous because the sharp curves the gas has to make results in a high risk of erosion.

[0020] The term membrane wall is commonly known and refers to a cooled wall arrangement. Such a wall is gas tight and comprises of an arrangement of interconnected conduits. Cooling is typically accomplished by evaporating cooling water. These conduits are fluidly connected via a common distributor to a supply for cooling medium and at their other ends fluidly connected to a common header to discharge used cooling medium.

[0021] The gasification reactor (2) is provided with a gasification chamber (35). Gasification chamber (35) is fluidly connected to a lower opening (32) for discharge of slag and fluidly connected at its upper end to a vertical transport conduit (34). Transport conduit (34) is provided at its lower end with an injection ring (33) to inject a quench gas or liquid to partly cool the hot synthesis gas as formed in the gasification chamber. The upper end of the vertical transport conduit is connected to gas reversal chamber (8). Gas reversal chamber (8) is suitably an in-line extension of vertical transport conduit (34), closed at its upper end and provided with an opening in its vertical walls, which opening fluidly connects with inner conduit (11).

[0022] The carbonaceous feed and an oxygen-containing stream are fed via lines (31) to the gasification chamber (35). In gasification chamber (35) a raw synthesis gas and a slag is obtained. To this end usually several burners (not shown) are present in the gasification chamber (35). The walls of the gasification chamber (35) and the walls of the transport conduit (34) are preferably water cooled, preferably by means of a membrane wall.

[0023] Figure 1 also shows that the quench vessel (6) is provided with an inlet (12) for gas at its upper end (5), and with an outlet (13) for cooled gas. The quench vessel (6) is provided at its upper end (5) with a first internal tubular wall part (16), which wall part (16) is fluidly connected to the inlet (12) for gas. The tubular wall part (16) is connected at its lower end (17) to a diptube (18) terminating in a water bath (19).

[0024] The internal tubular wall part (16) and the diptube (18) have a smaller diameter than the quench vessel (6) resulting in an upper annular space (21) between said internal tubular wall part (16) and the wall of quench vessel (6) and a lower annular space (22) between the diptube (18) and the wall of quench vessel (6). Annular space (21) and (22) are preferably gas tight separated by sealing (23) to avoid ingress of ash particles from space (22) into space (21).

[0025] The tubular wall part (16) preferably has a diameter, which is smaller than the diameter of the tubular diptube (18) at the outlet opening (17) of wall part (16). The tubular wall part (16) is oriented co-axial with the diptube (18) as shown in the Figure. The diptube (18) is open to the interior of the quench vessel (6) at its lower end (18a). This lower end (18a) is in fluid communication with a gas outlet (13) as present in the quench vessel wall (6a). The diptube (18) is partly submerged in a water bath (19).

[0026] Around the lower end of the diptube (18) a draft tube (27) is present to direct the syngas upwardly in the annular space (28) formed between draft tube (27) and diptube (18). At the upper discharge end of the annular space (28) deflector plate (27a) is present to provide a rough separation between entrained water droplets and the quenched syngas. Deflector plate (27a) preferably extends from the outer wall of the diptube (18). Preferably the lower part (26) of the diptube (18) has a smaller diameter than the upper part (25) as shown in Figure 1. This is advantageous because the layer of water as present on the inner wall of diptube (18) will increase in said lower end. Another result is that the annular area for the water bath (19) will increase. This is advantageous because it enables one to use a more optimized, smaller, diameter for quench vessel (6). The quench vessel (6) is further provided with an outlet (20) for water containing for example fly-ash.

[0027] The tubular wall part (16) is preferably formed by an arrangement of interconnected parallel arranged tubes resulting in a substantially gas-tight tubular wall running from a cooling water distributor to a header. The cooling of tubular wall part (16) can be performed by either sub-cooled water or boiling water. The walls of the diptube (18) are preferably of a simpler design, like for example a metal plate wall.

[0028] At the upper end of the diptube (18) a discharge conduit (30) is preferably present having an outflow opening for liquid water directed such that, in use, a film of water is achieved along the inner wall of the diptube (18). Discharge conduit (30) is connected to water supply conduit (29).

Figure 1 also shows preferred water spray nozzles (24) located in the diptube (18) to spray droplets of water into the syngas as it flows downwardly through the diptube (18). The nozzles (24) are preferably sufficiently spaced away in a vertical downward direction from the discharge conduit (30) to ensure that any non-evaporated water droplets as sprayed into the flow of syngas will contact a wetted wall of the diptube (18). Applicants have found that if such droplets would hit a non-wetted wall ash may deposit, thereby forming a very difficult to remove layer of fouling. It is preferred that the nozzles (24) are positioned in the larger diameter part (25) of the diptube (18). More residence time is achieved by the larger diameter resulting in that the water as injected has sufficient time to evaporate.

Figure 2 shows a configuration as in Figure 1 wherein the quench vessel is different. The reference numerals 2-4, 7-9, 11, α, 31-35 have the same meaning and same preferences as described for in Figure 1. The quench vessel (6') is provided with an inlet (12') for gas at its upper end (5'), an outlet (40) for cooled gas at its lower end (41) defining a pathway (42) for a product gas flow directed downwardly. The quench vessel (6') is provided at its upper end (5') with a first internal tubular wall part (43) which is fluidly connected to the inlet (12') for gas. The tubular wall part (43) is connected at its lower end (44) to a divergent conical part (45) having walls (46), which are inclined outwardly in the direction of the pathway (42) for gas. In the space (48), as enclosed by the divergent conical part (45), an arrangement of more than one nozzles (47) for atomisation and spraying a liquid quench medium in a downward direction into the pathway (42) for the gas flow is present.

[0029] The arrangement of more than one nozzles (47) for atomisation and spraying liquid in a downwardly direction may have any design which enables contacting of the synthesis gas flow and the liquid medium. Applicants have found a preferred design wherein the arrangement comprises of a number of radial disposed arms extending from the wall of the quenching vessel and through openings in the wall of the divergent conical part to a central position. The arms are provided with one or more downwardly directed nozzles. Preferably the minimal horizontal distance between the centre of the outlet opening of the nozzles and the wall of the divergent conical part is between 0.2 and 1 m.

[0030] Preferably from 4 to 15 arms are present. Each arm may suitably have from 3 to and including 10 nozzles. Preferably the nozzle closest to the central position has a slightly tilted main outflow direction between downwardly and to the central position. The arms are preferably present in one horizontal plane. Alternatively the arms may be present in different planes, for example in a staggered configuration. It is believed, without wishing to be bound to the following theory, that by providing the arrangement of more than one nozzle (47) at this location, the risk that ashes deposit on the wall is further reduced.

[0031] Because the synthesis gas contains a substantial amount of non-gaseous components it may be advantageous under these conditions to provide means for supplying a shielding gas around the nozzles. For the same reason the arms are provided with means to avoid or remove deposits to accumulate on top of the arms. Such means can be mechanical rapper means directly on the arms itself or on metal shields placed above said arm. Such means can also be acoustic cleaning means. Such means can also be blasting means to continuously or intermittently blast away any solid deposits or with which also remove any solid deposits. The shielding and/or blasting gas may be e.g. N_2, CO_2, steam or synthesis gas and is more preferably of the same source as the atomisation gas.

[0032] The first inner wall part (43) and/or the wall (46) of the divergent conical part (45) preferably has a water-cooled membrane wall design. The angle beta between the surface of the wall (46) of the divergent conical part (45) and the vertical axis is preferably between 3° to 30° and more preferably between 5° and 10°. The divergent conical part (45) is preferably followed at its lower end (49) by a second tubular inner wall (50) having a lower open end (51). With followed is here meant that both parts may optionally be fixed to each other to form a gas tight connection. The lower end (51) is in fluid communication with the outlet (40) for cooled gas.

[0033] The second tubular inner wall (50) may optionally be designed a membrane wall. Because the temperature conditions at that part of the quench vessel (6') are more moderate, a more simple design, suitably made from a high alloy steel plate, for this part is preferred. The first internal tubular wall part (43), divergent conical part (45) and second tubular inner wall (51) can be provided with one or more cleaning devices (51), which can be mechanical rappers, pneumatic blasters devices or acoustic cleaning devices.

[0034] The internal vessel dimensions which define the pathway (42) for gas flow are so chosen to achieve a certain minimal downward gas velocity of synthesis gas for a given design throughput. Preferably the gas velocity is at least 1 m/s when the gas passes the first internal tubular wall part (43).

[0035] The length of the second tubular inner wall (51) in the direction of the flow path for gas should be long enough to achieve the desired cooling after the quenching medium has been added in the upstream part. Preferably the ratio between the internal diameter of the second tubular inner wall and its length is between 1:1 and 1:6.

Claims

1. Configuration (1) for gasification and quenching, comprising a vertical elongated gasification reactor (2) having a product gas outlet (3) at its upper end (4), fluidly connected to an upper end (5) of a vertically elongated quench vessel (6) by means of a duct (7), wherein the upper end (4) of the gasification reactor (2) is provided with a gas reversal chamber (8) having a gas outlet (9) connected to the duct (7) and wherein the duct (7) is connected with the upper end (5) of the quench vessel (6) at a lower elevation than the gas reversal chamber (8).

2. Configuration according to claim 1, wherein the duct (7) comprises a downwardly position straight tubular conduit (10) wherein the angle α between the horizon and the tubular conduit (10) is between 40 and 70°.

3. Configuration according to claim 2, wherein the straight tubular conduit (10) comprises a co-axial inner conduit (11), wherein the inner conduit has a water-cooled membrane wall designed wall.

4. Configuration according to any one of claims 1-3, wherein the quench vessel (6) is provided with an inlet (12) for gas at its upper end (5), an outlet (13) for cooled gas, the quench vessel (6) being provided at its upper end (5) with a first internal tubular wall part (16), which wall part (16) is fluidly connected to the inlet (12) for gas and wherein tubular wall part (16) is connected at its lower end (17) to a diptube (18) terminating in a water bath (19).

5. Configuration according to any one of claims 1-3, wherein the quenching vessel (6) is provided with an inlet (12) for gas at its upper end (5), an outlet (40) for cooled gas at its lower end (41) defining a pathway (42) for a product gas flow directed downwardly, the quench vessel (6) being provided at its upper end (5) with a first internal tubular wall part (43) fluidly

connected to the inlet (12) for gas and wherein tubular wall part (43) is connected at its lower end (44) with a divergent conical part (45) having walls (46) which are inclined outwardly in the direction of the pathway (42) for gas, wherein an arrangement of more than one nozzle (47) for atomisation and spraying a liquid quench medium in a downward direction into the pathway (42) for the gas flow are present in the space (48) enclosed by the divergent conical part (45).

6. Vessel according to claim 5, wherein the first inner wall part (43) and/or the wall (46) of the divergent conical part (45) has a water-cooled membrane wall design.

7. Vessel according to any one of claims 5-6, wherein the angle beta between the surface of the wall of the divergent conical part and the vertical axis is between 3° to 30°.

8. Vessel according to any one of claims 5-7, wherein the divergent conical part (45) is followed at its lower end (49) by a second tubular inner wall (50) having a lower open end (51), which lower end (51) is in fluid communication with the outlet (40) for cooled gas.

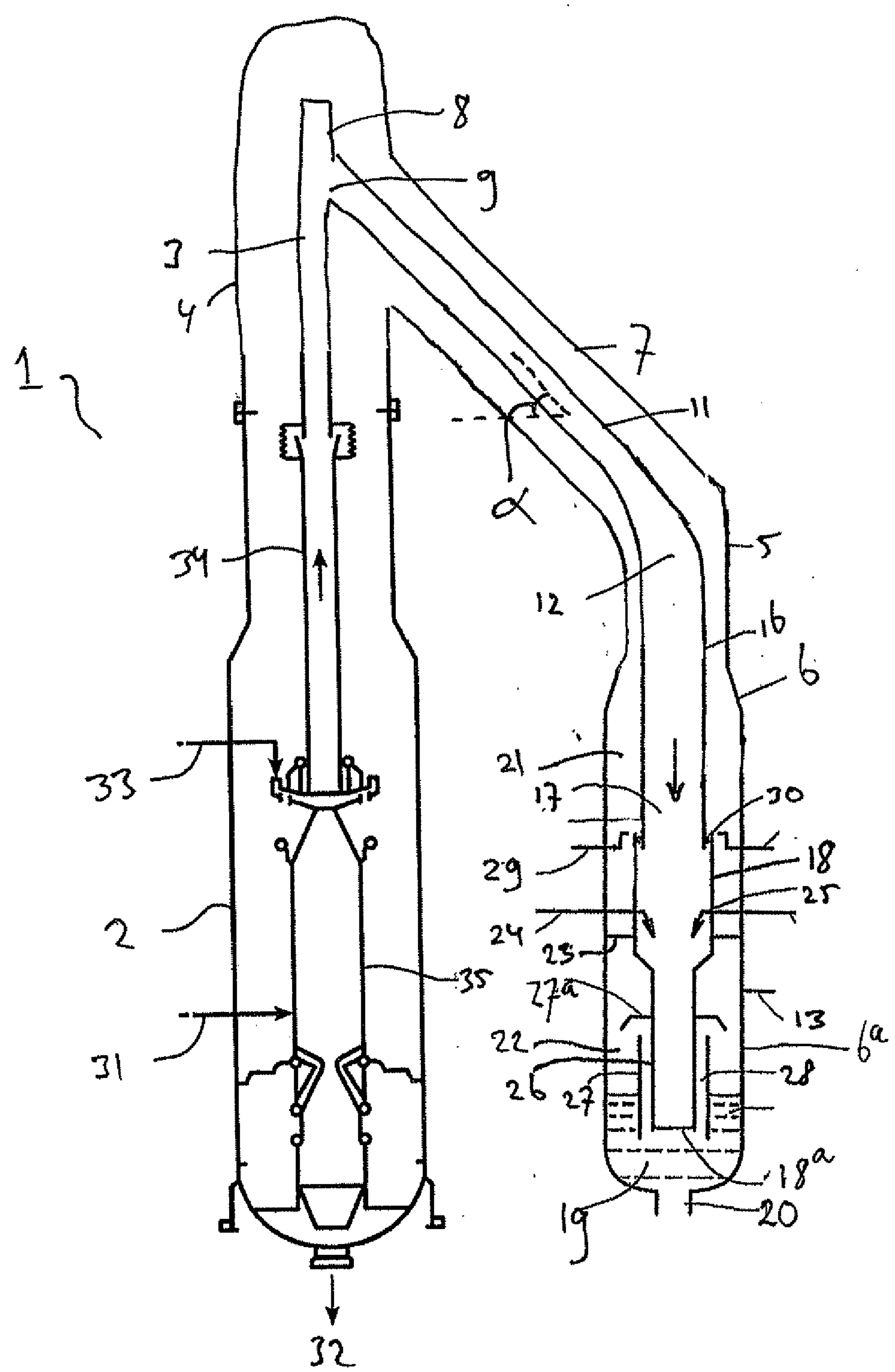
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Fig. 1

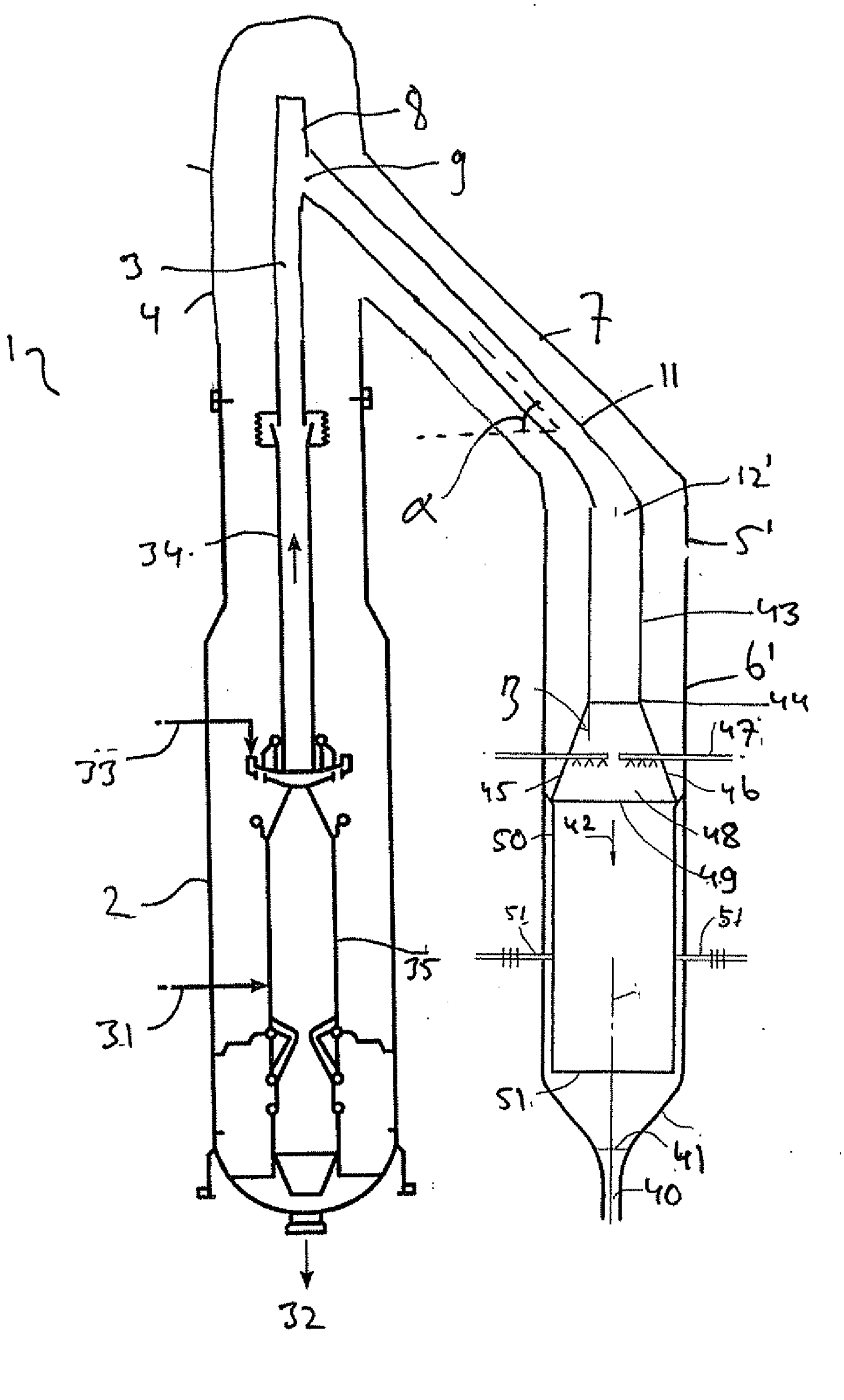
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Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 09 15 4336

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	17 September 2009	Lachmann, Richard

3

CATEGORY OF CITED DOCUMENTS

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