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Gasification method and device for producing synthesis gases by partial oxidation of fuels containing ash at elevated pressure and with quench-cooling of the crude gas

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Abstract

This invention relates to a method for the gasification of solid fuels such as bituminous coal, lignite coal, and petroleum coke in the flue stream with an oxidizing medium containing free oxygen, by partial oxidation at pressures between atmospheric pressure and 80 bar and at temperatures between 1,200 and 1,900 degrees, consisting of the process steps of pneumatic metering for pulverized fuel, gasification reaction in a reactor with cooled reactor chamber contour, quencher cooling, crude gas scrubbing, and partial condensation, wherein:

a pulverized fuel with a water content of < 10 wt.%, preferably < 2 wt.%, and a grain size of < 200 μm, preferably 100 μm, is fed to a pneumatic metering system, with the pulverized fuel from a bunker reaching at least one pressurized sluice and being subjected to a condensate-free gas at a pressure between atmospheric pressure and 80 bar, and is fed to a metering tank into the bottom of which is fed an inert gas, so that a fluidized bed with a density of 350 to 420 kg/m^3 is formed, which arrives at the burner of a reactor through the transport pipe,

the pulverized fuel fed through a transport pipe to the reactor, together with an oxidizing medium containing free oxygen, is subjected to partial oxidation in the

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reaction chamber with cooling shield, with the ash of the fuel being melted and transferred together with the hot gasification gas through the discharge device into the quenching chamber of the quenching cooler,

the quenching takes place at temperature between 180 and 260 °C,

the quenched steam-saturated crude gas is subjected to a crude gas scrubber or to a mechanical dust separator to cleanse it of entrained fines.

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COMPLETE SPECIFICATION

STANDARD PATENT

Applicant(s):

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Invention Title:

GASIFICATION METHOD AND DEVICE FOR PRODUCING SYNTHESIS GASES BY PARTIAL OXIDATION OF FUELS CONTAINING ASH AT ELEVATED PRESSURE AND WITH QUENCH-COOLING OF THE CRUDE GAS

The following statement is a full description of this invention, including the best method of performing it known to me/us:

Gasification method and device for producing synthesis gases by partial oxidation of fuels containing ash at elevated pressure and with quench-cooling of the crude gas

TECHNICAL FIELD

A gasification method and a device for implementing the method, are disclosed.

BACKGROUND ART

The autothermic flue stream gasification of solid, liquid, and gaseous fuels has been known in the technology of gas production for years. The ratio of fuel to gasification medium containing oxygen is chosen so that higher carbon compounds are completely cracked for reasons of synthesis gas quality into synthesis gas components such as CO and H_2, and the inorganic components are discharged as molten slag; see J. Carl, P. Fritz, NOELL-KONVERSIONSVERFAHREN, EF-Verlag für Energie- und Umwelttechnik GmbH, 1996, p. 33 and p. 73.

According to various systems used in industry, gasification gas and molten slag can be discharged separately or together from the reaction chamber of the gasification device, as shown in DE 197 131 A1. Either systems with refractory linings or cooled systems are used for the internal confinement of the reaction chamber structure of the gasification system; see DE 4446 803 A1.

EP 0677 567 B1 and WO 96/17904 show a method in which the gasification chamber is confined by a refractory lining. This has the drawback that the refractory masonry is loosened by the liquid slag formed during gasification, which leads to rapid wear and high repair costs. This wear process increases with increasing ash content. Thus such gasification systems have a limited service life before replacing the lining. Also, the gasification temperature and the ash content of the fuel are limited. Feeding in the fuel as a coal-water slurry causes considerable losses of efficiency - see C. Higman and M. van der Burgt, "Gasification", Verlag ELSEVIER, USA, 2003. A quenching or cooling system is also described in which the hot gasification gas and the liquid slag are carried off together through a conduit that begins at the bottom of the reaction chamber, and are fed into a water bath. This joint discharge of gasification gas and slag can lead to plugging of the conduit and thus to limitation of availability.

DE 3534015 A1 shows a method in which the gasification media, powdered coal and oxidizing medium containing oxygen, are introduced into the reaction chamber through multiple burners in such a way that the flames are mutually deflected. The gasification gas loaded with powdered dust flows upward and the slag flows downward into a slag-cooling system. As a rule, there is a device above the gasification chamber for indirect cooling utilizing the waste heat. However, there is the danger of plugging and/or erosion of the pipe system from the entrained dust. By separating the gasification gas and the slag, there is the danger of unwanted cooling of the slag and thus likewise the danger of plugging.

CN 200 4200 200 7.1 describes a "Solid Pulverized Fuel Gasifier", in which the powdered coal is fed in pneumatically and gasification gas and liquefied slag are introduced into a water bath through a central pipe for further cooling. This central discharge in the central pipe mentioned is susceptible to plugging that interferes with the overall operation, and reduces the availability of the entire system.

SUMMARY

According to a first aspect, there is provided a method for the gasification of solid fuels such as bituminous or lignite coals and petroleum coke in the flue stream with an oxidizing medium containing free oxygen, by partial oxidation at pressures between atmospheric pressure and 80 bar, and at temperatures between 1,200 and 1,900 degrees, consisting of the process steps of pneumatic metering for pulverized fuel, gasification reaction in a reactor with cooled reaction chamber contour, quench cooling, crude gas scrubbing, and partial condensation, wherein:

- a pulverized fuel with a water content < 10 wt.%, preferably < 2 wt.%, and a grain size of < 200 μm, preferably 100 μm, is fed to a pneumatic metering system, with the pulverized fuel from a bunker reaching at least one pressurized sluice and being subjected to a pressure between atmospheric pressure with a condensate-free gas and fed to a metering tank, into the bottom of which an inert gas is introduced so that a fluidized bed with a density of 350 to 420 kg/m^3 is produced, which passes through transport pipes to the burner of a reactor,

the pulverized fuel fed through a transport pipe to the reactor is subjected to partial oxidation together with an oxidizing medium containing free oxygen in the reaction chamber with cooling shield, with the ash of the fuel being melted and transferred together with the hot gasification gas through the discharge device into the quenching chamber of the quenching cooler,

- the quenching takes place at temperatures between 180 and 260 °C,

- the quenched steam-saturated crude gas is subjected to a crude gas scrubber or a mechanical dust separator to cleanse it of entrained fines.

To achieve long operating times, the pressurized jacket of the gasification reactor has to be protected reliably against the action of crude gas and against the high gasification temperatures of 1200 - 1900 °C. This is done by confining the reaction or gasification chamber with a cooled tubular shield that is hung in the pressurized jacket. The annular gap between tubular shield and pressurized jacket is flushed.

The fuel is fed to the head of the reactor in pulverized form through burners, using a pneumatic system by the flow transport principle. The crude gas leaves the gasification chamber together with the liquefied slag at the bottom of the reactor and is then cooled to a saturated state by injecting water, and is then freed of entrained fines. The scrubbed crude gas is then fed to further treatment steps.

In one embodiment the method consists of metered infeed of fuel, gasification reactor, quencher, and gas scrubber, to produce gases containing CO and H_2 by partial oxidation of dust-like fuels containing ash with a gasification medium containing free oxygen, at high temperatures and elevated pressure.

In embodiments of the gasification method for the gasification of solid fuels containing ash with an oxidizing medium containing oxygen, in a gasification chamber designed as a flue stream reactor, at pressures between atmospheric pressure and 80 bar, in which the reaction chamber contour is confined by a cooling system, with the pressure in the cooling system always being chosen to be higher than the pressure in the reaction chamber, may have the following features:

The fuel, e.g. bituminous coal or lignite coal, is dried and pulverized to a grain size of < 200 μm, preferably < 100 μm, and is sent through an operational bunker to a pressurized sluice, in which the dust-like fuel is brought to the desired gasification pressure by feeding in a non-condensable gas such as N_2 or CO_2. This is between atmospheric pressure and 80 bar, preferably 25 to 45 bar. Different fuels can be used at the same time. By placement of multiple pressurized sluices, they can be filled and pressurized alternately. The pressurized dust then goes to a metering tank in the bottom of which a very dense fluidized bed is produced by similarly feeding in a non-condensable gas; one or more transport pipes are immersed into the bed and open into the burners of the gasification reactor. One or more burners can be used. The fluidized dust is caused to flow through these lines from the metering tank to the burners by applying a pressure differential. The amount of flowing pulverized fuel can be measured, regulated, and monitored by measurement devices and monitors. In one embodiment the pulverized fuel may be mixed with water or oil and then can be fed to the burner of the gasification reactor as a slurry. An oxidizing medium containing free oxygen can be fed to the burners at the same time, and the pulverized fuel can be converted into crude synthesis gas by partial oxidation. The gasification takes place at temperatures between 1,200 °C and 1,900 °C. The reactor is equipped with a cooling shield that consists of water-cooled pipes welded gas-tight. The hot crude synthesis gas leaves the gasification chamber together with the liquid slag formed from the fuel ash, and arrives at a quenching chamber in which the gas can be cooled to the condensation point by spraying in water, at which point it is saturated with steam. Depending on the pressure, this saturation temperature is 180-260 °C. At the same time, the slag can be converted to the granular state. The quenching chamber can be an open area with no internals, to prevent deposition of slag or of dust entrained by the crude gas. The quenching water can be introduced into the quenching chamber through nozzles that are located directly on the jacket. The granulated slag can be discharged from the quenching chamber together with excess water through a slag sluice, and can be depressurized. There can be one or more slag discharges. The crude gas saturated with steam, which leaves the quenching chamber from the side at 180-260 °C, is then freed of entrained dust. One or more gas outlets can be provided. For this purpose, the crude gas can be first sent to a crude gas scrubber operated at process pressure, which is suitably a Venturi scrubber. The entrained dust can then be thereby removed down to a grain size of about 20 µm. This degree of purity may still inadequate for carrying out subsequent catalytic processes, for example crude gas conversion. It also has to be considered that salt mists can also be entrained in the crude gas, which may have detached from the powdered fuel during gasification and may be are carried off with the crude gas. To remove both the fines < 20 µm and the salt mists, the scrubbed crude gas can be fed to a condensation step in which the crude gas can be chilled indirectly by 5 °C to 10 °C. Water can then be condensed from the crude gas saturated with steam, which may absorb the described fine dust and salt particles. The condensed water containing the dust and salt particles can then be separated in a following separator. The crude gas purified in this way can then be fed directly, for example, to a crude gas converter or desulfurization system.

It would be advantageous if at least some provided a gasification method and a device that takes into account the different ash contents of fuels and has high availability.

BRIEF DESCRIPTION OF THE DRAWINGS

Notwithstanding any other forms which may fall within its scope, preferred forms of the method and device will now be described, by way of example only, with reference to the accompanying drawings. The Figures show:

Figure 1: Shows a block diagram of one embodiment of the proposed method;

Figure 2: Shows an embodiment of a metering system for pulverized fuel; and

Figure 3: Shows an embodiment of a gasification reactor with quenching cooler.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

Referring to the drawings 320 tons/hour of bituminous coal with a composition of

C 71.5 wt.%
H 4.2 wt.%
O 9.1 wt.%
N 0.7 wt.%
S 1.5 wt.%
Cl 0.03 wt.%,

an ash content of 11.5 wt.%, and a moisture content of 7.8 wt.%, is to be gasified at a pressure of 40 bar. The calorific value of the coal is 25,600 kJ/kg. The gasification takes place at 1,450 °C. 215,000 m^3 i. H./h of oxygen is needed for the gasification. The coal is first fed to a state-of-the-art drying and grinding unit in which the water content is reduced to < 2 wt.%. The grain size range after grinding is between 0 and 200 μm, and the amount of dried and ground pulverized fuel is 300 tons/hour. In accordance with Figure 1, the ground pulverized fuel is fed to the metering system 1.2, which is shown in Fig. 2. The pulverized fuel then is sent through the transport line 1.5 into the supply bunker 1.1 and is fed alternately to the pressurized sluices 1.2. The pulverized fuel is suspended in an inert gas such as nitrogen, for example, which is introduced through the line 1.6. After suspension, the pressurized pulverized fuel is fed to the metering tank 1.3. The pressurized sluice 1.2 is depressurized through the line 1.7 and can then be loaded again with pulverized fuel. There are three pressurized sluices that are alternately filled and depressurized. According to Fig. 3, three gasification reactors, each with a metering system, are provided for the gasification of 300 tons/hour of pulverized fuel. A dense fluidized bed is produced in the bottom of the metering tank 1.3, in which are immersed one or more dust transport lines 1.4, by feeding in a dry inert gas through the

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line 1.8 in an amount of 40,000 m^3 i. H./h, likewise nitrogen, for example, that serves as the transport gas.

In this example, three transport lines are provided in each case. The amount of pulverized fuel flowing in the transport line 1.4 is monitored, measured, and regulated in the system 1.9, and is fed to the burner of the gasification reactor 2 in Fig. 1 or Fig. 3. The loading density is 250-420 kg/m^3. The gasification reactor 2 is explained in further detail in Fig. 3. The pulverized fuel flowing through the transport lines 1.4 to the gasification reactor, 300 tons/hour, is subjected to partial oxidation at 1,450 °C in the gasification chamber 2.3 together with the oxygen in the amount of 215,000 m^3 i. H./h flowing in through the line 2.1, with 596,000 m^3 i. H./h of crude gas being formed, with the following composition:

H_2	20.8	vol.%
CO	71.0	vol.%
CO_2	5.6	vol.%
N_2	2.3	vol.%
NH_3	0.003	vol.%
HCN	0.002	vol.%
H_2S	0.5	vol.%
COS	0.07	vol.%

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The gasification chamber 2.3 is confined by a cooling shield 2.4 that consists of a water-cooled tube system welded gas-tight. The crude gas together with the liquid slag flows through the discharge opening 2.5 into the quenching cooler 3 (Fig. 1). The quenching cooler 3, connected rigidly to the gasification reactor 2 (Fig. 1), is shown in Fig. 3. It consists of a quenching chamber 3.1 made as an open space with no internals, into which water is sprayed through one or more rows of nozzles 3.2 and 3.3 to cool the hot crude gas. Condensate that occurs during the cooling of the crude gas in following system components is generally used to conserve fresh water. The amount of quenching water is about 500 m^3/h. The crude gas saturated at 217 °C has a steam fraction of 57 vol.% at the outlet 3.4 from the quenching chamber. The slag is collected in a water bath 3.5 in the bottom of the quenching tank and is periodically discharged through the outlet 3.6. A wear shell 3.7 is provided to protect the pressurized jacket from erosion and corrosion.

The crude gas leaving the quenching chamber 3.1 through the outlet 3.4 in Fig. 3 then reaches the crude gas scrubber 4 in Fig. 1, designed as a Venturi scrubber, and is subjected to about 100 m^3/h of wash water. Contained solids are removed from the wash water in the usual way and it is fed back again to the Venturi scrubber. To remove fines < 20 μm in size and salt mists not separated in the Venturi scrubber, the water-washed crude gas is subjected to partial condensation 5 according to Fig. 1, with the crude gas being chilled indirectly from 217 °C to 211 °C. The finest dust and salt particles are taken up by the steam condensing during the chilling and thus removed from the crude gas. The crude gas scrubber 4 and the partial condensation 5 to remove dust can be replaced by a separation step operating in wet or dry mode, in which the crude gas leaving the quenching chamber 3.1 is fed to a mechanical cleansing step, for example a centrifugal separator or a multiple tube filter. The crude gas cleansed of solids then has the following composition:

H_2	9.5	vol.%
CO	31.2	vol.%
CO_2	2.6	vol.%
N_2	1.1	vol.%
NH_3	0.001	vol.%
HCN	0.001	vol.%
H_2S	0.200	vol.%
COS	0.03	vol.%
H_2O	54.60	vol.%

The purified wet crude gas amounts to 1,320,000 m^3 NTP/h. It can be fed directly to a crude gas converter or other treatment steps.

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A reference herein to a prior art document is not an admission that the document forms part of the common general knowledge in the art in Australia.

In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word "comprise" or variations such as "comprises" or "comprising" is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

List of reference symbols used

1. Pneumatic metering system for pulverized fuel
1.1 Bunker
1.2 Pressurized sluice
1.3 Metering tank
1.4 Transport line
1.5 Transport line for pulverized fuel
1.6 Line for inert gas into 1.2
1.7 Pressure relief line
1.8 Line for inert gas into 1.3
1.9 Monitoring system
2. Reactor
2.1 Line for oxygen
2.2 Burner
2.3 Gasification chamber
2.4 Cooling shield
2.5 Discharge opening
3. Quenching cooler
3.1 Quenching chamber
3.2 Nozzle into 3
3.3 Nozzle into 3
3.4 Outlet from 3.1
3.5 Water bath
3.6 Discharge flow

3.7 Wear shell

4. Crude gas scrubber

5. Partial condensation

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CLAIMS:

1. A method for the gasification of solid fuels such as bituminous or lignite coals and petroleum coke in the flue stream with an oxidizing medium containing free oxygen, by partial oxidation at pressures between atmospheric pressure and 80 bar, and at temperatures between 1,200 and 1,900 degrees, consisting of the process steps of pneumatic metering for pulverized fuel, gasification reaction in a reactor with cooled reaction chamber contour, quench cooling, crude gas scrubbing, and partial condensation, wherein:

- a pulverized fuel with a water content < 10 wt.%, preferably < 2 wt.%, and a grain size of < 200 μm, preferably 100 μm, is fed to a pneumatic metering system, with the pulverized fuel from a bunker reaching at least one pressurized sluice and being subjected to a pressure between atmospheric pressure with a condensate-free gas and fed to a metering tank, into the bottom of which an inert gas is introduced so that a fluidized bed with a density of 350 to 420 kg/m^3 is produced, which passes through transport pipes to the burner of a reactor,

the pulverized fuel fed through a transport pipe to the reactor is subjected to partial oxidation together with an oxidizing medium containing free oxygen in the reaction chamber with cooling shield, with the ash of the fuel being melted and transferred together with the hot gasification gas through the discharge device into the quenching chamber of the quenching cooler,

- the quenching takes place at temperatures between 180 and 260 °C,

- the quenched steam-saturated crude gas is subjected to a crude gas scrubber or a mechanical dust separator to cleanse it of entrained fines.

2. The method as claimed in claim 1, wherein the gas is introduced into the pulverized fuel at a pressure between 25 and 45 bar.

3. The method as claimed in claim 1 or 2, wherein the inert gas nitrogen is fed in as the condensate-free gas.

4. The method as claimed in any one of the preceding claims, wherein the crude gas scrubber is a single- or multiple-stage Venturi scrubber.

5. The method as claimed in claim 4, wherein the Venturi scrubber is supplied with fresh water or recycled condensates that are formed in the cooling of the gas.

6. The method as claimed in any one of the preceding claims, wherein the water-scrubbed crude gas is next subjected to partial condensation with indirect cooling, whereby the crude gas is cooled down by a slight temperature differential of 0 to 15 degrees C, to separate fines and entrained salt mists.

7. The method as claimed in claim 6, wherein the water droplets separated during the partial condensation are separated by deposition from the crude gas.

8. The method as claimed in any one of the preceding claims, wherein the fuel ash is cooled directly with water and its granulate is collected in the bottom of the quenching chamber and is let out through an outlet.

9. The method as claimed in any one of the preceding claims, wherein the fuel is supplied to the reactor as a fuel-in-water slurry.

10. The method as claimed in any one of claims 1 to 8, wherein the fuels are fed to the gasification reactor through one or more burners.

11. The method as claimed in any one of the preceding claims, wherein the granulated slag is discharged through one or more outlets from the quenching chamber.

12. The method as claimed in any one of the preceding claims, wherein the quenched crude gas leaves the quenching chamber through one or more gas outlets.

13. The method as claimed in any one of the preceding claims, wherein one or more varieties of coal are gasified at the same time.

14. The method as claimed in any one of the claims, wherein the volume of the pulverized fuel stream is measured, monitored, and regulated in the transport pipe.

15. A device for implementing the method as claimed in any one of the preceding claims wherein:

a pneumatic metering system for pulverized fuel, a gasification reactor with cooled reaction chamber contour, a quenching cooler, a crude gas scrubber, and a partial condenser that are connected in series, with the pulverized fuel being fed through lines to a bunker whose outlet opens into at least one pressurized sluice, into which open a line for inert gas and a line for depressurized gas, with the discharge from the pressurized sluice leading to a metering tank in the bottom of which there is a line for inert gas, and into the top of which a transport line with fluidized fuel leads to a reactor,

- a reactor for the gasification of the supplied pulverized fuel with an oxidizing medium containing free oxygen, consisting of the transport pipe for the fluidized fuel and a line for the oxidizing medium that are fed by means of burners into the reaction chamber, which consists of a cooling shield consisting of water-cooled pipes welded gas-tight, and a discharge device into a quenching cooler,
- a quenching cooler with no internals, in which nozzles are arranged in one or more nozzle rings, through which the necessary quenching water is sprayed in, with the nozzles ending flush with a wear shell made of metal that is placed to protect the pressurized jacket of the reactor, the water bath, the outflow, and an outlet,
- a dust separator located at the outlet of the quenching cooler.

16. The device as claimed in claim 15, wherein the dust separator represents a crude gas scrubber followed by a partial condensation system or a mechanical cleansing stage such as a centrifugal separator or a membrane filter.

17. The device as claimed in claim 15, wherein there are two pressurized sluices in parallel with one another.

18. The device as claimed in any one of claims 15 to 17, wherein three transport pipes transport fluidized pulverized fuel to the burner of the reactor.

19. The device as claimed in any one of claims 15 to 18, wherein the stream of pulverized fuel in the transport pipe is monitored, measured, and regulated by a pressure gauge and/or a flow volumeter.

20. The device as claimed in any one of claims 15 to 19, where in a single- or multiple-stage Venturi scrubber is used for the crude gas scrubber.

21. The device as claimed in any one of claims 15 to 20, wherein the crude gas scrubber triggers a crude gas converter or is followed by a desulfurization system.

22. A method for the gasification of solid fuels substantially as herein described with reference to the accompanying drawings.

23. A device for the gasification of solid fuels substantially as herein described with reference to the accompanying drawings.

Fig. 1

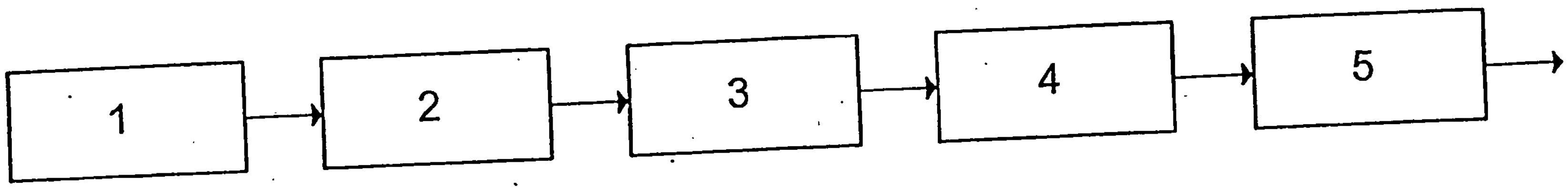

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Fig. 2

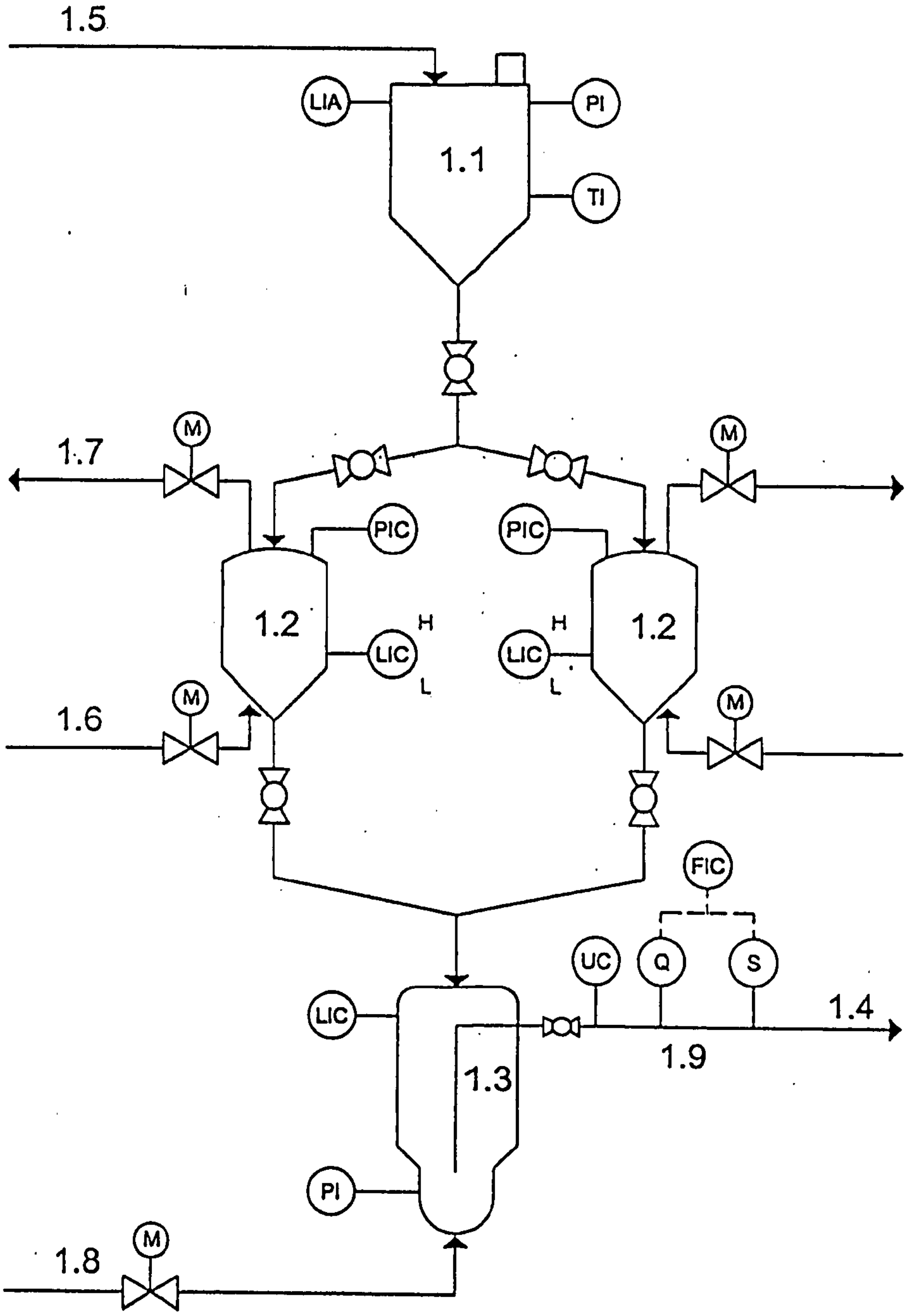

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Fig. 3