(19)

LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère de l'Économie

(11) N° de publication : **LU504708**

(12) **BREVET D'INVENTION** **B1**

(21) N° de dépôt: LU504708

(22) Date de dépôt: 10/07/2023

(51) Int. Cl.:
C10B 39/02, F23G 7/06

(30) Priorité:

(43) Date de mise à disposition du public: 10/01/2025

(47) Date de délivrance: 10/01/2025

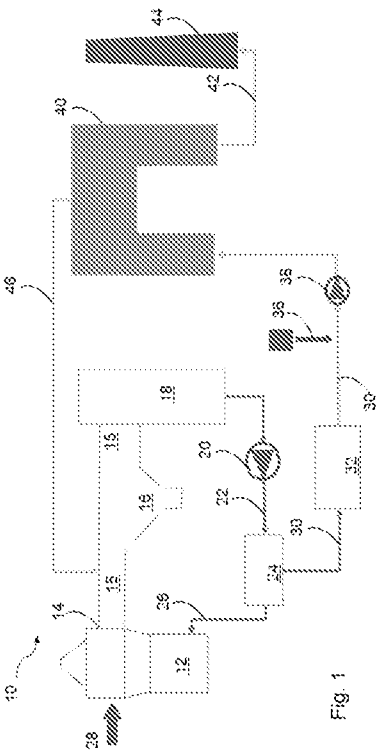
(73) Titulaire(s):
PAUL WURTH S.A. – 1122 Luxembourg (Luxembourg)

(72) Inventeur(s):
FABBRI Andrea – Italy, CALCAGNO Riccardo – Italy, GIOVANNINI Matteo – Italy

(74) Mandataire(s):
OFFICE FREYLINGER S.A. – L-8001 STRASSEN (Luxembourg)

(54) **Coke dry quenching plant and method for coke dry quenching and gas treating.**

(57) A coke dry quenching plant 10 and a method for coke dry quenching and off-gas treating, wherein the coke dry quenching plant 10 comprises: a cooling chamber 12 for cooling hot coke down to a predefined temperature; an off-gas conduct 15 for conducting the gas from an off-gas outlet 14 of the cooling chamber 12 to a heat recovery apparatus 18; a first dedusting unit 16 for dedusting the gas, wherein the first dedusting unit 16 is arranged in the off-gas conduct 15 downstream of the cooling chamber 12 and upstream of the heat recovery apparatus 18; the heat recovery apparatus 18 being configured to cool the gas down to a predefined first temperature range; a first fan unit 20 arranged downstream of the heat recovery apparatus; wherein the coke dry quenching plant further comprises a sub- economizer unit 24 arranged downstream of the first fan unit 20 and connected to the cooling chamber 12 via a process cooling gas conduct 26 and wherein the sub- economizer unit 24 is connected to a regenerative thermal oxidizer 40 via an excess gas conduct 30; wherein the sub-economizer unit 24 and/or the process cooling gas conduct and/or the excess gas conduct is/are configured to distribute or split the gas into the process cooling gas conduct 26 and/or the excess gas conduct 30.



COKE DRY QUENCHING PLANT AND METHOD FOR COKE DRY QUENCHING AND GAS TREATING

Technical field

[0001] The present invention generally relates to a coke dry quenching plant and a method for coke dry quenching and gas treating.

Background Art

[0002] In order to produce coke for a (blast) furnace or any other application, coal is subjected in a coke oven (battery) to temperatures of approximately 1400°C to 1000°C, whereby said coal is subjected a dry distillation procedure (or also "carbonization"). After the generation of hot coke within the coke oven, the coke is transferred to a coke quenching plant. The most common quenching techniques are based on coke water/wet quenching (CWQ) or coke dry quenching (CDQ).

[0003] In particular coke dry quenching permits that the hot coke is quenched from approximately 1100 °C down to 180 °C. Coke dry quenching is considered advantageous because it produces relatively dry coke with a relatively small amount of moisture, which is considered particularly advantageous in cases coke is to be fired within a blast furnace plant. A further advantage is a significantly lower water consumption in comparison to coke water quenching processes.

[0004] In addition, coke dry quenching also allows to recover energy whilst equivalent carbon dioxide (CO_2) emissions are saved.

[0005] During coke dry quenching, several gases, respectively a gas mixture, is formed. This gas mixture usually comprises considerable varying amounts of hydrogen (H_2) and carbon monoxide (CO). In the following, this gas mixture will be generally referred to as "gas" or "excess gas". This gas is also sometimes referred to as "lower bleeder gas". In order to keep coke dry quenching process under stable operating conditions, it is necessary to allow a continuous gas extraction from the cooling gas ducts of a coke dry quenching plant. This may be achieved, for example, via a chimney that guides the gas towards the atmosphere.

[0006] However, in order to minimize the emissions of said gases and comply to local legal environmental requirements, it is generally necessary to provide for a post-combustion of the formed gases. Yet, such a post-combustion of the gases used and/or generated in the cooling chamber may not be performed entirely or merely incompletely within a common coke quenching plant.

Technical problem

[0007] It is an object of the present invention to provide for an enhanced coke dry quenching plant and coke dry quenching method allowing to treat the gases generated during quenching. This problem is solved by the subject-matter of the independent claims.

General Description of the Invention

[0008] In order to achieve the above-mentioned object, the present invention proposes, in a first aspect, a coke dry quenching plant for quenching coke and for treating an off-gas therefrom, wherein the coke dry quenching plant comprises: a cooling chamber (configured) for cooling hot coke down to a predefined temperature; an off-gas conduct (configured) for conducting the off-gas from an off-gas outlet of the cooling chamber to a heat recovery apparatus; a first dedusting unit (configured) for dedusting the off-gas, wherein the first dedusting unit is arranged in the off-gas conduct downstream of the cooling chamber and upstream of the heat recovery apparatus, the heat recovery apparatus being configured for cooling the off-gas down to a predefined first temperature range; and a first fan unit arranged downstream of the heat recovery apparatus. The coke dry quenching plant further comprises a sub-economizer unit configured to cool the off-gas down to a predefined second temperature range and arranged downstream of the first fan unit, wherein the sub-economizer unit is connected to (an inlet of) the cooling chamber via a process cooling gas conduct for providing process cooling gas to the cooling chamber and wherein the sub-economizer unit is connected to a regenerative thermal oxidizer via an excess gas conduct for providing excess gas to the regenerative thermal oxidizer, and wherein the sub-economizer unit (itself) and/or the process cooling gas conduct and/or the excess gas conduct (to the regenerative thermal oxidizer) is/are configured for (controllably) distributing the process cooling gas into the process cooling gas conduct or the excess gas conduct or into both (i.e. for controllably splitting the gas between the process cooling gas conduct and the excess gas conduct).

[0009] The proposed coke dry quenching plant and method advantageously allow to perform an excess gas treatment before remaining components of the gas are released into the atmosphere. Moreover, the treatment is performed whilst the amount of energy recovered is advantageously maximized.

[0010] Due to the use of a regenerative thermal oxidizer, the proposed coke dry quenching plant and method further allow to reduce the amount of otherwise required additional combustible gas (for example natural gas or coke oven gas). Indeed, in common prior art processes, such additional combustible gas is necessary for performing a post-combustion treatment. Hence, operational costs of the plant (operated) according to the present invention are also significantly reduced.

[0011] In addition, the proposed coke dry quenching plant and/or the method may easily be adapted to already existing coke dry quenching plants in case retrofits are carried out.

[0012] The proposed coke dry quenching plant and method also allow to provide for an off-gas treatment that is applicable to a continuous flow of (excess) gas from the cooling chamber of a CDQ plant. Due to the proposed coke dry quenching plant and method, the continuously flowing excess gas obtained from the off-gas of the cooling chamber can be treated whilst having a particularly high flowrate (in comparison to known processes and plants) within a range e.g. of about 40 Nm^3/T to about 240 Nm^3/T coke quenched, such as from about 50 Nm^3/T to about 200 Nm^3/T coke quenched (Nm^3 = normal cubic meter at NTP, i.e. at a temperature of 20 °C and an absolute pressure of 1 atm, T = metric tonne), and/or within a temperature range e.g. of approximately 130 °C up to approximately 200 °C, and/or with a pressure e.g. of about +3000 Pa to about +7000 Pa gauge. In other words, the proposed coke dry quenching plant and method allow to treat the excess gas, whilst providing the possibility to choose form a certain range of determinable process parameters, which in turn gives an operator or operating system a significantly increased freedom for piloting or adapting the gas treatment process as well as the quenching process.

[0013] It has been further found that a process cooling gas composition and an excess gas composition, i.e. the composition of a gas conducted from a heat recovery apparatus to the cooling chamber or from a heat recovery apparatus to the regenerative thermal oxidizer, may be generated that is identical or at least similar to the composition exemplarily given in the following table:

	Typical Value % vol.	Max Value % vol.	Minimum Value % vol.	Value during Start up % vol.
H_2	0.7	5	0.2	25
H_2O	3.9	16	2	0
CO	3.9	8	0.5	0
CO_2	16.1	20	10	0
O_2	0.2	2	0	0
N_2	Balance	Balance	Balance	Balance
Coke dust	1 g/Nm^3	2 g/Nm^3	1 g/Nm^3	1 g/Nm^3

[0014] The inventors have further found that a rather small change in the process parameters of the coke dry quenching operation may lead to higher contents of H_2 and CO in the excess gas exiting the regenerative thermal oxidizer (RTO). Since the process cooling gas used within the cooling chamber has a lower content of reactive oxygen in comparison to the recirculation gas exiting the RTO, the quantity of coke loss generated in the CDQ plant is lowered. This in turn leads to a lower gasification rate of coke, hence a reduced loss of coke. In fact, the process cooling gas of the CDQ, which has the same composition than the excess gas, has a reduced amount of CO_2 which, in contact with hot coke over 600°C, influences the amount of CO and thus the Boudouard reaction: $C + CO_2 \leftrightharpoons 2\ CO$.

[0015] Due to this reaction, the quantity of coke lost within the cooling chamber is therefore reduced. As a result, if during standard operation the amount of coke loss is around 1.0 wt.-% - 1.5 wt.-% of the total coke input, higher contents of H_2 and CO in the gas entering the cooling chamber can lead to a coke loss lower than about 1 wt.-%, such as lower than about 0.9 wt.-% or even lower than about 0.8 wt.-%.

[0016] It has been further found that steam production of the coke dry quenching (CDQ) plant is usually related not only to the thermal energy, but also to the above parameter of coke loss (gasification), which increases the enthalpy of the gas stream that “burns” portions of the coke. The minimization of the coke loss can lead to a slightly decrease of steam flowrate, reducing also the thermal content of input flow to the heat recovery apparatus (e.g. boiler). While those effects would result in an overall lower steam production, the effect of reduced steam from coke loss is compensated by the (heat and quantity of the) recirculation gas fed from the regenerative thermal oxidizer through the recirculation conduct to the off-gas conduct.

[0017] Indeed, it has been further found by the inventors that the overall energy balance is in any case positive due to the an “autothermal” reduction of the excess gas combustion. The recirculation conduct which connects the RTO to first dedusting unit, provides additional gas (recirculation gas) and thermal input to the heat recovery apparatus which produces additional steam. Thereby, considering the reference case of a CDQ with a post-combustion unit, also the need for support gas (or other fuels) is lessened. This in turn leads to a smaller CO_2 footprint, reducing both the total C-gasification and CO_2 emission.

[0018] “Coke dry quenching plant” generally refers to facilities configured for quenching or cooling hot coke. A coke dry quenching plant has at least one cooling chamber. “Cooling chamber” generally refers to an entity that is configured for (temporarily) storing hot coke in order to cool it down. Cooling chambers are used to cool down coke under controlled process conditions, generally from a temperature of about 1100°C to a temperature of about 180°C.

[0019] “Off-gas conduct” generally refers to a line, pipeline or other constructional element that is configured to convey the gas released, generated or coming from the cooling chamber, i.e. the off-gas, via an off-gas outlet of the cooling chamber to a heat recovery apparatus. A dedusting unit may be arranged within or be an integral part the off-gas conduct.

[0020] “Dedusting unit” generally refers to an apparatus for dedusting gas. For example, a dedusting unit may be a filter, a cyclone, a dust chamber, a separator, a Venturi scrubber, or a similar device for separating particles form the gas. The first dedusting unit is preferably formed as a dust chamber. The coke dry quenching plant may comprise more than one dedusting unit. For example, a first dedusting unit may be arranged in the off-gas conduct downstream of the cooling chamber and upstream of the heat recovery apparatus.

[0021] “Heat recovery apparatus” refers to an apparatus that is configured for recovering heat from the entering hot off-gas, generally at a temperature range of about 800 to about 950 °C and at a pressure range of about -2000 to about -4000 Pa gauge, and thereby cool down the off-gas to a predefined first temperature range, such as a range of about 160 to about 180 °C, at a preferred pressure range of about -3000 to about -5000 Pa gauge.

[0022] “Fan unit” generally refers to a device for moving, conveying or pressurizing a gas, such as a compressor, a fan or a turbine. The coke dry quenching plant may comprise more than one fan unit, the first fan unit being arranged upstream of the sub-economizer and downstream of the heat recovery apparatus.

[0023] “Sub-economizer unit” generally refers to an apparatus configured to (further) cool down the entering gas from temperature range of about 170 to about 200 °C, at a pressure of about 6000 to about 8000 Pa gauge, to an outlet temperature (second temperature range) of about 130 to about 160 °C at a pressure of about 6000 to about 8000 Pa gauge. It may optionally itself be configured to distribute/split an entering gas (stream) into two or more outgoing gas streams. Alternatively or additionally, the distribution or splitting may be effected by the process cooling gas conduct and/or the excess gas conduct, such as with one or more appropriate valve arrangements and/or fan units within said conducts. Furthermore, the sub-economizer unit can for example be arranged downstream of the first fan unit. The sub-economizer unit is connected to the cooling chamber via a process cooling gas conduct for conducting process cooling gas to the cooling chamber and likewise connected to a regenerative thermal oxidizer via an excess gas conduct for conducting excess gas to the regenerative thermal oxidizer. In other words, the sub-economizer unit or the process cooling gas conduct or the excess gas conduct or a combination thereof is configured to distribute or split the gas into the process cooling gas conduct and/or the excess gas conduct. For example, a control or regulation valve can advantageously be installed in the excess gas conduct at the outlet of or further downstream the sub-economizer. Preferably, such a valve may be configured to control or regulate the pressure inside the cooling chamber in order to set it to a preferred specific value or value range. Additionally or alternatively, a further, e.g. second, fan unit (further described below) may be arranged within said excess gas conduct to effect or assist the distribution/splitting.

[0024] “Regenerative thermal oxidizer”, also called RTO or “thermal oxidizer” or “thermal incinerator”, refers to a commonly known device, respectively technology, for treating gases. The regenerative thermal oxidizer is a gas treatment device allowing to lessen air pollution and decompose hazardous gases at high temperatures. Regenerative thermal oxidizer may present in various forms, such as for example ceramic-bed based RTO, direct fired thermal oxidizer, flameless thermal oxidizer (FTO) or similar forms. The use of a regenerative thermal oxidizer in combination with a cooling chamber of a coke dry quenching plant also allows that the heat of waste gas coming from the combustion within the RTO can be recovered and used for heating up the (inlet) gas and air before said gas mixture enters the combustion chamber of the RTO.

[0025] It has further been found by the inventors that an arrangement combining an RTO with a coke dry quenching process also allows that in cases where the amount of hydrogen forming part of the gas generated within the cooling chamber has risen to a certain amount, e.g. about even as low as 0.7 vol.-%, the RTO does not require any additional fuel firing during its normal operation. Common RTO require fuel during the start-up phase which only occurs occasionally during the year, such as for a maximum of 1 day of startup periods. In view of an exemplary coke dry quenching plant configured to cool 100 tph (tonnes per hour) of hot coke, it is possible to use an RTO to treat excess gas having a flowrate of about 13000 Nm^3/h. In comparison to that, most prior art standard post-combustion apparatuses require more than 2800 Nm^3/h of fuel to burn coke oven gas. Due to the proposed arrangement comprising an RTO technology, such high amounts of fuel and gas can be saved.

[0026] According to an embodiment, the coke dry quenching plant further comprises an air introducing unit for introducing air into the excess gas conduct. The air introducing unit allows that air is mixed with the excess gas to form an enhanced excess gas (prior to) entering the RTO, which in turn enables to precisely control the mixing and temperature of the gas entering the RTO. The autothermal energy of excess gas may however be higher than required for (stable) RTO operation. Hence, it may be beneficial or desirable to bleed some gas and heat out from the RTO. This can be advantageously done through a chimney conduct to the chimney.

[0027] According to the same or another embodiment, the air introducing unit is advantageously arranged upstream of the thermal oxidizer, preferably fluidly connected to or arranged within the excess gas conduct.

[0028] According to the same or another embodiment, the regenerative thermal oxidizer and/or a (downstream) chimney conduct and/or a (downstream) recirculation conduct may be configured to (controllably) distribute or split the gas into the chimney conduct configured for conducting the gas to a chimney and/or the recirculation conduct configured for conducting the gas as recirculation gas into the first dedusting unit. The control or regulation of the distribution/splitting (e.g. using control or regulation valves similar to those described above in the context of the sub-economizer) is made to control the temperature inside oxidizer chamber or RTO. The autothermal energy may be higher than required for a stable operation of the RTO and, in such cases, some thermal energy may advantageously be removed (or bled) from the system, the overall aim or priority being to send the hot recirculation gas (with its extra thermal energy) back to the heat recovery unit, thereby increasing the steam production.

[0029] According to the same or another embodiment, a second dedusting unit may be arranged downstream of the sub-economizer unit and upstream of the regenerative thermal oxidizer. Such a second dedusting unit advantageously allows for further removal of dust from the excess gas, which in turn improves the reliability of (RTO) plant due to a reduced risk of dust clogging.

[0030] According to the same or another embodiment, the air introducing unit may be arranged downstream of the second dedusting unit such that the air introducing unit is configured to introduce air into the excess gas conduct downstream of the second dedusting unit and upstream of the regenerative thermal oxidizer to provide an enhanced excess gas.

[0031] According to the same or another embodiment and as already briefly mentioned above, a second fan unit is advantageously arranged in the excess gas conduct, upstream of the regenerative thermal oxidizer and preferably downstream of the second dedusting unit. Indeed, a second dedusting (further) reduces the dust load in the excess gas, thereby rendering the operation of the second fan unit more reliable.

[0032] According to the same or another embodiment, the air introducing unit is arranged within/fluidly connected to the excess gas conduct, upstream of the second fan unit. Hence, a second fan unit allows for enhanced control of the conveying of the excess gas and preferably the air introduced into the excess gas.

When air is introduced, it further facilitates its thorough mixing with the excess gas to form the so-called enhanced excess gas and allows for an improved control of the pressure within the RTO.

[0033] In a second aspect, the invention also concerns a method for coke dry quenching and off-gas treating. The advantages and embodiments given in view of the coke dry quenching plant also apply to the method.

[0034] The invention thus also proposes a method for coke dry quenching and off-gas treating, wherein the method comprises the following steps: evacuating an off-gas from a coke dry quenching cooling chamber of a coke dry quenching plant, conducting the off-gas via a first dedusting unit to a heat recovery apparatus, wherein the first dedusting unit is arranged downstream of the coke dry quenching cooling chamber and upstream of the heat recovery apparatus; cooling down the off-gas in the heat recovery apparatus to a predefined first temperature range; and accelerating the cooled off-gas, by a first fan unit arranged downstream of the heat recovery apparatus. The method further comprises distributing or splitting the gas (leaving/about to leave the sub-economizer) as process cooling gas into a process cooling gas conduct and/or as excess gas into an excess gas conduct within or downstream the sub-economizer unit configured to cool the off-gas down to a predefined first temperature range and arranged downstream of the first fan unit, wherein the sub-economizer unit is connected to the cooling chamber via the process cooling gas conduct and wherein the sub-economizer unit is connected to a regenerative thermal oxidizer via the excess gas conduct; and wherein the sub-economizer unit itself, or the process cooling gas conduct, or the excess gas conduct, or a combination thereof, is configured to distribute or split the gas into the process cooling gas conduct or the excess gas conduct.

[0035] According to embodiments, the method may further comprise introducing air into the excess gas conduct, upstream of the thermal oxidizer, to provide an enhanced excess gas.

[0036] According to embodiments, the method may further comprise separating gas, within or downstream the regenerative thermal oxidizer, such that the gas is (controllably) distributed or split into a chimney conduct conducting the gas to a chimney or into a recirculation conduct feeding the gas back into the off-gas conduct as a hot recirculation gas.

[0037] According to embodiments, the gas entering the regenerative thermal oxidizer may be preheated, preferably inside ceramic packing media of the RTO itself, advantageously by residual heat of the exhaust gas at the exit of the RTO, preferably to temperatures within a temperature range of about 700 to about 850 °C.

[0038] According to advantageous embodiments, the excess gas within the excess gas conduct has a flowrate within a range of within a range of about 40 to about 240 Nm^3/T coke quenched, such as from about 50 to about 200 Nm^3/T coke quenched, and within a temperature range of approximately 130 °C up to approximately 200 °C and/or with a pressure of about +3000 to about +7000 Pa gauge. Due to the proposed coke dry quenching plant and method, a continuously flow of (excess) gas of the coke dry quenching plant can be treated whilst having a particularly high flowrate (in comparison to known processes and plants).

[0039] According to embodiments, the recirculation gas exiting the regenerative thermal oxidizer into the recirculation conduct preferably has a temperature within a temperature range of about 800 to about 950 °C, a gas flowrate in a range of about 4 Nm^3/T to about 30 Nm^3/T, and a pressure in a range of about 2000 to about 5000 Pa gauge.

[0040] According to an embodiment, the gas exiting the chimney comprises a mix of the following typical composition: about 3.1 vol.-% H_2O, about 13.5 vol.-% CO_2, about 0 vol.-% CO, about 0 vol.-% H_2, about 77.5 vol.-% N_2 and about 5.9 vol.-% O_2, wherein said values may vary within 0.3 vol.-%, preferably within 0.2 vol.-%, the total (including potential trace amounts of other gases) adding up to 100 vol.-% of the gases present.

[0041] The terms “about” and “approximately” in the present context mean that a given numeric value covers a range of values from -10 % to +10 % of said numeric value, preferably a range of values form -5 % to +5 % of said numeric value.

Brief Description of the Drawings

[0042] A preferred embodiment of the invention will now be described, by way of example, with reference to the accompanying drawing in which:

Fig. 1 is a schematic illustration of the coke dry quenching plant and gas treatment method.

Description of Preferred Embodiments

[0043] Fig 1. illustrates schematically an example of a coke dry quenching plant according to an embodiment. Fig. 1 also schematically illustrates an example of how the method according to an embodiment of the invention is performed.

[0044] Fig. 1 shows a coke dry quenching plant 10 for quenching coke and for treating a off-gas. The hot coke is quenched, meaning cooled down, within a cooling chamber 12 of the coke dry quenching plant 10 to a predefined temperature, such as from temperatures of about 1100 °C to a predefined temperature of for example about 180 °C. The quenching is done with a cooling gas admitted through cooling gas conduct 28 into the cooling chamber 12.

[0045] The cooling chamber 12 has at least one off-gas outlet 14 for evacuating the (hot) off-gas from said cooling chamber 12, the (hot) off-gas being the result of the cooling gas introduced into the cooling chamber 12 (i.e. fresh cooling gas through cooling gas inlet 28 and process cooling gas through process cooling gas conduct 26) and generated during quenching. The off-gas outlet 14 is fluidly connected to an off-gas conduct 15 which conveys, respectively guides, the off-gas from the off-gas outlet 14 of the cooling chamber 12 to a heat recovery apparatus 18 via a first dedusting unit 16. In Fig. 1, the dedusting unit 16 is configured as a dust chamber, but other configurations are also possible. The first dedusting unit 16 is arranged in the off-gas conduct 15 downstream of the cooling chamber 12 and upstream of the heat recovery apparatus 18. In other words, the first dedusting unit 16 is arranged in between (the off-gas outlet 14 of) the cooling chamber 12 and the heat recovery apparatus 18 to at least partially dedust the off-gas.

[0046] The heat recovery apparatus 18 cools the entering (at least partially dedusted) off-gas down to temperatures of about 800 to about 950 °C, whereby heat is recovered and can be transferred to other processes (not shown) for heating purposes. Thermal energy recovered in the heat recovery apparatus may amount for example to about 1620 MJ/T coke. The (partially cooled down) off-gas is extracted from the heat recovery apparatus 18 by means of a first fan 20 downstream of the heat recovery apparatus 18. The (partially cooled down) off-gas is subsequently conveyed to a sub-economizer unit 24 downstream of the first fan unit 20, the first fan unit 20 being arranged within a cooled off-gas conduct 22 of the heat recovery apparatus 18.

[0047] The sub-economizer unit 24 is connected to the cooling chamber 12 via a process cooling gas conduct 26 for conducting process cooling gas to the cooling chamber 12, as well as to an excess gas conduct 30 for conducting excess gas to a regenerative thermal oxidizer 40. The sub-economizer unit 24 itself, or the process cooling gas conduct 26, or the excess gas conduct 30, or any combination of these three components is configured to (controllably) distribute the gas into the process cooling gas conduct 26 or the excess gas conduct 30, or both, wherein the respective flow rates of process cooling gas and excess gas can be adjusted as desired or necessary, e.g. by one or more regulating valves and/or or fan units.

[0048] In the embodiment illustrated in Fig. 1, the excess gas entering the excess gas conduct 30 is advantageously subjected to a further (i.e. second) dedusting within a second dedusting unit 32, which is preferably configured as a cyclone. The second dedusting unit 32 is advantageously arranged within the excess gas conduct 30 downstream of the sub-economizer unit 24 and upstream of an air introducing unit 36.

[0049] An air introducing unit 36 installed within the excess gas conduct 30 is provided to inject air into said excess gas conduct 30, thereby providing an enhanced excess gas with changed gas composition and temperature. In the embodiment illustrated in Fig. 1, the air introducing unit 36 is arranged downstream of the second dedusting unit 32 and upstream of the second fan unit 38. The temperature of the enhanced excess gas may thus be precisely controlled before it enters the regenerative thermal oxidizer, RTO, 40. Preferred temperatures at this point can be e.g. between 120 and 140 °C, such as between 125 and 130 °C.

[0050] The second fan unit 38 is arranged in the excess gas conduct 30 downstream of the inlet of the air introducing unit 36. The second fan allows to accelerate the enhanced excess gas before entering the RTO 40.

[0051] When the enhanced excess gas enters the RTO 40, the gas is preheated by an internal preheating system (not shown) that advantageously uses the heat energy of the (part of the) gas that is discharged through the chimney conduct 42 and the chimney 44. The hot gas which is present in the RTO is partially recirculated as recirculation gas to the coke dry quenching process via recirculation conduct 46 and partially discharged via chimney 44 into the atmosphere, wherein a regulated discharging through chimney 44 allows to bleed some gas and heat out of the process, e.g. to improve stable operation of the RTO 40.

[0052] On the other hand, the (part of the) gas which is recirculated as recirculation gas via the recirculation conduct 46 is advantageously injected via an inlet (not shown) upstream of or into the primary dedusting unit 16. The advantage of recirculating (part of the) gas from the RTO is that the volume of the gas entering the heat recovery apparatus 18 is increased while keeping essentially the same temperature. As a consequence, the heat recovery apparatus 18, which is advantageously configured as a heat recovery steam generator in the embodiment of Fig. 1, increases the production of valuable high-pressure steam.

[0053] During operation, the heat recovery apparatus 18 will treat a gas in a temperature range over 800°C with a pressure in a range of -2000 kPa to 0.0 kPa. The hot gas stream of recirculation gas re-collected from the RTO 40 and conducted within recirculation conduct 46 has similar temperatures of 800 to 900 °C and a pressure above 0.0 kPa.

[0054] It is understood that the regulation of the different gas flows, e.g. in the sub-economizer unit 24 or the RTO 40 is generally realized by controlled or automated valves (not shown). Due to such an arrangement of automated valves in the RTO 40 and an appropriate bleeding through chimney conduct 42 and chimney 44, the RTO may be operated in stable conditions and the temperature of its oxidation chamber (not shown) can be kept in a predefined and advantageous range of about 800 to 850 °C.

Legend:

10	coke dry quenching plant
12	(coke dry quenching) cooling chamber
14	off-gas outlet (for cooling chamber off-gas)
15	off-gas conduct (for cooling chamber off-gas)
16	first dedusting unit (for dedusting off-gas)
18	heat recovery apparatus
20	first fan unit
22	cooled off-gas conduct
24	sub-economizer unit
26	process cooling gas conduct (for recirculated process cooling gas)
28	cooling gas inlet
30	excess gas conduct (for excess gas)
32	second dedusting unit (for dedusting excess gas)
36	air introducing unit (for introducing air into excess gas to provide enhanced excess gas)
38	second fan unit
40	regenerative thermal oxidizer
42	chimney conduct
44	chimney
46	recirculation conduct (for recirculating recirculation gas to the off-gas conduct)

Claims

1. A coke dry quenching plant (10) for quenching coke and for treating an off-gas therefrom, wherein the coke dry quenching plant (10) comprises:

   - a cooling chamber (12) for cooling hot coke down to a predefined temperature;

   - an off-gas conduct (15) for conducting the off-gas from an off-gas outlet (14) of the cooling chamber (12) to a heat recovery apparatus (18);

   - a first dedusting unit (16) for dedusting the off-gas, wherein the first dedusting unit (16) is arranged in the off-gas conduct (15) downstream of the cooling chamber (12) and upstream of the heat recovery apparatus (18);

   - the heat recovery apparatus (18) being configured to cool the off-gas down to a predefined first temperature range;

   - a first fan unit (20) arranged downstream of the heat recovery apparatus;

   wherein the coke dry quenching plant further comprises:

   - a sub-economizer unit (24) arranged downstream of the first fan unit (20), wherein the sub-economizer unit (24) is connected to the cooling chamber (12) via a process cooling gas conduct (26) and wherein the sub-economizer unit (24) is connected to a regenerative thermal oxidizer (40) via an excess gas conduct (30); and wherein the sub-economizer unit (24) and/or the process cooling gas conduct and/or the excess gas conduct is/are configured to distribute or split the gas into the process cooling gas conduct (26) and/or the excess gas conduct (30).

2. The coke dry quenching plant (10) according claim 1, wherein the coke dry quenching plant (10) further comprises an air introducing unit (36) for introducing air into the excess gas conduct (30).

3. The coke dry quenching plant (10) according to claim 2, wherein the air introducing unit (36) is arranged upstream of the regenerative thermal oxidizer (40).

4. The coke dry quenching plant (10) according to any one of claims 1 to 3, wherein the regenerative thermal oxidizer (40) and/or a downstream chimney conduct (42) and/or a downstream recirculation conduct (46) is configured to distribute or split the gas into a chimney conduct (42) for conducting the gas to a chimney (44) or a recirculation conduct (46) for feeding the gas into the off-gas conduct (15).

5. The coke dry quenching plant (10) according to any one of claims 1 to 4, wherein a second dedusting unit (32) is arranged downstream of the sub-economizer unit (24) and upstream of the regenerative thermal oxidizer (40).

6. The coke dry quenching plant (10) according to claim 5, wherein the air introducing unit (36) is arranged downstream of the second dedusting unit (32), such that the air introducing unit (36) is configured to introduce air into the excess gas conduct (30) downstream of the second dedusting unit (32) and upstream of the regenerative thermal oxidizer (40).

7. The coke dry quenching plant (10) according to any one of claims 5 or 6, wherein a second fan unit (38) is arranged in the excess gas conduct (30) downstream of the second dedusting unit (32) and upstream of the regenerative thermal oxidizer (40).

8. The coke dry quenching plant (10) according to claim 7, wherein the air introducing unit (26) is arranged upstream of the second fan unit (38).

9. A method for coke dry quenching and off-gas treating, wherein the method comprises the following steps:

   - evacuating an off-gas from a coke dry quenching cooling chamber (12) of a coke dry quenching plant (10);

- conducting the off-gas via a first dedusting unit (16) to a heat recovery apparatus (18), wherein the first dedusting unit (16) is arranged downstream of the coke dry quenching cooling chamber (12) and upstream of the heat recovery apparatus (18);
- cooling down the off-gas in the heat recovery apparatus (18) to a predefined first temperature range;
- driving the gas by a first fan unit (20) arranged downstream of the heat recovery apparatus (18),

wherein the method further comprises

- distributing or splitting the gas into a process cooling gas conduct (26) and/or an excess gas conduct (30) within or downstream the sub-economizer unit (24) arranged downstream of the first fan unit (20), wherein the sub-economizer unit (24) is connected to the cooling chamber (12) via the process cooling gas conduct (26) and wherein the sub-economizer unit (24) is connected to a regenerative thermal oxidizer (40) via the excess gas conduct (30); wherein the sub-economizer unit (24) and/or the process cooling gas conduct (26) and/or the excess gas conduct (30) is/are configured to distribute or split the gas into the process cooling gas conduct (26) and/or the excess gas conduct (30).

10. The method according to claim 9, wherein the method further comprises introducing air into the excess gas conduct (30) and upstream of the regenerative thermal oxidizer (40).

11. The method according to any one of claims 9 or 10, wherein the method further comprises distributing or splitting the gas into a chimney conduct (42) conducting the gas to a chimney (44) and/or into a recirculation conduct (46), such that the gas is distributed or split into a chimney conduct (42) conducting the gas to a chimney (44) or a recirculation conduct (46) feeding the gas into the off-gas conduct (15).

12. The method according to any one of claims 9 to 11, wherein the gas entering the regenerative thermal oxidizer (40) is preheated inside a ceramic packing media of the regenerative thermal oxidizer (40) by residual heat of exhaust gas at an exit of the regenerative thermal oxidizer (40) at temperatures within a temperature range of about 700 to about 850 °C.

13. The method according to any one of claims 9 to 12, wherein the gas within the excess gas conduct (30) has a flowrate within a range of about 40 to about 240 Nm^3/T coke quenched and a temperature within a range of approximately about 130 up to about 200 °C, and/or a pressure within a range of about +3000 to about +7000 Pa gauge.

14. The method according to any one of claims 9 to 13, wherein the gas exiting the regenerative thermal oxidizer (40) into the recirculation conduct (46) has a temperature within a range of about 800 to about 950 °C, a gas flowrate within a range of about 4 Nm^3/T to about 30 Nm^3/T coke quenched, and a pressure within a range of about 2000 to about 5000 Pa gauge.

15. The method according to any one of claims 9 to 14, wherein the gas exiting the chimney (44) comprises a mix of the following: about 3.1 vol.-% H_2O, about 13.5 vol.-% CO_2, about 0.0 vol.-% CO, about 0.0 vol.-% H_2, about 77.5 vol.-% N_2 and about 5.9 vol.-% O_2.

REVENDICATIONS

1. Installation d’extinction à sec de coke (10) pour éteindre du coke et pour traiter un gaz de dégagement de celui-ci, dans laquelle l’installation d’extinction à sec de coke (10) comprend :
- une chambre de refroidissement (12) pour refroidir le coke chaud jusqu’à une température prédéfinie ;
- une conduite de gaz de dégagement (15) pour conduire le gaz de dégagement d’une sortie de gaz de dégagement (14) de la chambre de refroidissement (12) à un appareil de récupération de chaleur (18) ;
- une première unité de dépoussiérage (16) pour dépoussiérer le gaz de dégagement, dans laquelle la première unité de dépoussiérage (16) est agencée dans la conduite de gaz de dégagement (15) en aval de la chambre de refroidissement (12) et en amont de l’appareil de récupération de chaleur (18) ;
- l’appareil de récupération de chaleur (18) étant conçu pour refroidir le gaz de dégagement jusqu’à une première plage de température prédéfinie ;
- une première unité de ventilateur (20) disposée en aval de l’appareil de récupération de chaleur ;

dans laquelle l’installation d’extinction à sec de coke comprend en outre :
- une sous-unité d’économiseur (24) disposée en aval de la première unité de ventilateur (20), dans laquelle la sous-unité d’économiseur (24) est connectée à la chambre de refroidissement (12) via une conduite de gaz de refroidissement de procédé (26) et dans laquelle la sous-unité d’économiseur (24) est connectée à un oxydeur thermique régénératif (40) via une conduite de gaz en excès (30) ;

et dans laquelle la sous-unité d’économiseur (24) et/ou la conduite de gaz de refroidissement de procédé et/ou la conduite de gaz en excès est/sont conçues pour distribuer ou diviser le gaz dans la conduite de gaz de refroidissement de procédé (26) et/ou la conduite de gaz en excès (30).

2. Installation d’extinction à sec de coke (10) selon la revendication 1, dans laquelle l’installation d’extinction à sec de coke (10) comprend en outre une unité d’introduction d’air (36) pour introduire de l’air dans la conduite de gaz en excès (30).

3. Installation d’extinction à sec de coke (10) selon la revendication 2, dans laquelle l’unité d’introduction d’air (36) est disposée en amont de l’oxydeur thermique régénératif (40).

4. Installation d’extinction à sec de coke (10) selon l’une quelconque des revendications 1 à 3, dans laquelle l’oxydeur thermique régénératif (40) et/ou un conduit de cheminée en aval (42) et/ou une conduite de recirculation en aval (46) est conçu pour distribuer ou diviser le gaz dans un conduit de cheminée (42) pour conduire le gaz vers une cheminée (44) ou une conduite de recirculation (46) pour alimenter le gaz dans la conduite de gaz de dégagement (15).

5. Installation d’extinction à sec de coke (10) selon l’une quelconque des revendications 1 à 4, dans laquelle une seconde unité de dépoussiérage (32) est disposée en aval de la sous-unité d’économiseur (24) et en amont de l’oxydeur thermique régénératif (40).

6. Installation d’extinction à sec de coke (10) selon la revendication 5, dans laquelle l’unité d’introduction d’air (36) est disposée en aval de la seconde unité de dépoussiérage (32), de sorte que l’unité d’introduction d’air (36) est conçue pour introduire de l’air dans la conduite de gaz en excès (30) en aval de la seconde unité de dépoussiérage (32) et en amont de l’oxydeur thermique régénératif (40).

7. Installation d’extinction à sec de coke (10) selon l’une quelconque des revendications 5 ou 6, dans laquelle une seconde unité de ventilateur (38) est agencée dans la conduite de gaz en excès (30) en aval de la seconde unité de dépoussiérage (32) et en amont du l’oxydeur thermique régénératif (40).

8. Installation d’extinction à sec de coke (10) selon la revendication 7, dans laquelle l’unité d’introduction d’air (26) est disposée en amont de la seconde unité de ventilateur (38).

9. Procédé d’extinction à sec de coke et de traitement de gaz de dégagement, dans lequel le procédé comprend les étapes suivantes :
- l’évacuation d’un gaz de dégagement d’une chambre de refroidissement d’extinction à sec de coke (12) d’une installation d’extinction à sec de coke (10) ;
- la conduite du gaz de dégagement via une première unité de dépoussiérage (16) vers un appareil de récupération de chaleur (18), dans lequel la première unité de dépoussiérage (16) est disposée en aval de la chambre de refroidissement d’extinction à sec de coke (12) et en amont de l’appareil de récupération de chaleur (18) ;
- le refroidissement du gaz de dégagement dans l’appareil de récupération de chaleur (18) jusqu’à une première plage de température prédéfinie ;
- l’entraînement du gaz par une première unité de ventilateur (20) disposée en aval de l’appareil de récupération de chaleur (18),
dans lequel le procédé comprend en outre
- la distribution ou la séparation du gaz dans une conduite de gaz de refroidissement de procédé (26) et/ou une conduite de gaz en excès (30) à l’intérieur ou en aval de la sous-unité d’économiseur (24) disposée en aval de la première unité de ventilateur (20), dans lequel la sous-unité d’économiseur (24) est connectée à la chambre de refroidissement (12) via la conduite de gaz de refroidissement de procédé (26) et dans lequel la sous-unité d’économiseur (24) est connectée à un oxydeur thermique régénératif (40) via la conduite de gaz en excès (30) ; dans lequel la sous-unité d’économiseur (24) et/ou la conduite de gaz de refroidissement de procédé (26) et/ou la conduite de gaz en excès (30) est/sont conçue(s) pour distribuer ou diviser le gaz dans la conduite de gaz de refroidissement de procédé (26) et /ou la conduite de gaz en excès (30).

10. Procédé selon la revendication 9, dans lequel le procédé comprend en outre l’introduction d’air dans la conduite de gaz en excès (30) et en amont de l’oxydeur thermique régénératif (40).

11. Procédé selon l’une quelconque des revendications 9 ou 10, dans lequel le procédé comprend en outre la distribution ou la séparation du gaz dans un conduit de cheminée (42) conduisant le gaz vers une cheminée (44) et/ou dans une conduite de recirculation (46), de sorte que le gaz est distribué ou divisé dans un conduit de cheminée (42) conduisant le gaz vers une cheminée (44) ou une conduite de recirculation (46) alimentant le gaz dans la conduite de gaz de dégagement (15).

12. Procédé selon l’une quelconque des revendications 9 à 11, dans lequel le gaz entrant dans l’oxydeur thermique régénératif (40) est préchauffé à l’intérieur d’un milieu de garnissage en céramique de l’oxydeur thermique régénératif (40) par la chaleur résiduelle du gaz d’échappement au niveau d’une sortie de l’oxydeur thermique régénératif (40) à des températures comprises dans une plage de températures d’environ 700 à environ 850 °C.

13. Procédé selon l’une quelconque des revendications 9 à 12, dans lequel le gaz à l’intérieur de la conduite de gaz en excès (30) a un débit dans une plage d’environ 40 à environ 240 Nm^3/T de coke éteint et une température dans une plage d’environ 130 jusqu’à environ 200 °C, et/ou une pression manométrique dans une plage d’environ +3 000 à environ +7 000 Pa.

14. Procédé selon l’une quelconque des revendications 9 à 13, dans lequel le gaz sortant de l’oxydeur thermique régénératif (40) dans la conduite de recirculation (46) a une température dans une plage d’environ 800 à environ 950 °C, un débit de gaz dans une plage d’environ 4 Nm^3/T à environ 30 Nm^3/T de coke éteint, et une pression manométrique dans une plage d’environ 2 000 à environ 5 000 Pa.

15. Procédé selon l’une quelconque des revendications 9 à 14, dans lequel le gaz sortant de la cheminée (44) comprend un mélange des éléments suivants : environ 3,1 % en vol. d’H_2O, environ 13,5 % en vol. de CO_2, environ 0,0 % en

vol. de CO, environ 0,0 % en vol. d'H_2, environ 77,5 % en vol. de N_2 et environ 5,9 % en vol. d'O_2.

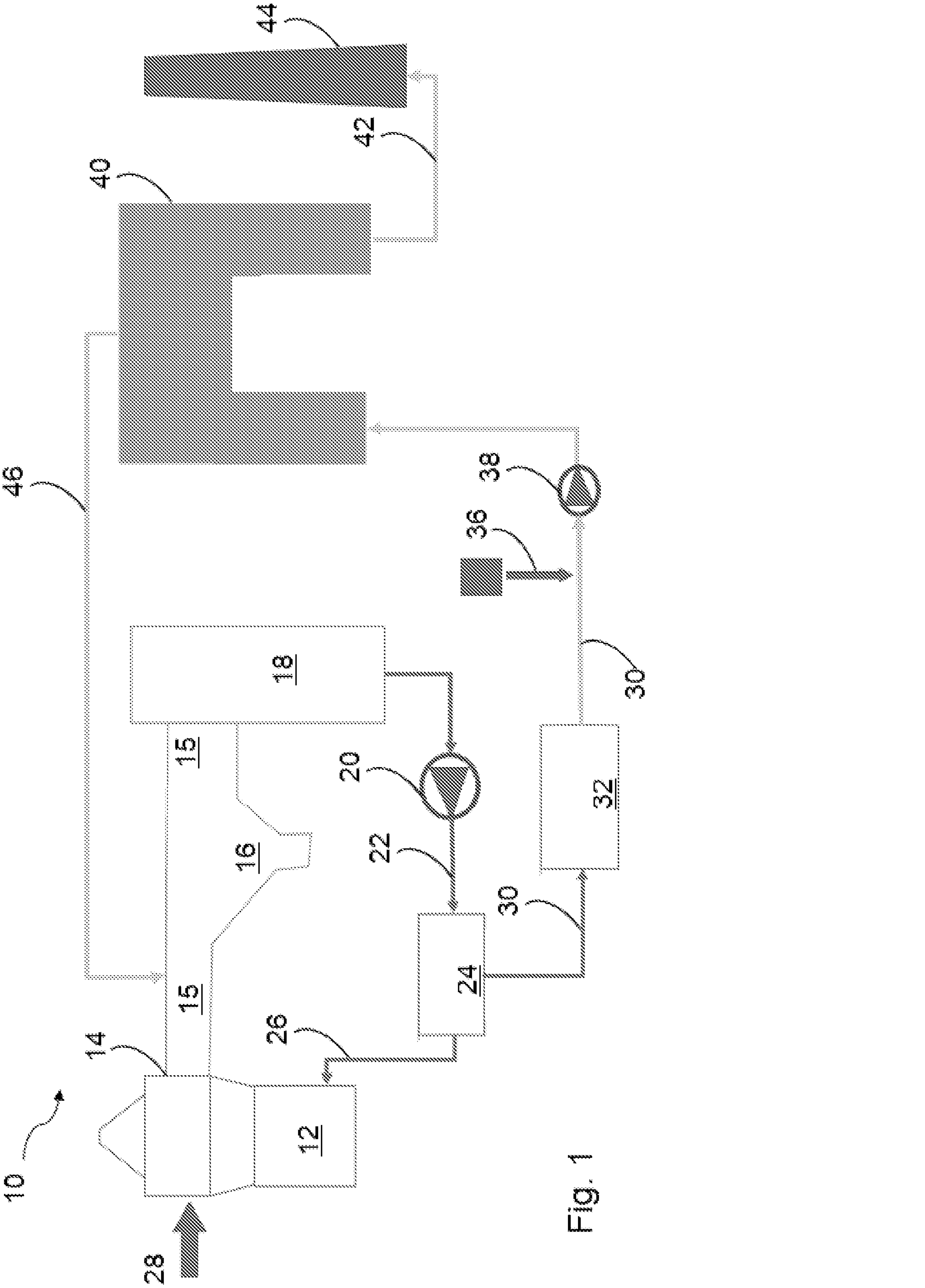


Fig. 1