

Description**OBJECT OF THE INVENTION**

5 [0001] The present invention relates to a method for separating CO₂ based on regenerative chemical absorption, which uses an absorber where the CO₂ remains retained in an absorbent liquid, and a regenerator where the CO₂ is released, obtaining a regenerated absorbent that is re-used in the absorber. The invention proposes a configuration of the entire capturing process which allows a more efficient operation and, therefore, significantly reduces the energy requirements mainly associated with the regeneration of the absorbent, as well as a lesser thermal degradation of same.

BACKGROUND OF THE INVENTION

10 [0002] The regenerative chemical absorption of acid gases has been used since the 1930s in a number of industrial processes. The basic process was patented by R. R. Bottoms (US Patent No. 1783901), and after it, a number of configurations and/or chemical absorbents have been developed over the years for the purpose of optimizing the entire process for separating CO₂ and, in particular, significantly reducing the energy consumption mainly associated with the regeneration of the absorbent.

15 [0003] Different variants of the conventional arrangement of the absorber have also been proposed, described in specialized literature (US Patent No. 8192530). On the other hand, most of the patents registered in this field concern modifications applied in the regenerator: harnessing energy from the sensible heat of the outlet stream of the regenerator, preheating the condensates at the inlet of the regenerator, partially evaporating the stripped at the outlet of the regenerator such that the total energy input into drum of the regeneration unit is minimized, pressurizing the upper section of the regenerator to lower the water/CO₂ ratio in the *stripping* stream of the regeneration unit, etc. All these modifications have led to important energy reductions in the regeneration of the absorbent compared with the conventional arrangement.

20 [0004] In recent years, processes for separating CO₂ based on chemical absorption have sparked enormous interest on an industrial level as a result of the possibility of being used in the field of CO₂ capture and storage technologies, mainly in processes for producing electric energy, in the cement industry and in the production of steel. The earliest references to patents for applying chemical absorption for mitigating CO₂ emissions into the atmosphere in specialized literature date back to the mid-1990s (WO 1995/021683). Despite being considered a mature technology in the industrial field, the application of chemical absorption for separating CO₂ coming from combustion and/or process gases entails certain difficulties which must be solved in order to develop it on a commercial scale, which still have not been solved in an effective manner.

25 [0005] These difficulties are mainly summarized in the high energy consumption associated with the regeneration of the absorbent and in the degradation said absorbent experiences due to oxidative and thermal mechanisms occurring during the capture process. These aspects mean that the use of a chemical absorption unit in an electrical production facility based on the combustion of fossil fuels can involve up to a 10 point-loss of net yield in the power cycle, rendering its implementation on an industrial scale economically inviable today (Pulverized coal oxycombustion power plants. Volume 1: Bituminous coal to electricity, Final report 1291. DOE-NETL, 2007, pp. 5-6).

30 [0006] With respect to the degradation of the absorbent, this parameter is extremely relevant in the definition of the operating conditions in the regeneration unit. According to G. T. Rochelle (Rochelle, G. T.; Current Opinion in Chemical Engineering, 2012, 1(2): 183-90), the process for separating CO₂ by means of chemical absorption based on compounds with rapid kinetics, as occurs with the use of primary and secondary amines, is favored by operating at high temperature and high pressure in terms of energy consumption per ton of CO₂. Therefore, the operating temperature in the desorption unit is defined on the basis that it produces the maximum degradation allowable in the absorbent, that is, that the observed degradation ratios are offset by a significant reduction in the specific consumption per ton of CO₂ captured during the regeneration of the absorbent (Oexmann, J.; Ather, A., International Journal of Greenhouse Gas Control, 2010, 4(1), 36-43).

35 [0007] Today, there are a number of companies holding licenses for chemical absorption processes on a commercial scale applied specifically to the capture of CO₂ in industrial processes, which shows the interest that these developments spark in the field of environmental technology and chemical and industrial processes where the separation of CO₂ acid gases from a gas stream is required.

DESCRIPTION OF THE INVENTION

40 [0008] The present invention proposes an alternative configuration with respect to the conventional system of separating CO₂ from a gas stream by means of chemical absorption, based on the optimization of the cyclic operating capacity of the absorbent used by means of a particular arrangement of the streams involved in the CO₂ absorption-desorption process and a very thorough control of the operating conditions of the inlet streams into the regenerator, mainly in terms

of temperature and distribution of feed flow rates to the equipment.

[0009] In this sense, the energy consumption associated with the regeneration process is significantly reduced and favors lower thermal degradation of the absorbent. This invention has been developed to be applied in technologies for capturing CO₂ from stationary sources, but they may be applicable for any process which requires separating acid gases from a gas stream.

[0010] The invention consists of a process and a system for regenerative chemical absorption applied to the capture of CO₂ from stationary sources, which allows adjusting the degree of regeneration required by the absorbent by significantly reducing the energy consumption of the process. In general, the objective of the proposed configuration is to optimize the cyclic capacity during operation of the absorbent so as to minimize the energy requirements in the drum of the absorber system.

[0011] To achieve this objective, the present invention provides a method for regenerative chemical absorption applied to the capture of CO₂ from stationary sources, which allows adjusting the degree of regeneration of the absorbent by means of using the described system, and in which the treatment of the different gas streams generated takes place.

[0012] Therefore, a first aspect of the present invention relates to a method for separating CO₂ coming from a gas stream, comprising the following steps:

a) absorbing the CO₂ coming from a gas stream to be treated at a temperature preferably less than 60 °C, preferably between 40 °C and 60 °C, and a pressure comprised in a range of between 1 and 1.5 bar, by means of putting said stream in contact in an absorber with an absorbent solution in which the CO₂ will be retained;

b) recirculating up to 75 % of the stream comprising the CO₂-rich absorbent solution coming from step a) to the lower bed of the absorption system. The operation under these conditions allows adjusting the cyclic working capacity range of the absorbent during operation in an optimized manner;

c) desorbing CO₂ in a regenerator from the stream comprising the CO₂-rich absorbent solution coming from step a) not recirculated to step b) at a temperature of between 80 °C and 120 °C, a pressure of between 1.5 and 5 bar and a steam stripping flow rate of between 10 and 90 % by volume with respect to the desorbed CO₂ flow rate, where said stream is split into at least two streams by means of a set of heat exchangers, prior to the inlet of the regenerator;

d) recovering the absorbent solution resulting from step c) from the absorber of step a).

[0013] In a preferred embodiment, the CO₂ is absorbed from the stream to be treated in step a) of the method of the invention in the absorber unit from the gas phase to the liquid phase, where it is dissolved and chemically bonds with the absorbent or absorbent solution. It is also possible to use absorbents which only operating with physical mechanisms, and not chemical mechanisms, of absorption.

[0014] In a preferred embodiment, the absorbent solution contained in the absorption unit comprises any one aqueous solution of CO₂ absorbents, and more preferably an aqueous solution of a compound having an amine base, which can be selected, though without being limited to one amine from the list comprising monoethanolamine (MEA), triethanolamine (TEA), methyldiethanolamine (MDEA), diisopropanolamine (DIPA) and diglycolamine (DGA), piperidine (PP), piperazine (PZ), 2-amino-2-methyl-1-propanol (AMP), monomethylethanolamine (MMEA), etc., or any of their combinations.

[0015] Another object of the invention is the absorption system used in this method which is based on the fundamental incorporation of an absorber which receives the gas to be treated with CO₂, which is absorbed by means of a absorbent solution, a set of heat exchangers conditioning the temperature of the CO₂-rich absorbent solution exiting the absorber and a regenerator, in which the absorbent solution is regenerated, releasing it from the CO₂, for re-using it and incorporating it back into the absorber.

[0016] Based on this basic configuration, the system of this invention proposes first the incorporation of a recirculation line directed to the absorber constituting a bypass of the outlet of the CO₂-rich absorbent solution, which is partially conducted back to the absorber for the purpose of optimizing the CO₂ absorption capacity of the absorbent used. Secondly, the system incorporates a particular set of heat exchangers which, besides thermally conditioning the CO₂-rich solution, divides it into at least two streams which are introduced in the regenerator in areas located at different heights, stratifying the feed into the regenerator, which causes a decrease in the temperature profile of the regenerator, achieving a reduction in energy consumption associated with the regeneration of the absorbent.

[0017] In this manner, the system allows significantly reducing the specific consumption associated with the regeneration of the absorbent compared with a conventional configuration of the absorption system. It has been demonstrated that the level of reduction of consumption is higher the more concentrated the acid gas is in the gas stream to be treated.

[0018] The invention assures, therefore, an operation of the regenerator at a thermal level that is lower than the level proposed in conventional operating modes. As a result, it is possible to work with a higher load or concentration of CO₂ in the regenerated absorbent and, in this manner, to shift the cyclic operating capacity thereof to areas where the energy consumption associated with desorbing CO₂ is lower. The decrease obtained in the temperature profile of the regenerator reduces the degradation rate of the absorbent associated with thermal mechanisms.

DESCRIPTION OF THE DRAWINGS

[0019] To complement the description that is being made and for the purpose of helping to better understand the features of the invention, according to a preferred practical embodiment thereof, a set of drawings is attached as an integral part of said description, wherein the following has been depicted with an illustrative and non-limiting character:

Figure 1.- Shows a diagram of the CO₂ absorption-desorption system of the invention.

Figure 2.- Shows a detail of the set of heat exchangers.

Figure 3. Shows a graph depicting the enthalpy of CO₂ solubility depending on the load of the absorbent expressed in moles of CO₂ per mole of absorbent (generic absorbent). The cyclic operating capacity for a conventional configuration and a configuration according to the system of the invention are indicated in a generic manner.

PREFERRED EMBODIMENT OF THE INVENTION

[0020] A preferred embodiment of the system object of this invention is described below.

[0021] Specifically, the absorption-desorption system of CO₂ including the elements described below has been depicted in Figure 1:

1.- Gas stream to be treated

2.- Absorber

3.- Clean gas

4.- CO₂-rich outlet absorbent solution

5.- First impeller pump

6.- CO₂-rich absorbent solution

7.- Recirculated CO₂-rich absorbent solution

8.A.- First heat exchanger

8.B.- Second heat exchanger

9.- Set of exchangers

10.- Primary stream

11.- Heat exchanger for harnessing energy from the gas stream at the outlet of the regenerator

12.- Main inlet stream into the CO₂-rich absorbent solution regenerator

13.- Secondary stream

14.- Alternative inlet streams into the CO₂-rich absorbent solution regenerator

15.- Regenerator

16.- Gas outlet stream from the regenerator

17.- Condensate separator

18.- Gas stream having a high concentration of CO₂

19.- Condensate stream

20.- Drum

21.- Stripped regenerated absorbent solution

22.- Second impeller pump

23.- Inlet stream of regenerated absorbent solution

[0022] As can be observed in Figure 1, the system incorporates an absorber (2) comprising a packing column which may be both structured and non-structured, and a lower bed, which receives the gas stream to be treated (1) which will come into contact in the absorber (2) with an absorbent liquid which is used for retaining CO₂ of the gas to be treated (1). The absorber (2) incorporates a CO₂ (4)-rich outlet absorbent solution, an inlet for the inlet stream of regenerated absorbent solution (23), a stream of recirculated CO₂-rich absorbent solution (7) and an outlet through which the clean gas (3) free of CO₂ is discharged.

[0023] The inlet stream of regenerated absorbent solution (23) coming from the regenerator (15) is at a temperature which has been adjusted to values close to that of the gas stream to be treated (1) by means of using a second heat exchanger (8B).

[0024] On the other hand, the absorber (2) incorporates an inlet for recirculated CO₂-rich absorbent solution recirculation line (7), which is conducted back to the lower bed of the absorber (2) for the purpose of increasing the load thereof by means of a first heat exchanger (8A) which lowers its temperature.

[0025] In a preferred embodiment, the design of the absorber (2) requires an increase in section in the lower bed with respect to the rest of the column, as shown in Figure 1.

[0026] It can also be seen in Figure 1 that the CO₂-rich outlet absorbent solution (4) is removed from the absorber (2)

at the lower part thereof and impelled by means of a first impeller pump (5) which impels the CO₂-rich outlet absorbent solution (4) to then be separated into the recirculated CO₂-rich absorbent solution (7) and into a CO₂-rich absorbent solution (6), which is previously introduced in the set of heat exchangers (9).

[0027] The set of heat exchangers (9) receives the mentioned CO₂-rich absorbent solution (6), where the temperature of this stream is adjusted in an optimized manner before being split and directed to the regenerator (15), and it receives a stripped regenerated absorbent solution (21) coming from the regenerator (15), and the inlet stream of regenerated absorbent solution (23) exits the set of heat exchangers (9), directed to the absorber (2), and a primary stream (10) and a secondary stream (13) also exit as a consequence of the mentioned splitting of the CO₂-rich absorbent solution (6).

[0028] The set of heat exchangers (9) comprising the following elements can be seen in Figure 2:

6.- CO₂-rich absorbent solution

9.- Set of exchangers

10.- Primary stream

13.- Secondary stream

13.A.- Alternative for removing from the first exchanger the secondary inlet stream into the CO₂-rich absorbent solution regenerator

13.B.- Alternative for removing from the second exchanger the secondary inlet stream into the CO₂-rich absorbent solution regenerator

13.C.- Alternative for removing from successive exchangers the secondary inlet stream into the CO₂-rich absorbent solution regenerator

21.- Stripped regenerated absorbent solution

21.A.- Alternative for feeding regenerated absorbent solution to successive exchangers in the set of exchangers

21.B.- Alternative for feeding regenerated absorbent solution to the second exchanger in the set of exchangers

21.C.- Alternative for feeding regenerated absorbent solution to the first exchanger in the set of exchangers

23.- Regenerated solution inlet stream into the absorber

24.- First internal exchanger of the set of exchangers

25.- Second internal exchanger of the set of exchangers

26.- Successive exchangers of the set of exchangers

[0029] The set of exchangers (9) depicted in Figure 2 comprises a series of N internal heat exchangers (24, 25, 26), preferably between 2 to 4 heat exchangers, where the CO₂-rich absorbent solution (6) is heated at different levels by means of the use of the stripped regenerated absorbent solution (21) coming from the bottom of the regenerator (15). The stream of -rich absorbent solution CO₂ (6) is split into two main streams. The primary stream (10) is heated by means of the use of all the internal heat exchangers (24, 25, 26), whereas the secondary stream (13) can be removed at the outlet of each of the internal exchangers, giving rise to inner streams (13A, 13B, 13C). The stream of stripped regenerated absorbent solution (21) can in turn be split into different substreams, referred to as (21A, 21B, 21C), to achieve a more precise adjustment of the thermal level of the primary stream of the rich solution (10) and, therefore, of the temperature profile of the regenerator (15).

[0030] The distribution of the CO₂-rich absorbent solution (6) between the primary stream (10) and the secondary stream (11) is preferably established in the range of between 0.25 and 0.75. The primary stream (10) is then preheated in an indirect contact second exchanger (11) indirect contact using the outlet stream from the regenerator (16), at a temperature greater than 100 °C, giving rise to a main inlet stream into the regenerator (12).

[0031] The regenerator (15) receives the stream from the absorber (2) at different heights and temperatures, such that the degree of regeneration of the absorbent is adjusted in an optimal manner.

[0032] The main inlet stream into the regenerator (12) is introduced in the upper part of the regenerator (15). On the other hand, the secondary stream (13) is introduced at a temperature less than the temperature set for the primary stream (10) in an intermediate bed of the regenerator (15), Achieving a temperature profile which optimizes the energy requirements of the entire capturing process. The secondary stream (13) can in turn be split into another additional stream (14) in order to be fed in at different heights of the regenerator (15).

[0033] This configuration allows obtaining a partial regeneration of the absorbent, shifting the cyclic capacity thereof into areas with a lower energy requirement of CO₂ desorption. The energy necessary for the regeneration of the absorbent to occur is provided to the regenerator (15) by means of a drum (20) preferably using vapor as the working fluid.

[0034] On the other hand, the outlet stream (16) at the upper part of the regenerator, which stream is primarily made up of CO₂ and water vapor, is introduced in a separator (17), where the stream having a high concentration of CO₂ saturated in water (18) and a condensate stream (19) are obtained, which is subsequently recirculated to the regenerator (15).

[0035] Lastly, the stripped regenerated absorbent solution (21) is removed from the lower part of the regenerator (15) and impelled by means of a second pump (22) to the set of exchangers (9) prior to being reincorporated into the absorption

system (23).

[0036] The regenerator (15) preferably works in a pressure range comprised between 1.5 and 5 bar, and at a maximum temperature less than 120 °C, more preferably, in a temperature range comprised between 100 °C y 120 °C, such that lesser degradation of the absorbent is assured.

[0037] The invention is illustrated below by means of tests performed by the inventors, which clearly shows the specificity and effectiveness of the method of the invention for capturing CO₂.

[0038] Particularly, a process for separating CO₂ from a synthetic gas stream has been performed in a laboratory-scale unit based on two operative configurations which correspond on one hand to a conventional configuration and on the other to a configuration according to the system of the invention.

[0039] In this sense, A synthetic gas flow rate of 7 L/min, with a composition of 60 %v/v CO₂, saturated with water vapor and completed with N₂ has been used. Monoethanolamine in aqueous solution at 30 %w/w has been used as absorbent, as it is a reference absorbent. The amount total of absorbent used in the system is 2 L. The absorption of CO₂ is performed at a pressure of 1 atm and at a temperature of 50 °C in a column having 3 cm in diameter and 2 m in height, using as an absorption bed 6 mm ceramic Raschig rings. The regeneration of the absorbent is performed at a pressure of 2 bar in a column having 3 cm in diameter and 1 m in height using 6 mm stainless steel 316L Raschig rings.

[0040] The conventional configuration consisted of having a recirculation rate in the absorber of 0 (7), a single internal heat exchanger (24) makes up the set of exchangers (9) and the infeeding of the regenerator (15) is performed by means of using a single primary stream (10) introduced at the upper part of the regenerator (15). The absorbent flow rate was set at 7.01 kg/h, which corresponds with an UG ratio equal to 12, with the inlet temperature into the absorber being 49 °C.

[0041] The configuration of the invention uses a partial recirculation of the stream of recirculated CO₂-rich absorbent solution (7), a set of exchangers (9) made up of internal heat exchangers (24, 25), and the inlet stream has been distributed to the regenerator in two streams: a primary stream (10) in the upper part of the regenerator (15) and a secondary stream (13) in the intermediate area of the regenerator (15). This secondary stream (13) was removed at the outlet of the first internal heat exchanger (24) of the set of exchangers (9). The absorbent flow rate was set at 8.18 kg/h, which corresponds with an L/G ratio equal to 14, with the inlet temperature of the gas into the absorber being 47 °C.

[0042] The most relevant operating conditions and the results obtained are summarized in Table 1. The operation by means of the method of the invention allowed increasing the cyclic capacity of the absorbent and the CO₂ separation yield during the separation operation as a result of a higher load of the rich absorbent in the absorption step. This increase in load is primarily due to the recirculation of part of the recirculated CO₂-rich absorbent solution (7). Stratifying the feed into the regenerator (15) caused a decrease in the temperature profile in the regenerator (15) and, therefore, a stripped solution with a higher load of CO₂. This shift in the cyclic operating capacity of the absorbent allowed the use of the new configuration to achieve an 11 % reduction of the specific consumption of energy associated with the regeneration of the absorbent, producing a net benefit with respect to the conventional configuration of processes of this type. Furthermore, the lower thermal level obtained in the regenerator favors a reduction of the degradation of the absorbent associated with thermal mechanisms.

Table 1		Configuration			
		Units	Conventional	Invention	
Operating parameters					
Absorber	L/G ratio	kg/kg	12	14	
	Recirculation rate	%	-	20	
Regenerator	Temperature at bottom		°C	120	118
	Primary feed	Flow rate	kg/h	7.01	5.73
		Temperature	°C	112	108
	Secondary feed	Flow rate	kg/h	-	2.45
		Temperature	°C	-	100
	Distribution in set (21C/21B)		-	100/0	80/20
Results					
Stripped absorbent load		mol CO ₂ /mol absorbent	0.15	0.19	
Rich absorbent load		mol CO ₂ /mol absorbent	0.34	0.41	
Cyclic capacity		mol CO ₂ /mol absorbent	0.19	0.22	

(continued)

Results			
CO ₂ capture yield	%	96	98
Specific consumption of captured CO ₂	GJ/t CO ₂	4.55	4.05

Claims

1. Method for separating CO₂ from a gas stream based on chemical absorption, comprising the following steps:

a) absorbing the CO₂ coming from the gas stream to be treated at a temperature of between 40 °C and 60 °C and a pressure in a range of between 1 and 1.5 bar, by means of putting said stream in contact in an absorber with an absorbent solution in which the CO₂ will be retained;

b) recirculating into the absorber up to 75 % of the stream comprising the CO₂-rich absorbent solution coming from step a);

c) desorbing CO₂ in a regenerator from the stream comprising the CO₂-rich absorbent solution coming from step a) not recirculated to step b) at a temperature of between 80 °C and 120 °C a pressure of between 1.5 and 5 bar and a steam stripping flow rate of between 10 and 90 % by volume with respect to the desorbed CO₂ flow rate, where said stream is split into at least two streams by means of a set of heat exchangers, prior to the inlet of the regenerator;

d) recovering the absorbent solution resulting from step c) from the absorber of step a).

2. Method according to claim 1, wherein the CO₂ of the gas stream to be treated in step a) is transferred to the liquid phase where it is dissolved and chemically bonds to the absorbent.

3. Method according to any of the preceding claims, wherein the recirculated flow rate of step b) reaches between 25 % and 75 % of the total of the CO₂-rich solution coming from step a).

4. Method according to any of the preceding claims, wherein the recirculation of the stream coming from step b) takes place in the lower bed of the absorber of step a).

5. Method according to any of the preceding claims, wherein the streams coming from step c) are introduced in areas located at different heights of the regenerator of step d).

6. System for carrying out the method described in any one of the preceding claims, comprising:

- an absorber (2) comprising a packed column and a lower bed, which has:

- an inlet receiving the gas stream to be treated (1) which will come into contact in the absorber (2) with an absorbent liquid which is used for retaining the CO₂ from the gas to be treated (1),

- an outlet for a stream of CO₂-rich absorbent solution (4),

- an inlet for an inlet stream of regenerated absorbent solution (23),

- an inlet for a stream of recirculated CO₂-rich absorbent solution (7), and

- an outlet through which the clean gas (3) free of CO₂ is discharged,

- a regenerator (15)

which receives a main inlet stream into CO₂-rich absorbent regenerator (12),

from which there departs an outlet stream of stripped regenerated absorbent (21), and an outlet stream (16) mainly made up of CO₂ and water vapor, and

comprising a drum (20) which generates the energy necessary for regenerating the absorbent,

- a set of heat exchangers (9) located between the absorber (2) and the regenerator (15)

which receives the CO₂-rich absorbent solution (6),

as well as a stripped regenerated absorbent solution (21) coming from the regenerator (15), and

from which there exits an inlet stream of regenerated absorbent solution (23) directed to the absorber (2), and from which there exits a stream of CO₂-rich absorbent which is directed to the regenerator (15),

5 **characterized in that** the absorber (2) additionally comprises an inlet for a recirculated CO₂-rich absorbent solution recirculation line (7), which is conducted back to the lower bed of the absorber (2) for the purpose of increasing the load thereof by means of a first heat exchanger (8A) which lowers its temperature.

10 7. System according to claim 6, **characterized in that** within the set of heat exchangers (9) the stream of CO₂-rich absorbent solution (6) is split into a primary stream (10) and a secondary stream (13), wherein both are directed to the upper part and to the intermediate bed of the regenerator (15), respectively.

8. System according to claim 7, **characterized in that** the distribution of the stream of CO₂-rich absorbent solution (6) between the primary stream (10) and the secondary stream (13) is established in the range of between 0.25 and 0.75.

15 9. System according to claim 7, **characterized in that** it additionally comprises a second indirect contact exchanger (11) in which the primary stream (10) is preheated using the outlet stream from the regenerator (16), giving rise to the main inlet stream into the regenerator (12).

20 10. System according to claim 7, **characterized in that** the secondary stream (13) is split into an additional stream (14) in order to be fed in at different heights of the regenerator (15).

25 11. System according to claims 6 and 7, **characterized in that** the set of heat exchangers (9) comprises internal heat exchangers (24, 25, 26) which heat the primary stream (10), and the secondary stream (13) is obtained from inner streams (13A, 13B, 13C) which are removed at the outlet of each of the internal exchangers (24, 25, 26), and **in that** the stream of stripped regenerated absorbent solution (21) can in turn be split into different substreams (21 A, 21B, 21C) which enter each of the internal heat exchangers (24, 25, 26).

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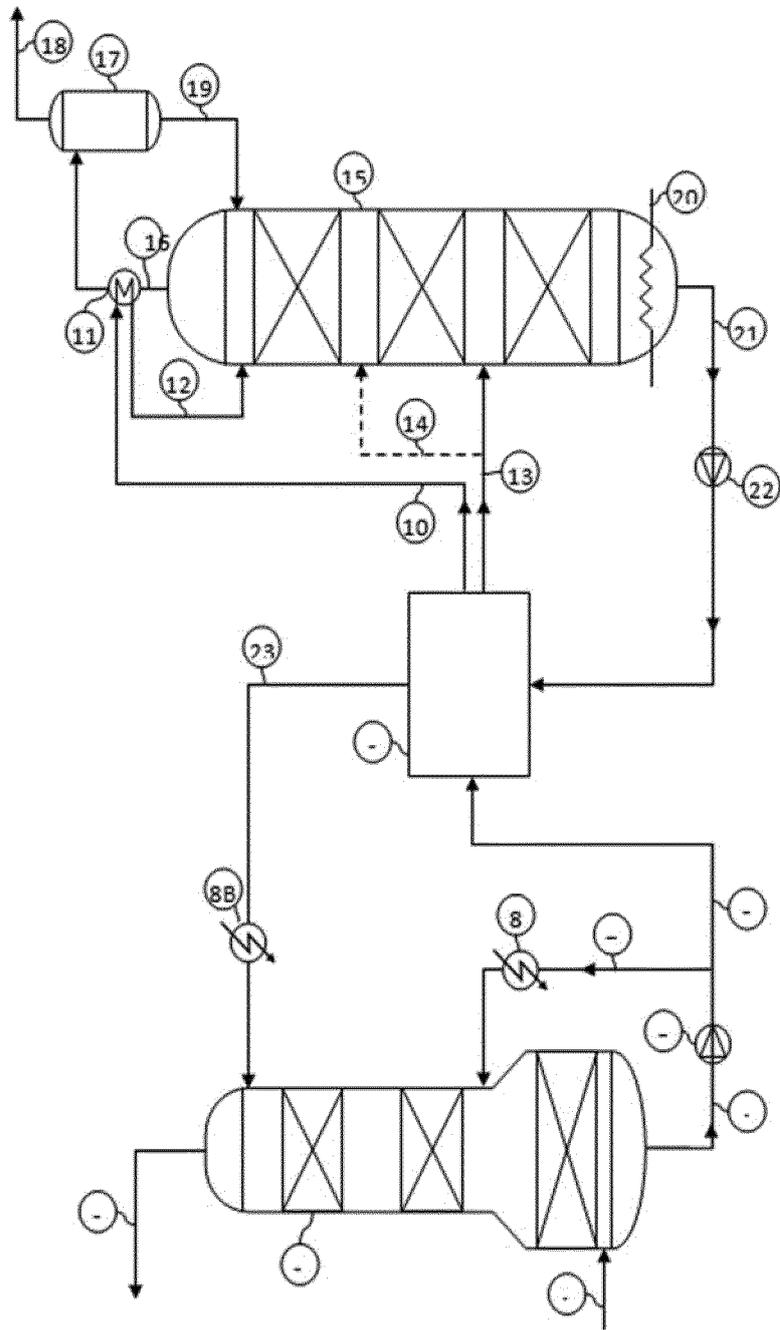


FIGURE 1

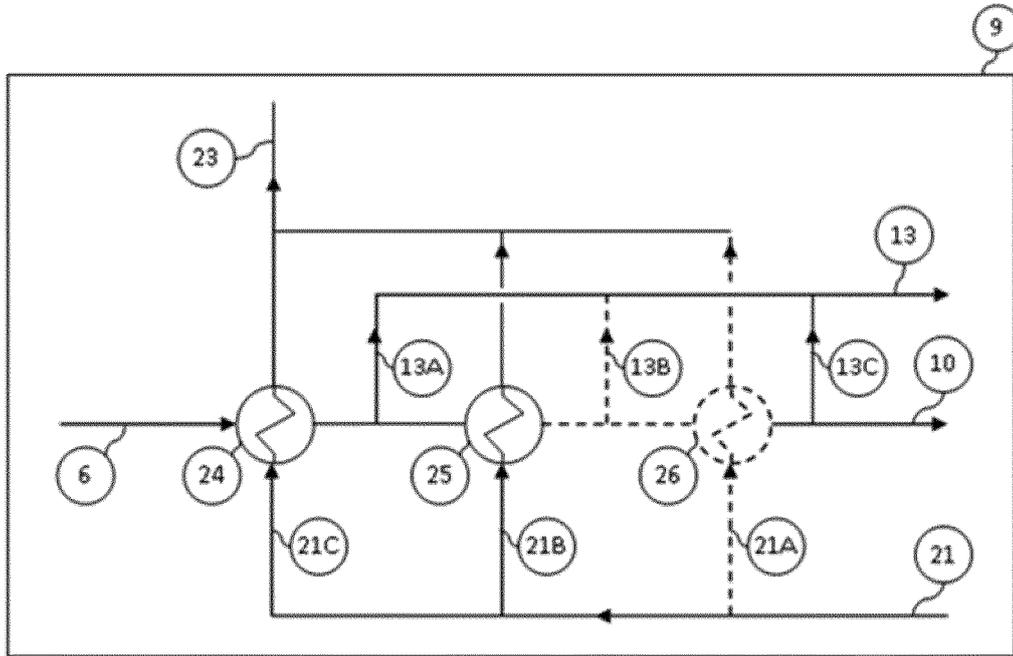


FIGURE 2

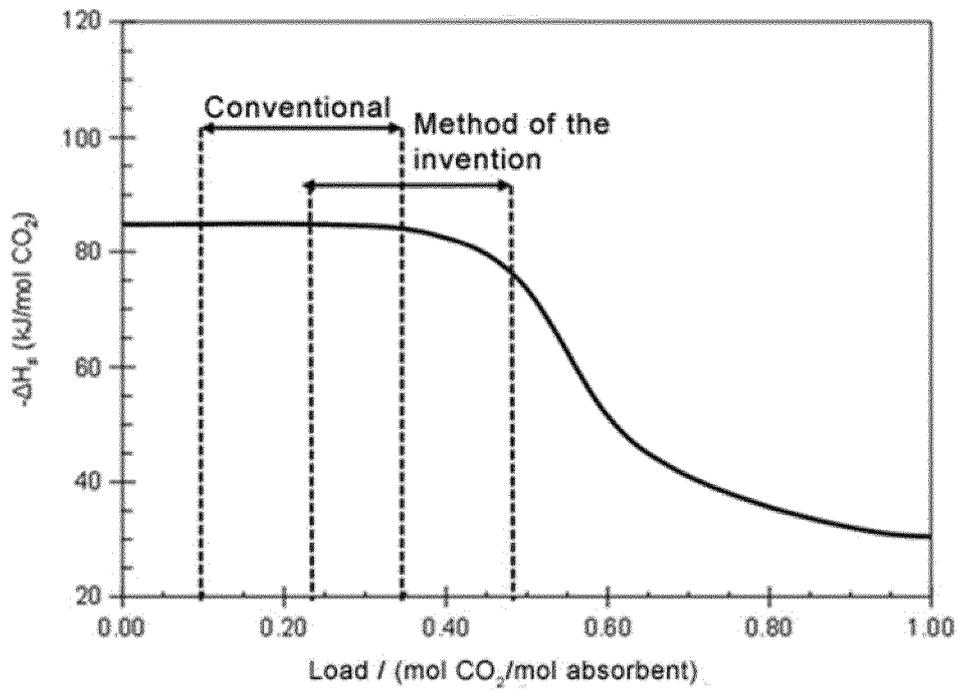


FIGURE 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/ES2017/000073

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A. CLASSIFICATION OF SUBJECT MATTER

B01D53/14 (2006.01)**B01D53/62** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

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B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

15

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, INVENES, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

20

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2011041685 A1 (TANAKA HIROSHI ET AL.) 24/02/2011, figure 2, paragraphs[21 - 42].	1-11
A	US 6800120 B1 (WON RAY ET AL.) 05/10/2004, columns 4 - 7.	1-11
A	WO 2009035340 A1 (AKER CLEAN CARBON AS ET AL.) 19/03/2009, figure 1, claim 1.	1-11

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 Further documents are listed in the continuation of Box C.
 See patent family annex.

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* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance.

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search

29/09/2017

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/ES2017/000073

Information on patent family members

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