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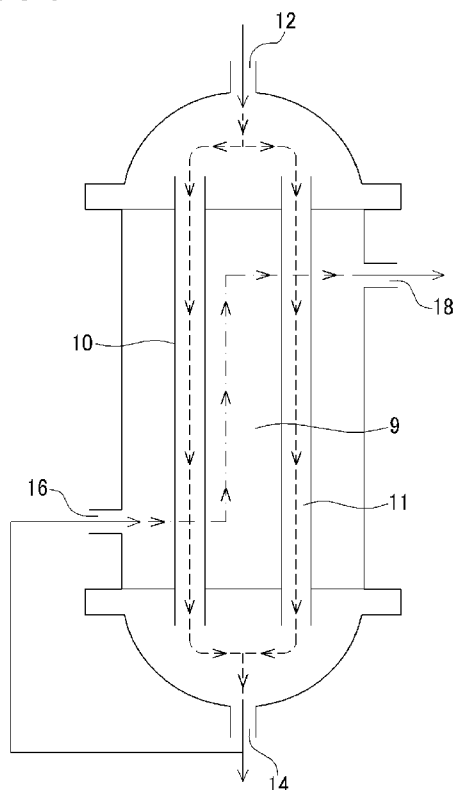
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(54) Title: ETHANOL DEHYDRATION DEVICE OF MULTI-TUBE TYPE USING PRESSURE SWING ADSORPTION PROCESS

[Fig. 2]



(57) Abstract: Disclosed is an ethanol dehydration device of a multi-tube type using pressure swing adsorption process in which producing dehydrated ethanol and regenerating an absorbent are alternately performed in one bed having a multi-tube. The dehydration device effectively transfers heat since it has a multi-tube type bed and minimizes heat loss by using a heat source generated during the absorption. Thereby, it improves the regeneration of absorbent and productivity. In addition, it is possible to save the early investment cost due to decreasing the installation cost and site of the dehydration bed.



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Description

Title of Invention: ETHANOL DEHYDRATION DEVICE OF MULTI-TUBE TYPE USING PRESSURE SWING ADSORPTION PROCESS

Technical Field

- [1] The described technology relates generally to an ethanol dehydration device of a multi-tube type using pressure swing adsorption process, and particularly, to an ethanol dehydration device of a multi-tube type using pressure swing adsorption process that alternately produces a dehydrated product and recycles an adsorbent in one bed by a multi-tube system.

Background Art

- [2] Generally, anhydrous ethanol is produced by dehydrating ethanol using at least two dehydration beds in which dehydrated ethanol is produced in one bed while an adsorbent is regenerated in the other bed using vacuum and a portion of the obtained product.
- [3] In this way, the anhydrous ethanol product is produced in a system in which the production and regeneration are repeatedly performed in at least two beds.
- [4] During the process, attention should be paid to keep each bed warm and to externally radiate heat. Particularly, the high-temperature gaseous water/ethanol mixture supplied to the dehydration bed somewhat deteriorates the process efficiency since it is difficult to effectively transfer heat.

Disclosure of Invention

Technical Problem

- [5] One aspect of the present invention provides an ethanol dehydration device of a multi-tube type using pressure swing adsorption process such that heat transfer efficiency and productivity are improved.

Solution to Problem

- [6] According to one aspect of the present invention provides an ethanol dehydration device of a multi-tube type using pressure swing adsorption process, including:
- [7] a plurality of tubes of which an absorbent is charged inside and outside thereof;
- [8] a plurality of first inlets disposed in an upper end of each tube and into which a gaseous water/ethanol mixture flows;
- [9] a plurality of first outlets disposed on a lower end of the tube and from which dehydrated ethanol flows, wherein the ethanol is dehydrated by an absorbent by passing the gaseous water/ethanol mixture flowing into the first inlets through the inside of the

tube;

[10] a plurality of second inlets disposed between the first inlet and the first outlet and through which the dehydrated ethanol coming from the first outlet flows; and

[11] a plurality of second outlets disposed between the first inlet and the first outlet and through which a gaseous water/ethanol mixture flows, wherein the gaseous water/ethanol mixture is formed by passing the dehydrated ethanol flowing in the second inlet through the outside of the tube to regenerate the absorbent absorbing moisture.

[12] According to another aspect of the present invention provides an ethanol dehydration device of a multi-tube type using pressure swing adsorption process, including:

[13] a plurality of tubes charged with an absorbent at the inside and outside thereof;

[14] a plurality of first inlets disposed on one side surface of the tube and through which a gaseous water/ethanol mixture flows;

[15] a plurality of first outlets disposed on the other side surface of the tube and through which dehydrated ethanol flows, wherein the ethanol is dehydrated by an absorbent by passing the gaseous water/ethanol mixture flowing in the first inlets through the outside of the tube;

[16] a plurality of second inlets disposed in the lower end of tube and through which the dehydrated ethanol coming from the first outlet flows; and

[17] a plurality of second outlets disposed on the upper end of the tube and through which a gaseous water/ethanol mixture flows, wherein the gaseous water/ethanol mixture is formed by passing the dehydrated ethanol flowing in the second inlet through the inside of the tube to regenerate the absorbent absorbing moisture.

Advantageous Effects of Invention

[18] The ethanol dehydration device of a multi-tube type using pressure swing adsorption process may effectively transfer heat and improve productivity, so it is possible to save the cost of early investment along with decreasing the installation charge and site of a dehydration bed.

Brief Description of Drawings

[19] FIG. 1 is a schematic view showing a pressure swing adsorption dehydration device according to one embodiment.

[20] FIG. 2 and FIG. 3 are schematic views showing a multi-tube type of bed according to one embodiment.

[21] <Description of Reference Numerals Indicating Primary Elements in the Drawings>

[22] 2: crude ethanol reservoir 4: heater

[23] 6, 20: 4-way valve 8: multi-tube type bed

[24] 9: outside of tube 10: tube

[25] 11: inside of tube 12, 32: first inlet

- [26] 14, 34: first outlet 16, 36: second inlet
[27] 18, 38: second outlet 22: product reservoir
[28] 24: vacuum pump

Best Mode for Carrying out the Invention

- [29] Exemplary embodiments will hereinafter be described in detail. However, these embodiments are only exemplary, and the present invention is not limited thereto. The present invention may, however, be embodied in many different forms and should not be construed as limited to the exemplary embodiments set forth herein.
- [30] FIG. 1 is a schematic view showing a pressure swing adsorption dehydration device according to one embodiment.
- [31] As shown in FIG. 1, crude ethanol having a moisture concentration of 5 to 15 volume% stored in a crude ethanol reservoir 2 is moved to a heater 4 and heated to about 130 to 140°C. Then the crude ethanol having passed through 4-way valve 6 is passed into a multi-tube type bed 8 to produce dehydrated ethanol and to regenerate absorbent. The dehydrated ethanol product is passed through a 4-way valve 20 and moved into a product reservoir 22. On the other hand, a portion of the dehydrated ethanol product is drawn into a reservoir (not shown) and maintained under vacuum by a vacuum pump 24 in order to regenerate the absorbent.
- [32] In other words, producing the product and regenerating the absorbent are alternately performed in one bed in which a multi-tube is mounted, and the multi-tube type bed 8 will now be described with reference to FIG. 2 and FIG. 3.
- [33] FIG. 2 and FIG. 3 show schematic views showing a multi-tube type bed according to one embodiment, which has one bed 8 having a multi-tube inside thereof.
- [34] Firstly, when the crude ethanol, which is a gaseous water/ethanol mixture, flows in a first inlet 12 and is passed through the inside 11 of a tube 10 disposed in the bed 8, it is dehydrated by an absorbent charged in the inside 11 of the tube 10 and flows out through a first outlet 14 to provide a dehydrated ethanol product having high purity. A portion of the obtained dehydrated ethanol product flows in a second inlet 16 and is passed through the outside 9 of the tube 10 disposed in the bed 8 to regenerate the absorbent used for dehydrating ethanol. The adsorbed moisture is bound with the ethanol supplied from the second inlet 16 to provide a water/ethanol mixture and flows out through a second outlet 18.
- [35] That is, the gas flow passes from the first inlet 12 through the inside 11 of the tube 10 and is adsorbed, and it simultaneously produces a dehydrated ethanol product that flows out through a first outlet 14. A portion of the gas flow of the obtained product flows in through the second inlet 16 and passes through the outside 9 of the tube 10 to regenerate the absorbent, and a water/ethanol mixture having a relatively low con-

centration, which is 80 to 85 volume% of ethanol, flows out through the second outlet 18.

[36] Furthermore, when the product is produced and the absorbent is regenerated during the process, the gas flow is changed by the 4-way valves 6 and 20.

[37] That is, as shown in FIG. 3, when a gaseous water/ethanol mixture flows in through a first inlet 32 and passes through the outside 9 of a tube disposed in the bed 8, it is dehydrated by an absorbent charged at the outside 9 of the tube 10 and flows out through a first outlet 34 to provide dehydrated ethanol. When a portion of the obtained dehydrated ethanol product flows in a second inlet 36 and passes through the inside 11 of the tube 10 disposed in the bed 8, the water-absorbed absorbent is regenerated, and simultaneously the obtained gaseous water/ethanol mixture flows out through a second outlet 38.

[38] In other words, when the gas flow passes through the outside 9 of the tube 10 from the first inlet 32 to the first outlet 34, it is adsorbed, and simultaneously the dehydrated ethanol is produced; and when a portion of gas flow of the product is passed through the inside 11 of the tube 10 from the second inlet 36 to the second outlet 38, the absorbent is regenerated.

[39] As shown in FIG. 2 and FIG. 3, collectively looking at the embodiment, a gaseous water/ethanol mixture is passed from the first inlet 12 to the first outlet 14 as the flow order in FIG. 2, so it may be absorbed at the inside 11 of the tube 10; furthermore, it is passed from the first inlet 32 to the first outlet 34 as the flow order in FIG. 3, so it may be absorbed at the outside 9 of the tube 10.

[40] In addition, the dehydrated ethanol is passed from a second inlet 16 to a second outlet 18 as the flow order in FIG. 2, so a adsorbent is regenerated at the outside 9 of a tube 10; furthermore, it is passed from a second inlet 36 to a second outlet 38 as the flow order in FIG. 3, so the absorbent may be regenerated at the inside 11 of a tube 10.

[41] According to one embodiment, the adsorption is effectively performed under the low temperature and high pressure and the desorption is effectively performed under the high temperature and low pressure in the multi-tube type bed according to the present invention.

[42] According to one embodiment, the adsorption is performed under a pressure of 0.1 to 0.6 kg/cm², and the desorption is performed under a pressure of -0.5 to -0.9 kg/cm² in a bed.

[43] As mentioned above, the absorbing at the inside of a tube and the regenerating at the outside of a tube may be alternately performed in the multi-tube type bed according to a present invention; on the other hand, the generating at the inside of tube and the absorbing at the outside of a tube may also be alternately performed. Thereby, the high temperature gaseous water/ethanol mixture supplied into the bed effectively transfers

the heat.

- [44] In other words, the heat source generated by adsorbing the high temperature gaseous mixture induces the heat transfer phenomenon by the multi-tube according to the present invention. In addition, it also supplies the heat source to the absorbent during the regeneration to increase the regenerativity. As a result, energy is saved.
- [45] The gaseous water/ethanol mixture flowing in the first inlet 12 in FIG. 2 and the first inlet 32 in FIG. 3 includes 80 to 95 volume% of ethanol. The dehydrated ethanol flowing out through the first outlet 14 and the first outlet 34 has a high ethanol concentration of 99.5 volume% or more.
- [46] According to one embodiment, the multi-tube type bed may have 2 to 10 tubes.
- [47] The absorbent is Zeolite 3A or 4A.
- [48] In addition, according to one embodiment, the volume of the inside 11 of the tube 10 of the multi-tube type bed charged with the absorbent is the same as that of the outside 9. According to another embodiment, the charged absorbent has a weight ratio of the outside 9 to the inside 11 of the tube 10 of 0.5 to 2.0.
- [49] The pressure swing adsorption dehydration device may include 1 to 5 multi-type type beds 8 according to the present invention.
- [50] In addition, the multi-tube type bed may be usable for a pre-adsorption process, a post-adsorption process, or both a pre-adsorption process and a post-adsorption process.
- [51] The pre-adsorption process refers to a process of producing 99.5 volume% or more of a product that is concentrated by a single-top (using one column) concentration process instead of the multi-top (using two or three columns) concentration process during the distillation process, including pre-concentrating 80 to 90 volume% of crude ethanol into 92 to 95 volume% using the multi-tube type bed and dehydrating the ethanol using the conventional two beds.
- [52] The post-adsorption process refers to a process of producing a product by dehydrating 92 to 96 volume% of the concentrated ethanol obtained from the pre-adsorption process and the multi-top distillation process into 99.5 volume% using the multi-tube type bed.
- [53] In the view of the process cycle, the pre-adsorption process is the same as the post-adsorption process. According to one embodiment, the absorbent used in the pre-adsorption process is Zeolite 4A, and that of post-adsorption process is Zeolite 3A.
- [54] The following Table 1 schematically illustrates a process cycle of the conventional ethanol dehydration device with pressure swing absorption process, and the following Table 2 schematically illustrates a process cycle of the ethanol dehydration device of a multi-tube type using pressure swing adsorption process according to one embodiment.
- [55] Table 1

[Table 1]

A bed	adsorption			under reduc ed press ure	purge	pressi ng	adsorption			under reduc ed press ure	purge	pressi ng
B bed	under reduc ed press ure	purge	pressi ng	adsorption			under reduc ed press ure	purge	pressi ng	adsorption		

[56] Table 2

[Table 2]

inside tube	adsorption			under reduc ed press ure	purge	Press ing	adsorption			under reduc ed press ure	purge	press ing
outside tube	under reduc ed press ure	purge	press ing	adsorption			under reduc ed press ure	purge	press ing	adsorption		

[57] As shown in Table 1, the conventional dehydration device has two beds, of which the product is produced in one bed while the absorbent is regenerated in the other bed.

These processes are repeatedly performed in the two beds.

[58] In addition, the conventional dehydration device requires the total adsorption time of 3.5 to 7 minutes, which is for 0.5 to 1 minute to reduce the pressure, for 2.5 to 5

minutes to purge, and for 0.5 to 1 minute to press.

[59] The purge time refers to the time for flowing in a portion of the dehydrated product to regenerate the adsorbent.

[60] On the other hand, it includes a system including one multi-tube type bed in which producing the dehydrated product at the inside of one tube and regenerating the adsorbent at the outside of tube are alternately performed, and these processes are repeatedly carried out inside and outside of the tube in one bed.

[61] Furthermore, the dehydration device reduces the purge time to 1 to 3 minutes due to the effective heat transfer between the inside and the outside of the tube compared to the purge time of the conventional dehydration device of 2.5 to 5 minutes and increases the decompression time of 2 to 4 minutes compared to the conventional 0.5 to 1 minute, so the productivity is improved by minimizing the product amount used for the purge process.

[62] On the other hand, when Zeolite 3A is used as the adsorbent, the dehydrated ethanol concentration and the ethanol concentration of the gaseous water/ethanol mixture flowing out during regeneration of the adsorbent are shown in the following Table 3.

[63] The ethanol concentration is measured under normal process conditions by a moisture quantity analysis according to the Karl-Fisher method. The normal process conditions refers to process conditions in which the product produced from continuously driving the ethanol dehydration device of a multi-tube type using pressure swing adsorption process is to have a concentration of 99.5 volume% or more when it is measured by the Karl-Fisher method.

[64] Table 3

[Table 3]

	Concentration of dehydrated ethanol in the first outlet 14 and the first outlet 34	Ethanol concentration of gaseous water/ethanol mixture when the adsorbent is regenerated from the second outlet 18 and the second outlet 38
Ethanol concentration (volume%)	99.5 volume% or more	80 to 85 volume%

Industrial Applicability

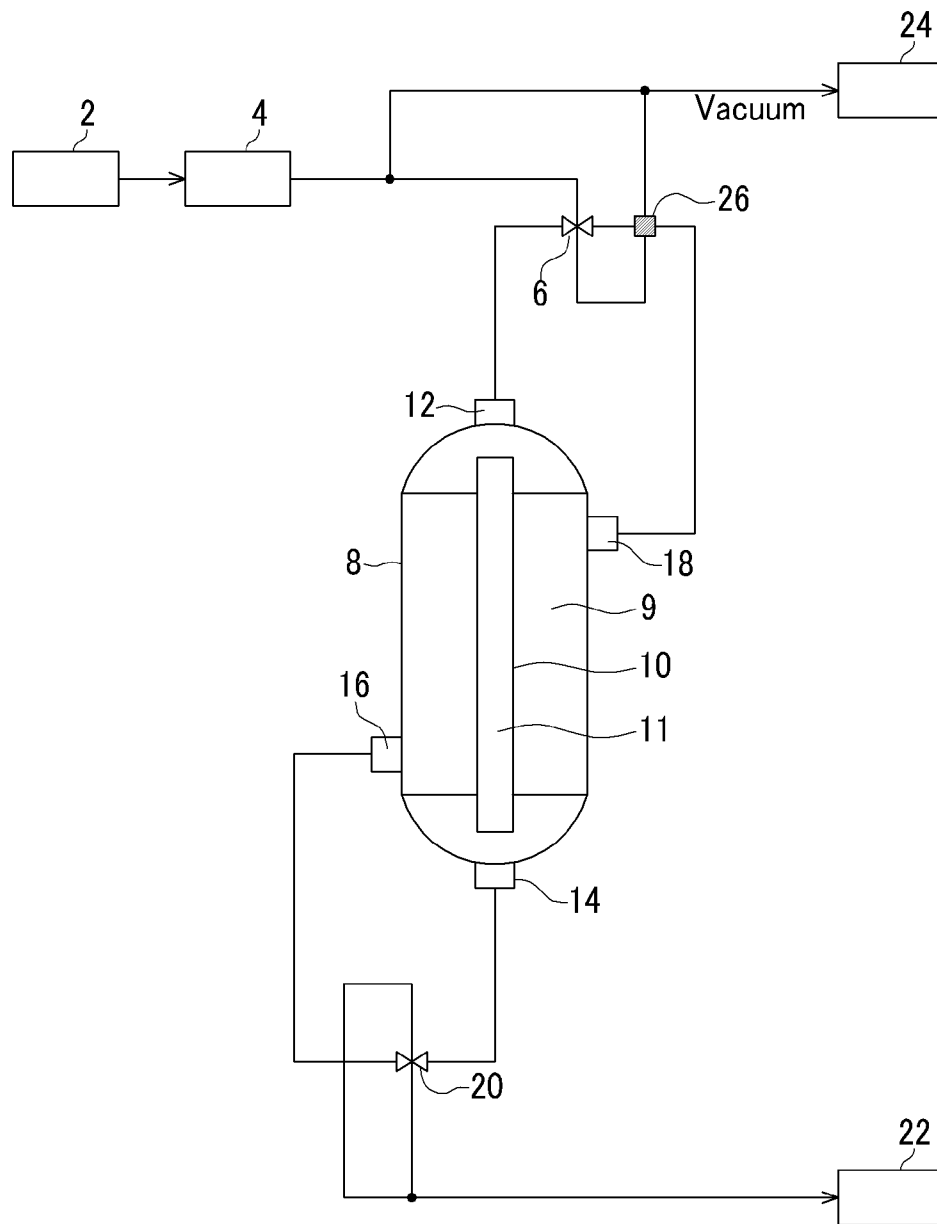
- [65] The ethanol dehydration device of a multi-tube type using pressure swing adsorption process may effectively transfer heat and improve productivity, so it is possible to save the cost of early investment along with decreasing the installation charge and site of a dehydration bed.

Claims

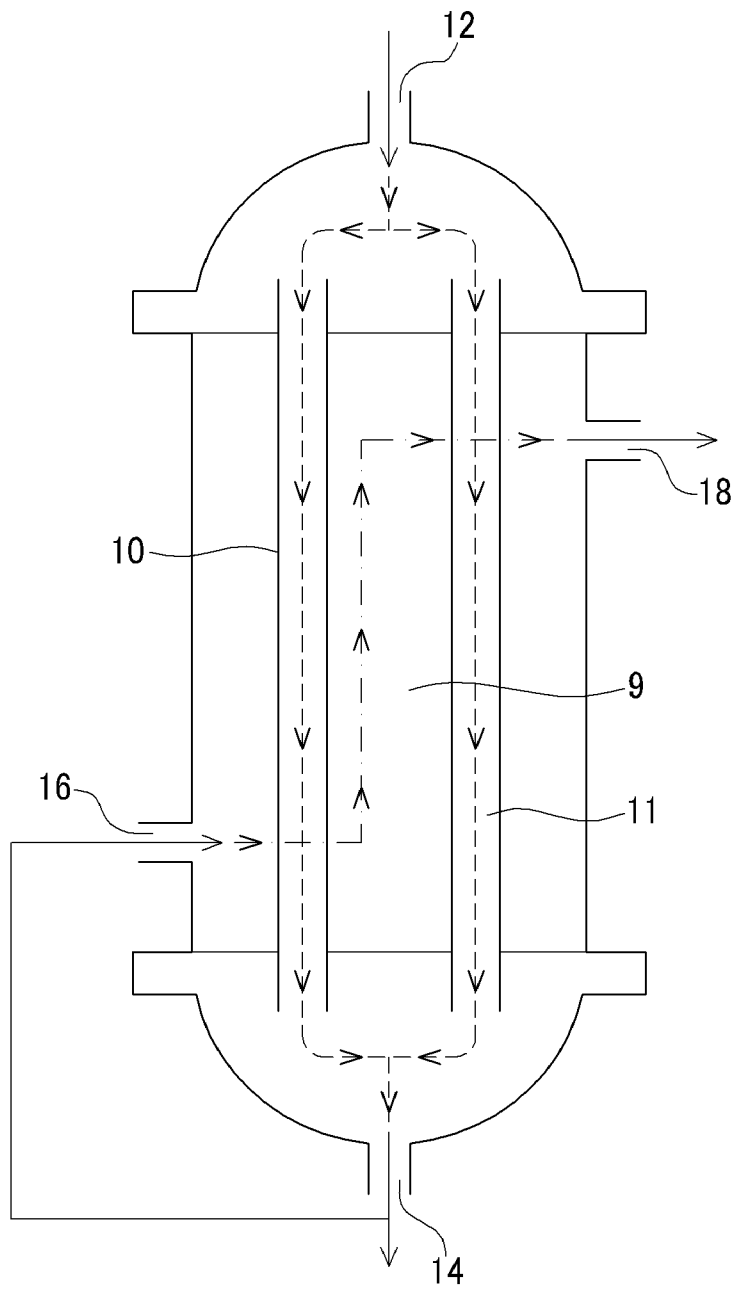
- [Claim 1] An ethanol dehydration device of a multi-tube type using pressure swing adsorption process, comprising:
a plurality of tubes of which an absorbent is charged inside and outside thereof;
a plurality of first inlets disposed in an upper end of each tube and into which a gaseous water/ethanol mixture flows;
a plurality of first outlets disposed on a lower end of the tube and from which dehydrated ethanol flows, wherein the ethanol is dehydrated by an absorbent by passing the gaseous water/ethanol mixture flowing into the first inlets through the inside of the tube;
a plurality of second inlets disposed between the first inlet and the first outlet and through which the dehydrated ethanol coming from the first outlet flows; and
a plurality of second outlets disposed between the first inlet and the first outlet and through which a gaseous water/ethanol mixture flows, wherein the gaseous water/ethanol mixture is formed by passing the dehydrated ethanol flowing in the second inlet through the outside of the tube to regenerate the absorbent absorbing moisture.
- [Claim 2] The dehydration device of claim 1, wherein 2 to 10 tubes are present in the multi-tube type bed.
- [Claim 3] The dehydration device of claim 1, wherein the absorbent is Zeolite 3A or 4A.
- [Claim 4] The dehydration device of claim 1, wherein the absorbent has a weight ratio of outside of the tube to the inside the tube of 0.5 to 2.0.
- [Claim 5] The dehydration device of claim 1, comprising 1 to 5 multi-tube beds.
- [Claim 6] The dehydration device of claim 1, wherein the dehydrated ethanol comprises 99.5 volume% or more of ethanol.
- [Claim 7] An ethanol dehydration device of a multi-tube type using pressure swing absorption process, comprising:
a plurality of tubes charged with an absorbent inside and outside thereof;
a plurality of first inlets disposed on one side surface of the tube and through which a gaseous water/ethanol mixture flows;
a plurality of first outlets disposed on the other side surface of the tube and through which dehydrated ethanol flows, wherein the ethanol is dehydrated by an absorbent by passing the gaseous water/ethanol mixture

flowing in the first inlets through the outside of the tube;
a plurality of second inlets disposed on the lower end of tube and through which the dehydrated ethanol coming from the first outlet flows; and
a plurality of second outlets disposed on the upper end of the tube and through which a gaseous water/ethanol mixture flows, wherein the gaseous water/ethanol mixture is formed by passing the dehydrated ethanol flowing in the second inlet through the inside of the tube to regenerate the absorbent absorbing moisture.

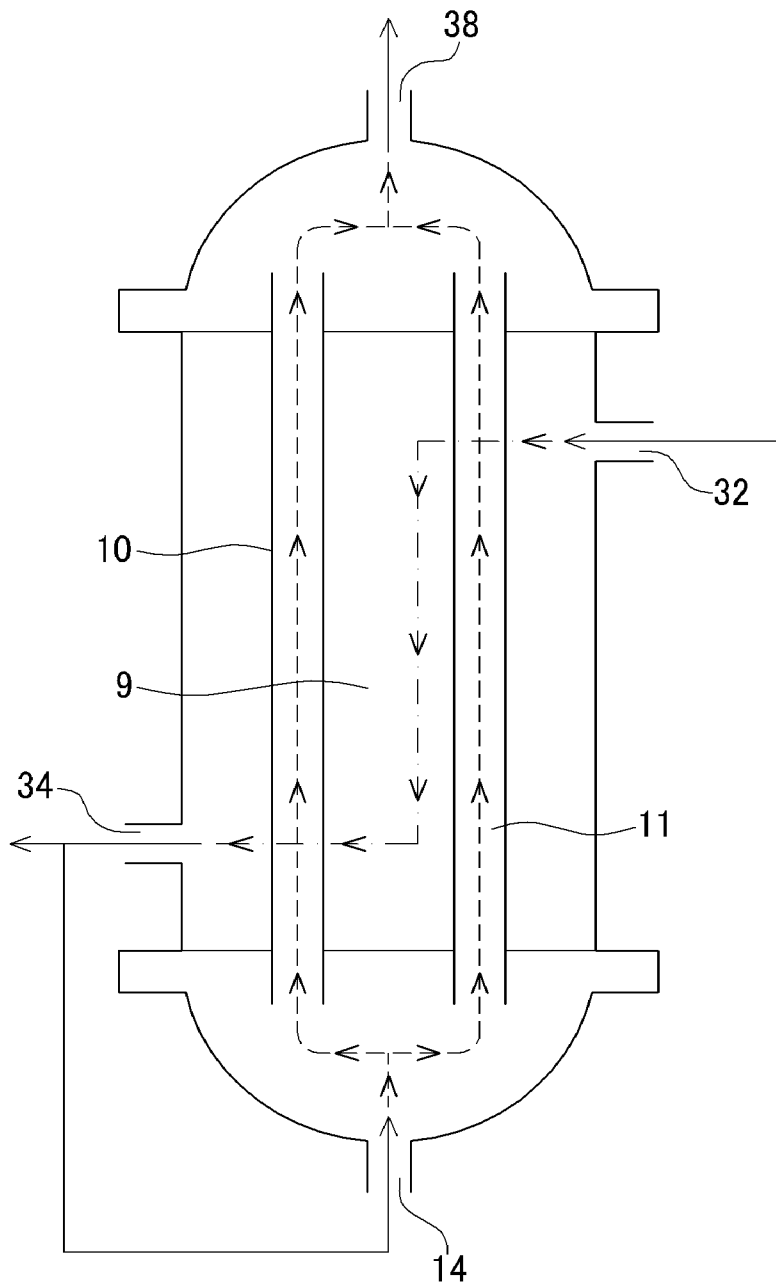
[Fig. 1]



[Fig. 2]



[Fig. 3]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR 2009/004886

A. CLASSIFICATION OF SUBJECT MATTER IPC⁸: B01D 53/047 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC⁸: B01D		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched -----		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) WPI, EPODOC, PAJ, STN-Patdpa		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2007/047622 A1 (ARCHER-DANIELS-MIDLAND COMPANY) 26 April 2007 (26.04.2007) <i>Claims, Figures 1 and 2, abstract</i> --	1-7
A	FR 2907023 A1 (MAGUIN SA.) 18 April 2008 (18.04.2008) <i>Claims</i> --	1-7
A	RU 2265473 C1 (KHIMSINTEZ RES PRODN ASSOC STOCK CO.) 10 December 2005 (10.12.2005) <i>Derwent abstract; (online); retrieved from EPOQUE WPI database ; retrieved on 20.11.2009</i> ----	1-7
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
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Date of the actual completion of the international search 23 November 2009 (23.11.2009)		Date of mailing of the international search report 9 December 2009 (09.12.2009)
Name and mailing address of the ISA/ AT Austrian Patent Office Dresdner Straße 87, A-1200 Vienna Facsimile No. +43 / 1 / 534 24 / 535		Authorized officer STEPANOVSKY M. Telephone No. +43 / 1 / 534 24 / 135

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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