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(54) Falling film tube bundle heat exchanger

(57) The present invention relates to a falling film tube bundle heat exchanger (1) with vertical tubes, comprising a cylindrical mantle (2) with vertical axis closed to the opposite ends by respective bottoms, superior (3) and inferior (4),

- a first falling film tube bundle (F_1) with vertical tubes (5), mounted in said mantle (2), with tube plates (6,7), respectively superior and inferior, circumferentially fixed, tightened against a fluid under pressure, to the mantle (2) itself, in which they define between them a first heat exchange zone (12),
- at least a second tube bundle (F_2) with vertical tubes (8), mounted in said mantle (2), with tube plates (9,10), respectively superior and inferior, circumferentially fixed, tightened against a fluid under pressure, to the mantle (2) itself, in which they define between them a second heat exchange zone (14), said superior plate (9) being fixed to said mantle (2) in fixed axially spaced relationship from the inferior tube plate (7) of said first tube bundle (F_1),
- a holding and distribution zone (13), comprised between the inferior tube plate (7) of said first tube bundle (F_1), and the superior tube plate (9) of said second tube bundle (F_2), being open, in said holding and distribution zone (13) the respective inferior (5b,8b) and superior (5a,8a) ends of said first (F_1) and second (F_2) tube bundle.

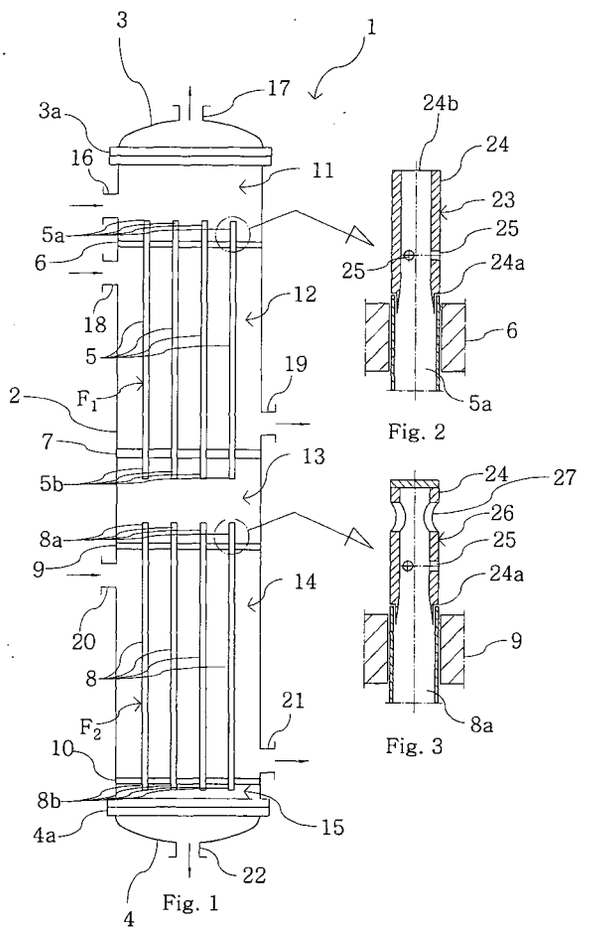


Fig. 2

Fig. 3

Fig. 1

EP 1 491 836 A1

Description

Field of application

[0001] In its most general aspect the present invention relates to a tube bundle heat exchanger, with vertical tubes, useful for carrying out heat exchange between at least two fluids, with the so-called falling film technique.

[0002] A heat exchanger of the said type, and to which refers the present invention, generally comprises a plurality of rectilinear tubes, grouped to form a tube bundle through at least two tube plates, positioned near the opposite ends of said tubes, that are open on the outside of the plates themselves.

Prior Art

[0003] It is known and widespread, in the chemical and the food industry, the use of apparatuses as concentrators, evaporators, condensers and alike, that comprise, or are constituted by a tube bundle heat exchanger, with vertical tubes, of the so-called falling film type.

[0004] In order to obtain a simplified exposition, in rest of the description, for the concentration of a selected solution reference will be made to the use of heat exchangers of the considered type.

[0005] In the heat exchange between two fluids, as per the cited falling film technique, a first fluid, called main fluid in the rest of the description, for example a solution to be concentrated, goes down alongside the inner wall of the tubes, without filling them, forming a thin film, that leaves a considerable empty space in the centre of the tubes themselves and for their whole length; a second fluid, called operating fluid in he rest of the description, flows in the heat exchanger, from the outside of the respective tube bundle, coming into contact with the external wall of every single tube.

[0006] To said end, the vertical tubes, that constitute such a tube bundle, have opposite ends open and in fluid communication with the outside of the exchanger. Moreover, to grant the formation of a respective main fluid "falling film" in every vertical tube, in every upper end of said tubes a crop end of tube is coaxially engaged, fitted, in an intermediate position, with one or more through radial holes at predetermined distance from the underlying tube plate.

[0007] Generally, a predetermined liquid head of the solution to be concentrated is formed above said holes, which solution overflow through the holes inside the crop ends of the tubes, forming the desired liquid film.

[0008] In the rest of the description and in the following claims, said crop end of tube is also called ferule.

[0009] The vapor (or gas) that, inside each tube, frees itself from the solution to be concentrated, goes up the respective tube, to be discharged (or collected) outside the exchanger, while the solution to be concentrated exits from the bottom ends of the tubes, to be collected and discharged outside said exchanger.

[0010] It is known that, to increase the efficiency of the heat exchanger of the said type, as for a whole series of other and well known operating needs, a falling film heat exchanger is as much widely used, in which at least two distinct zones are defined, separated one from the other, tightened against a fluid under pressure, and crossed by the same vertical tubes of the only tube bundle comprised in said heat exchanger, each of said zones being intended to be crossed by a respective operating fluid.

[0011] Considering a heat exchanger with two heat exchange zones and that uses two different operating fluids, the known art provides a cylindrical mantle with vertical axis, closed at the opposite ends by respective walls or bottoms, a falling film tube bundle with vertical tubes, axially extended in said mantle having tube plates, respectively upper and bottom, fixed gas tight to said mantle, in proper spaced relationship from said bottoms. A third tube plate, in-between the previous, is circumferentially fixed, gas tight, to said mantle. The tubes are engaged tightly in said tubular plates, generally by flaring.

[0012] Although advantageous from various points of view, the descending film heat exchangers structured in the above schematically described way, have recognized drawbacks, among which the most relevant one is represented by the difficulty to assure the necessary and desired tightness between the two (or more) different zones in which every exchanger is subdivided. Such difficulty is above all due to the welding and flaring operations that, besides being numerous, have to be carried out in objectively awkward conditions.

[0013] In particular it's widely known that, the bigger the exchanger dimensions are, especially its height and the bigger is the length of the tube bundle and, therefore, the bigger is the "depth" or distance of the opposite ends of the exchanger at which it's required to operate (to weld and to flare), so, the bigger is said difficulty to assure an appropriate tightness between the heat exchange zones.

[0014] The lack of this tightness may cause a substantial drop of the overall yield of the exchanger and, so, of the device in which said exchanger is working and, so, of the operation, for example concentration of solutions, in charge to said device.

Summary of the invention

[0015] The problem underlying the present invention is that of providing a falling film tube bundle heat exchanger, with vertical tubes, of the above mentioned type, having structural and functional characteristics so as to allow a substantial simplification of the assembly and setting operations of the tube bundle inside the respective mantle, disengaging said operations from the exchanger height, from the tube length, so as to assure

in every case the tightness between the different inner heat exchange zones of the exchanger itself, so as to overcome all the drawbacks mentioned with reference to the prior art.

[0016] This problem is solved, according to the present invention, by a falling film tube bundle heat exchanger with vertical tubes, comprising a cylindrical mantle with vertical axis closed to the opposite ends by respective bottoms, superior and inferior, characterized in that it comprises:

- a first falling film tube bundle with vertical tubes, mounted in said mantle, with tube plates, respectively superior and inferior, circumferentially fixed, tightened against a fluid under pressure, to the mantle itself, in which they define between them a first heat exchange zone,

- at least a second tube bundle with vertical tubes, mounted in said mantle, with tube plates, respectively superior and inferior, circumferentially fixed, tightened against a fluid under pressure, to the mantle itself, in which they define between them a second heat exchange zone, said superior plate being fixed to said mantle in fixed axially spaced relationship from the inferior tube plate of said first tube bundle,

- a holding and distribution zone, comprised between the inferior tube plate of said first tube bundle, and the superior tube plate of said second tube bundle, being open, in said holding and distribution zone the respective inferior and superior ends of said first and second tube bundle,

- a plurality of ferules arranged with vertical axis in said holding and distribution zone, every ferule having an end coaxially engaged in a respective tube of said second tube bundle and the other end closed.

[0017] The advantages and the features of the method according to the present invention will become clearer from the description of an exemplificative embodiment thereof, made herein below with reference to the attached drawings, for indicative and non-limiting purposes.

Brief description of the drawings

[0018]

Figure 1 schematically illustrates a tube bundle heat exchanger of the descending film type, according to the present invention;

Figures 2 and 3 schematically illustrate in enlarged view respective details of the heat exchanger of figure 1.

Detailed description of a preferred embodiment

[0019] With reference to figure 1, a heat exchanger 1, of the so-called descending film type comprises a mantle 2, with a vertical axis A-A, closed at the opposite ends by respective bottoms, upper 3 and lower 4, fixed thereto through respective flanges 3a, 4a; a first descending film-tube bundle F_1, with vertical tubes 5, is axially extended in said mantle 2, with tube plates 6, 7 respectively superior and inferior, circumferentially fixed, tightened against a fluid under pressure, to the mantle 2 itself. The tubes 5 have opposite ends 5a, 5b open and extending externally to the respective tube plates 6, 7.

[0020] In axial alignment with said first tube bundle F_1, and in fixed spaced relationship from it, in said mantle 2 a second tube bundle F_2 with vertical tubes 8 is mounted, with tube plates 9, 10, respectively superior and inferior, circumferentially fixed, tightened against a fluid under pressure, to the mantle itself. The tubes 8 also have opposite ends 8a, 8b open and extending from the respective tube plates 9, 10.

[0021] Because of the presence of said tubular plates 6, 7, 9, 10, in the heat exchanger 1 five zones 11, 12, 13, 14, 15 are defined, ordered in axial sequence; the first zone 11 is comprised between the superior end 3 and the superior tube plate 6 of the first tube bundle F_1; the second zone 12, is comprised between the tube plates 6, 7 of said first tube bundle F_1; the third zone 13 is comprised between the inferior tube plate 7 of the first tube bundle F_1 and the superior tube plate 9 of the second tube bundle F_2; the fourth zone 14 is comprised between the tube bundles 9, 10 of the second tube bundle F_2; the fifth zone 15 is comprised between the tube plate 10 of the second tube bundle F_2 and the inferior bottom 4 of said mantle 2.

[0022] The first zone 11, named also distribution zone, is in fluid communication with the outside through a duct 16, provided for the input of main fluid, for example, a solution to be concentrated, and trough a duct 17, for the output of the possible vapors freed inside the tubes 5 of the first tube bundle F_1. In said zone 11 the superior ends 5a of the tubes 5 of the first tube bundle F_1 are open.

[0023] The second zone 12, or heat exchange zone, is separated, tightened against a fluid under pressure, from said zone 11, while it is in fluid communication with the outside of the mantle 2 trough ducts, superior 18 and inferior 19. The duct 18 is used for the input of a heat exchange operating fluid.

[0024] The fourth zone 14, heat exchange zone too, is in communication with the outside of the mantle 2 through a superior duct 20, for the input of a second heat exchange operating fluid and through an inferior duct 21 that provides for the output of said fluid from the heat exchanger 1.

[0025] Said heat exchange zones 12, 14 are mutually

spaced in the axis A-A direction, from the third zone 13, from which they are separated, tightened against a fluid under pressure.

[0026] In said zone third zone 13, or holding and intermediate distribution zone, the inferior ends 5b of the tubes 5 of the first tube bundle F_1 and the superior ends 8b of the tubes 8 of the second tube bundle F_2 are open.

[0027] At last, the fifth zone 15, or gathering zone, that constitutes a kind of tank for collecting the concentrate solution, is separated, tightened against a fluid under pressure, from said zone 14, while it is in communication with the outside of the exchanger 1 through a duct 22 for the output of said solution. In said zone 15 the inferior ends 8b of the tubes 8 of the second tube bundle F_2.

[0028] To grant the formation, by the main fluid, of a falling film contacting the inner wall of every tube 5 of the first tube bundle F_1, avoiding that in some part of it, said liquid may fill, even only partially, the central "empty" zone of the tube, in the distribution zone 11, the one comprised between the upper bottom 3 of the heat exchanger of the present invention, and the first tube bundle F_1, a plurality of per se known ferules 23 is operating, one for each tube 5.

[0029] Particularly (Fig. 2), every ferule 23 has end 24b free, open in said distribution zone 11 and, in an intermediate position, is fitted with one or more through radial holes at predetermined distance from the underlying tube plate 6, so as to form a liquid head (solution to be concentrated) in the distribution zone 11.

[0030] In the intermediate holding and distribution zone 13 too, a plurality of ferules 26 (Fig. 3) is active, one for each tube 8 of the second tube bundle F_2. Said ferules' 26 radial holes 25, at predetermined distance from the underlying tube plate 9, allow the formation of a predetermined liquid head in the zone 13.

[0031] This liquid head is substantially maintained constant by, for example, the already partially concentrated solution (main fluid) that is fed in said 13, by gravity ("rains"), from the tubes 5, of the overhanging first tube bundle F_1.

[0032] To prevent it from flowing directly in the tubes 8 of the second tube bundle F_2, filling the central portion, i.e. to assure a regular formation of the desired liquid film falling inside said tubes 8, according to an aspect the present invention, said ferules 26 are closed above (Fig. 3), while they are fitted with further appropriate radial apertures 27, in positions suited to allow the output of the gaseous flux possibly freed in the tubes of the second tube bundle F_2.

[0033] The heat exchanger according to the present invention has structural and functional characteristics so as to substantially simplify the assembly and setting operations of the tube bundle inside the respective mantle, allowing the disengagement of said operations from the exchanger height, and obtaining the vantage of assuring in every case the tightness between the different inner heat exchange zones of the exchanger itself.

[0034] It was also surprisingly noted that the formation of a liquid head in the intermediate zone 13, for the holding and distribution of the solution already partially concentrated or, more in general of the main fluid already partially thermally treated, determines an advantageous remix of the liquid, leveling its concentration and its temperature.

[0035] The invention thus conceived is susceptible to further variants and modifications all of which fall within the inventive concept and, as such, fall within the scope of protection of the invention itself, as defined by the following claims.

Claims

1. Falling film tube bundle heat exchanger (1) with vertical tubes, comprising a cylindrical mantle (2) with vertical axis closed to the opposite ends by respective bottoms, superior (3) and inferior (4), **characterized in that** it comprises:

   - a first falling film tube bundle (F_1) with vertical tubes (5), mounted in said mantle (2), with tube plates (6, 7), respectively superior and inferior, circumferentially fixed, tightened against a fluid under pressure, to the mantle (2) itself, in which they define between them a first heat exchange zone (12),

   - at least a second tube bundle (F_2) with vertical tubes (8), mounted in said mantle (2), with tube plates (9, 10), respectively superior and inferior, circumferentially fixed, tightened against a fluid under pressure, to the mantle (2) itself, in which they define between them a second heat exchange zone (14), said superior plate (9) being fixed to said mantle (2) in fixed axially spaced relationship from the inferior tube plate (7) of said first tube bundle (F_1),

   - a holding and distribution zone (13), comprised between the inferior tube plate (7) of said first tube bundle (F_1), and the superior tube plate (9) of said second tube bundle (F_2), being open, in said holding and distribution zone (13) the respective inferior (5b, 8b) and superior (5a, 8a) ends of said first (F_1) and second (F_2) tube bundle,

2. Heat exchanger according to claim 1, **characterized in that** it comprises a plurality of ferules (26) arranged with vertical axis in said holding and intermediate distribution zone (13) and engaged one for each tube (8) of said second tube bundle (F2) .

3. Heat exchanger according to claim 2, **characterized in that** said plurality of ferules (26) arranged in said holding and distribution zone (13), have an

end coaxially engaged in a respective tube (8) of said second tube bundle (F_2) and the other end closed, said ferules (26) being fitted with radial apertures (27), in positions suited to allow the output of a gaseous flux.

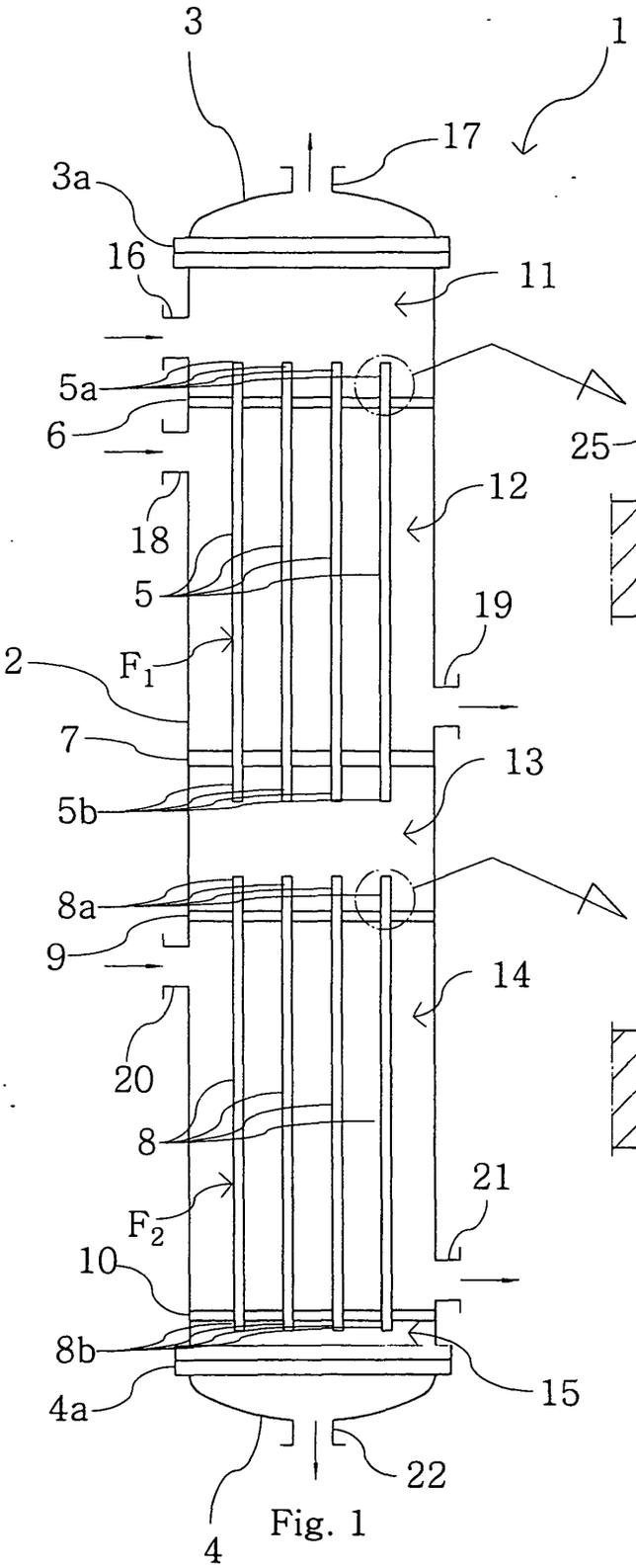


Fig. 1

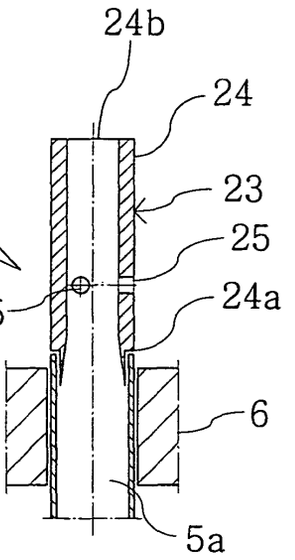


Fig. 2

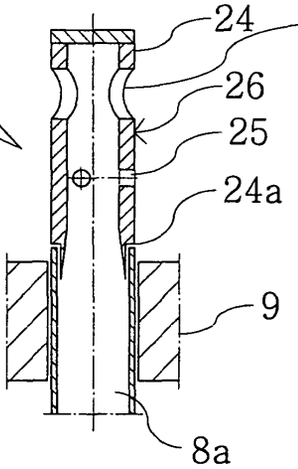


Fig. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 01 4714

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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TECHNICAL FIELDS SEARCHED (Int.Cl.7)

F28D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	3 December 2003	Mootz, F

CATEGORY OF CITED DOCUMENTS

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