

**LIQUID DISTRIBUTOR FOR NON-VERTICAL DISTILLATION COLUMN,
AND DISTILLATION COLUMN THUS EQUIPPED**

The present invention relates to a liquid distributor for distillation column, of the type comprising a main volume which, in its lower part, has outlet openings distributed in a region.

Floating oil platforms produce residual gases. For economic and environmental reasons, it is becoming more and more necessary to recover these gases. One method consists in converting them into heavier hydrocarbons, which are in liquid form and are therefore easier to transport, using the Fischer-Tropsch process which consumes large amounts of oxygen.

It would therefore be beneficial to be able to install an air distillation column on board a floating platform or a barge, but proper operation of equipment of this type is compromised by serious difficulties. Specifically, a first imperative is for the liquid to be distributed uniformly at the column head over the entire cross section of the latter, despite the oscillations of its axis due to the motion of the waves.

The object of the invention is to provide a liquid distributor whose operation has very little sensitivity to oscillations of this type.

To this end, the invention relates to a liquid distributor of the aforementioned type, characterized in that it comprises a transport element designed to convey the liquid delivered by at least one opening in the perforated bottom under gravity to a supply point not located plumb with this opening.

The distributor according to the invention may have one or more of the following characteristics:

- the opening consists of a single perforation or of a plurality of perforations close to one another;
- the transport element has an inlet end located below and plumb with the said opening and separated from the outlet end of the latter;

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- the transport element comprises a conduit which is open at the top in the form of a funnel or closed in the form of a tube, this conduit being straight, bent at one or more points or curved;

5 - at its outlet end, the transport element comprises a device for irrigating an irrigation zone whose area is greater than that of the said opening;

 - the average diameter of the said region is less than the average diameter of the surface containing
10 the outlet orifices of the transport elements, the ratio of the diameters being, in particular, from 1 to 6 approximately;

 - the distributor comprises transport elements which are associated with a group of mutually separated
15 openings and are designed to convey the liquid flows delivered by these openings to substantially a common supply point not located plumb with the said openings;

 - the transport element comprises a plurality of conduits, in particular a plurality of tubes, whose
20 inlets are designed to receive the liquid flows delivered by the said openings, these conduits joining to form a single conduit for the group of openings;

 - the total rate of the said flows remains substantially constant when the distributor becomes
25 inclined;

 - the transport element or elements associated with two openings that are substantially diametrically opposite with respect to a central axis of the said region and have equal area, lead substantially to a
30 common supply point;

 - the liquid flow output by at least one opening or group of openings is conveyed by the transport element or elements in such a way that its flow rate becomes higher when the irrigated zone is elevated under
35 the effect of the inclination, and lower in the converse case;

 - the transport element associated with each opening leads to a supply point located angularly at an



angle of 180° from this opening with respect to a central axis of the distributor;

- the openings are arranged in a first substantially horizontal plane as substantially circular concentric rings, each corresponding to a ring of outlet orifices which is arranged in a second substantially horizontal plane, located below the first plane and including the same number of supply points, and one transport element connects each point in the first ring to an associated point in the second ring;

- the pairs of associated points are angularly offset by the same angle about the axis of the rings, the transport elements associating two rings forming an envelope surface in the form of a sleeve, and all the transport elements together forming a series of such envelope surfaces nested in each other;

- the said angular offset is reversed from one envelope surface to the next;

- the said angular offset is between 80 and 100° approximately;

- the said angular offset is between approximately 100 and 180° ;

- the outlet ends of the transport elements supply the liquid to a plurality of secondary distribution containers with a perforated bottom.

The invention also relates to a distillation column, characterized in that, at at least one level, it includes a liquid distributor as defined above, positioned on top of a distillation section.

According to other characteristics of this distillation column:

- the distillation section has cross-corrugated packing;

- the distributor is the head distributor of the column, the said main volume being at least partially accommodated in the upper dome of this column;

- the transport elements feed the liquid directly to the distillation section;

- the column is on board a floating structure such as a floating oil platform or a barge.

Illustrative embodiments of the invention will now be described with reference to the appended
5 drawings, in which:

- Figure 1 schematically represents an axial section of a container with a perforated bottom in the inclined position;

- Figure 2 schematically represents a
10 perspective view of a liquid distributor according to the invention, arranged at the head of a distillation column;

- Figure 3 is a schematic plan view of the distributor in Figure 2;

15 - Figure 4 schematically represents a liquid transport element of this distributor;

- Figures 5 and 5A are similar views of two variants;

20 - Figure 6 schematically illustrates another embodiment of the liquid distributor according to the invention;

- Figure 7 is a schematic perspective view illustrating the operating principle of yet another
25 embodiment of the liquid distributor according to the invention;

- Figure 8 is a view from above of a concrete embodiment of the second stage of the distributor in Figure 7; and

30 - Figures 9 and 10 schematically represent two variants of a detail of the distributor according to the invention.

Figure 1 represents a container 1 in the form of a dish whose bottom 2 is perforated with openings 3 and has a circular shape of normally vertical axis X-X. The
35 openings 3 may, in particular, be circular holes and, unless otherwise indicated, it will be assumed that this is the case and that the holes are all identical.

When the container contains a liquid L and the

axis X-X is inclined by an angle α to the vertical, the openings 3 located at a given distance r from this axis will supply different liquid flow rates, because they have different depths of liquid above them.

5 Thus, in the inclination plane, which is the plane of Figure 1, the high opening 3A supplies a flow rate Q_A proportional to $\sqrt{h-r\sin\alpha}$, while the low opening 3B supplies a flow rate Q_B proportional to $\sqrt{h-r\sin\alpha}$. Under the the oscillatory conditions due to the motion of the waves, if the container forms a head distributor of an
10 on-board distillation column, with its radius substantially equal to that of the column, the difference in flow rate may be of the order of 10% or more, which is unacceptable for assuring satisfactory operation of the
15 column.

 Figures 2 and 3 represent a liquid distributor 4 which comprises the container 1 and which, in contrast, ensures virtually uniform distribution of the liquid over the entire cross-section of the distillation column
20 5, irrespective of its inclination, under the aforementioned oscillatory conditions. As a variant, the container 1 could moreover be replaced by a series of funnels with perforated bottom, or by a bundle of perforated tubes.

25 In its upper part, the distillation column 5 comprises a cylindrical shell 6 of axis X-X, and an upper dome 7. The column is on board a floating structure schematized at S in Figure 2. The upper distillation section 8 of the column consists of cross-
30 corrugated packing.

 As is well known, this type of packing includes superposed cross-corrugated packing sections or packs 9, each of which is in the form of a cylindrical slab occupying the entire cross-section of the column.

35 Each pack 9 consists of a stack of corrugated strips with oblique corrugations. Each strip has a vertical general plane, all the strips have the same

height, and the corrugations are alternatively inclined in one direction and in the other from one strip to the next. The corrugations of adjacent strips thus touch at a large number of intersection points. Furthermore, the
5 packs 9 are offset angularly by 90° from one pack to the next relative to the general axis of the column.

The container 1, open at the top and with a diameter much less than the internal diameter of the shell 6, is accommodated in the dome 7. The ratio of the
10 diameters is typically from 1 to 6. The bottom 2 of the container 1 has a number of openings 3 equal to the number of desired distribution points for the liquid on the upper pack 9, i.e. typically 1000 to 3000 openings for a column with a diameter of approximately 4 m.

15 The distributor 4 furthermore includes one straight tube 10 per opening 3. Each tube 10 has an upper inlet orifice 11 arranged just under the corresponding opening 3, and a lower outlet orifice 12 arranged just above the upper surface 13 of the upper
20 pack 9. If $\underline{r}$ and R respectively denote the distances from the axis X-X to the orifices 11 and 12, then $R > \underline{r}$. Furthermore, as can be seen clearly in Figures 2 and 3, the point 12 is angularly offset by 90° around the axis X-X, relative to the point 11.

25 The openings 3 are arranged in a series of concentric rings. Each ring 14 of average diameter $\underline{r}$ has an associated ring 15 of average diameter R on the surface 13, and all the tubes connecting these two rings are inclined in the same direction. All the tubes 10
30 associated with two given corresponding rings 14 and 15 thus together constitute generatrices of a hyperboloid of revolution 16.

For two pairs of adjacent rings 14 and 114, the tubes 10 are inclined in opposite directions, thus
35 forming two hyperboloids of revolution 16 and 116 nested in one another. The hyperboloid 116 schematized in Figure 2 thus corresponds to the rings 114 and 115 located immediately inside the aforementioned rings 14

and 15.

In this way, all the tubes 10 together form a stack of hyperboloids of revolution whose generatrices are alternately inclined in the two directions.

5 When the axis X-X is vertical, all the tubes 10 supply the same liquid flow rate because of the symmetry of revolution of the distributor 4 as a whole.

 When the axis X-X is inclined, the radius of the container 1, which is much less than that of the column,
10 has the effect of reducing the flow-rate differences between the openings 3 in its bottom 2.

 Furthermore, the pairs of substantially diametrically opposite openings belonging to two adjacent rings 14, 114 are connected by their tubes 10
15 at two points 12, 112 which are adjacent to one another because they are located substantially in the same radial half-plane passing through the axis X-X and belonging to two adjacent rings 15, 115.

 Consequently, the zone of the surface 13 located
20 just below the points 12 and 112 receives the sum of the flow rates delivered by a pair of substantially diametrically opposite openings of the container 1, which sum is virtually constant for all the pairs of openings.

25 It is therefore sufficient for the area of the zone in question to be small enough for the two flow rates to be properly re-mixed by the cross-corrugated packing, in order for the distribution of the liquid over the entire surface 13 to remain permanently quasi-
30 uniform in spite of the oscillations of the axis X-X.

 It will furthermore be noted that the structure of the distributor 1 allows the rising gas to pass without significant head loss between the tubes 10 and around the container 1.

35 Figure 4 represents a straight tube 10, provided at its inlet with a spout 17 which guarantees collection of all the liquid delivered by the corresponding opening 3. All the spouts 17 are fixed in place by means of a

plate 18 which has orifices of the same diameter as the container 1, arranged at a short distance below the bottom 2 and fixed to the latter.

Furthermore, as schematized in Figure 2, all the tubes 10 are positioned relative to one another, at an intermediate level between the container 1 and the surface 13, by a suitable positioning structure 118.

Figure 5 illustrates several modifications to the arrangement in Figure 4:

10 - On the one hand, the spout 17 is omitted, and the inlet orifice 11 of the tube 10, with a diameter much greater than that of the opening 3, is positioned just below the lower end of the latter, but separated from it, by means of the plate 18 connected to the
15 container 1.

 - On the other hand, the tubes 10 are curved with an upper part 20 for accelerating the liquid, with a large slope, and a lower part 21 with a smaller slope.

 - Lastly, the lower ends 12 of the tubes 10 are
20 equipped with an irrigating rose 22, which promotes spreading of the distribution of the liquid over the surface 13. This is because the irrigation rose 22 distributes the liquid over an area of the surface 13 greater than the area of the corresponding opening 3.

25 In this example, the curved tubes associated with two corresponding rings are wound so as to generate a sleeve-shaped surface around the axis X-X. All the curved tubes thus together form a series of such mutually nested surfaces, the winding directions of the
30 tubes being reversed from one surface to the next.

 The variant in Figure 5A differs from the previous one, on the one hand, in the omission of the irrigation rose 22 and, on the other hand, by the shape of the tube 10. Specifically, the latter has an inclined
35 main straight part, like the one in Figure 4, and is bent to form two end parts which are also straight but are vertical.

Figure 6 illustrates another way of correcting

the effects of the inclination of the column, by obtaining a liquid distribution which anticipates the distribution defects in the packing due to the inclination. Specifically, under the effect of the inclination, the liquid tends to accumulate on one side of the column, while the other side progressively dries out. It may therefore be expedient to supply the side which is becoming dry with a higher liquid flow rate, and the opposite side with a lower flow rate.

10 To that end, tubes 10A and 10B associated with substantially diametrically opposite openings 3A and 3B lead to points 12A, 12B on the surface 13 which are also substantially diametrically opposite but which are reversed relative to the two openings. The point 12A (or
15 12B, respectively) is thus substantially in the same radial half-plane, relative to the axis X-X, as the opening 3B (or 3A, respectively). This arrangement therefore makes it possible to irrigate more strongly the packing zones which may dry out under the effect of
20 the inclination. However, in order as before to obtain a structure which is permeable to the rising gas and without crossover between the tubes 10, creation of the numerous tubes 10 presupposes, in this case, that they are arranged in a complex shape, in particular a
25 helicoid shape, which is more complicated than in the embodiment in Figures 1 and 2.

In the example in Figure 6, the point 12A is angularly offset by 180° about X-X' relative to the point 11A. For angles of between 100° and 180° , a varying
30 degree of correction or "overcompensation" effect is obtained for the distribution, the maximum being reached for 180° .

The flow-rate compensation mode in Figures 1 and 2 is again found in the embodiment of the distributor 4
35 schematized in Figure 7, but in a configuration with two distribution stages. The container 1 whose bottom 2 has a number n of openings 3 which is very much less than the total number N of irrigation points for the surface

13, for example thirty-two openings 3, thus forms a stage 104 for precise pre-distribution of the liquid. The openings 3 are arranged in a single ring, close to the peripheral wall of the container 1.

5 At a lower level, there is an extra stage 105 for local distribution of the liquid, consisting of $n/2=16$ secondary containers 101 which are open at the top and have a perforated bottom 102, with the same area and the same perforation factor, these being distributed
10 regularly over the cross-section of the column (only two containers 101 have been represented, for the sake of clarity). Each bottom 102 is pierced by n' openings 103 such that $(n/2) \times n' = N$, i.e. for example $n' = 200$, which corresponds to $N = 3200$ holes.

15 Each secondary container 101 is fed by two tubes 10A, 10B, themselves respectively fed by two diametrically opposite openings 3A, 3B, as before. There is therefore, on the one hand, compensation for the inclination within the distribution stage 104, plus a
20 significant reduction in the effect of the inclination in each secondary container 101, by virtue of the small sizes of the latter.

 As a variant, as illustrated by dot/dash lines in Figure 7, the openings 3A and 3B may be associated by
25 replacing the two tubes 10A and 10B with a single T-tube 110 which receives the liquid flows delivered by the two diametrically opposite openings and combines them to form a single flow in the stem of the T.

 Figure 7 represents a set of containers 101
30 which are remote from one another, in order to explain the way in which the distributor operates. In practice, however, use will be made of a single container 101 (Figure 8) which substantially occupies the diameter of the surface 13 and is subdivided axisymmetrically into
35 sixteen compartments 123, all having the same area and the same perforation factor, here two hundred holes (not shown) per compartment. These sixteen compartments may, for example, be obtained by means of five mutually

parallel partitions 23, forming chords of the container 101 including one diameter, and ten partitions 24 perpendicular to the preceding ones.

As will be understood, the flow-rate correction or "overcompensation" mode schematized in Figure 6 can also be applied to transporting the liquid from the container 1 to the containers 101, or to the compartments 123 in the case of a two-stage distributor.

In each of the embodiments described above, instead of consisting of a single perforation with relatively large diameter, each opening 3 may consist of a group of perforations 203 which have smaller diameters and are close to one another. The resulting advantage is that it is possible to obtain a given liquid flow rate with a depth H_2 (Figure 10) less than the depth H_1 needed in the case of a single perforation (Figure 9) which creates a perturbing vortex effect. The diameter of the multiple perforations 203 must, however, remain sufficient to avoid any risk of obstruction by impurities contained in the liquid to be distilled.

As will be understood, the invention also applies to reflux liquid distribution in a column which is fixed but whose axis is not perfectly vertical.

WO-A-90/10 497 describes, amongst others, packing which is similar to the aforementioned cross-corrugated packing but is perforated in a different way. The term "cross-corrugated packing" used here also comprises such packing, as well as any similar packing.

CLAIMS

1. Liquid distributor for distillation column, of the type comprising a main volume (1) which, in its lower part, has outlet openings (3) distributed in a region (2), characterized in that it comprises a transport element (10; 110) designed to convey the liquid delivered by at least one opening (3) under gravity to a supply point (12, 112; 101, 123) not located plumb with this opening.
2. Distributor according to Claim 1, characterized in that the opening (3) consists of a single perforation or of a plurality of perforations (203) close to one another.
3. Distributor according to Claim 1 or 2, characterized in that the transport element (10; 110) has an inlet end (11) located below and plumb with the said opening (3) and separated from the outlet end of the latter.
4. Distributor according to any one of Claims 1 to 3, characterized in that the transport element (10; 110) comprises a conduit which is open at the top in the form of a funnel or closed in the form of a tube, this conduit being straight, bent at one or more points or curved.
5. Distributor according to any one of Claims 1 to 4, characterized in that, at its outlet end, the transport element comprises a device (22) for irrigating an irrigation zone whose area is greater than that of the said opening (3).
6. Distributor according to any one of Claims 1 to 5, characterized in that the average diameter of the said region (2) is less than the average diameter of the surface containing the outlet orifices (12) of the transport elements, the ratio of the diameters being, in particular, from 1 to 6 approximately.
7. Distributor according to any one of Claims 1 to 6, characterized in that it comprises transport elements

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(10; 110) which are associated with a group of mutually separated openings (3A, 3B) and are designed to convey the liquid flows delivered by these openings to substantially a common supply point (12, 112; 101, 123) not
5 located plumb with the said openings.

8. Distributor according to Claim 7, characterized in that the transport element (110) comprises a plurality of conduits, in particular a plurality of tubes, whose inlets are designed to receive the liquid
10 flows delivered by the said openings (3A, 3B), these conduits joining to form a single conduit for the group of openings.

9. Distributor according to Claim 7 or 8, characterized in that the total rate of the said flows
15 remains substantially constant when the distributor becomes inclined.

10. Distributor according to Claim 9, characterized in that the transport element or elements (10A, 10B) associated with two openings (3A, 3B) that are substantially diametrically opposite with respect to a central axis (X-X) of the said region (2) and have equal area,
20 lead substantially to a common supply point.

11. Distributor according to any one of Claims 1 to 8, characterized in that the liquid flow output by at
25 least one opening or group of openings (3A, 3B) is conveyed by the transport element or elements (10A, 10B) in such a way that its flow rate becomes higher when the irrigated zone is elevated under the effect of the inclination, and lower in the converse case.

30 12. Distributor according to Claim 11, characterized in that the transport element (10A, 10B) associated with each opening (3A, 3B) leads to a supply point located angularly at an angle of 180° from this opening with respect to a central axis (X-X) of the distributor.

35 13. Distributor according to any one of Claims 1 to 12, characterized in that the openings (3) are arranged in a first substantially horizontal plane (2) as substantially circular concentric rings, each

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corresponding to a ring of outlet orifices (12) which is arranged in a second substantially horizontal plane, located below the first plane, and including the same number of supply points, and in that one transport
5 element (10) connects each point in the first ring to an associated point in the second ring.

14. Distributor according to Claim 13, characterized in that the pairs of associated points are angularly offset by the same angle about the axis (X-X) of the
10 rings, the transport elements (10) associating two rings forming an envelope surface (16, 116) in the form of a sleeve, and all the transport elements together forming a series of such envelope surfaces nested in each other.

15. Distributor according to Claim 14, characterized
15 in that the said angular offset is reversed from one envelope surface (16, 116) to the next.

16. Distributor according to Claims 9 and 15 taken together, characterized in that the said angular offset is between 80 and 100° approximately.

20 17. Distributor according to Claims 11 and 15 taken together, characterized in that the said angular offset is between approximately 100 and 180°.

18. Distributor according to any one of Claims 1 to 17, characterized in that the outlet ends of the
25 transport elements (10, 110) supply the liquid to a plurality of secondary distribution containers (101; 123) with a perforated bottom (102).

19. Distillation column, characterized in that, at at least one level, it includes a liquid distributor (4)
30 according to any one of Claims 1 to 18, positioned on top of a distillation section (8).

20. Distillation column according to Claim 19, characterized in that the distillation section (8) has cross-corrugated packing.

35 21. Distillation column according to Claim 19 or 20, characterized in that the distributor (4) is the head distributor of the column (5), the said main volume (1) being at least partially accommodated in the upper dome



(7) of this column.

22. Distillation column according to any one of Claims 19 to 21, characterized in that the transport elements (10) feed the liquid directly to the distillation section (8).

23. Distillation column according to any one of Claims 19 to 22, characterized in that it is on board a floating structure (S) such as a floating oil platform or a barge.



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