

LIQUID DISTRIBUTOR TO BE USED IN MASS TRANSFER
AND/OR HEAT EXCHANGING TOWER

5 The present invention relates to a liquid distributor
to be used in a substance (ie. mass transfer) and/or heat
exchanging tower. The liquid distributor is a device which is used in a tower in
which a counter-flow of a liquid and a gas is effected and
thereby the liquid and the gas are come into contact with
10 each other, and which is used for uniformly distributing
a liquid onto a structure packed in the inside of the tower,
so-called packing.

 There are many kinds of liquid distributors
15 conventionally used in a substance and/or heat exchanging
tower which vary in their methods of distribution. One
conventional distributor comprises a plurality of liquid
distributing tubes placed in parallel along the lateral
axis of a tower, the distributing tubes having opening
20 nozzle holes at intervals along the lower part thereof.
In the distributing tube of this type, the liquid falls
on the packing from the nozzle holes and the liquid is
distributed onto the packing at the position of the nozzle
holes. The distributing tubes are connected to a main
25 tube provided also in parallel to the lateral axis of the
tower, and the main tube is connected to a longitudinal
tube provided in parallel to the longitudinal axis of
the tower. The amount of liquid flowing from the nozzle
holes depends on the head of liquid accumulating in the

longitudinal tube, the diameter of the nozzle and the number of nozzles. Among these parameters, it is the head that changes when the distributor is used. The flow of the liquid changes depending on the change in the head. When
5 the head is high, flow velocity increases; on the other hand, when the head is low, flow velocity is reduced. Due to this change in flow velocity, nozzle holes are generally opened in a vertically downward direction on the distributing tube so that the direction of flow and
10 the distributing position do not change. If the diameter of a nozzle and the number of nozzles are determined on the basis of the case of a large amount of flow, the liquid readily flows out from the nozzle holes near the longitudinal tube when the amount of flow is small, and
15 thereby it becomes difficult to distribute the liquid uniformly.

The amount of a liquid to be distributed in a substance and/or heat exchanging tower varies according to the operation conditions of the tower. When the amount of
20 liquid to be distributed increases or decreases largely during operation, such a distributor as mentioned above which is provided with nozzle holes at intervals on the lower part thereof is not effective.

Another type of distributor is a so-called overflow
25 type which comprises distributing tubes formed in a U-shaped trough. In this type of distributor, a liquid to be distributed overflows from a notch of the upper end of the U-shaped trough; such a distributor however occupies a larger area of the tower due to its construction, which

may cause pressure loss of a rising gas at the time of operation.

There is another type of distributor which comprises guide pins provided on the notches guiding a liquid
5 downwardly under capillary action and letting the liquid fall from the lower end of the pin, to accomplish uniform liquid distribution. However the cost thereof is very high. In a distributor of this kind, in order to effect uniform overflow of a liquid, it is necessary for the upper end
10 surface of the distributor to be kept horizontal; This results in difficulties in its provision in a tower.

Moreover, in such a type of distributor, it is also necessary to prevent waves from occurring in the surface of a liquid so as to enable uniform overflow of the liquid, but
15 it is technically difficult to remove waves. When the amount of liquid to be distributed is large and flow velocity is high, it is difficult to prevent waves from occurring.

As another method there is known the method according to Japanese Patent Public Disclosure No. 45991/1988,
20 which comprises providing openings in the side-wall of a distributing tube formed in a U-shaped trough, letting a liquid flow out from the openings, strike a guide wall and spread as a result. According to this method, however, a considerable velocity must be imparted to the out-
25 flowing liquid, and hence the method is not applicable to slow flowing liquids.

It has now been found that the uniform
5 distribution of a liquid can be improved remarkably by
providing a nozzle hole on the upper part of a distributing
tube, fixing a sheet-like material on the surface of the
distributing tube lower than the nozzle hole, and providing,
in the side part of the distributing tube located lower than
10 the nozzle and/or the upper part of the sheet-like material,
a surface which is inclined in a direction crossing with
the axis of the distributing tube or which is horizontal.

A first embodiment of the present invention relates
to a liquid distributor to be used in a substance and/or
15 heat exchanging tower, which distributes and supplies a
liquid to be treated from the upper part of the inside
of the substance and/or heat exchanging tower to the whole
area of said tower through distributing tubes, in which
the distributing tube provided along the lateral axis of
20 said tower has at least one nozzle hole provided on the
upper side thereof; a sheet-like material is fixed on the
surface of the distributing tube at a position lower than
said nozzle hole in such a manner that it comes into contact
with the surface of said distributing tube, extends in the
25 axis direction of the distributing tube and is spaced apart
from the distributing tube at the lower end thereof, said
sheet-like material having zigzag notches formed on the
lower end thereof; and the side part of the distributing
tube located lower than the nozzle and/or the upper part

of the sheet-like material has a surface which is inclined in a direction crossing with the axis of the distributing tube or is horizontal.

A second embodiment of the present invention relates to a liquid distributor to be used in a substance and/or heat exchanging tower, which distributes and supplies a liquid to be treated from the upper part of the inside of the substance and/or heat exchanging tower to the whole area of said tower through distributing tubes, in which the distributing tube provided along the lateral axis of said tower has at least one nozzle hole provided the upper side thereof; a sheet-like material is fixed on the surface of the distributing tube at a position lower than said nozzle hole in such a manner that it comes into contact with the surface of said distributing tube, extends in the axis direction of the distributing tube and is spaced apart from the distributing tube at the lower end thereof, said sheet-like material having liquid-ramifying plates formed on the lower end thereof, which are opened in opposite directions in series or a number at a time in the direction crossing with the axis of the distributing tube; and the side part of the distributing tube located lower than the nozzle and/or the upper part of the sheet-like material have a surface which is inclined in a direction crossing with the axis of the distributing tube.

Figs. 1a through 1d show the liquid distributor according to the present invention; Fig. 1a is a perspective view of the liquid distributor according to

the present invention; Fig. 1b is an enlarged view of the distributing tube in the liquid distributor according to the present invention; Figs. 1c and 1d are cross-sectional views of the distributing tubes of two embodiment of the liquid distributor according to the present invention;

Fig. 2 is a cross-sectional view of the longitudinal tube, the main tube and the distributing tubes in the liquid distributor according to a preferable embodiment of the present invention;

Fig. 3 is a perspective view of the distributing tube in the liquid distributor according to another embodiment of the present invention;

Fig. 4 is a perspective view of the distributing tube in the liquid distributor according to another embodiment of the present invention;

Fig. 5 is a perspective view of the distributing tube in the liquid distributor according to another embodiment of the present invention;

Fig. 6 is a perspective view of the distributing tube in the liquid distributor according to another embodiment of the present invention;

Fig. 7 is a perspective view of the distributing tube in the liquid distributor according to another embodiment of the present invention; and

Fig. 8 is a perspective view of the distributing tube in the liquid distributor according to another embodiment of the present invention.

Hereunder, the present invention will be described referring to Examples.

5 Figs. 1a through 1d show an embodiment of the liquid distributor of the present invention.

The liquid distributor according to one embodiment of the present invention is composed of a longitudinal tube (1) to be provided in parallel to the longitudinal axis of the tower, a main tube (2) to be provided in parallel to the lateral axis of the tower, and distributing tubes (3) 10 branched from the main tube.

Nozzle holes (4) are provided on the upper part of the distributing tube (3) at optional intervals. The number of nozzle holes may vary. Along the side of the 15 distributing tube lower than the nozzle holes, a sheet-like material (5) is attached extending along the axis of the distributing tube. Here, it is not always a necessary requirement to fix the sheet-like material (5) on the part of the distributing tube lower than the nozzle holes; the 20 sheet-like material (5) may be fixed on a part of the distributing tube above the nozzle holes and hung down over each side of the distributing tube, and holes are opened in the material to correspond with nozzle holes.

The lower end of the sheet-like material (5) does not 25 come into contact with the distributing tube and is spaced apart from it. In addition, on the lower end of the sheet-like material (5), notches (8) are provided.

Projections and depressions (6) acting as a means for diffusing liquid may be formed on the surface of the sheet-like material (see Fig. 3). Alternatively, the sheet-like material may have many holes (7) provided together with
5 or in place of the projections and depressions (6) acting as a means for diffusing liquid (see Fig. 4). Further, it is preferable to provide an oxide layer on the surface of the sheet-like material and/or the distributing tube by subjecting the material to a nitric acid treatment and
10 the like, or subject it to satin finishing or provide fine flaws therein, to thereby improve wettability thereof by the liquid.

Explaining the flow of the liquid, the liquid to be distributed flows from the longitudinal tube (1) to the
15 main tube (2) and is then branched from the main tube (2) into distributing tubes (3). The branched liquid flows out from the nozzle holes (4) of the distributing tube (3). The liquid having flowed out falls downwardly spreading over the surface of the upper part of the distributing tube.

20 The distributing tube is preferably composed of a round pipe, and in this case the face of the upper part of the pipe has a surface inclined along the vertical line. As a result, the liquid having flowed out from the nozzle holes which are provided on the upper part of the tube diffuses in
25 a lateral direction as it falls downwardly along the surface of the pipe.

The reason is as follows. When the liquid is flowed downwardly from the point on the upper part of the plate standing vertically, it flows in a straight line and thus tends not to diffuse on the plate. However, when the above
5 operation is carried out on an inclined plate, the liquid easily diffuses in a lateral direction, and in an extreme case when the liquid falls upon a horizontal plate, it diffuses in all lateral directions.

Therefore, as the position of the nozzle hole is
10 near the top of the distributing tube, the inclination of the surface of the tube in the position becomes larger, which is advantageous for the diffusion of the liquid.

Accordingly, it is preferable to provide the nozzle hole at the top of the pipe. Besides, the diffusion of the
15 liquid can be further accelerated by using a square pipe as the distributing tube with the upper surface thereof being horizontal.

In the present invention, it is an essential requirement that "the side part of the distributing tube
20 located at a position lower than the nozzle and/or the upper part of the sheet-like material have a surface which is inclined in a direction crossing with the axis of the distributing tube or is horizontal". Here, an embodiment satisfying the requirement that "the side part of the
25 distributing tube located lower than the nozzle and/or the upper part of the sheet-like material have a surface which is inclined in a direction crossing with the axis of the distributing tube or is horizontal" includes the above-mentioned embodiment, namely, an embodiment in which the

side of the distributing tube located lower than the nozzle
in inclined as in such a case that a nozzle hole is opened
on the top of a round pipe or the like (Fig. 1c), as well
as an embodiment as shown in Fig. 1d, in which the upper
5 side of the sheet-like material located lower than the
nozzle hole is inclined in a direction crossing with the
axis of the distributing tube or horizontal. If this
requirement is satisfied, the above-mentioned effects can
be obtained and the diffusion of the liquid in a lateral
10 direction is accelerated.

When the diameter of the nozzle is small and the
head of the liquid is high, a flow velocity of the liquid
becomes high, which may cause sprinkling of the liquid to
the outside of the upper part of the distributing tube;
15 in such a case, it is preferable to provide a cover (10)
at the place opposing the nozzle hole (4) which covers the
nozzle hole (see Fig. 5).

The liquid flowing out of the nozzle hole is supplied
onto the sheet-like material extended along the side of
20 the distributing tube lower than the nozzle hole. When the
surface of the sheet-like material includes a part inclined
to a vertical direction, the diffusion of the liquid is
further accelerated. The liquid thus diffused in a lateral
direction falls on the packing from the lower end of the
25 sheet-like material.

It is preferable to provide the sheet-like material
(5) on both sides of the distributing tube. By doing so,
the liquid having flowed from the nozzle hole provided on
the upper part of the distributing tube can be diffused

while being divided into both sides. It is preferable also from this point of view that the nozzle hole is provided on the top of the distributing tube in practice. The sheet-like material to be fixed on the side part of
5 the distributing tube may be constituted by one sheet-like material hung on the tube at the top thereof and pendant to both sides of the tube, or two sheet-like materials may be fixed one on each side of the distributing tube.

On the surface of the sheet-like material, means (6) for diffusing the liquid may be provided (Fig. 3).
10 The means for diffusing the liquid may be constructed by providing projections and depressions on the surface of the sheet-like material (Fig. 4), by opening a plurality of holes on the surface of the sheet-like material (Fig. 4),
15 by corrugating the sheet-like material or by forming channels on the surface of the sheet-like material. In addition, the means for diffusing the liquid may be constructed by laminating the sheet-like material with a net-like material or by constructing the sheet-like
20 material itself as a net.

The liquid flowing down the surface of the sheet-like material reaches the zigzag notches (8) provided on the lower end of the sheet-like material and falls down upon the packing from the crests of the notches towards the lower
25 side. By it, the position from which the liquid falls down can be kept constant and thereby uniform distribution of the liquid can be effected.

The points of the zigzag notches may be round or sharp. Alternatively, a plate-like or stick-like material may be provided on the lower end of the sheet-like material at intervals.

5 In the case that only zigzag notches are formed on the lower end of the sheet-like material as above, when the amount of the flowing liquid is large, the liquid flows down not only from the points of the notches but also from the cracks of the notches, and as a result, the liquid runs
10 down forming a liquid film. In addition, where the liquid is of strong surface tension, a liquid film is formed similarly. However, in this case, the film is not a uniform film and the downflowing liquid converges in several spots. According to the changes in the amount of the flow,
15 the spots where the liquid converges are moved. As a result, the positions from which the liquid falls down are varied, which is undesirable from the viewpoint of the uniform distribution of the liquid. In order to prevent such a disadvantage, the zigzag notches on the lower end of
20 the sheet-like material may be folded to either side. By doing so, it is difficult for a liquid film to be formed.

 Further, in other more improved embodiments of the present invention, in order to dissolve the above disadvantage, liquid-ramifying plates (9) are provided
25 in series on the lower end of the sheet-like material (5) and these plates are folded in opposite directions (Fig. 7); that is, extended to either side of the plane of the sheet.

As a result, the liquid running from the upper part down the surface of the sheet-like material is branched by ramifying plates, thereby the formation of a liquid film is inhibited and the liquid falls down from the tip of each ramifying plate. Besides, by providing these liquid-ramifying plates on the lower end of the sheet-like material, it becomes possible to distribute the liquid broadly in the region surrounded by the points of the liquid-ramifying plates, whereas the liquid is distributed linearly along the lower end of the sheet-like material when such ramifying plates are not provided. As a result, further diffused distribution of the liquid can be effected.

Here, it is preferable that liquid-ramifying plates are placed at proper intervals. If adjacent liquid-ramifying plates are positioned close to each other, the formation of a liquid film tends to easily occur between adjacent ramifying plates even when these plates are opened, which is undesirable for the distribution of the liquid.

Moreover, the end of the liquid-ramifying plate may be fine. Adopting such a construction, the liquid is caused to fall continuously even when the amount of the flowing liquid is small.

It is preferable to enlarge the opening angle of the liquid-ramifying plate as the amount of the liquid to be distributed increases. This is because if the opening angle of the liquid-ramifying plate is small, a liquid film is easily formed. In practice, a preferable opening angle is of the order of 60 to 120°.

The liquid-ramifying plates may be opened in the opposite directions in series or a number at a time in the directions crossing with the axis of the distributing tube. The point of the liquid-ramifying plate may be round or sharp. In addition, the opened liquid guide plate may be crooked or flexed downwardly.

Liquid guide channels may be formed on the surface of the liquid-ramifying plate. Further, a hole with an optional size may be provided on the liquid-ramifying plate or the liquid-ramifying plate may be composed of a net-like material. In addition, the liquid-ramifying plate may be composed of a stick-like material or a needle-like material.

Moreover, instead of the liquid-ramifying plates, pendant components may be provided in series on the lower end of the sheet-like material with being opened to opposite directions one by one or several by several alternately. The same effects as mentioned above can be obtained by adopting such a constitution.

In conventional distributors of this kind, the interval between the distributing tubes is of the order of 10 cm and the interval between the nozzle holes is of the order of 10 cm. Therefore, the liquid has fallen on one spot per about 100 cm².

According to the present invention, even if the interval between the distributing tubes and that between the nozzle holes is the same as those of the conventional apparatus, the number of points which the liquid falls onto may be increased. Further, a remarkably large distribution

can be effected by branching the liquid to both sides of the distributing tube.

In addition, as described above, in a conventional distributor in which nozzle holes are provided on the lower part of the distributing tube, uniform distribution of the liquid could not be effected where the amount of the liquid is small. Whereas in the distributor of the present invention in which nozzle holes are provided on the upper part of the distributing tube, almost the same pressure can be obtained at any holes from the head in the longitudinal tube by maintaining the distributing tube to be nearly horizontal, and thereby uniform distribution can be accomplished even where the amount of the liquid is small.

As described above, the liquid distributor of the present invention may accomplish a uniform flow amount of the liquid from plural nozzle holes by locating the nozzle holes on the upper part of the distributing tube, and improve the distribution effects of the liquid and thereby accomplish uniform distribution of the liquid by providing an inclined surface on which the liquid runs down and providing zigzag notches on the lower end of the sheet-like material.

In the liquid distributor according to the present invention, a plurality of distributing tubes (3) are connected to the main tube (2); in order that almost the same amount of the liquid is flowed to each of the distributing tube connected to the part of the main tube near the longitudinal tube (1) and that far from the

longitudinal tube (1), it is preferable that the inside
of the main tube is tapered as shown in Fig. 2 in such
a manner that the diameter of the part of the main tube
far from the longitudinal tube is larger than that near
5 from the longitudinal tube. In Fig. 2, (3a) refers to
a distributing tube connected to the part of the main
tube near the longitudinal tube (1), and (3b) refers to
a distributing tube connected to the part of the main
tube far from the longitudinal tube (1). In Fig. 2 are
10 omitted holes (4).

The size, the shape and the arrangement of the nozzle
holes are free.

Hereunder, various embodiments of the present
invention will be described, referring to drawings.

15 In the liquid distributor of the present invention,
projections and depressions (6) which act as means for
diffusing the liquid may be provided on the surface of
the sheet-like material, as shown in Fig. 3.

In addition, as shown in Fig. 4, a plurality of
20 holes (7) which act as means for diffusing the liquid may
be provided on the sheet-like material.

In addition, as shown in Fig. 5, a cover (10) may
be fixed on the spot opposing the nozzle hole to prevent
the liquid flowing out from the nozzle hole from being
25 sprinkled to the outside.

In the liquid distributor of the present invention,
the distributing tube may be composed of a trigonal or
polygonal pipe, as shown in Fig. 6.

Further, as shown in Fig. 7, liquid-ramifying plates (9) may be provided on the lower end of the sheet-like material. The liquid-ramifying plates may be opened in opposite directions in series or a number at a time.

5 Moreover, as shown in Fig. 8, pendant components (12) may be provided on the lower end of the sheet-like material. The pendant components may be opened in opposite directions in series or a number at a time.

10 According to the distributing tube of the present invention, a liquid can be uniformly distributed to a packing mounted in the inside of a substance and/or heat exchanging tower.

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CLAIMS:

1. A liquid distributor to be used in a mass transfer and/or heat exchanging tower, which distributes and supplies a liquid to be treated from the upper part of the inside
5 of the tower to the whole area of said tower through distributing tubes, said distributor having a distributing tube provided along the lateral axis of said tower which has at least one nozzle hole provided on the upper side thereof; a sheet-like material is fixed on the
10 surface of the distributing tube at a position lower than said nozzle hole in such a manner that it comes into contact with the surface of said distributing tube, extends in the axis direction of the distributing tube and is spaced apart from the distributing tube at the lower end thereof, said
15 sheet-like material having zigzag notches formed on the lower end thereof; and the side part of the distributing tube located lower than the nozzle and/or the upper part of the sheet-like material has a surface which is inclined in a direction crossing with the axis of the distributing
20 tube or is horizontal.
2. A liquid distributor to be used in a mass transfer and/or heat exchanging tower, which distributes and supplies a liquid to be treated from the upper part of the inside
25 of the tower to the whole area of said tower through distributing tubes, said distributor having a distributing tube provided along the lateral axis of said tower which has at least one nozzle hole provided on the upper side thereof; a sheet-like material is fixed on the surface of the distributing tube at a position lower than



said nozzle hole in such a manner that it comes into contact with the surface of said distributing tube, extends in the axis direction of the distributing tube and is spaced apart from the distributing tube at the lower end thereof, said

5 sheet-like material having liquid-ramifying plates formed on the lower end thereof, which are opened in opposite directions in series or a number at a time in the direction crossing with the axis of the distributing tube; and the side part of the distributing tube is located at a position

10 lower than the nozzle and/or the upper part of the sheet-like material have a surface which is inclined in a direction crossing with the axis of the distributing tube.

3. A liquid distributor to be used in a mass transfer and/or heat exchanging tower, which distributes and supplies

15 a liquid to be treated from the upper part of the inside of the tower to the whole area of said tower through distributing tubes, said distributor having a distributing tube provided along the lateral axis of said tower which has at least one nozzle hole provided on the upper

20 side thereof; a sheet-like material is fixed on the surface of the distributing tube lower than said nozzle hole in such a manner that it comes into contact with the surface of said distributing tube, extends in the axis direction of the distributing tube and is spaced apart from the

25 distributing tube at the lower end thereof, said sheet-like material having pendant components formed on the lower end in series, which are opened in opposite directions in series or a number at a time in the direction crossing with the axis of the distributing tube; and the side part of the



distributing tube located lower than the nozzle and/or the upper part of the sheet-like material have a surface which is inclined in a direction crossing with the axis of the distributing tube.

5 4. A liquid distributor according to any of Claims 1 - 3 wherein projections and depressions which act as means for diffusing liquid are provided on the surface of the sheet-like material.

10 5. A liquid distributor according to any of Claims 1 - 3 wherein a plurality of holes which act as means for diffusing liquid are provided on the surface of the sheet-like material.

15 6. A liquid distributor according to any of Claims 1 - 3 wherein a cover for preventing liquid from being sprinkled is located over the nozzle hole of the distributing tube.

7. A liquid distributor according to any of Claims 1 - 3 wherein the distributing tube is composed of a trigonal or polygonal pipe.

20 8. A liquid distributor according to Claim 1 wherein the zigzag notches on the lower end of the sheet-like material are folded to the opposite sides.



9. A liquid distributor to be used in a mass transfer and/or heat exchanging tower, which distributes and supplies a liquid to be treated from the upper part of the inside
5 of the tower to the whole area of said tower through distributing tubes, said distributor having a distributing tube provided along the lateral axis of said tower which has at least one nozzle hole provided on the upper side thereof and opening on to a surface which extends downwardly to terminate at an edge provided with notches, serrations teeth or other means for ramifying a liquid film flowing over the surface, the surface
10 for at least part of the distance between the nozzle and said edge being inclined in a direction crossing the axis of the distributing tube or being horizontal.
10. A liquid distributor as claimed in Claim 1, Claim 2, Claim 3 or Claim 9, substantially as shown in any one of Figures 1a - d and Figures 3 to 8 or any one of these Figures in conjunction with Figure 2.