

GAS-LIQUID CONTACT TRAY

The invention is related to a gas-liquid contact tray comprising a bubble area and one or more downcomers provided at its upper end with a downcomer opening for receiving liquid. Such trays can be used in gas liquid contacting devices. A typical use of these trays is as distillation column internals.

Background of the invention

German patent publication 764103 describes the use of flat and curved impingement plates in the downcomer opening to limit the froth height in the downcomer. The publication is directed to so-called cross-over tray configurations for use in so-called foaming gas-liquid systems. Figure 4 of this publication discloses an embodiment wherein three curved plates are placed in the downcomer opening. The tangent at the upper end of the illustrated plates form an angle with the horizontal of more than zero degrees.

When trying to increase the liquid and/or gas flows of the gas-liquid contacting columns as described above a maximum load will be observed. Higher loads will result in that the column fails to function as a liquid-gas contactor or separator due to a phenomena known as flooding. Flooding is described as excessive accumulation of liquid inside the column. The well known flooding mechanisms are downcomer back-up, jet flooding and downcomer choking. These mechanisms are described in Distillation Design, Henry Z. Kister, McGraw-Hill Inc., 1992, pages 267-291. According to this publication downcomer back-up is due to a build-up of liquid inside the downcomer causing the liquid to back-up on the tray leading to liquid accumulation on that tray. The liquid

height in the downcomer is determined by the tray pressure drop, liquid height on the tray and frictional losses in the downcomer and downcomer slot area. Jet flooding or entrainment flooding is caused by a too high gas velocity leading to the entrainment of liquid, either by droplets or froth, to the tray above. The liquid will accumulate and leads to flooding. Downcomer choking is caused by a too high aerated liquid velocity in the downcomer. At a certain velocity the friction losses in the downcomer and downcomer entrance become excessive, and the frothy gas-liquid mixture cannot be transported to the tray below, causing liquid accumulation on the tray. With the term froth is to be understood any gas-liquid mixture present on the tray not depending on any flow regime.

Summary of the invention

The present invention aims to provide a gas-liquid contacting tray as described above which permits a higher gas and/or liquid loads. Thus a tray is aimed at having an improved capacity. This aim is achieved by the following tray.

Gas-liquid contact tray comprising a bubble area and one or more downcomers provided at its upper end with a downcomer opening for receiving liquid, wherein the downcomer opening and downcomer is provided with a flow directing plate, wherein the flow directing plate has an upper end which extends horizontally in the direction of the bubble area.

It has been found that when the tray according to the invention is used in a gas-liquid contacting column an improved capacity is observed.

The gas-liquid contact tray according to the invention will typically comprise a circular bubble area, one or two segmental downcomer openings and optionally a plurality of further downcomer openings spaced in this

bubble area. The downcomer opening may be any form, for example, segmental, rectangular, square or circular.

Detailed description of the invention

The invention shall be described in greater detail
5 below.

Preferably a weir is present on the tray. A weir is a device positioned on or about on the boundary of the bubble area and the downcomer opening which ensures that a certain pre-selected amount of liquid is present on the
10 upper surface of the bubble area. The height of the weir may be selected from conventional values known to one skilled in the art. The weir may suitably be inclined towards the direction of the liquid flowing towards the downcomer opening. To further improve the liquid handling
15 capacity the overflow weir is preferably inclined towards the bubble area, such that an imaginary line, drawn from the top of the overflow weir to the base of the overflow weir, forms an angle α with the horizontal plane of the tray which is smaller than 80° and more preferably larger
20 than 30° . The overflow weir height lies preferably in the range from 25 mm to $1/6$ of the height of the tray spacing.

The upper end of the directing plate extends horizontally in the direction of the bubble area. In
25 other words the tangent line at the upper end of the plate is horizontally positioned.

The number of directing means can be from 1 to 10. This number will for example depend on the position of the downcomer opening on the tray. In case of a downcomer
30 opening positioned at the side of the tray, as for example the segmental downcomer of DE-A-764103, the number of plates will preferably be from 1 and 4 and more preferably from 2 to 4.

In case the downcomer openings are spaced in the bubble area, such that, when in use, a liquid enters the downcomer opening from opposite sides of the downcomer opening the number of directing plates will preferably be from 2 to 10 and more preferably from 4 to 6. When substantially the same amount of froth is expected to flow from both sides of such a downcomer it is preferred to have the same number of directing plates inclined towards each of the flow directions. When more froth is expected to flow from one side, more directing plates having an upper end being inclined in that direction may be present than directing plates pointing towards the side where less froth is flowing from. When the downcomer opening is rectangular shaped an anti-jump baffle may be present as for example described in US-A-5382390. The flow directing plates can then be advantageously positioned at either side of the anti-jump baffle.

The directing plates suitably have a lower end which is directed towards the downcomer opening. The lower end may be positioned above tray level. Preferably the lower part of the directing plate extends downwards into the downcomer.

The lower part of the directing plates may be vertically positioned or inclined relative to each other. The lower end is preferably positioned at the level of the upper end of the weir or below. In the absence of a weir, the lower end is preferably positioned at tray level or below. The length of the lower end below the tray level or top weir level will depend, for example, on the spacing between the individual directing plates. Smaller spacing will generally require that this distance increases. Optionally the different directing plates may extend with different lengths into the downcomer.

The upper part of the directing plates may be for example hooked or curved. For practical plate

manufacturing reasons a hooked design is favoured. The upper end of the directing plate may extend to a position above the bubble area. Preferably the height of the directing plates above the tray surface increases when they are positioned further away from the bubble area. The vertical distance between the horizontal tangent lines of two consecutive plates will preferably increase at increasing height above the tray.

Suitably the horizontal distance at top weir level (or tray level in the absence of a weir) between two consecutive directing plates bending in the same direction is between 0.015 and 0.1 m and preferably between 0.015-0.05 m.

The distance of the directing plate above the tray will depend on the shape of the directing plate, typical gas and liquid loading on the tray and the kind of gas and liquid to be contacted or separated. Suitably the directing plates will extend to between 5 and 85% of tray spacing above the tray surface, wherein tray spacing is the distance between two consecutive contacting trays when placed in a column. Suitably the tray spacing is between 0.2-1 m.

The directing plates may be solid, partly perforated, perforated with a varying open area or with a constant open area. The shape of the perforations might be any shape. For example materials like expanded metal or other corrugated sheet material could be used to make the directing plates. Preferably the directing plate is a solid metal sheet.

Various possible tray layouts of the downcomer openings present in the bubble area of the tray are known to one skilled in the art. Examples of such tray layouts which may advantageously be used in combination with the present invention are disclosed in GB-A-1422132, GB-A-1422131, GB-A-1416732, GB-A-1416731, BE-584426,

US-A-4550000, EP-A-882481, WO-9626779, US-A-5382390, US-A-3410540, US-A-5318732, EP-A-155056, US-A-5223183 and US-A-5098615.

For the present invention it is not critical which
5 kind of openings are used in the bubble area of the tray. Examples of possible openings are sieve tray openings, valve tray openings, bubble cap openings and fixed valve openings. Examples of these openings can be found in
10 general text books such as the aforementioned general textbook of Kister on pages 260-267 and in US-RE-27908, US-A-5120474, WO-A-9828056, WO-A-9737741, US-A-5911922, US-A-3463464 and US-A-5454989.

The invention shall be illustrated with the following Figures.

15 Figure 1 is three dimensional view of part of a tray according the invention as placed in a column.

Figure 1 is three dimensional view of part of a tray (1), part of a column wall (2) and a downcomer (3) having a rectangular downcomer opening (4). As shown
20 bubble area (5) is present along both elongated sides of the downcomer opening (4). The bubble area (5) is provided with openings (6) for passage of upwardly moving gas. The downcomer (3) is also provided with a weir (7) and an anti jump baffle (8). Two flow directing
25 plates (9) are positioned at either side of the anti jump baffle (8). As shown the tangent line at the upper end of the plate (9) runs horizontal. Because the flows towards the rectangular downcomer opening (4) will be predominately from both of the elongated sides of the
30 downcomer (3), the flow directing plates (9) only point towards these elongated sides. The flow directing plates (9) as shown are substantially parallel and vertically arranged at their lower end (10). The upper end is curved such that they point horizontally towards
35 the opposite liquid flows flowing, when in use, from the

spaces above bubble area (5) into the downcomer opening (4). The elongated upper end runs parallel to the elongated sides of the downcomer (3). The downcomer walls (11) point towards each other in the flow direction of the liquid. The lower end of the downcomer is provided with a cover (12). In cover (12) a plurality of openings (13) are present.

The tray according to the invention is preferably used in a gas-liquid contacting or separation column, which column is provided with these trays axially spaced away from each other. Contacting can be an absorption process wherein a downwardly moving liquid is contacted with an upwardly moving gas. Separation is typically a distillation process to separate one or more components from a feed. Typically the feed of a distillation process is supplied to an intermediate position in the column, wherein trays are present above and below said inlet position. Such a column is further provided with reboiler, condensation and reflux means.

The column is preferably used for contacting or separation of gas-liquid systems of the foaming and non-foaming type. The advantages of the present invention are especially achieved for non-foaming type systems because downcomer back-up is a more frequent problem for such systems. Non-foaming systems have a typically higher clear liquid velocity in the downcomer than foaming systems. Examples of foaming systems are amine-absorbers, sour water strippers, glycerol contactors and amine absorbers. Examples of non-foaming systems are H₂S strippers and hydrocarbon-hydrocarbon separation, for example de-propanisers, de-ethanisers, de-methanisers, atmospheric crude distillation and the vacuum distillation of petroleum fractions boiling above 350 °C.

The invention shall be illustrated with the following non-limiting examples.

Comparative experiment A

5 A test unit is provided with 3 cross-flow trays each tray provided with a rectangular downcomer. The downcomers are provided with two directing plates. The upper end of the vanes are so positioned that the tangent line makes an angle of 60° with the horizontal plane. The horizontal distance between the plates at weir level is 10 0.025 m. To this column a liquid and gas flow is introduced at respective upper and lower ends. At an air load of $340 \text{ m}^3/\text{h}$ it is observed that the maximum attainable water load is approximately $18.1 \text{ m}^3/\text{h}$.

Example 1

15 Comparative experiment A is repeated except that the upper end of the vanes are so positioned that the tangent line makes an angle of 0° with the horizontal plane, such that the vanes extend horizontal according to the present invention. At an air load of $340 \text{ m}^3/\text{h}$ it is observed that 20 the maximum attainable water load is greater than $18.1 \text{ m}^3/\text{h}$.

Comparative Experiment B

25 Example 1 is repeated except that a downcomer is used having no flow directing plates. At an air load of $340 \text{ m}^3/\text{h}$ it is observed that the maximum attainable water load is approximately $14.5 \text{ m}^3/\text{h}$.

C L A I M S

1. Gas-liquid contact tray comprising a bubble area and one or more downcomers provided at its upper end with a downcomer opening for receiving liquid, wherein the downcomer opening and downcomer is provided with a flow directing plate, wherein the flow directing plate has an upper end which extends horizontally in the direction of the bubble area.
2. Tray according to claim 1, wherein the plate extends downwards into the downcomer.
3. Tray according to any one of claims 1-2, wherein the number of directing plates is from 1 to 10.
4. Tray according to any one of claims 2-3, wherein the horizontal distance at top weir level, or tray level in the absence of a weir, between two consecutive directing plates extending in the same direction is between 0.015-0.05 m.
5. Tray according to any one of claims 2-4, wherein the lower end of the directing plate is positioned at the level of the upper end of the weir or below or, in the absence of a weir, the lower end of the directing plate is positioned at tray level or below.
6. Tray according to any one of claims 1-5, wherein the directing plates extend to between 5 and 85% of tray spacing above the tray surface, wherein tray spacing is the distance between two consecutive trays when placed in a gas-liquid contacting column.
7. Tray according to any one of claims 1-6, wherein the downcomer opening is rectangular.
8. Tray according to claim 7, wherein a vertical anti-jump baffle is present along the longitudinal centre line of the downcomer opening and wherein the flow directing

plates are positioned at either side of the anti-jump baffle.

9. Tray according to any one of claims 1-8, wherein a weir is present on the boundary of bubble area and downcomer opening.

10. Gas-liquid contacting column provided with a plurality of trays according to any one of claims 1-9 axially spaced from each other.

11. Use of a column according to claim 10 as a distillation column or an absorption column.

12. Use according to claim 11, wherein the gas-liquid system to be contacted is of the non-foaming type.