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A tray valve for a tray column

The invention relates to a tray valve for a tray column in accordance
5 with the preamble of claim 1. A gaseous phase (vapour) is brought
into contact with a liquid phase on trays in a tray column. The tray
valve of a tray column of this type permits a variable vapour passage
through a tray opening using a movable valve body. The invention
relates to a method for the insertion of the valve body into the tray
10 opening.

A tray valve for a circular tray opening is known from GB-A-
1,018,924. The valve body of this tray valve includes a plurality of
guide limbs which are attached to the edge of a circular top plate and
are perpendicular to the plate. Barbs for the anchoring of the valve
15 body are arranged at the guide limbs. The valve body can be inserted
into the tray opening by hand, with the guide limbs and/or barbs
being resiliently deformed. Depending on the material, a plastic
deformation can occur which has to be reversed with an additional
operation after the insertion of the valve body. A disadvantage of this
20 valve design consists of the guide limbs being easy to deform. The
guide limbs are strained mechanically in the operation of the column
such that tray valves can lose their valve bodies due to a deformation
of the guide limbs.

A tray valve with two guide limbs is known from US-A 3,770,255. The
25 guide limbs are attached diametrically opposite one another to two

parallel sides of a trapezium-shaped top plate. The trapezium approximately has the shape of an elongate rectangle at whose short sides the guide limbs are arranged. The guide limbs merge at their lower ends into angled, outwardly directed surfaces which are parallel to the top plate and serve as barbs. The insertion of the valve body makes an operation necessary in which the guide limbs are bent inwardly using an instrument so that the barbs can be introduced into the tray opening. In this operation, plastic deformations occur at the guide limbs and/or barbs which have to be at least partly reversed again with an additional operation after the insertion.

The insertion operation takes place in a similar manner with a widespread round valve with three guide limbs. Examples of further tray valves are shown e.g. in H. Z. Kister, "Distillation Design", McGraw-Hill, Inc. 1992, pages 253 ff.

It is the object of the invention to provide a tray valve, wherein an insertion operation can be carried out more simply and with fewer complications. This object is satisfied by the tray valve defined in claim 1.

The tray valve for a tray column includes an opening in a tray for a vapour passage and a valve body which is made to match the rim of the tray opening. The valve body consists of a top plate and vertically downwardly directed guide limbs arranged at the edge of this plate. The guide limbs have barbs for the anchoring of the valve body at the rim of the opening. The plate edge lies on one plane, the plate plane, optionally with the exception of dimple-like, downwardly direction raised portions. The outer surfaces of the guide limbs each contain a stroke region which is perpendicular to the plate plane. The material and shape for the valve body are selected with respect to its insertion

into the tray opening such that a resilient deformation, and optionally partly plastic deformation, of the valve body results on insertion which is largely restricted to the top plate in the form of an upward arching. Any deformation at the inserted valve body can be reversed at the inserted valve body, with the exception of a slight residual deformation, by an application of force onto the top plate. Weakened portions, for example in the form of grooves, slots or bores, can be provided in the top plate and facilitate a forming of the upward arching.

Dependent claims 2 to 6 relate to advantageous embodiments of the tray valve in accordance with the invention. Methods for the insertion of valve bodies of these tray valves in the tray column form the subject matter of claims 7 to 9.

The invention will be explained in the following with reference to the drawings. These are shown:

Fig. 1 a valve body of the tray valve in accordance with the invention and a corresponding tray opening for a vapour passage through the tray;

Fig. 2 a longitudinal section through the tray valve of Fig. 1 with an inserted valve body;

Fig. 3 a shaped piece of sheet metal from which the valve body of Fig. 1 can be manufactured by shaping;

Fig. 4 an illustration for the explanation of geometrical relationships between the valve body and the tray opening;

- Fig. 5 a shaped piece of sheet metal to form a second embodiment;
- Fig. 6 a longitudinal section through the tray valve in accordance with the second embodiment;
- 5 Fig. 7 a circular top plate with respect to a third embodiment;
- Fig. 8 an illustration of how the valve body of the third embodiment is inserted into the tray opening; and
- Fig. 9 a section of a guide limb with a barb generated by stamping and shaping.
- 10 A first embodiment of the tray valve 1 in accordance with the invention with a tray opening 2 in the tray 10 and a valve body 3 is shown in the Figures 1 and 2. The valve body 3, which permits a variable vapour passage through the tray opening 2, is shown separately therefrom. Fig. 2 shows a longitudinal section through the
- 15 tray valve 2 with inserted valve body 3. The valve body 3 made to match a rim 20 of the opening includes a top plate 4 and two guide limbs 5 which are arranged at the edge of this plate 3 and are directed vertically downwardly. The rim 20 of the opening has a rectangular shape with two short sides 21 and two long sides 22. The top plate 4
- 20 correspondingly has four straight edge sides 41 and 42 which lie on a rectangle, with the sides 41 being bent edges and the sides 42 coming to rest outside the rim 20 of the opening above the tray 10. The guide limbs 5 have barbs 6 with which the valve body 3 can be anchored to the rim 20 of the opening so that the stroke is bounded and the valve
- 25 body 3 cannot be raised out of the tray opening 2 with a maximum vapour passage. The top plate 4 has dimple-like, downwardly directed elevation portions 40 ("dimples") at the long edge sides 42 with which

it is ensured that the tray valve 1 always makes a minimal vapour passage possible. With the exception of the dimples, the plate edge lies on a plane which will be termed the plate plane in the following.

(Instead of dimples 40 at the top plate 4, corresponding upwardly

- 5 directed dimples are also possible in the tray 10 at the rim 20 of the opening). The outer surfaces of the guide limbs 5 each contain a stroke region 50 which is perpendicular to the plate plane. The barbs 6 are arranged at the two guide limbs 5 standing diametrically opposite to one another.

- 10 In accordance with the invention, a material is used and a shape is selected for the valve body 3 with respect to an insertion thereof such that a resilient deformation, and optionally partly plastic deformation, of the valve body 3 results which is largely restricted to the top plate 4. The deformation visible as an upward arching occurs where a
- 15 maximum bending stress results due to the cooperation of the bending moment and the resistance moment - as a result of the force effects required for the insertion of the valve body 3. This location is on the top plate 4 of the valve body 3 in the tray valve 1 in accordance with the invention.

- 20 If a plastic deformation is present after the insertion, with the exception of a small residual deformation, it can be reversed at the inserted valve body 3 by exertion of a force effect onto the top plate 4. The eccentrically positioned dimples 40 also permit a temporary bending over in the opposite direction so that the originally provided
- 25 shape is achievable practically without traces of a residual deformation. Weakened portions, for example in the form of grooves, slits or bores, can be provided in the top plate 4 which reduce the resistance moment locally and facilitate a forming of the upward arching (cf. Fig. 7).

As a rule, the spacing of the guide limbs 5 is relatively large in comparison with their vertical lengths so that the said deformation of the valve body 3 is largely restricted to the top plate 4. The guide limbs 5 and the barbs 6 remain practically undeformed on insertion.

- 5 Each barb 6 is made in the manner of a tab. It has a planar upper side surface 61 (or only a straight upper edge 610, see Fig. 6) which lies parallel to the plate plane. The barb 6 also has an outer side surface 62 with a projecting inclination. The spacing to a central axis directed perpendicular to the plate plane (not shown) decreases for
10 this side surface 62 - starting at the upper edge 610 and continuing downwardly. Thanks to the upper side surface 61 (or the upper edge 610), no variable slanting position of the valve body 3 results on the maximum vapour passage through the tray valve 1; the stroke region 50 is thus clearly upwardly bounded. Consequently, the maximum
15 value of the vapour passage is adopted reproducibly due to the special design of the barbs 6. Tray valves with barbs are known from the prior art in which a curved surface for the stroke bounding does not permit such a reproducibility.

- The valve body 3 can be made from a metal sheet by shaping. Fig. 3
20 shows a shaped piece of sheet metal 31 from which the valve body 3 of Fig. 1 can be manufactured by further shaping. The top plate 4, the guide limbs 5 and the barbs 6 form parts of the contiguous piece of sheet metal 31. (The guide limbs 5 and/or the barbs 6 could also be manufactured as separate parts which were joined together to the
25 valve body 3). The shaping of the sheet metal takes place by a stamping or a cutting and also includes a plastic shaping, in particular a bending or punching of the piece of sheet metal.

The rim 20 of the opening is quadrangular or, for example, also circular. The top plate 4 has corresponding rims which lie on a quadrangle or circle and project over the rim 20 of the opening. The quadrangles are preferably rectangles, see Fig. 1, or trapeziums, see
5 Fig. 4, with approximately the shape of rectangles. Fig. 4 shows a representation for the explanation of geometric relationships between the valve body 3 and the tray opening 2. The trapezium shape is drawn in a somewhat exaggerated manner with a relatively pronounced deviation from the rectangular shape. A plan view of the
10 tray opening 2 with cross-sectioned guide limbs 5 is shown at the top in Fig. 4. The bottom of Fig. 4 shows an oblique image with the geometric situation of the valve body 3 in the region which is formed by the stroke regions 50 with the edges 51.

The guide limbs 5 are aligned parallel to one another and to the short
15 quadrangle sides 21. Gaps 71', 71" are provided between the guide limbs 5 and the short rims 21 of the opening. The valve body cannot seize at the rim 20 of the opening by a wedging canting due to these gaps 71', 71". If the one guide limb 5 contacts the rim 21 of the opening at the gap 71", the other gap 71' has its maximum opening:
20 gap 71. What is illustrated with reference to Fig. 4 applies with respect to this maximum gap 71. Vertical edges 51 of the guide limbs 5 span two rectangles over a height h of the stroke regions 50 and perpendicular thereto whose largest diagonal D is shorter than the length S of the corresponding edge side 22. (In Fig. 4, all diagonals are
25 equally long; equal to D). The difference between the length S and the diagonal D has a value which is larger than 0.3 mm. This difference preferably amounts to around 1 mm. Gaps 72', 72" are likewise provided at the long rims 22 of the opening and are each approximately 0.25 to 1.5 mm large, preferably 0.5 mm.

The thickness of the top plate 4 or of the piece of sheet metal 31 has a value in the range from 0.5 to 3 mm. The area of the opening 2 for the vapour passage has a value in the range from 500 to 2000 mm². The length of the barb 6 has a value in the range from 2 to 10 mm. The height h of the stroke ranges is larger than 5 and smaller than 20 mm and preferably has a value in the range from 7 to 15 mm.

Fig. 5 shows a shaped piece of sheet metal 32 with respect to a second embodiment and Fig. 6 shows a longitudinal section through the corresponding tray valve 1. The guide limbs 5 each bear one barb 6 each at the vertical edges 51, the barb having an upper edge 610 parallel to the plate plane and an outer side surface 62 with a projecting inclination.

The guide limbs 5 can each also have only one barb 6. A barb of this type is advantageously arranged in the middle between the edges 51 and is made relatively wide (not shown).

A material from a variety of material types can be used to produce the valve body 3, namely the following material types: unalloyed steel (carbon steel), low alloyed and alloyed steels, in particular stainless steels (ferritic and austenitic) or special steels (e.g. duplex, supra), light metals (e.g. titanium, aluminium), high-resistance metals and alloys (e.g. with zirconium, tantalum, copper, zinc; in particular the nickel-based alloy monel), plastics (e.g. polypropylene PP, PVDF), ceramic material as well as carbon and fibre reinforced composite materials, in particular carbon fibre reinforced composite materials. Whether the top plate 4 deforms resiliently or rather plastically depends on the choice of the material.

Tray columns include a respective plurality of tray valves 1 in accordance with the invention on their trays 10. The tray valves 1 can

be inserted relatively easily into these columns: a respective first guide limb 5 is advantageously introduced into the opening 2 provided for the vapour passage. The second guide limb 5 is set onto the rim 20 of the opening 2 with the inclined outer side surfaces 62 of the barb 6.

- 5 The barbs 6 are forced to make a pivot movement into the inner region of the opening 2 and the top plate 4 is forced to form an upward arching by application of a force onto the top plate 4, for example by means of a force impact by means of a blow above the second guide limb 5, such that the second guide limb 5 and its two barbs 6
- 10 penetrate into the opening 2 while carrying out a snap-in movement. The same also applies correspondingly when the guide limb 5 only bears one barb 6. The valve body 3 can also be inserted by setting on the barbs 6 of both guide limbs 5 at both sides (cf. Fig. 8) and by exertion of a subsequent force blow. A larger force is required in this
- 15 process than with a setting on at one side.

With a suitably made pressing device, the valve bodies 3 can be inserted simultaneously in each case with a group of adjacent tray valves 1, with this also being able to take place without exertion of a force impact, that is e.g. via a uniform stroke movement.

- 20 A plastic deformation occurring on the upward arching of the top plate 4 in the form of an upwardly convex arch can be reversed at least partly without a special tool having to be used with which the valve body 3 can be acted on from the lower side of the tray. A simple tool is sufficient with which a force acting on a middle region of the top plate
- 25 can be exerted over the tray. Since the upward arching means an enlarging of the passage opening for the vapour flow, a small upward arching has a favourable effect and can therefore also be left.

Fig. 7 shows a top plate 4 with respect to a third embodiment which is circular and in whose surface grooves 45 are provided. These grooves 45 facilitate the deformation of the top plate 4 which is necessary on the insertion into the tray opening 2. This is illustrated in Fig. 8 in which the upward arching is shown by means of kink points at the grooves 45. Instead of the grooves 45, slits or rows of small-calibre bores can also be provided. The groove 45 can be replaced by one slit or by a plurality of slits.

The barbs 6 can also be generated by a stamping and shaping (in one workstep). The barb 6 shown in Fig. 9 has an upper edge 610 generated by stamping and an outer side shaped by punching with a middle part 62 with a projecting inclination. The barbs 6 of Figures 5 and 6 can be replaced by barbs 6 in accordance with Fig. 9. Only one such barb 6 can also be provided in the middle of the guide limb 5, with it advantageously extending over a large region of the guide limb width.

Claims

1. A tray valve (1) for a tray column, with an opening (2) in a tray (10) for a vapour passage, the opening having a rim (20), and a
5 valve body (3) which is made to match the rim of the opening and includes a top plate (4) and vertically downwardly directed guide limbs (5) at the edge of this plate, with the guide limbs having barbs (6) to anchor the valve body to the rim of the opening, with the plate edge - optionally with the exception of
10 dimple-like, downwardly directed raised portions (40) - lying on one plane, the plate plane, and with the outer surfaces of the guide limbs each containing a stroke region (50) which is perpendicular to the plate plane, characterised in that a material and a shape are selected for the
15 valve body with respect to its insertion into the tray opening (2) such that a resilient deformation, and optionally partly plastic deformation, results on the insertion which is largely limited to the top plate in the form of an upward arching; and in that any deformation at the inserted valve body can be reversed, with the
20 exception of a slight residual deformation, by an application of force onto the top plate, with weakened portions, for example in the form of grooves, slits or bores, being able to be provided in the top plate which facilitate a formation of the upward arching on the insertion of the valve body.
- 25 2. A tray valve in accordance with claim 1, characterised in that the barbs (6) are arranged at two guide limbs (5) diametrically opposite to one another; that each barb is made in the manner of a tab or tongue with a) a straight upper edge (610) or a planar

upper side surface (61) which lie parallel to the plate plane such that the stroke region (50) is clearly upwardly bounded and b) an outer side surface (62) with a projecting incline, wherein the guide limbs (5) each bear at least one barb (6) at or
5 between vertical edges (51).

3. A tray valve in accordance with claim 1 or claim 2, characterised in that the rim (20) of the opening is quadrangular; in that the top plate (4) correspondingly has four straight edge sides (41, 42) lying on a quadrangle; in that the quadrangles are
10 preferably rectangles or are trapeziums with approximately the shape of rectangles; in that the guide limbs (5) are aligned parallel to one another and to the short quadrangle sides (21); and in that gaps (71', 71'', 72', 72'') are provided between the guide limbs and the rims (21, 22) of the opening, and the
15 vertical edges (51) of the guide limbs spanning, with respect to these gaps, two rectangles over the height (h) of the stroke regions (50) and perpendicular thereto, the largest diagonal (D) of said two rectangles being shorter than the length (S) of the corresponding rim side (22); and in that the difference between
20 the length of the rim side and the said diagonal has a value larger than 0.3 mm, preferably a value of around 1 mm.

4. A tray valve in accordance with any one of the claims 1 to 3, characterised in that the valve body (3) is made from a metal sheet by shaping; the top plate (4), the guide limbs (5) and
25 preferably all the barbs (6) are parts of a contiguous piece of sheet metal (31; 32) and the shaping includes a stamping of the sheet metal or a cutting of the sheet metal and a plastic shaping, in particular bending or punching of the piece of sheet metal.

5. A tray valve in accordance with any one of the claims 1 to 4, characterised in that a material can be used from a plurality of material types for the production of the valve body (3), namely the following material types: unalloyed steel, low alloyed and alloyed steels, in particular stainless steels or special steels, light metals, high-resistance metals and alloys, plastics, ceramic materials as well as carbon and fibre reinforced composite materials, in particular carbon fibre reinforced composite materials.
6. A tray valve in accordance with any one of the claims 1 to 5, characterised in that the thickness of the top plate (4) has a value in the range from 0.5 to 3 mm; in that the area of the opening (2) for the vapour passage has a value in the range from 500 to 2000 mm²; in that the length of the barbs (6) has a value in the range from 2 to 10 mm; and in that the height (h) of the stroke region (5) is larger than 5 and smaller than 20 mm, preferably having a value in the range from 7 to 15 mm.
7. A method for the insertion of valve bodies (3) into the tray column in accordance with claim 1, characterised in that the top plate is forced to form an upward arching by application of a force onto the top plate (4), for example of a force impact by means of a blow, such that the barbs are pivoted into the inner region of the opening and the guide limbs and their barbs penetrate into the opening while carrying out a snap-in movement, wherein a first guide limb (5) is advantageously introduced into

the opening (2) provided for the vapour passage before the force effect, the second guide limb is set at its barb (6) onto the rim (20) of the opening and is acted on by the force above the second guide limb.

8. A method in accordance with claim 7, characterised in that the valve bodies (3) are inserted simultaneously and without exerting a force impact using a pressing device with a respective group of adjacent tray valves (1).
9. A method in accordance with claim 7 or claim 8, characterised in that plastic deformation created on the upward arching of the top plate (4) in the form of an upwardly convex arch is reversed at least in part in that a force acting on a middle region of the top plate is exerted using a tool.