

Solid-bowl screw centrifuge with overflow weir

The invention relates to a solid-bowl screw centrifuge according to the preamble of claim 1.

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Solid-bowl screw centrifuges are known in the most diverse embodiments.

10 For example, DE 102 03 652 B4 discloses a solid-bowl screw centrifuge with a device for discharging clarified liquid from a drum which has a cover with an outlet with which is associated a throttling device, in particular a restrictor plate, the distance of which from the outlet is variable. The outlet furthermore
15 has nozzles for discharge of the clarified liquid which, for saving energy, are correspondingly oriented - especially tangentially - in the circumferential direction.

20 Nozzles on solid-bowl screw centrifuges and their effect of energy saving in the case of a corresponding orientation at an angle to the drum axis are also known from DE 39 04 151 A1.

25 The publication "Patent Abstracts of Japan", number 11179236 A, in contrast discloses that guide plates can be associated with outlet ports in the drum cover, which are partially closed off in each case by a weir plate which form an overflow weir, which guide plates
30 impart a swirl to the liquid discharging from the drum, wherein the repelling effect which occurs is to be utilized for saving energy. The guide plates are attached on the outer side of the overflow weir, for example on the weir plates. The guide plates are
35 designed as flat plates, for example, which are oriented parallel to the rotational axis of the drum, wherein the plane in which the flat planes lie do not intersect the drum axis and for example include an angle of about 45° with the radially extending straight

line which extends in each case through the rotational axis of the drum and the respective outlet port.

It is also known - for example from US 2004/0072668 A1
5 or WO 2008/138345 A1 - to arrange a housing instead of
an overflow weir on the weir plate of the outlet port,
wherein the overflow weir or a nozzle is then formed at
the outlet port in an inclined side of the housing.
These constructions, however, bring along the
10 disadvantage that co-rotating, relatively complexly
formed liquid chambers, which form a part of the
rotating system, are formed on the outer side of the
drum cover, so that the clarification or separation
process continues in the liquid chambers. Undesirable
15 deposits from this separation process can result in the
chambers, which involve cleaning problems and out-of-
balance problems.

For this reason, DE 10 2010 032 503 A1 and DE 10
20 2010061 563 A1 turn away from the last-described
method.

According to DE 10 2010 032 503 A1, the overflow weir
is left directly on the weir plates on the drum cover
25 and the liquid, which has already vacated the rotating
system via the overflow weir, is only deflected in the
circumferential direction. After discharge from the
drum, a clarification effect can no longer occur, the
entire discharging liquid jet being deflected through
30 the deflection device in the circumferential direction
instead.

According to DE 10 2010061 563 A1, it is provided that
the weir plate has a material recess which forms at
35 least a part of a discharge channel or a complete
discharge channel, wherein the discharge channel is
designed in such a way that it deflects in a suitable
manner flow discharging from the drum.

Consequently, the two embodiments discussed last have proved to be successful. Nevertheless, there is a further demand for optimization, especially with regard to a good energy recovery with simultaneous assurance
5 of a low tendency toward contamination.

Embodiments seek to provide solutions to the previously described problem.

- 10 According to an aspect, there is provided a solid-bowl screw centrifuge with at least one or more discharge weirs for discharging clarified liquid out of a drum which has a rotational axis and a direction of rotation, having the following features:
- 15 a. at least one or more outlet ports in a drum cover,
- b. wherein a weir plate, which has a recess, is associated with the at least one outlet port in each case,
- 20 c. wherein an open discharge channel, by means of which a deflection from a direction parallel to the rotational axis of the drum essentially into a circumferential direction opposite the direction of rotation is carried out, is formed
- 25 at the outlet opening in the recess,
- d. wherein the discharge channel is designed in such a way that discharging liquid is directed via the bottom of the discharge channel up to an overflow edge,
- 30 e. wherein the bottom of the discharge channel is inclined inwardly toward the rotational axis toward the overflow edge relative to the tangential direction by an inclination angle $\delta > 0$ at the location of the overflow edge.

Accordingly, it is provided that the bottom of the discharge channel is inclined inwardly toward the rotational axis toward the overflow edge relative to the tangential direction by an inclination angle δ at the location of the overflow edge.

A main advantage of this embodiment is again that product deposits cannot easily form, as in the case of the housings in the manner of WO 2008/138345 A1. Rather, as a result of the open design of the discharge channels this disadvantage is avoided in turn. In this case, the constructional embodiment is simple and stable. Moreover, the discharging product flow is deflected onto a radial diameter so that a particularly large saving of energy ensues.

Preferably, $\delta > 0^\circ$ and $\delta < 25^\circ$, especially $\delta \geq 10^\circ$ and $\delta \leq 20^\circ$, apply to the angle δ in this case since a particularly advantageously outflow behavior can be achieved in such a way.

Advantageous embodiments of the invention are to be gathered from the appended claims.

The invention is described in more detail below with reference to the drawing. In the drawing:

Figs. 1a-c show different views of a segment of a schematically represented drum cover of a solid-bowl screw centrifuge according to the invention; and

5 Fig. 2 shows a schematic view of a known solid-bowl screw centrifuge.

Fig. 2 is to illustrate the basic construction of a solid-bowl screw centrifuge. The drive along with the control unit, a hood and further elements which are
10 taken for granted for the person skilled in the art, are not shown here.

Fig. 2 shows a solid-bowl screw centrifuge 1 with a drum 3 which is rotatable around a rotational axis D and in which is arranged a similarly rotatable screw 5. Radial directions perpendicular to the rotation axis D are identified by "R".

20 The drum 3 and the screw 5 have in each case an essentially cylindrical section and a section which in this case tapers in a conical manner.

An axially extending central inlet pipe 7 serves for feeding the material to be centrifuged, via a distributor 9, into the centrifuging chamber 11 between the screw 5 and the drum 3.

If, for example, a turbid slurry is directed into the centrifuge coarse solid particles are deposited on the drum wall. A liquid phase is formed more toward the
30 inside.

The screw 5 preferably rotates at a slightly lower or higher speed than the drum 3 and conveys the centrifuged solid material toward the conical section out of the drum 3 to the solid material outlet 13. The liquid in contrast flows toward the larger drum diameter at the rear end of the cylindrical section of
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the drum 3 and is diverted there over a weir which has outlet ports 15 in a drum cover 17, wherein a weir plate 19, which is attached on the outer side of the drum cover in a radially adjustable manner in this case, is associated with each outlet port 15. The inner radial edge of the weir plate 19 therefore defines an overflow edge and consequently also the actual weir or the actual overflow weir 21. The liquid flows out of the drum at the overflow weir 21 which rotates in the circumferential direction U with the drum 1 so that the liquid, which flows in the direction X parallel to the rotational axis D over the overflow weir 21, in addition to the axial velocity component as a result of the discharging from the drum, in particular also has a velocity in the circumferential direction U (perpendicular to the image plane of Fig. 1, see also Fig. 2) and also a radial component, brought about as a result of centrifugal force, in the outward direction from the center of rotation.

According to the invention, e.g. in the case of a solid-bowl screw centrifuge in the manner of Fig. 2, the drum cover can be provided with discharge weirs 23 in the manner of Fig. 1 which replace the weir plates 19, especially in order to achieve a saving of energy.

The discharge weirs 23 again have in each case a flange-like weir plate 25 which is arranged on the drum cover. In this case, the weir plates 25 are provided with holes 27 for fastening on the drum cover 17 in order to screw down the respective weir plate on the drum cover 17 by means of bolts (not shown here). This fastening is simple and preferred. However, other types of fastening of the weir plate(s) 25 on the drum cover are also conceivable.

According to Fig. 1, the weir plate 25 is designed as a ring segment, wherein it is advantageous (but not absolutely necessary) - especially in order to avoid a

slight play by avoidance of gaps or the like - if the ring segments are in direct or very close abutment in the circumferential direction and in such a way form an encompassing ring of weir plates 25. The weir plate(s)
5 25 can also have another shape, however, e.g. a rectangular or a semi-circular shape.

Figs. 1a-c only show one of the discharge weirs 23.

10 Each weir plate 25, as a basis of the discharge weir - with regard to the rotational axis D - has an arc section-like inner edge 25a and an outer edge 25b and also two circumferential edges 25c and 25d which here are oriented radially to the rotational axis D. This
15 embodiment is also advantageous since an encompassing ring can easily be formed but is not compulsory.

Formed in the inner edge 25a - see especially Fig. 1b - is a recess 29 which extends outwardly from the inner
20 edge 25a with regard to the installed state on the drum cover 17 and terminates radially just before the outer edge 25b.

According to Figs. 1a and b, the recess 29 has a first
25 edge section 29a, which extends preferably radially or at a small angle relative to the radial (angle γ is preferably smaller than 25°), and a second edge section 29b which is oriented preferably perpendicularly, or in the main perpendicularly, to the first edge section 29a
30 and which preferably extends tangentially, or in the main tangentially (angle in relation to the tangential direction is 0° or smaller than 20°), to an imaginary circle with a radius r_b to the rotational axis D.

35 At least the edge section 29b preferably aligns with a corresponding port, lying beneath the weir plate 25, in the actual drum cover (not shown here; but see Fig. 1). The edge section 29b essentially forms the overflow edge via which liquid discharges axially from the drum.

Adjoining the side of the second edge section 29b facing away from the first edge section 29a is preferably a (third) edge section 29c adjoining at an obtuse angle relative to the second edge section, and adjoining this (third) edge section is preferably a fourth edge section 29d which in this case is in the shape of an arc and connects the third edge section to the arc-shaped inner edge 25a of the weir plate 25. The outflow behavior at this recess has proved to be advantageous.

On the outer side of the weir plate 25 facing away from the drum cover in the installed state, a discharge channel is also formed at the recess 29 and is open in the radially inward direction (in relation to the rotational axis) and has a bottom and two side walls, of which one is formed from a guide plate piece 31a and one formed by a part of the weir plate 25 itself.

The guide plate section 31a and also two guide plate pieces 31b, c, forming the bottom, together serve, in conjunction with the weir plate 25, for deflecting a liquid flow, discharging axially from the drum through the recess 29, essentially against the direction of rotation K in the direction -K, which as a result of the additional driving effect in the circumferential direction produced by the deflection leads to a favorable operation from the energy point of view.

The guide plate pieces 31a, b and/or c can also be formed as sections of a single superordinate and correspondingly correctly bent or cast guide plate, or can be interconnected, for example by welding.

As explained already, the three guide plate pieces 31a, b, c and the weir plate 25 itself together form the discharge channel which is open toward the rotational axis D.

The first guide plate piece 31a is preferably formed at right angles to the second and to the third guide plate piece 31b, c. It forms not only the side wall of the discharge channel but also ensures the actual deflection of the liquid jet from the axial direction X into a circumferential direction -K which is perpendicular thereto.

10 The first guide plate piece 31a, as a side wall of the discharge channel, directly adjoins the first edge section 29a of the recess 29 by its side or surface facing the drum.

15 The first guide plate piece in a preferred embodiment is not arranged here perpendicularly to the weir plate or to the drum cover thereunder but at an acute angle, wherein the angle α between the plane of the weir plate 25 as a base plate and the first guide plate piece 31a should preferably be 0° or greater than 0° and smaller than 45° , preferably smaller than or equal to 15° (see Fig. 1c). The reference edge for the angle α is perpendicular to the weir plate and is measured on the inner edge of the guide plate piece and of the weir plate.

As a result of this, a first deflection of the liquid from the axial direction into the circumferential direction is no longer achieved. Therefore, the first guide plate piece 31a has the radius or the bend 31a'' and then extends in the section 31''' preferably parallel or preferably at a slight angle toward the weir plate. The angle β , to which $\beta > 0^\circ$ and $\beta < 30^\circ$, especially $\beta < 20^\circ$, applies, is preferably formed in this case between the plane of the weir plate 25 and the plane in which the flat section 31''' lies or into which the bend of the first guide plate piece (31a) extends.

The guide plate piece 31a can therefore also again have a plurality of sections or even individual pieces or components. Evident from Figure 1c is that the guide plate piece in this case has a flat section 31a' a radius 31a'' and a flat section 31a''' adjoining the radius. Especially significant is the radius since it principally effects the deflection so that the first guide plate piece could be reduced even to a radius or curved section.

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As explained already, the first guide plate piece 31a, as a side wall of the discharge channel, also adjoins the second and the third guide plate piece 31b, c which form the bottom of the discharge channel.

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The second and the third guide plate piece 31b, c are preferably oriented perpendicularly, or in the main perpendicularly (angle between 90° and 110°), to the plane of the drum cover or the weir plate 25 (which lies perpendicularly to the rotational axis) and arranged on the outer side of the weir plate 25 (in the installed position on the drum) and preferably in a material-bonding manner (e.g. fastened by welding).

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The second guide plate piece 31b in this case preferably aligns with the second edge section 29b. The third guide plate piece 31c aligns with the third edge section 29c, but is longer than said third edge section 29c and ensures a deflection of the discharging liquid jet from the tangential direction, preferably slightly inward toward the rotational axis. The corresponding angle δ between the tangential direction T and the outflow direction A from the bottom of the discharge channel - in this case from the third guide plate piece 31c - toward the rotational axis is preferably larger than 0° and smaller than 25° .

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The guide plate pieces can be sections of one plate or separate plate elements. They can also again consist

of a plurality of sub-segments or pieces in each case or be divided into such.

The principle of operation of the drain channel shall
5 once more be explained in more detail below.

Liquid which discharges from the drum is deflected by the first guide plate piece 31a in the circumferential direction of the drum and against the rotational
10 direction K of said drum. Preferably, even a deflection by an angle γ of between 0° and at most 25° relative to the radial direction R, oriented slightly toward the base plate or toward the subjacent drum cover, is carried out, which in a positive manner further reduces
15 the blockage tendency.

An angle ε of the overflow edge can be 0° to the radial R or up to $\pm 10^\circ$, preferably $\pm 5^\circ$.

20 In this case, the bottom - formed here from the first and the second guide plate piece 31b, c - of the inwardly open discharge channel prevents the deflected liquid from being sprayed in the outward direction. Instead, the bottom ensures a continuation of the
25 liquid jet in the circumferential direction right to the end of said bottom of the discharge channel where the liquid jet leaves the discharge channel in the direction A at the outflow edge/overflow edge 31k.

30 The liquid jet, deflected in the circumferential direction, is directed slightly inward by the bottom of the discharge channel - in this case by the second guide plate piece 31b - first of all essentially tangentially and then by the third guide plate piece
35 31c, oriented at an obtuse angle thereto, is directed from the tangential direction T even toward the rotational axis and leaves the third guide plate piece 31c in the direction which is defined by the

orientation of this guide plate piece 31c, as a result of which the energy gain is especially large.

5 A single discharge channel and a single recess 29 are preferably formed on each weir plate. However, a plurality of discharge channels and recesses 29 can also be formed on a single weir plate.

10 The term guide plate piece 31 is not to be understood too narrowly. This preferably consists in each case of a section of a metal plate. In the sense of this application, however, "guide plate pieces" consisting of non-metallic materials are also conceivable, providing these are suitable for being able to fulfill
15 the necessary deflecting and directing function for the liquid.

Also to be referred to as being very advantageous is that the area of the recess 29 up to the inner edge 25a
20 of the weir plate 25 should preferably be smaller, especially by 25% or more smaller, preferably 30% smaller, than the imaginary cross section - the imaginary cross-sectional area - of the discharge channel in the region of the overflow edge (which in
25 the main can be calculated as the product of the width of the bottom by the height of the discharge channel) which is defined by the height of the guide plate piece 31a in the region of the overflow edge 31k. In this case, the area or the cross section of the recess 29
30 should preferably be equal to or larger than the fictive imaginary cross section of the discharge channel at the overflow edge since in such a way a once again excellent outflow behavior ensues.

List of designations

	Solid-bowl screw centrifuge	1
	Drum	3
5	Screw	5
	Inlet pipe	7
	Distributor	9
	Centrifuging chamber	11
	Solid-material outlet	13
10	Outlet ports	15
	Drum cover	17
	Weir plate	19
	Discharge weir	21
	Discharge weirs	23
15	Weir plate	25
	Inner edge	25a
	Outer edge	25b
	Circumferential edges	25c, 25d
	Holes	27
20	Recess	29
	Edge sections	29a, b, c, d
	Rotational axis	D
	Radius	r_b
	Guide elements	31a, b, c
25	Edge	31k
	Direction of rotation	K
	Axial direction	X
30	Angle	$\alpha, \beta, \gamma, \delta$
	Radius	r_b
	Radial direction	R

Patent claims

1. A solid-bowl screw centrifuge with at least one or more discharge weirs for discharging clarified
5 liquid out of a drum which has a rotational axis and a direction of rotation, having the following features:
 - a. at least one or more outlet ports in a drum cover,
 - 10 b. wherein a weir plate, which has a recess, is associated with the at least one outlet port in each case,
 - c. wherein an open discharge channel, by means of which a deflection from a direction parallel
15 to the rotational axis of the drum essentially into a circumferential direction opposite the direction of rotation is carried out, is formed at the outlet opening in the recess,
 - d. wherein the discharge channel is designed in
20 such a way that discharging liquid is directed via the bottom of the discharge channel up to an overflow edge,
 - e. wherein the bottom of the discharge channel is inclined inwardly toward the rotational axis
25 toward the overflow edge relative to the tangential direction by an inclination angle δ > 0 at the location of the overflow edge.
2. The solid-bowl screw centrifuge as claimed in
30 claim 1, wherein $\delta > 10^\circ$ and $\delta < 25^\circ$ apply to the inclination angle δ .
3. The solid-bowl screw centrifuge as claimed in
35 claim 2, wherein $\delta \geq 10^\circ$ and $\delta \leq 20^\circ$ apply to the inclination angle δ .

4. The solid-bowl screw centrifuge as claimed in claim 1, wherein the bottom of the discharge channel is formed from one or more guide plate pieces.
- 5 5. The solid-bowl screw centrifuge as claimed in one of the preceding claims, wherein the side walls of the discharge channel are formed from an additional guide plate piece and the weir plate.
- 10 6. The solid-bowl screw centrifuge as claimed in one of the preceding claims, wherein the first guide plate piece has an arced shape or at least one arc-shaped section.
- 15 7. The solid-bowl screw centrifuge as claimed in claim 6, wherein the first guide plate piece also has one or two flat section.
- 20 8. The solid-bowl screw centrifuge as claimed in one of the preceding claims, wherein the first guide plate piece in itself is formed in one piece or in a multiple of pieces.
- 25 9. The solid-bowl screw centrifuge as claimed in one of the preceding claims, wherein a plurality of guide plate pieces are formed from a single plate element.
- 30 10. The solid-bowl screw centrifuge as claimed in one of the preceding claims, wherein the guide plate pieces or sections of the guide plate pieces are interconnected, preferably by welding.
- 35 11. The solid-bowl screw centrifuge as claimed in one of the preceding claims, wherein the first guide plate piece, as a side wall of

the discharge channel, by its side or surface facing the drum, directly adjoins a first edge section of the recess and in that the angle α between the plane of the weir plate and the first guide plate piece is preferably between 0 and 45°, especially between 5° and 25°.

12. The solid-bowl screw centrifuge as claimed in one of the preceding claims, wherein an angle β , to which $\beta > 0^\circ$ and $\beta < 30^\circ$, especially $\beta < 20^\circ$, applies, is formed between the plane of the weir plate and the plane into which extends the bend of the first guide plate piece.

13. The solid-bowl screw centrifuge as claimed in one of the preceding claims, wherein the second guide plate piece is preferably oriented perpendicularly, or in the main perpendicularly, to the weir plate and tangentially, or in the main tangentially, to the circumferential direction.

14. The solid-bowl screw centrifuge as claimed in one of the preceding claims, wherein the second and third guide plate piece align totally or partially with the corresponding edges of the recess in the weir plate.

15. The solid-bowl screw centrifuge as claimed in one of the preceding claims, wherein the at least one recess in the weir plate has one or more straight edge sections.

16. The solid-bowl screw centrifuge as claimed in one of the preceding claims, wherein the at least one recess in the weir plate has, at

least in certain sections, at least one curved arc-shaped edge section.

- 5 17. The solid-bowl screw centrifuge as claimed in one of the preceding claims, wherein the cross-sectional area of the recess up to the inner edge of the weir plate is smaller than the imaginary cross section of the drain channel in the region of the overflow edge.
- 10 18. The solid-bowl screw centrifuge as claimed in claim 17, wherein the cross-sectional area of the recess up to the inner edge of the weir plate is by more than 25% smaller than the imaginary cross
- 15 section of the drain channel in the region of the overflow edge.
- 20 19. The solid-bowl screw centrifuge as claimed in claim 17, wherein the cross-sectional area of the recess up to the inner edge of the weir plate is by more than 30% smaller than the imaginary cross section of the drain channel in the region of the overflow edge.