[0012] Thus it is an object of the invention to provide a membrane filter with reduced blocking propensity.

Solution

[0013] Improving upon known membrane filers it is proposed according to the invention that the at least one tub includes an inner edge respectively between adjacent slots in at least one vertical sectional view which inner edge at least in a portion of a lower half of the slots has an angle relative to horizontal of less than 60° in any point. This configuration can either be implemented by a greater slant angle or rounding this inner edge. This creates a flow impact portion at lower inner edges of the wall for the liquid flowing below the gas cushion wherein hair and fibrous compounds are stripped off by the liquid flow in the flow impact portion which reduces the blocking propensity of the slots and of the membrane portion arranged there above.

[0014] In an advantageously embodiment of the membrane filter according to the invention the gas distribution system is configured at a bottom side of the at least one membrane carrier. In this case the membrane carrier and the gas distribution system are one component. Thus the gas is distributed into the liquid to be filtered directly at a bottom side of the membrane carrier, thus at locations where it exits from the gas distribution system. Thus the gas bubbles flow around the membrane carrier and the membranes attach therein directly at their intended locations. The configuration of the gas distribution system at the bottom side of the membrane carrier helps to prevent potential deviating gas flows.

[0015] Due to the small blow in depth an energy requirement for the gas loading is reduced compared to systems with a gas distribution system that is separately installed below the membrane carrier. The low production costs presents another advantage since the membrane filter has one less component due to the configuration of the gas distribution system at a base of the membrane carrier.

[0016] In order to provide a stripping of hair and fibrous compounds at the rounded or slanted inner edge of the tub a horizontal extension of this inner edge of approximately of 10 – 15 mm is required. In the simplest case this requirement causes a configuration of the tub that is configured accordingly thick.

[0017] In the membrane filter according to the invention the gassing system can be installed in an alternative as a separate component below the membrane carrier

gassing. The slots that become wider in downward direction thus form a variable "throttle" for the gas volume flowing through the slots for different gas volume flows. Through the cross sectional shape of the throttle the volume dependent filling level in the slots can be influenced.

[0026] In another advantageous embodiment of the membrane filter according to the invention the slots have cross sectional surfaces with different sizes. This because different geometric configuration of the tub, in particular also when gas conduction channels are connected at some of the slots which shall facilitate flushing differently sized membrane surfaces with the gas volume flowing through the different slots it is advantageous to adapt the gas volume flowing through the slots through the geometric configuration of the slots to adapt to different required gas volumes. Thus in slots to which a gas conducting channel adjoins which transports the gas into portions of the membrane filter which are arranged further outward and away from the tub larger cross sectional surfaces of the slots are implemented in that the slots have a greater width.

[0027] In another advantageous embodiment of the membrane according to the invention the at least one gas inlet laterally adjoins the at least one tub. This is part advantageous when the gas distribution system is configured at a bottom side of the membrane carrier. In this case the gas distribution is provided at the level of the slots which helps to prevent vertical flows of the gas and thus a sloshing of the gas cushion out of the tube.

[0028] In case of a gas distribution system that is separated from the membrane carrier the gas inlet can be alternatively also provided from above through the base of the tub that is arranged on top. Alternatively a gas inlet that is separate from the tub and the gas distribution system can provide that the gas flows into the tub for example from a separate tube that is positioned below the tub.

[0029] Based on the known method it is provided according to the invention that the liquid flow generated below the gas cushion flows respectively between adjacent slots in at least one vertical sectional view against an inner edge of the at least one tub which inner edge at least in a portion of a lower half of the slots has an angle relative to horizontal of less than 60°. Thus hair and fibrous compounds at the inner edge are stripped off and blocking the slots and the membrane portions arranged there above is substantially avoided. Thus the blocking propensity of the membrane filter is reduced overall.

Patent Claims

1. A membrane filter (1, 36, 71, 83, 92, 101) for filtering a liquid (28, 37) to be filtered, the membrane filter comprising:

a. at least one membrane carrier (4, 41, 77, 96, 121) at which membranes (122) are attached which facilitate filtering a liquid permeate (29, 44) from the liquid and wherein the membrane carrier includes a permeate collecting cavity (25, 47, 80, 90, 97, 124) at which the membranes (122) are connected with an open permeate side, and a permeate outlet (14, 48, 81) for letting the permeate (29, 44) out of the permeate collecting cavity (25, 47 80, 90, 97, 124);

b. a gas distribution system (18, 62, 126, 133, 141, 147) arranged below the at least one membrane carrier (4, 41, 77, 96, 121) and including at least one downward open and upward closed tub (19, 63, 107, 113, 127, 134, 142, 148) which includes a wall (109, 119, 129, 143) with downward open vertical slots (21, 65, 110, 115, 130, 136, 144) for distributing a gas (26, 38) into the liquid; and

c. at least one gas inlet (13, 46, 108, 146, 149) into the gas distribution system (18, 62, 126, 133, 141, 147);

characterized in that

d. the at least one tub (19, 63, 107, 113, 127 134, 142, 148) includes an inner edge (112, 117, 132, 140, 145) respectively between adjacent slots (21, 65, 110, 115, 130, 136, 144) in at least one vertical cross section wherein the inner edge encloses an angle relative to horizontal of less 60° at least in a portion of a lower half (23, 69) of the slots (21, 65, 110, 115, 130, 136, 144) in each point.

2. The membrane filter (1, 36, 71, 83, 92, 101) according to claim 1, characterized in that the gas distribution system (18, 62, 126, 133, 141, 147) is configured at a bottom side of the at least one membrane carrier (4, 41, 77, 96, 121).

3. The membrane filter (1, 36, 71, 83, 92, 101) according to one of the claims 1 or 2, characterized in that the at least one tub (19, 63, 107, 113, 127 134, 142, 148) includes at least one vertical rib (67, 114, 131) extending from the wall (109, 119, 129, 135, 143) in an inward direction and respectively arranged between adjacent slots (21, 65, 110, 115, 130, 136, 144) wherein an extension of the vertical rib into

the at least one tub (19, 63, 107, 113, 127 134, 142, 148) decreases in a downward direction.

4. The membrane filter (1, 36, 71, 83, 92, 101) according to one of the preceding claims, characterized in that the gas distribution system (18, 62, 126, 133, 141, 147) includes downward open gas distribution channels (66, 137) which adjoin at least a portion of the slots (21, 65, 110, 115, 130, 136, 144) on an outside for forwarding and distributing the gas (26, 38) away from the at least one tub (19, 63, 107, 113, 127 134, 142, 148).

5. The membrane filter (1, 36, 71, 83, 92, 101) according to the preceding claim, characterized in that the gas conducting channels (66, 137) adjoin the slots (21, 65, 110, 115, 130, 136, 144) with a vertical upward offset.

6. The membrane filter (1, 36, 71, 83, 92, 101) according to one of the preceding claims, characterized in that the slots (21, 65, 110, 115, 130, 136, 144) become wider in a downward direction.

7. The membrane filter (1, 36, 71, 83, 92, 101) according to one of the preceding claims, characterized in that the slots (21, 65, 110, 115, 130, 136, 144) have cross sectional surfaces with different sizes.

8. The membrane filter (1, 36, 71, 83, 92, 101) according to one of the preceding claims, characterized in that the at least one gas inlet (13, 46, 108, 146, 149) laterally adjoins the at least one tub (19, 63, 107, 113, 127, 134, 142, 148).

9. A method for filtering a liquid in a membrane filter (1, 36, 71, 83, 92, 101), including at least one membrane carrier (4, 41, 77, 96, 121), at least one gas inlet (13, 46, 108, 146, 149), and a gas distribution system (18, 62, 126, 133, 141, 147) with at least one downward open and upward closed tub (19, 63, 107, 113, 127, 134, 142, 148) which includes a wall (109, 119, 129, 135, 143) with downward open slots (21, 65, 110, 115, 130, 136, 144), wherein

a. a gas (26, 38) flows through the at least one gas inlet (13, 46, 108, 146, 149) into the at least one tub (19, 63, 107, 113, 127, 134, 142, 148),

b. the gas (26, 38) fills the at least one tub (19, 63, 107, 113, 127, 134, 142, 148) and the slots (21, 65, 110, 115, 130, 136, 144) up to a portion of a height of the slots (21, 65, 110, 115, 130, 136, 144) with a gas cushion (27),

c. the gas (26, 38) flows out the gas cushion (27) through the slots (21, 65, 110, 115, 130, 136, 144) in a laterally outward direction from the at least one tub (19, 63, 107, 113, 127 134, 142, 148) and thus flows into the liquid at several locations below the at least one membrane carrier (4, 41, 77, 96, 121),

d. the gas (26, 38) generates a liquid flow at a phase boundary below the gas cushion (27) during a lateral flow of the gas through the slots (21, 65, 110, 115, 130, 136, 144) wherein the liquid flow is parallel to the lateral gas flow,

e. the gas (26, 38) rises in the membrane filter (1, 36, 71, 83, 92, 101), and thus generates an upward movement of the liquid in the membrane filter (1, 36, 71, 83, 92, 101), and

f. the rising liquid and the gas (26, 38) flush the at least one membrane carrier (4, 41, 77, 96, 121) and membranes (122) attached thereon,
characterized in that

g. the liquid flow that is generated below the gas cushion (27) flows against an inner edge (112, 117, 132, 140, 145) of the at least on tub (19, 63, 107, 113, 127, 134, 142, 148) respectively between adjacent slots (21, 65, 110, 115, 130, 136, 144) in at least one vertical cross section, wherein the inner edge includes an angle relative to horizontal of less than 60° at least in a portion of a lower half (23, 69) of the slots (21, 65, 110, 115, 130, 136, 144).

10. The method according to claim 9, characterized in that the gas (26, 38) after flowing through some of the slots (21, 65, 110, 115, 130, 136, 144) flows through the gas conducting channels (66, 137) into portions of the membrane filter (1, 36, 71, 83, 92, 101) which are further remote in outward direction from at least one tub (19, 63, 107, 113, 127, 134, 142, 148).

11. The method according to claim 9 or 10, characterized in that the gas distribution system (18, 62, 126, 133, 141, 147) is configured at a bottom side of the at least one membrane carrier (4, 41, 77, 96, 121) and that the gas (26, 38) flows

around the at least one membrane carrier (4, 41, 77, 96, 121) after flowing into the liquid.

Patent Claims

1. A membrane filter (1, 36, 71, 83, 92, 101) for filtering a liquid (28, 37) to be filtered, the membrane filter comprising:

a. at least one membrane carrier (4, 41, 77, 96, 121) at which membranes (122) are attached which facilitate filtering a liquid permeate (29, 44) from the liquid and wherein the membrane carrier includes a permeate collecting cavity (25, 47, 80, 90, 97, 124) at which the membranes (122) are connected with an open permeate side, and a permeate outlet (14, 48, 81) for letting the permeate (29, 44) out of the permeate collecting cavity (25, 47 80, 90, 97, 124);

b. a gas distribution system (18, 62, 126, 133, 141, 147) arranged below the at least one membrane carrier (4, 41, 77, 96, 121) and including at least one downward open and upward closed tub (19, 63, 107, 113, 127, 134, 142, 148) which includes a wall (109, 119, 129, 143) with downward open vertical slots (21, 65, 110, 115, 130, 136, 144) for distributing a gas (26, 38) into the liquid; and

c. at least one gas inlet (13, 46, 108, 146, 149) into the gas distribution system (18, 62, 126, 133, 141, 147);

characterized in that

d. the at least one tub (19, 63, 107, 113, 127 134, 142, 148) includes an inner edge (112, 117, 132, 140, 145) respectively between adjacent slots (21, 65, 110, 115, 130, 136, 144) in at least one vertical cross section orthogonal to the wall (20, 64, 109, 119, 129, 135, 143) wherein the inner edge encloses an angle relative to horizontal of less 60° at least in a portion of a lower half (23, 69) of the slots (21, 65, 110, 115, 130, 136, 144) in each point.

2. The membrane filter (1, 36, 71, 83, 92, 101) according to claim 1, characterized in that the gas distribution system (18, 62, 126, 133, 141, 147) is configured at a bottom side of the at least one membrane carrier (4, 41, 77, 96, 121).

3. The membrane filter (1, 36, 71, 83, 92, 101) according to one of the claims 1 or 2, characterized in that the at least one tub (19, 63, 107, 113, 127 134, 142, 148) includes at least one vertical rib (67, 114, 131) extending from the wall (109, 119, 129, 135, 143) in an inward direction and respectively arranged between adjacent slots (21, 65, 110, 115, 130, 136, 144) wherein an extension of the vertical rib into

the at least one tub (19, 63, 107, 113, 127 134, 142, 148) decreases in a downward direction.

4. The membrane filter (1, 36, 71, 83, 92, 101) according to one of the preceding claims, characterized in that the gas distribution system (18, 62, 126, 133, 141, 147) includes downward open gas distribution channels (66, 137) which adjoin at least a portion of the slots (21, 65, 110, 115, 130, 136, 144) on an outside for forwarding and distributing the gas (26, 38) away from the at least one tub (19, 63, 107, 113, 127 134, 142, 148).

5. The membrane filter (1, 36, 71, 83, 92, 101) according to the preceding claim, characterized in that the gas conducting channels (66, 137) adjoin the slots (21, 65, 110, 115, 130, 136, 144) with a vertical upward offset.

6. The membrane filter (1, 36, 71, 83, 92, 101) according to one of the preceding claims, characterized in that the slots (21, 65, 110, 115, 130, 136, 144) become wider in a downward direction.

7. The membrane filter (1, 36, 71, 83, 92, 101) according to one of the preceding claims, characterized in that the slots (21, 65, 110, 115, 130, 136, 144) have cross sectional surfaces with different sizes.

8. The membrane filter (1, 36, 71, 83, 92, 101) according to one of the preceding claims, characterized in that the at least one gas inlet (13, 46, 108, 146, 149) laterally adjoins the at least one tub (19, 63, 107, 113, 127, 134, 142, 148).

9. A method for filtering a liquid in a membrane filter (1, 36, 71, 83, 92, 101), including at least one membrane carrier (4, 41, 77, 96, 121), at least one gas inlet (13, 46, 108, 146, 149), and a gas distribution system (18, 62, 126, 133, 141, 147) with at least one downward open and upward closed tub (19, 63, 107, 113, 127, 134, 142, 148) which includes a wall (109, 119, 129, 135, 143) with downward open slots (21, 65, 110, 115, 130, 136, 144), wherein

a. a gas (26, 38) flows through the at least one gas inlet (13, 46, 108, 146, 149) into the at least one tub (19, 63, 107, 113, 127, 134, 142, 148),

b. the gas (26, 38) fills the at least one tub (19, 63, 107, 113, 127, 134, 142, 148) and the slots (21, 65, 110, 115, 130, 136, 144) up to a portion of a height of the slots (21, 65, 110, 115, 130, 136, 144) with a gas cushion (27),

c. the gas (26, 38) flows out the gas cushion (27) through the slots (21, 65, 110, 115, 130, 136, 144) in a laterally outward direction from the at least one tub (19, 63, 107, 113, 127 134, 142, 148) and thus flows into the liquid at several locations below the at least one membrane carrier (4, 41, 77, 96, 121),

d. the gas (26, 38) generates a liquid flow at a phase boundary below the gas cushion (27) during a lateral flow of the gas through the slots (21, 65, 110, 115, 130, 136, 144) wherein the liquid flow is parallel to the lateral gas flow,

e. the gas (26, 38) rises in the membrane filter (1, 36, 71, 83, 92, 101), and thus generates an upward movement of the liquid in the membrane filter (1, 36, 71, 83, 92, 101), and

f. the rising liquid and the gas (26, 38) flush the at least one membrane carrier (4, 41, 77, 96, 121) and membranes (122) attached thereon,
characterized in that

g. the liquid flow that is generated below the gas cushion (27) flows against an inner edge (112, 117, 132, 140, 145) of the at least on tub (19, 63, 107, 113, 127, 134, 142, 148) respectively between adjacent slots (21, 65, 110, 115, 130, 136, 144) in at least one vertical cross section orthogonal to the wall (20, 64, 109, 119, 129, 135, 143), wherein the inner edge includes an angle relative to horizontal of less than 60° at least in a portion of a lower half (23, 69) of the slots (21, 65, 110, 115, 130, 136, 144).

10. The method according to claim 9, characterized in that the gas (26, 38) after flowing through some of the slots (21, 65, 110, 115, 130, 136, 144) flows through the gas conducting channels (66, 137) into portions of the membrane filter (1, 36, 71, 83, 92, 101) which are further remote in outward direction from at least one tub (19, 63, 107, 113, 127, 134, 142, 148).

11. The method according to claim 9 or 10, characterized in that the gas distribution system (18, 62, 126, 133, 141, 147) is configured at a bottom side of the

at least one membrane carrier (4, 41, 77, 96, 121) and that the gas (26, 38) flows around the at least one membrane carrier (4, 41, 77, 96, 121) after flowing into the liquid.

[0012] Thus it is an object of the invention to provide a membrane filter with reduced blocking propensity.

Solution

[0013] Improving upon known membrane filers it is proposed according to the invention that the at least one tub includes an inner edge respectively between adjacent slots in at least one vertical sectional view orthogonal to the wall which inner edge at least in a portion of a lower half of the slots has an angle relative to horizontal of less than 60° in any point. This configuration can either be implemented by a greater slant angle or rounding this inner edge. This creates a flow impact portion at lower inner edges of the wall for the liquid flowing below the gas cushion wherein hair and fibrous compounds are stripped off by the liquid flow in the flow impact portion which reduces the blocking propensity of the slots and of the membrane portion arranged there above.

[0014] In an advantageously embodiment of the membrane filter according to the invention the gas distribution system is configured at a bottom side of the at least one membrane carrier. In this case the membrane carrier and the gas distribution system are one component. Thus the gas is distributed into the liquid to be filtered directly at a bottom side of the membrane carrier, thus at locations where it exits from the gas distribution system. Thus the gas bubbles flow around the membrane carrier and the membranes attach therein directly at their intended locations. The configuration of the gas distribution system at the bottom side of the membrane carrier helps to prevent potential deviating gas flows.

[0015] Due to the small blow in depth an energy requirement for the gas loading is reduced compared to systems with a gas distribution system that is separately installed below the membrane carrier. The low production costs presents another advantage since the membrane filter has one less component due to the configuration of the gas distribution system at a base of the membrane carrier.

[0016] In order to provide a stripping of hair and fibrous compounds at the rounded or slanted inner edge of the tub a horizontal extension of this inner edge of approximately of 10 – 15 mm is required. In the simplest case this requirement causes a configuration of the tub that is configured accordingly thick.

[0017] In the membrane filter according to the invention the gassing system can be installed in an alternative as a separate component below the membrane carrier

gassing. The slots that become wider in downward direction thus form a variable "throttle" for the gas volume flowing through the slots for different gas volume flows. Through the cross sectional shape of the throttle the volume dependent filling level in the slots can be influenced.

[0026] In another advantageous embodiment of the membrane filter according to the invention the slots have cross sectional surfaces with different sizes. This because different geometric configuration of the tub, in particular also when gas conduction channels are connected at some of the slots which shall facilitate flushing differently sized membrane surfaces with the gas volume flowing through the different slots it is advantageous to adapt the gas volume flowing through the slots through the geometric configuration of the slots to adapt to different required gas volumes. Thus in slots to which a gas conducting channel adjoins which transports the gas into portions of the membrane filter which are arranged further outward and away from the tub larger cross sectional surfaces of the slots are implemented in that the slots have a greater width.

[0027] In another advantageous embodiment of the membrane according to the invention the at least one gas inlet laterally adjoins the at least one tub. This is part advantageous when the gas distribution system is configured at a bottom side of the membrane carrier. In this case the gas distribution is provided at the level of the slots which helps to prevent vertical flows of the gas and thus a sloshing of the gas cushion out of the tube.

[0028] In case of a gas distribution system that is separated from the membrane carrier the gas inlet can be alternatively also provided from above through the base of the tub that is arranged on top. Alternatively a gas inlet that is separate from the tub and the gas distribution system can provide that the gas flows into the tub for example from a separate tube that is positioned below the tub.

[0029] Based on the known method it is provided according to the invention that the liquid flow generated below the gas cushion flows respectively between adjacent slots in at least one vertical sectional view orthogonal to the wall against an inner edge of the at least one tub which inner edge at least in a portion of a lower half of the slots has an angle relative to horizontal of less than 60°. Thus hair and fibrous compounds at the inner edge are stripped off and blocking the slots and the membrane portions arranged there above is substantially avoided. Thus the blocking propensity of the membrane filter is reduced overall.

Patent Claims

1. A membrane filter for filtering a liquid to be filtered, the membrane filter comprising:

a. at least one membrane carrier at which membranes are attached which facilitate filtering a liquid permeate from the liquid and wherein the membrane carrier includes a permeate collecting cavity at which the membranes are connected with an open permeate side, and a permeate outlet for letting the permeate out of the permeate collecting cavity;

b. a gas distribution system arranged below the at least one membrane carrier and including at least one downward open and upward closed tub which includes a wall with downward open vertical slots for distributing a gas into the liquid; and

c. at least one gas inlet into the gas distribution system ;

characterized in that

d. the at least one tub includes an inner edge respectively between adjacent slots in at least one vertical cross section orthogonal to the wall wherein the inner edge encloses an angle relative to horizontal of less 60° at least in a portion of a lower half of the slots in each point.

2. The membrane filter according to claim 1, characterized in that the gas distribution system is configured at a bottom side of the at least one membrane carrier.

3. The membrane filter according to one of the claims 1 or 2, characterized in that the at least one tub includes at least one vertical rib extending from the wall in an inward direction and respectively arranged between adjacent slots wherein an extension of the vertical rib into the at least one tub decreases in a downward direction.

4. The membrane filter according to one of the preceding claims, characterized in that the gas distribution system includes downward open gas distribution

channels which adjoin at least a portion of the slots on an outside for forwarding and distributing the gas away from the at least one tub .

5. The membrane filter according to the preceding claim, characterized in that the gas conducting channels adjoin the slots with a vertical upward offset.

6. The membrane filter according to one of the preceding claims, characterized in that the slots become wider in a downward direction.

7. The membrane filter according to one of the preceding claims, characterized in that the slots have cross sectional surfaces with different sizes.

8. The membrane filter according to one of the preceding claims, characterized in that the at least one gas inlet laterally adjoins the at least one tub.

9. A method for filtering a liquid in a membrane filter , including at least one membrane carrier , at least one gas inlet , and a gas distribution system with at least one downward open and upward closed tub which includes a wall with downward open slots, wherein

a. a gas flows through the at least one gas inlet into the at least one tub,

b. the gas fills the at least one tub and the slots up to a portion of a height of the slots with a gas cushion ,

c. the gas flows out the gas cushion through the slots in a laterally outward direction from the at least one tub and thus flows into the liquid at several locations below the at least one membrane carrier,

d. the gas generates a liquid flow at a phase boundary below the gas cushion during a lateral flow of the gas through the slots wherein the liquid flow is parallel to the lateral gas flow,

e. the gas rises in the membrane filter, and thus generates an upward movement of the liquid in the membrane filter, and

f. the rising liquid and the gas flush the at least one membrane carrier and membranes attached thereon,

characterized in that

g. the liquid flow that is generated below the gas cushion flows against an inner edge of the at least on tub respectively between adjacent slots in at least one vertical cross section orthogonal to the wall, wherein the inner edge includes an angle relative to horizontal of less than 60° at least in a portion of a lower half of the slots.

10. The method according to claim 9, characterized in that the gas after flowing through some of the slots flows through the gas conducting channels into portions of the membrane filter which are further remote in outward direction from at least one tub.

11. The method according to claim 9 or 10, characterized in that the gas distribution system is configured at a bottom side of the at least one membrane carrier and that the gas flows around the at least one membrane carrier after flowing into the liquid.