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(54) A METHOD OF SEPARATING A LIQUID FEED MIXTURE COMPRISING YEAST

(57) The present invention provides a method (100) of separating liquid feed mixture comprising yeast. The method comprises the steps of a) introducing (101) the liquid feed mixture into a centrifugal separator (1); b) continuously discharging (102) a separated liquid heavy phase comprising yeast from the centrifugal separator; c) continuously discharging (103) a separated liquid light phase from the centrifugal separator; and d) introducing (104) a portion of the separated liquid light phase into the separated liquid heavy phase comprising yeast; thereby decreasing the viscosity of the separated liquid heavy phase. The present invention further provides a separation system (90) for separating liquid feed mixture comprising yeast.

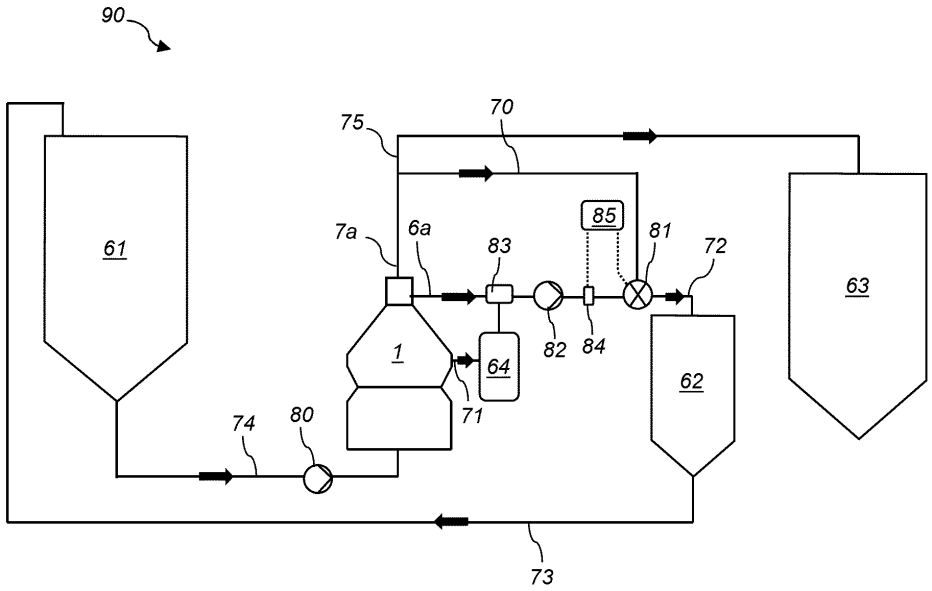

Fig. 3

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Description

Field of the Invention

[0001] The present invention relates to the field of centrifugal separators, and more a centrifugal separator for separating at least on liquid heavy phase from a liquid feed mixture.

Background of the Invention

[0002] Centrifugal separators are generally used for separation of liquids and/or for separation of solids from a liquid. During operation, liquid mixture to be separated is introduced into a rotating bowl and heavy particles or denser liquid, usually water, accumulates at the periphery of the rotating bowl whereas less dense liquid accumulates closer to the central axis of rotation. This allows for collection of the separated fractions, e.g. by means of different outlets arranged at the periphery and close to the rotational axis, respectively.

[0003] In a centrifugal separator for clarification of beer, which has a sludge space where the separated heavy phase comprising yeast is collected, the yeast is usually ejected through intermittent discharges by outlets in the periphery of the separator bowl while the clarified beer is leaving the centrifugal separator through a liquid light phase outlet. Due to the high pressure put on the yeast during such discharge the yeast is killed and therefore sent to waste.

[0004] A variant of a centrifugal separator for clarification of beer is disclosed in WO2021058287, in which yeast concentrate is flowing into a set of outlet pipes from a position close to the periphery in the sludge space to a liquid heavy phase outlet. Such yeast cells leaving the centrifugal separator by the liquid heavy phase outlet have a high probability to survive the centrifugation and may be used for the next brewing batch.

[0005] However, there is still a need for improvements in such a separation system in which a vital yeast fraction is continuously discharged from the separator.

Summary of the Invention

[0006] It is an object of the invention to at least partly overcome one or more limitations of the prior art. In particular, it is an object to provide

[0007] As a first aspect of the invention, there is provided a method of separating liquid feed mixture comprising yeast, the method comprising the steps of

a) introducing the liquid feed mixture into a centrifugal separator;

b) continuously discharging a separated liquid heavy phase comprising yeast from the centrifugal separator;

c) continuously discharging a separated liquid light phase from the centrifugal separator; and

d) introducing a portion of the separated liquid light phase into the separated liquid heavy phase comprising yeast; thereby decreasing the viscosity of the separated liquid heavy phase.

[0008] Step (a) of introducing the liquid feed mixture may comprise introducing the liquid feed mixture to the inlet of a centrifuge bowl of the centrifugal separator, so that the liquid feed mixture is separated into at least a separated liquid heavy phase and a separated liquid light phase. The liquid heavy phase has a density that is higher than the density of the liquid light phase. The introducing of step a) may comprise pumping the liquid feed mixture, e.g. from a storage tank or a fermentation tank. The yeast may be yeast used in a brewing process.

[0009] Step b) of continuously discharging a separated liquid heavy phase may comprise continuously discharging the liquid heavy phase using a plurality of outlet conduits arranged for transporting liquid heavy phase from an outer portion of the centrifuge bowl to a liquid heavy phase outlet. Such outlet conduits may be a set of pipes or may be conduits integrated into the centrifuge bowl wall. "Continuously discharging" is thus different from "intermittently discharging", and thus comprises discharging the separated liquid heavy phase continuously during separation of the liquid feed mixture. During "intermittent discharge of a heavy phase" a liquid light phase is discharged during a major period of time and the liquid heavy phase, together with e.g. a sludge phase, is ejected during short time intervals, usually during fractions of a second.

[0010] Step c) of continuously discharging a separated liquid light phase may be performed using a pump wheel or a paring disc in the separator, as known in the art. However, the discharge of the separated liquid light phase may also be performed without using any pump wheel or paring disc.

[0011] Steps b) and c) may be performed simultaneously.

[0012] Step d) of introducing a portion of the separated liquid light phase into the separated liquid heavy phase comprising yeast is thus performed after the separated liquid light phase and heavy phase have been discharged from the centrifugal separator. The introduction of liquid light phase into the liquid heavy phase decreases the viscosity of the separated liquid heavy phase, i.e. the phase comprising yeast.

[0013] The first aspect of the invention is based on the insight that reintroducing a smaller portion of the separated liquid light phase into the separated liquid heavy phase and decreasing its viscosity makes the separated liquid heavy phase more useable in the whole separation system. For example, it makes the separated liquid heavy phase easier to handle and pump to e.g. a container or other equipment downstream, such as easier to pump back to equipment in the fermentation process. Thus, with a decreased viscosity of the separated liquid heavy phase, it may be easier to pump to a tank located at a

large distance from the separator. Moreover, a reduced viscosity of the liquid heavy phase also reduces the risk of hygienic issues that may arise in the pipes if pumping a thick yeast fraction. Further, decreasing the viscosity by using a portion of the separated liquid light phase is easily implemented, and does not require any introduction of additional liquid, such as water, into the whole system.

[0014] In embodiments of the first aspect, the method is further comprising adjusting
the counter pressure of the liquid heavy phase outlet of the centrifugal separator with respect to the liquid light phase outlet of the centrifugal separator, or vice versa, as disclosed in e.g. WO2015063017. This may be used to adjust the viscosity or consistence of the liquid heavy phase comprising yeast. However, even with such an adjustment, it may be beneficial to further dilute the liquid heavy phase with a portion of the separated liquid light phase in order to facilitate handling of the liquid heavy phase in the system.

[0015] In embodiments of the first aspect, step d) comprises introducing less than 10%, such as less than 5 %, such as less than 2 % of the volume of the separated liquid light phase into the separated liquid heavy phase comprising yeast.

[0016] In embodiments of the first aspect, the method is further comprising a step of
e) intermittently discharging a sludge phase from the centrifugal separator.

[0017] The sludge phase may be discharged by ejection through a set of intermittently openable outlets in the centrifuge bowl, such as outlets arranged at the outer periphery of the bowl. The sludge phase may, after discharge, comprise dead yeast cells. Thus, not all yeast cells of the liquid feed mixture must be continuously discharged as a liquid heavy phase.

[0018] In embodiments of the first aspect, the separated liquid heavy phase comprises live yeast cells. Thus, the liquid heavy phase, as discussed above, being continuously discharged in step b) may comprise live yeast cells, such as at least 50 % live yeast cells, such as at least 75 % live yeast cells. As a further example, the separated liquid heavy phase may comprise live yeast cells of up to 5% less than the live yeast of the liquid feed mixture. In other words, the increase of dead yeast cells through the centrifugal separator may be less than 5 %.

[0019] In embodiments of the first aspect, the separated liquid light phase comprises clarified beer.

[0020] In embodiments of the first aspect, the method is further comprising a step of
f) pumping the separated liquid heavy phase to a container after step d).

[0021] Due to the decreased viscosity due to the introduced small portion of liquid light phase, the separated liquid heavy phase may be more easily pumped for further use in the process.

[0022] As an example the container may be storage tank or a fermentation tank.

[0023] The storage tank may be a storage tank or collection tank for storage of the yeast fraction during a defined period of time until further use in the process. After storage in such a tank, it may be pumped or transported to a fermentation tank.

[0024] The fermentation tank may be the same fermentation tank from which the liquid feed mixture is introduced into a centrifugal separator during step a) or a different fermentation tank.

[0025] In embodiments of the first aspect, step d) comprises the sub steps of:

d1) measuring the flow and/or density of the separated liquid heavy phase and;
d2) introducing a portion of the separated liquid light phase into the separated liquid heavy phase; thereby decreasing the viscosity of the separated liquid heavy phase, based on the measured flow and/or density of step d1).

[0026] Thus, the introduction of the liquid light phase into the liquid heavy phase may be based upon measurements of the separated liquid heavy phase. Step d) may thus be performed if the density of the liquid heavy phase is too high, such as above a threshold value or within a specific density interval, or if the flow of the liquid heavy phase is too low, such as below a threshold value or within a specific flow interval.

[0027] As a second aspect of the invention, there is provided a separation system for separating liquid feed mixture comprising yeast, the system comprising

a centrifugal separator for separating the liquid feed mixture into a liquid light phase and a liquid heavy phase comprising yeast, and wherein the centrifugal separator comprises discharging means for continuous discharge of the liquid heavy phase;
a first stationary liquid outlet pipe for receiving separated liquid heavy phase comprising yeast;
a second stationary liquid outlet pipe for receiving separated liquid light phase;
a valve member arranged for regulating the introduction of a portion of the separated liquid light phase from the second stationary liquid outlet pipe into the separated liquid heavy phase in the first stationary liquid outlet pipe.

[0028] This aspect may generally present the same or corresponding advantages as the former aspect. Effects and features of this second aspect are largely analogous to those described above in connection with the first aspect. Embodiments mentioned in relation to the first aspect are largely compatible with the second aspect of the invention.

[0029] The centrifugal separator may be as described in WO2021058287. The centrifugal separator may thus comprise a centrifuge bowl in which the separation takes place. The centrifuge bowl is arranged for rotation around

an axis of rotation (X). The first stationary outlet pipe may be in fluid connection with a first outlet chamber of the centrifuge bowl, and the second stationary outlet pipe may be in fluid connection with a second outlet chamber of the centrifuge bowl. The first and/or second outlet pipes may be sealed to the centrifuge bowl, e.g. by a mechanical hermetic seal or a hydrohermetic seal.

[0030] The valve member may be arranged downstream of the centrifugal separator, such as in the first stationary outlet pipe or in a connection of a part of the second outlet pipe with the first outlet pipe. The valve member may be any suitable liquid regulating valve used in processing lines, such as in beer production lines.

[0031] A "stationary outlet pipe" may be a single pipe or several pipes in series. It thus refers to the piping system into which a separated phase is transported after the liquid feed mixture has been separated in the centrifugal separator.

[0032] In embodiments of the second aspect of the invention, the second liquid outlet pipe comprises a main pipe for transport of a larger fraction of the separated liquid light phase and connection pipe, which branches off from the main pipe and connects the main pipe with the a first stationary liquid outlet pipe. The valve member is arranged for regulating the flow of separated liquid light phase in the connection pipe to the first stationary liquid outlet pipe.

[0033] Moreover, the separation system may comprise a pump arranged for pumping the separated liquid light phase that is to be introduced into the first stationary outlet pipe. Such pump may thus be arranged in the connection pipe, such as downstream of the branching off of the connection pipe and the valve member.

[0034] In embodiments of the second aspect, the system is further comprising a container downstream of the first stationary liquid outlet pipe and the valve member. Thus, such container may be arranged for holding the discharged liquid heavy phase into which liquid light phase has been introduced. The container may be a storage tank or a fermentation tank. The fermentation tank may be the same or a different fermentation tank from which the liquid feed mixture that is separated in the centrifugal separator originates from.

[0035] As an example, the system may comprise a storage tank for holding the yeast containing liquid heavy phase for a period of time and a further connection to a fermentation tank, so that the yeast may be transported to the fermentation tank at a later point in time. A pump may be used for pumping the liquid heavy phase to the container and/or fermentation tank.

[0036] In embodiments of the second aspect, the system is further comprising a sensing member for measuring the flow and/or density of the separated liquid heavy phase in the first stationary liquid outlet pipe.

[0037] As discussed in relation to the first aspect above, the sensing means, such as a flow sensor or density meter, may be used in a control system for determining the amount of liquid light phase that is to be reintroduced into the heavy phase. Therefore, the system may further comprise a control unit configured for receiving a signal from the sensing member and to generate an operational signal to the valve member, such as a signal comprising information on when to open or close the valve member. The control unit may thus comprise any suitable type of programmable logical circuit, processor circuit, or microcomputer, a microprocessor, or other processing logic that may interpret and execute instructions. Thus, the control unit may comprise a processor and an input/output interface for communicating with the valve member and for receiving information about the flow and/or density of the liquid heavy phase.

[0038] In embodiments of the second aspect, the separation system is further comprising a container, such as a storage tank, downstream of the second stationary liquid outlet pipe. Such a container may thus be used for storing a separated liquid light phase, such as beer, until further processing in a brewery system.

[0039] Furthermore, the separation system may comprise a fermentation tank from which the liquid feed mixture is transported to the centrifugal separator. Thus, the system may therefore also comprise piping and a liquid feed pump for transporting the liquid feed mixture to the centrifugal separator from such a fermentation tank.

[0040] The centrifugal separator may be a disc stack centrifugal separator. Thus, in embodiments of the second aspect, the centrifugal separator comprises a stack of separation discs for increasing the separation area within the centrifugal separator.

[0041] Furthermore, the centrifugal separator may comprise a rotatable part comprising a centrifuge bowl which encloses the separation space, as well as a drive member for rotating the rotatable part, and hence the centrifuge bowl, around an axis of rotation (X).

[0042] The centrifuge bowl further comprises an inlet for receiving the liquid feed mixture, a first outlet in fluid connection with first stationary liquid outlet pipe and a second outlet in fluid connection with the second stationary outlet pipe. The centrifugal separator may further be arranged for intermittent discharge of a sludge phase, and the system may comprise a container, such as a cyclone, for receiving the discharged sludge phase. For the intermittent discharge, the centrifugal separator may comprise a sludge outlet is in the form of a set of intermittently openable outlets arranged at the periphery of the centrifuge bowl.

[0043] Furthermore, the centrifugal separator may comprise a plurality of liquid heavy phase outlet conduits for continuous transport of separated liquid heavy phase from a space radially outside the stack of separation discs to liquid heavy phase outlet chamber in the centrifugal separator.

[0044] The space radially outside the disc stack may thus be the sludge space of the centrifuge bowl. The heavy phase outlet chamber is thus the chamber in the centrifuge bowl from which the heavy phase is discharged. The heavy phase outlet chamber may be a

sealed chamber and may e.g. comprise a paring disc or a pump wheel.

[0045] Thus, the centrifugal separator may comprise a centrifuge bowl in which the separation takes place, and the liquid heavy phase outlet conduits may be a plurality of individual pipes within the centrifuge bowl. Such pipes may extend into the sludge space of the centrifuge bowl, as shown e.g. in WO2021058287.

[0046] However, the liquid heavy phase outlet conduits do not necessarily need to be individual pipes. Thus, as an example, the centrifugal separator may comprise a centrifuge bowl in which the separation takes place, and the liquid heavy phase outlet conduits are a plurality of conduits integrated in the wall of the centrifuge bowl. The outlet conduits may thus be in the form of channels extending within a wall, such as the upper bowl hood, of the centrifuge bowl.

Brief description of the Drawings

[0047] The above, as well as additional objects, features and advantages of the present inventive concept, will be better understood through the following illustrative and non-limiting detailed description, with reference to the appended drawings. In the drawings like reference numerals will be used for like elements unless stated otherwise.

Figure 1 shows a schematic drawing of a centrifugal separator that can be used in the method and of the present disclosure.

Figure 2 shows a schematic drawing of an example of a centrifuge bowl which forms part of the centrifugal separator of Fig. 1

Figure 3 shows a schematic drawing of a separation system according to the present disclosure.

Figure 4 illustrates a method of separating liquid feed mixture comprising yeast.

Detailed Description

[0048] The centrifugal separator and the method according to the present disclosure will be further illustrated by the following description with reference to the accompanying drawings.

[0049] As used herein, the term "axially" denotes a direction which is parallel to the rotational axis (X). Accordingly, relative terms such as "above", "upper", "top", "below", "lower", and "bottom" refer to relative positions along the rotational axis (X). Correspondingly, the term "radially" denotes a direction extending radially from the rotational axis (X). A "radially inner position" thus refers to a position closer to the rotational axis (X) compared to "a radially outer position".

[0050] Figs.1 and 2 schematically show a centrifugal separator and the centrifuge bowl of the centrifugal separator of the present disclosure. The centrifugal separator may be used in the method and the separation system of the present disclosure.

[0051] Fig. 1 show a cross-section of an embodiment of a centrifugal separator 1 configured to separate a heavy phase and a light phase from a liquid feed mixture. The heavy phase may thus be a liquid heavy phase comprising yeast, and the light phase may be clarified beer. The centrifugal separator 1 has a rotatable part 4, comprising the centrifuge bowl 5 and drive spindle 4a.

[0052] The centrifugal separator 1 is further provided with a drive motor 3. This motor 3 may for example comprise a stationary element and a rotatable element, which rotatable element surrounds and is connected to the spindle 4a such that it transmits driving torque to the spindle 4a and hence to the centrifuge bowl 5 during operation. The drive motor 3 may be an electric motor. Alternatively, the drive motor 3 may be connected to the spindle 4a by transmission means such as a drive belt or the like, and the drive motor may alternatively be connected directly to the spindle 4a.

[0053] The centrifuge bowl 5, shown in more detail in Fig. 2, is supported by the spindle 4a, which is rotatably arranged in a frame 2 around the vertical axis of rotation (X) in a bottom bearing 22 and a top bearing 21. The stationary frame 2 surrounds centrifuge bowl 5.

[0054] In the centrifugal separator as shown in Fig. 1, liquid feed mixture to be separated is fed to the bottom to the centrifuge bowl 5 via the drive spindle 4a. The drive spindle 4a is thus in this embodiment a hollow spindle, through which the feed is supplied to the centrifuge bowl 5. However, in other embodiments, the liquid feed mixture to be separated is supplied from the top, such as through a stationary inlet pipe extending into the centrifuge bowl 5.

[0055] After separation has taken place within the centrifuge bowl 5, separated liquid heavy phase is discharged through stationary outlet pipe 6a, whereas separated liquid light phase is discharged through stationary outlet pipe 7a.

[0056] Fig. 2. shows a more detailed view of the centrifuge bowl 5 of the centrifugal separator 1.

[0057] The centrifuge bowl 5 forms within itself a separation space 9a and a sludge space 9b, located radially outside the separation space 9a. In the separation space 9a, a stack 10 of separation discs 40 is arranged coaxially around the axis of rotation (X) and axially below a top disc 50. The stack 10 is arranged to rotate together with the centrifuge bowl 5 and provides for an efficient separation of the liquid feed mixture into at least a liquid light phase and a liquid heavy phase. Thus, in the separation space 9a, the centrifugal separation of the liquid feed mixture takes place during operation. The sludge space 9b is in this embodiment confined between an inner surface 13 of the centrifuge bowl 5 and an axially movable operating slide 16.

[0058] The disc stack 10 is supported at its axially lowermost portion by distributor 11. The distributor 11 comprises an annular conical base portion arranged to conduct liquid mixture from the center inlet 14 of the centri-

fuge bowl 5 to a predetermined radial level in the separation space 9a, and a central neck portion extending upwards from the base portion.

[0059] The centrifuge bowl 5 further comprises an inlet 14 in the form of a central inlet chamber formed within or under the distributor 11. The inlet 14 is arranged for receiving the liquid feed mixture and is thus in fluid communication with the hollow interior 4b of the spindle 4a, through which the liquid feed is supplied to the centrifuge bowl 5.

[0060] The inlet 14 communicates with the separation space 9a via passages 17 formed in the base portion of the distributor 11. The passages 17 may be arranged so that liquid mixture is transported to a radial level that corresponds to the radial level of the cut-outs 41 provided in the separation discs 40. The cut-outs 41 form axial channels within the disc stack and distributes the liquid feed mixture throughput the disc stack 10.

[0061] There is a plurality of outlet conduits in the form of pipes 30 for transporting separated liquid heavy phase from the sludge space 9b to a first outlet chamber 6. In Fig. 2 the outlet pipes have their inlet end portions 31 stretching out in the sludge space 9b to a diameter larger than the disc stack diameter. When clarifying beer, the heavy phase flowing in the outlet conduits 30 is yeast concentrate. The plurality of outlet conduits 30 have their inlet end portions 31 extending into the sludge space 9b a distance from the surrounding inner wall of the centrifuge bowl 5, i.e. so that there is a gap between the inlet end portions 31 and the surrounding wall.

[0062] The outlet conduits 30 extend from a radially outer position of the sludge space 9b to the first outlet chamber 6. The outlet conduits 30 consequently have their inlet end portions 31 arranged at the radially outer position and a conduit outlet 32 arranged at a radially inner position. Further, the plurality of outlet pipes 30 are arranged with an upward tilt relative the radial plane from the inlet end portions 31 to the conduit outlet 32. Further, there may be vortex nozzles arranged at the outlet end portions 32 for providing a stable flow, as discussed in WO2021058287A1.

[0063] In embodiments, the centrifugal separator comprises at least four outlet pipes 30, such as at least eight outlet pipes 30, such as at least twelve outlet pipes 30.

[0064] The radially inner portion of the disc stack 10 communicates with a second outlet chamber 7 for a separated light phase of the liquid feed mixture. The second outlet chamber 7 of the centrifuge bowl 5 communicates with a stationary outlet pipe 7a for discharging the separated liquid light phase from the centrifuge bowl 5.

[0065] The first and second outlet chambers 6, 7 have mechanical seals 12, 11. As this is an airtight design, they are also often called hermetic seals. The inlet channel 4b is also sealed at lower end of the hollow spindle 4a, thus preventing communication between the inlet channel 4b and the surroundings. This mechanical seal is not shown in this figure.

[0066] The centrifuge bowl 5 is further provided with outlets 15 at the radially outer periphery of the sludge space 9b. These outlets 15 are evenly distributed around the rotor axis (X) and are arranged for intermittent discharge of a sludge component of the liquid feed mixture. The sludge component comprises denser particles forming a sludge phase. The opening of the outlets 15 is controlled by means of an operating slide 16 actuated by operating water channels below the operating slide 16, as known in the art. In its position shown in the drawing, the operating slide 16 abuts sealingly at its periphery against the upper part of the centrifuge bowl 5, thereby closing the sludge space 9b from connection with outlets 15, which are extending through the centrifuge bowl 5.

[0067] During operation of the separator as shown in Fig. 1 and 2, the centrifuge bowl 5 is brought into rotation by the drive motor 3. Via the spindle 4a, liquid feed mixture comprising yeast is brought into the separation space 9a, as indicated by arrow "A". Depending on the density, different phases in the liquid feed mixture is separated between the separation discs 40 of the stack 10. Heavier component, such as a liquid heavy phase and a sludge phase, move radially outwards between the separation discs of the stack 10 to the sludge space 9b, whereas the phase of lowest density, such as a liquid light phase, moves radially inwards between the separation discs of the stack 10 and is forced through the outlet pipe 7a via the second outlet chamber 7, as indicated by arrow "C". The liquid of higher density, i.e. the liquid heavy phase comprising yeast - is instead discharged via the outlet conduits 30 to the first outlet chamber 6 and further out via stationary outlet pipe 6a, as indicated by arrow "B". Thus, during separation, an interphase between the liquid of lower density and the liquid of higher density is formed in the centrifuge bowl 5, such as radially within the stack of separation discs. Solids, or sludge, may accumulate at the periphery of the sludge space 9b and is emptied intermittently from within the centrifuge bowl by the sludge outlets 15 being opened, whereupon sludge and a certain amount of fluid is discharged from the separation chamber 15 by means of centrifugal force, as indicated by arrow "D". Yeast cells present in this phase usually do not survive the intermittent discharge. The discharge of the sludge phase may also take place continuously, in which case the sludge outlets 17 take the form of open nozzles and a certain flow of sludge and/or heavy phase is discharged continuously by means of centrifugal force.

[0068] Fig. 3 shows an overview of a separation system 90 used in the method 100 of separating liquid feed mixture comprising yeast according to the present disclosure, whereas Fig. 4 schematically illustrates the different steps of the method 100.

[0069] The separation system 90 is used in a brewing process. Liquid feed mixture comprising yeast is fed from a fermentation tank 61 to the centrifugal separator 1 via piping 74 using the feed pump 80. The liquid feed mixture is separated in the centrifugal separator 1 into clarified beer - the liquid light mixture - and a liquid heavy phase

comprising yest - the liquid heavy phase - as discussed in relation to Figs. 1 and 2 above. The liquid heavy phase comprising live yeast is continuously discharged to stationary outlet pipe 6a and the liquid light phase is continuously discharged to stationary outlet pipe 7a at the top of the separator 1. During separation, also a sludge phase is discharged intermittently from the centrifugal separator 1. This phase is collected in in a collection tank 64 or cyclone via piping 71.

[0070] The clarified beer is transported via main pipe 75 to a clarified beer collection tank 63. However, the main pipe 75 also branches off to a connection pipe 70 so that clarified beer may be reintroduced via regulating valve 81 if needed.

[0071] Pump 82 is used to pressurize the liquid heavy phase that has been discharged into stationary outlet pipe 6a. The flow and/or density of the liquid heavy phase is measured by sensing member 84 arranged in connection with or within stationary outlet pipe 6a. The sensing member 84 may thus be both a flow and a density meter. The measured values are collected by control unit 85. This unit 85 may be a stand-alone unit or be part of the control system used for operating the centrifugal separator 1. Depending on the measured value, the control unit regulates the regulating valve 81 so that a portion of the clarified beer is reintroduced into the liquid heavy phase via the connection pipe 70. There may also be a sensing member (not shown) downstream of the regulating valve 81. As an example, the control unit 85 may be configured to keep the flow or density of the liquid heavy phase within a certain interval so that it can easily be pumped to vital cell collection tank 62. Control unit 85and thus controls the amount of clarified beer introduced into the liquid heavy phase. This control may for example comprise controlling the time during which regulating valve 81 is open or the flow in the connection pipe 70. As also illustrated in Fig. 3, there is a valve member 83 installed in the first stationary outlet pipe 6a that also allows liquid heavy phase to be directed to the collection tank 64 used for collecting the discharged sludge phase.

[0072] The liquid heavy phase comprising yeast into which a portion of clarified beer has been introduced is further pumped via pipe 72 to vital yeast collection tank 62. For this, there may be further pumps used (not shown), such as a pump downstream of the regulating valve 81.

[0073] Due to the introduction of the clarified beer, the viscosity of the separated liquid heavy phase comprising yeast is decreased, which in turn provides for the liquid heavy phase being more easily pumped to the collection tank 62, with little stress on the yest cells. Vital cell collection tank 62 thus comprises live cells that could repitched pack to the brewery process and reused. For this, there could be a connection pipe 73 that leads back to the same fermentation tank 61 from which the liquid feed mixture was obtained, or it could be a different fermentation tank.

[0074] Consequently, as illustrated in Fig. 4, the method of the present disclosure comprises the steps of

a) introducing 101 the liquid feed mixture into a centrifugal separator 1;
b) continuously discharging 102 a separated liquid heavy phase comprising yeast from the centrifugal separator;
c) continuously discharging 103 a separated liquid light phase from the centrifugal separator; and
d) introducing 104 a portion of the separated liquid light phase into the separated liquid heavy phase comprising yeast; thereby decreasing the viscosity of the separated liquid heavy phase.

[0075] The method may also comprise a steps of

e) intermittently discharging 107 a sludge phase from the centrifugal separator (1) and
f) pumping (108) the separated liquid heavy phase to a container 62 after step d).

[0076] Further, the step d) may comprise the sub steps of:

d1) measuring 105 the flow and/or density of the separated liquid heavy phase and;
d2) introducing 106 a portion of the separated liquid light phase into the separated liquid heavy phase; thereby decreasing the viscosity of the separated liquid heavy phase, based on the measured flow and/or density of step d1).

[0077] The invention is not limited to the embodiment disclosed but may be varied and modified within the scope of the claims set out below. The invention is not limited to the orientation of the axis of rotation (X) disclosed in the figures. The term "centrifugal separator" also comprises centrifugal separators with a substantially horizontally oriented axis of rotation. In the above the inventive concept has mainly been described with reference to a limited number of examples. However, as is readily appreciated by a person skilled in the art, other examples than the ones disclosed above are equally possible within the scope of the inventive concept, as defined by the appended claims.

Claims

1. A method (100) of separating liquid feed mixture comprising yeast, said method comprising the steps of

a) introducing (101) the liquid feed mixture into a centrifugal separator (1);
b) continuously discharging (102) a separated liquid heavy phase comprising yeast from the centrifugal separator;

c) continuously discharging (103) a separated liquid light phase from the centrifugal separator; and

d) introducing (104) a portion of the separated liquid light phase into the separated liquid heavy phase comprising yeast; thereby decreasing the viscosity of the separated liquid heavy phase.

2. A method (100) according to claim 1, further comprising a step of e) intermittently discharging (107) a sludge phase from the centrifugal separator (1).

3. A method (100) according to any previous claim, wherein the separated liquid heavy phase comprises live yeast cells.

4. A method (100) according to any previous claim, wherein the separated liquid light phase comprises clarified beer.

5. A method (100) according to any previous claim, further comprising a step of
f) pumping (108) the separated liquid heavy phase to a container (62) after step d).

6. A method (100) according to claim 5, wherein the container (62) is a storage tank (62) or a fermentation tank (61).

7. A method (100) according to any previous claim, wherein step d) comprises the sub steps of:

d1) measuring (105) the flow and/or density of the separated liquid heavy phase and;

d2) introducing (106) a portion of the separated liquid light phase into the separated liquid heavy phase; thereby decreasing the viscosity of the separated liquid heavy phase, based on the measured flow and/or density of step d1).

8. A separation system (90) for separating liquid feed mixture comprising yeast, said system comprising

a centrifugal separator (1) for separating the liquid feed mixture into a liquid light phase and a liquid heavy phase comprising yeast, and wherein the centrifugal separator (1) comprises discharging (30) means for continuous discharge of the liquid heavy phase;

a first stationary liquid outlet pipe (6a) for receiving separated liquid heavy phase comprising yeast;

a second stationary liquid outlet pipe (7a) for receiving separated liquid light phase;

a valve member (81) arranged for regulating the introduction of a portion of the separated liquid light phase from the second stationary liquid outlet pipe (7a) into the separated liquid heavy phase in the first stationary liquid outlet pipe (6a).

9. A separation system (90) according to claim 8, wherein the second liquid outlet pipe comprises a main pipe (75) for transport of a larger fraction of the separated liquid light phase and connection pipe (70), which branches off from said main pipe (75) and connects said main pipe (75) with said a first stationary liquid outlet pipe (6a), and wherein the valve member (81) is arranged for regulating the flow of separated liquid light phase in said connection pipe (70) to said first stationary liquid outlet pipe (6a).

10. A separation system (90) according to claim 8 or 9, further comprising a container (62) downstream of said first stationary liquid outlet pipe (6a) and said valve member (81).

11. A separation system (90) according to any one of claims 8 - 10, further comprising a sensing member (84) for measuring the flow and/or density of the separated liquid heavy phase in the first stationary liquid outlet pipe (6a).

12. A separation system (90) according to any one of claims 8-11, wherein the centrifugal separator (1) comprises a stack (10) of separation discs for increasing the separation area within the centrifugal separator (1).

13. A separation system (90) according to claim 12, wherein the centrifugal separator (1) comprises a plurality of liquid heavy phase outlet conduits (30) for continuous transport of separated liquid heavy phase from a space (9b) radially outside the stack of separation discs to a liquid heavy phase outlet chamber (6) in the centrifugal separator (1).

14. A separation system (90) according to claim 13, wherein the centrifugal separator (1) comprises a centrifuge bowl (5) in which the separation takes place, and wherein the liquid heavy phase outlet conduits (30) are a plurality of individual pipes within the centrifuge bowl (5).

15. A separation system (90) according to claim 13, wherein the centrifugal separator (1) comprises a centrifuge bowl (5) in which the separation takes place, and wherein the liquid heavy phase outlet conduits are a plurality of conduits integrated in the wall (13) of the centrifuge bowl (5)

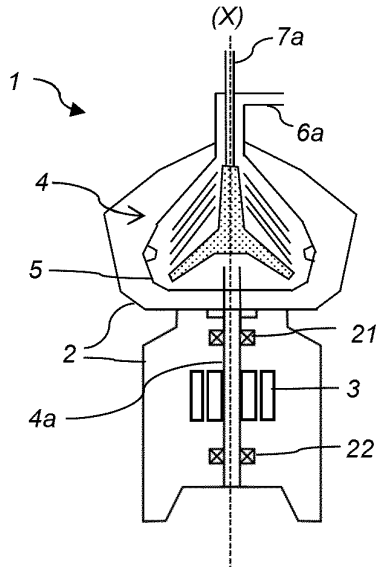
(X)
7a
1
6a
4
5
2
21
3
4a
22

Fig. 1

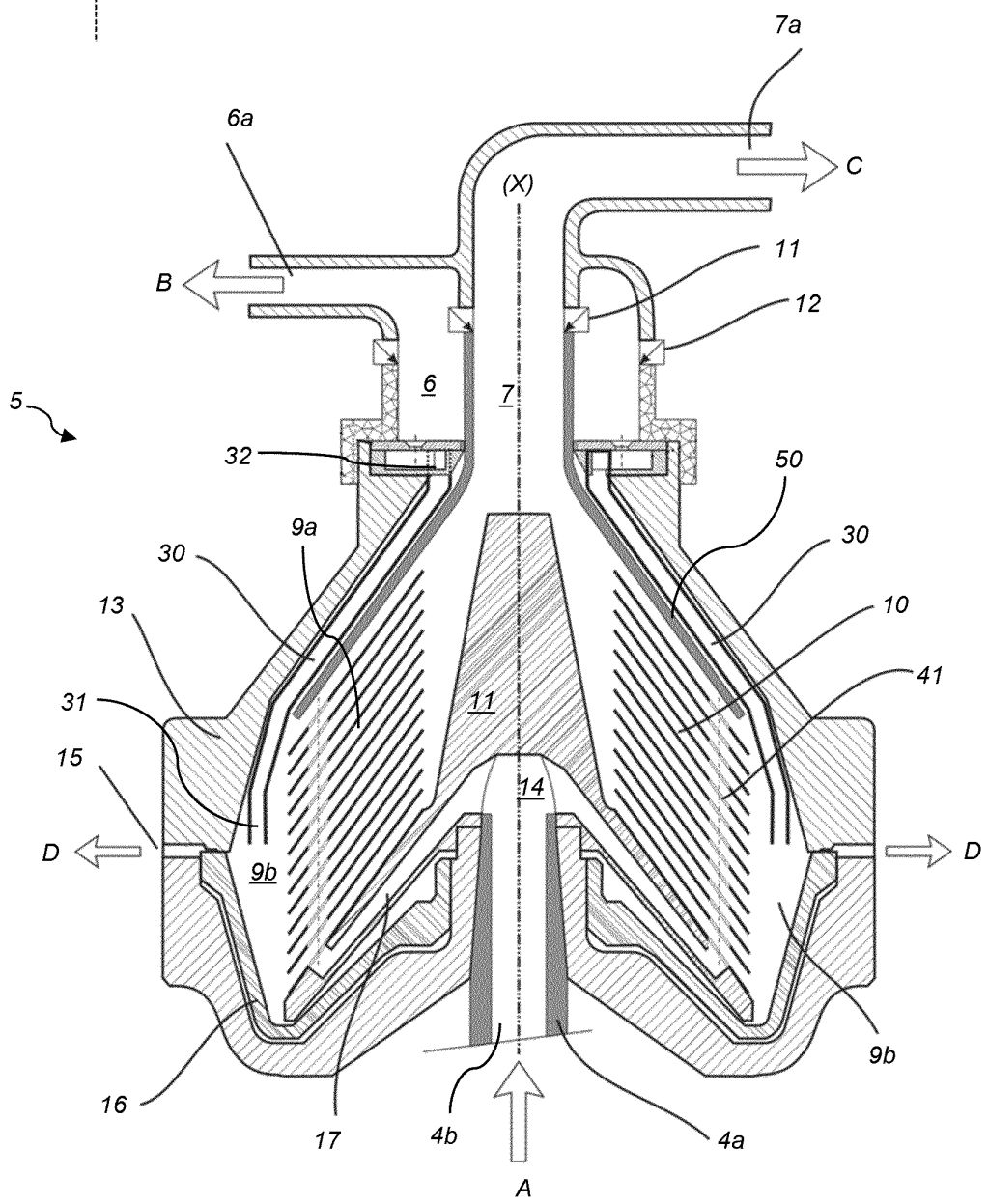
7a
6a
C
(X)
B
11
12
6
7
5
32
50
9a
30
30
13
10
41
31
11
15
14
D
D
9b
9b
16
17
4b
4a
A

Fig. 2

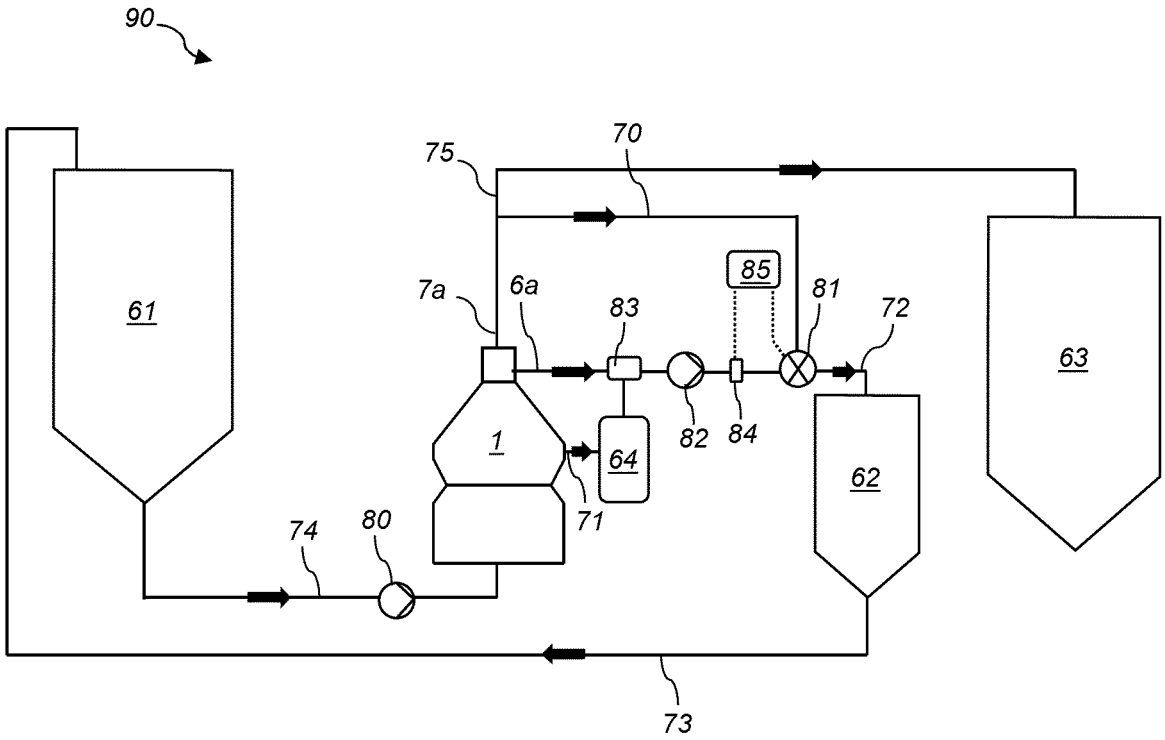

Fig. 3

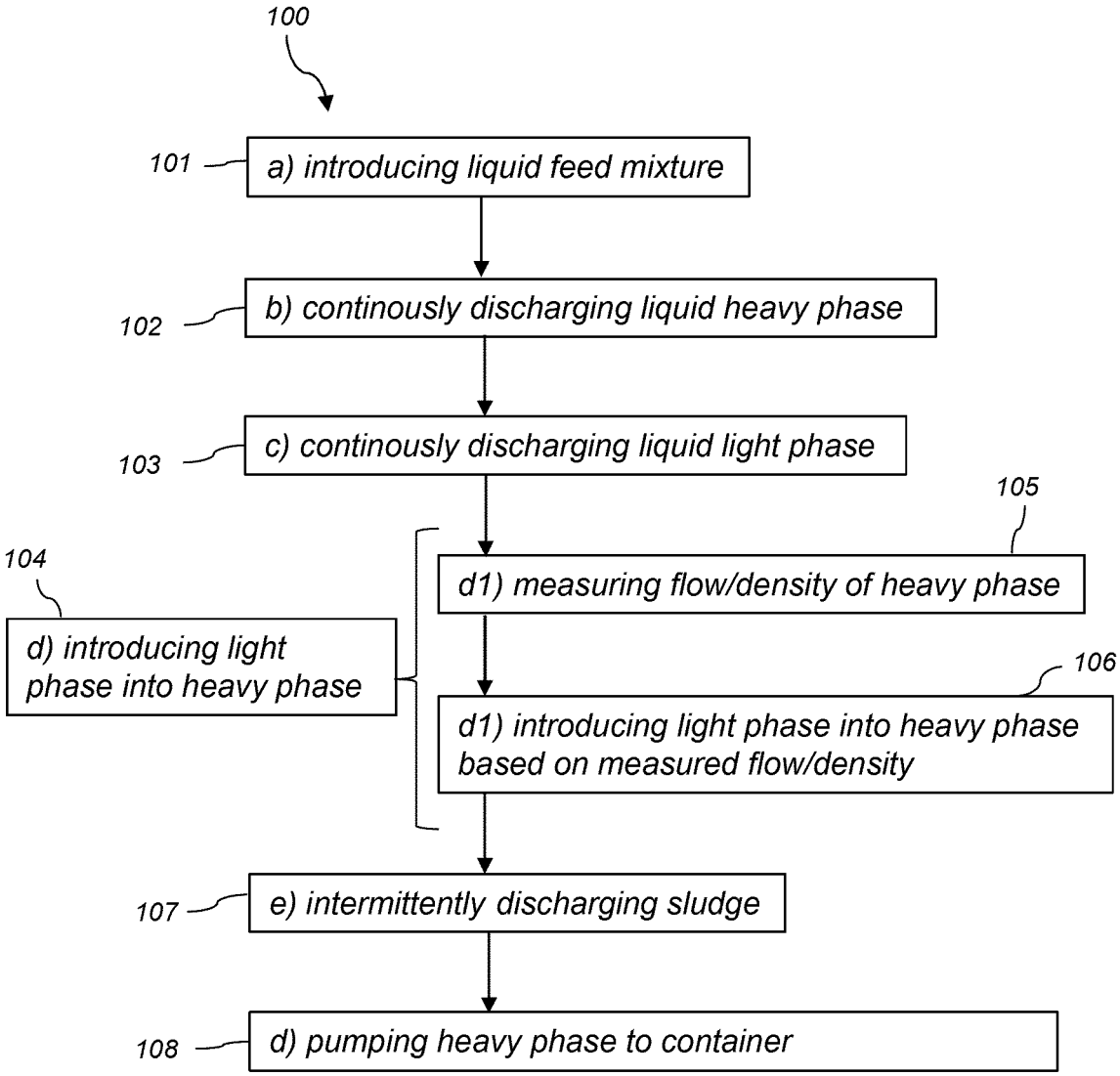
100
101
a) introducing liquid feed mixture
102
b) continously discharging liquid heavy phase
103
c) continously discharging liquid light phase
105
d1) measuring flow/density of heavy phase
104
d) introducing light phase into heavy phase
106
d1) introducing light phase into heavy phase based on measured flow/density
107
e) intermittently discharging sludge
108
d) pumping heavy phase to container

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
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Place of search	Date of completion of the search	Examiner
Munich	13 October 2022	Leitner, Josef

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