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(54) **CENTRIFUGAL SEPARATOR CONTROL SYSTEM**

(57) The present disclosure relates to a method of a control system (50) of controlling operation of a centrifugal separator (10), a control system (50) performing the method and a centrifugal separator (10) comprising the control system (50).

In an aspect, a method of a control system (50) of controlling operation of a centrifugal separator (10) is provided. The method comprises supplying (S101) control signals to a variable frequency drive (30, VFD), configured to control at least one of torque and speed of a motor (13) causing a rotational member (11, 12) of the separator (10) to rotate for separating a fluid mixture into at least a first component and a second component, the VFD (30) controlling (S102) the at least one of the torque and speed of the motor (13) based on monitored (S103) operational mode of the separator (10), receiving (S104) data indicating that the operational mode of the separator (10) should be adjusted, and supplying (S105), in response to the received data indicating that the operational mode of the separator (10) should be adjusted, updated control signals to the VFD (30) for adjusting the operational mode of the separator (10).

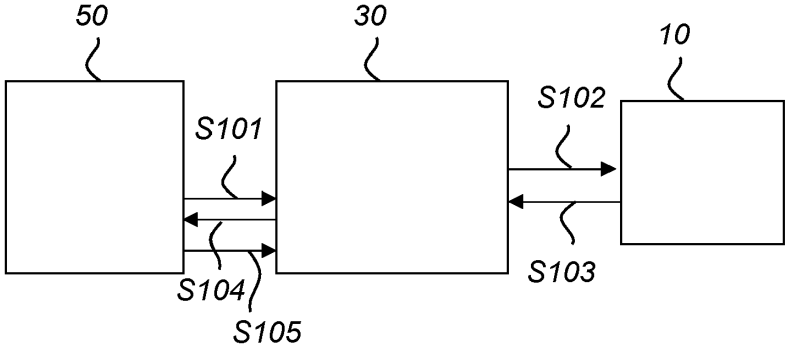

Figure 4

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a method of a control system of controlling operation of a centrifugal separator, a control system performing the method and a centrifugal separator comprising the control system.

BACKGROUND

[0002] Centrifugal separators are generally used for separation of liquids and/or for separation of solids from a liquid mixture. During operation, liquid mixture to be separated is introduced into a rotating centrifuge bowl and e.g. 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 different distances from the rotational axis.

[0003] The drive member used for rotating the centrifuge bowl may be a drive motor used to drive a shaft onto which the centrifuge bowl is mounted. The drive motor may be an electrical motor that is connected directly to the spindle.

[0004] Control schemes are known in the art for controlling operation of a centrifugal separator. To control the operation of the separator, speed and/or torque of a separator drive motor is controlled for causing a rotational member of the separator to rotate. This rotation will cause the separator to separate a fluid mixture into a first heavy component and a second light component.

[0005] To control the speed and torque of the motor, a variable frequency drive (VFD) is commonly used. The VFD varies frequency and amplitude of the voltage being supplied by the VFD to the motor of the separator to control the speed and torque of the motor accordingly.

[0006] A problem with the prior art control schemes is that the VFD initially is configured with operational parameters to be applied at the VFD upon the VFD controlling the torque and speed of the motor which then are applied throughout the control process, which provides for a highly static control schemes.

[0007] There is thus room for improving the prior art control scheme.

SUMMARY

[0008] One objective is to solve, or at least mitigate this problem in the art, and thus to provide an improved method of a control system of controlling operation of a separator.

[0009] This objective is attained in a first aspect by a method of a control system of controlling operation of a centrifugal separator. The method comprises supplying control signals to a variable frequency drive (VFD) configured to control at least one of torque and speed of a motor causing a rotational member of the separator to rotate for separating a fluid mixture into at least a first component and a second component, the VFD controlling the at least one of torque and speed of the motor based on monitored operational mode of the separator, receiving data indicating that the operational mode of the separator should be adjusted, and supplying, in response to the received data indicating that the operational mode of the separator should be adjusted, updated control signals to the VFD for adjusting the operational mode of the separator.

[0010] This objective is attained in a second aspect by a control system configured to control operation of a centrifugal separator, comprising a processing unit and a memory, said memory containing instructions executable by said processing unit, whereby the control system is operative to supply control signals to a VFD configured to control at least one torque and speed of a motor causing a rotational member of the separator to rotate for separating a fluid mixture into at least a first component and a second component, the VFD controlling the at least one of torque and speed of the motor based on monitored operational mode of the separator, receive data indicating that the operational mode of the separator should be adjusted, and to supply, in response to the received data indicating that the operational mode of the separator should be adjusted, updated control signals to the VFD for adjusting the motor load.

[0011] This objective is attained in a third aspect by a centrifugal separator configured to separate a fluid mixture into at least a first component and a second component, said centrifugal separator comprising a rotatable centrifuge bowl in which the separation takes place, a drive motor for causing rotation of the centrifuge bowl, a VFD configured to control at least one of torque and speed of the drive motor, and a separator control system configured to perform the method of the first aspect.

[0012] By enabling the control system to provide updated control signals, e.g, comprising an updated set of operational parameters to be applied at the VFD upon the VFD controlling the torque and/or speed of the motor, a far more dynamic separator control scheme is advantageously provided as compared to prior art control schemes, increasing both performance and robustness of the operation of the separator.

[0013] As is understood, the monitored operational mode of the separator may broadly relate to many types of modes such as a starting operational mode requiring a first set of operational parameters, a production operational mode requiring a second set of operational parameters, a stopping operational mode requiring a third set of operational parameters, a clean-in-place (CIP) operational mode requiring a fourth set of operational parameters, an intermittent solids discharge operational mode requiring a fifth set of operational parameters, etc. In an example, if the VFD is configured with operational parameters suitable for a particular starting operational mode, and adjusted set of operational parameters may be sent to the VFD for adjusting the operational mode such that a normal operating mode is entered.

[0014] The operational mode may further relate to a particular separator motor load where one motor load requires one set of operational parameters while another motor load requires a different set of operational parameters.

[0015] In an embodiment, the supplying, in response to the received data indicating that the operational mode of the separator should be adjusted, of updated control signals to the VFD for adjusting the operational mode of the separator comprises supplying an updated set of operational parameters to be applied at the VFD upon the VFD controlling the torque and/or speed of the motor.

[0016] In an embodiment, the supplying, in response to the received data indicating that the operational mode of the separator should be adjusted, of updated control signals to the VFD for adjusting the operational mode of the separator comprises instructing the VFD to apply either speed control or torque control of the motor of the separator.

[0017] In an embodiment, in response to receiving data indicating that the operational mode of the separator should be adjusted, the control system performs diagnostics of the separator.

[0018] In an embodiment, communication between the control system and the VFD is configured to be wireless.

[0019] Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the element, apparatus, component, means, step, etc." are to be interpreted openly as referring to at least one instance of the element, apparatus, component, means, step, etc., unless explicitly stated otherwise. The steps of any method disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] Aspects and embodiments are now described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 illustrates a prior art control scheme for controlling operation of a separator;

Figure 2 shows a cross-sectional view of a prior art centrifugal separator;

Figure 3 shows a more detailed view of a centrifuge bowl of the centrifugal separator 10 of Figure 2;

Figure 4 illustrates a control scheme for controlling operation of a separator according to an embodiment; and

Figure 5 illustrates a control system according to an embodiment.

DETAILED DESCRIPTION

[0021] The aspects of the present disclosure will now be described more fully hereinafter with reference to the accompanying drawings, in which certain embodiments of the invention are shown.

[0022] These aspects may, however, be embodied in many different forms and should not be construed as limiting; rather, these embodiments are provided by way of example so that this disclosure will be thorough and complete, and to fully convey the scope of all aspects of invention to those skilled in the art. Like numbers refer to like elements throughout the description.

[0023] Figure 1 illustrates a prior art control scheme for controlling operation of a separator 10. To control the operation of the separator 10, speed and/or torque of a separator drive motor is controlled for causing a rotational member of the separator 10 to rotate.

[0024] This rotation will cause the separator 10 to separate a fluid mixture into at least a first heavy component and a second light component as will be discussed in more detail in the following. As is understood, in some separators a third solid component is separated.

[0025] To control the speed and torque of the motor, a variable frequency drive 30 (VFD) is commonly used. The VFD 30 varies frequency and amplitude of the voltage being supplied by the VFD 30 to the motor of the separator 10 to increase/decrease the speed and torque of the motor, which in its turn increases/decreases the speed and torque with which the rotational member is rotated.

[0026] The speed of the motor is normally controlled by a built in controller within the VFD 30 that varies the torque continuously in order to maintain a set speed by controlling the voltage and thus the power being supplied to the motor. The power being supplied to the motor is determined based on a number of parameters, such as e.g. by motor properties, the amplitude and frequency of the current and voltage being fed to the motor, the phase between the current and the voltage, the speed of the motor, the temperature of the motor, etc. VFDs are known in the art and will not be described in detail herein.

[0027] A control system 40 is utilized to initially supply the VFD 30 in S101 with control signals in order for the VFD 30 to be able to control the motor of the separator 10 in S102 as required. This typically includes configuring the VFD 30 with initial operational parameters to be applied to the motor by the VFD 30, such as supplying the separator motor with voltage/current of a certain frequency and/or amplitude. However, after having supplied the initial parameters, they cannot be changed; any further adjustments must be undertaken by the VFD 30.

[0028] During operation of the separator 10, the VFD 30 may be supplied in S103 with data associated with operational mode of the separator 10, which may affect a load of the motor. Hence, the operational mode of the separator is monitored and fed back to the VFD 30 in S103, based on which the VFD 30 controls the speed and torque of the motor. Alternatively, motor load is computed by the VFD 30 from the current/voltage being supplied to the motor, for instance in combination with VFD knowledge about the motor, e.g. attained during calibration without necessarily receiving any data in S103.

[0029] For instance, assuming that the load of the motor exceeds a desired limit value, the VFD 30 may decide to reduce the load of the motor by decreasing the frequency and/or amplitude of the voltage supplied by the VFD 30 to the motor in S102. This will, for a given motor speed, decrease the motor current and thus motor load such that the desired limit value again is reached. The adjustment of the frequency and amplitude of the voltage supplied the VFD 30 is performed by a control algorithm within the VFD 30.

[0030] As is understood, while the load of the motor depends on the motor torque and speed, parameters such as motor type, size, voltage rating, etc., affect the load and typically varies between different motors.

[0031] Figures 2 and 3 illustrates a separator 10 to which a control scheme may be applied in an embodiment. As is understood, the control scheme according to embodiments described herein may be applied to any appropriate separator type, such as such as a clarifier, which is a centrifugal separator for solid - liquid separation, a purifier, which is a centrifugal separator for liquid - liquid - solid separation, and a concentrator, which is a centrifugal separator designed to separate three different phases, one solid phase and two liquid phases of different densities, and clean the densest/heaviest liquid phase.

[0032] Figure 2 shows a cross-sectional view of a prior art centrifugal separator 10 configured to separate a fluid mixture supplied to the separator 10 into a first heavy component and a second light component. As is understood, this is just an example of a separator in which embodiments can be implemented.

[0033] As mentioned, the centrifugal separator 10 has a rotational member comprising a centrifuge bowl 11 and drive spindle 12. As further mentioned, the separator 10 comprises a drive motor 13. This motor 13 provides driving torque to the spindle 12 and hence to the centrifuge bowl 11 during operation. The drive motor 13 maybe an electric motor. Illustrated is also a VFD 30 controlling the motor 13 as described hereinabove.

[0034] The centrifuge bowl 11, shown in more detail in Figure 3, is supported by the spindle 12, which is rotatably arranged in a frame 14 around the vertical axis of rotation (X) in a bottom bearing 15 and a top bearing 16. The stationary frame 14 surrounds centrifuge bowl 11.

[0035] Also shown in Figure 2 is an inlet pipe 17 extending into the centrifuge bowl 11 axially from the top. The fluid mixture that is to be separated in the disc-stack centrifugal separator is thus introduced via inlet pipe 17. After separation has taken place within the centrifuge bowl 11, the separated second light component, i.e. the separated liquid, is discharged through stationary outlet pipe 18. As is understood, while in this particular example the first heavy component is considered to be a waste product, it may alternatively be the second component which is considered to be the waste product.

[0036] Figure 3 shows a more detailed view of the centrifuge bowl 11 of the centrifugal separator 10 of Figure 2.

[0037] The centrifuge bowl 11 forms within itself a separation space 19 in which a stack 20 of separation discs is arranged coaxially around the axis of rotation (X) and is thus arranged to rotate together with the centrifuge bowl11. The stack 20 of separation discs provide for an efficient separation of the fluid mixture supplied via the inlet pipe 17.

[0038] The centrifugal separator 10 further comprises an inlet 21 in the form of a central inlet chamber into which a stationary inlet pipe 17 extends for supply of the fluid mixture to be separated. The inlet 21 communicates with the separation space 19 via passages 22.

[0039] The outlet 23 for the separated second light component is arranged in an outlet chamber, which is in fluid communication with the stationary outlet pipe 18 for discharge of the separated liquid.

[0040] The centrifuge bowl 11 is further provided with outlets 26 at the radially outer periphery of the separation space 19. These outlets 26 are evenly distributed around the rotor axis (X) and are arranged for intermittent discharge of the first heavy component, commonly referred to as a solids component, of the fluid mixture to be separated. The solids component comprises denser particles forming a sludge phase. The opening of the outlets 26 is controlled by means of an operating slide 25 actuated by operating water in channel 24, as known in the art. In its position shown in the drawing, the operating slide 25 abuts sealingly at its periphery against the upper part of the centrifuge bowl 11, thereby closing the separation space 19 from connection with outlets 25 which are extending through the centrifuge bowl 11.

[0041] During operation of the separator as shown in Figures 2 and 3, the centrifuge bowl 11 is brought into rotation by the drive motor 13. Via the inlet pipe 17, the fluid mixture is brought into the separation space 19, where solids particles move radially outwards between the separation discs, whereas the liquid moves radially inwards between the separation discs and is forced through the outlet 23. From there, the second light component, i.e. the separated liquid, is discharged via outlet pipe 18.

[0042] The solids, or sludge, that accumulate at the periphery of the separation space 19 is emptied intermittently from within the centrifuge bowl 11 by the sludge outlets 26 being opened. However, the discharge of sludge may also take place continuously, in which case the sludge outlets 26 take the form of open nozzles and a certain flow of sludge is discharged continuously by means of centrifugal force.

[0043] Again with reference to the prior art control scheme illustrated in Figure 1, while the control system in S101 supplies the VFD 30 with operating parameters to initially be applied when controlling operation of the drive motor of the separator 10, this prior art control scheme does not provide for precise separator control.

[0044] This issue is resolved in an embodiment by a control scheme illustrated in Figure 4.

[0045] Now, while a control system 50 is utilized to initially supply the VFD 30 in S101 with control signals in order for the VFD 30 to be able to control the motor of the separator 10 in S102 as required based on data indicating monitored operational mode of the separator fed back to the VFD 30 in S103, the control scheme according to this embodiment further enables the VFD 30 to forward the data indicating the operational mode of the separator in S104 to the control system 50, which in its turn is enabled to send updated control signals to the VFD 30 for adjusting the operational mode of the separator.

[0046] In other words, the control system 50 may further refine the control signals being supplied to the VFD 30 for the VFD to change frequency and/or amplitude of the voltage being supplied to the motor 13 of the separator 10.

[0047] For instance, assuming that the VFD 30 is arranged to control the motor of the separator 10 using one of three different operational parameters - p1, p2, p3 - in order to increase/decrease the speed and/or torque of the motor, where the operational parameters in this particular example relates to an automatic control function in the VFD 100 for controlling the torque of the motor 13, where p1 would result in the lowest motor torque and p3 would result in the highest motor torque upon the operational parameters being applied at the VFED 30. This is illustrated in Table 1 below. In practice, more than a hundred operational parameters may be taken into account by the VFD 30.

[0048] With the embodiment proposed in Figure 4, the control system 50 may update the control signals in S105 in response to the data received in S104 indicating an operational mode of the separator 10 in the form of motor load, for instance by sending an updated set of operational parameters - p2, p2', p2" - for adjusting the torque of the motor 13, where parameters p2' and p2" result in a motor torque greater than that caused by p2 but smaller than the motor torque caused by p3. Thus, this provides for a more accurately adjusted motor torque in a scenario where the torque resulting from p2 is slightly too low and the torque caused by p3 is slightly too high.

Table 1. Updating initially set VFD operational parameters.

Initially set VFD operational parameters	p1	p2	p3	
Updated parameters 1		p2, p2', p2"		
Updated parameters 2	p1	p2	p3	p4

[0049] In another example, the control system 50 may update the control signals in S105 in response to the data received in S104 indicating motor load, for instance by sending an updated set of operational parameters - p1, p2, p3, p4 - for adjusting the torque of the motor 13, where parameter p4 applied at the VFD 30 causes a motor torque which is higher than if p3 is applied. Thus, in case the motor load cannot be sufficiently increased by applying the initially set operational parameters p1, p2, p3 at the VFD 30, the control system 50 may update the set of operational parameters applied at the VFD 30 for adjusting the motor torque by further allowing the torque to increase to a value stipulated by VFD operational parameter p4, which will further increase the motor load.

[0050] Thus, in these exemplifying embodiments, the control system 50 supplies an updated set - p2, p2', p2" or p1, p2, p3, p4 - of operational parameters to be applied at the VFD 30 upon the VFD 30 controlling the torque and/or speed of the motor 13.

[0051] Advantageously, this provides for a far more dynamic separator control scheme as compared to the prior art control scheme illustrated in Figure 1, increasing both performance and robustness of the operation of the separator 10.

[0052] Particularly advantageous is that, with respect to the prior art control scheme illustrated in Figure 1 where large safety margins are required in VFD settings (e.g. in operational parameters p1, p2, p3 being applied) to protect the motor from overloading, since the control system 50 is capable of updating the control signals in S105, the safety margins set up with the initially supplied control signals of S101 need not be overly strict, since they can be updated continuously.

[0053] In an embodiment, the updated control signals being sent by the control system 50 to the VFD 30 in S105 includes instructing the VFD 30 to apply either *motor speed control* or *motor torque control* (based on the initially supplied operational parameters of S101 or updated operational parameters sent with the control signals in S105). As previously mentioned, the speed of the motor is normally controlled by a built in controller within the VFD 30 that varies the torque continuously in order to maintain a set speed by controlling the voltage and thus the power being supplied to the motor. Conversely, it may be that the speed is continuously varied in order to maintain a set torque.

[0054] As is understood, data associated with operational mode of the separator 10 may be fed back to the VFD, which in its turn may affect a motor load, and if it turns out that the motor load does not comply with a desired setpoint value, the VFD 30 may increase/decrease the frequency and/or amplitude of the voltage being supplied to the motor of the separator 10 in S102, wherein the motor load ultimately will arrive at the desired setpoint value.

[0055] In an embodiment, with the monitored motor load being supplied by the VFD 30 to the control system 50 in S104, the control system 50 is able to perform diagnostics of the separator 10 and motor 13. For instance, in case the motor load is unusually high, it may be required to stop the operation of the separator 10 and send out maintenance personnel to investigate the separator 10.

[0056] Further, it may be envisaged that communication between the control system 50 and the VFD 30 in S101, S104 and S105 is configured to be wireless. This is advantageous since the control system 50 in such case may be located (far) remote from the VFD 30. Alternatively, communication between the control system 50 and the VFD 30 occurs via wired connection in which case the control system 50 typically is located close to the VFD 30.

[0057] In the prior art control scheme illustrated with reference to Figure 1, the VFD 30 controls the separator by using motor speed control. In such a control scheme, if the speed of the motor 13 is to be changed from one speed to another (or to/from standstill), predetermined speed ramps are utilized where the speed is carefully increased/deceased in a linear fashion to avoid high motor load for extended periods. Since no motor load is fed back to the control system 40 in the prior art control scheme, unexpected motor load changes are not attended to.

[0058] If the motor load is unexpectedly high during ramp-up/ramp-down, due to e.g. bearing faults, valves erroneously opening, slip within drive system, etc., the VFD 30 will continue the control the speed to attain a desired setpoint value in accordance with the above-mentioned speed ramp. This might lead to the motor 13 or separator 10 overheating or even breaking down, in particular during an emergency stop caused by a bearing failure. In other words, the static prior art control scheme does not allow updating the speed ramp control being applied.

[0059] Further, since the speed ramp initially is supplied as configuration data in 101, the range of the ramp-up/ramp-down values are poorly adapted to the actual state of the separator 10 in terms of for instance previous load conditions, ambient temperature, fluid mixture flow, etc.

[0060] A useful alternative to speed ramps is torque control, where the torque is controlled to a certain value until a set speed is reached. The VFD 30 can then switch control mode to applying speed control and the torque is controlled by the VFD 30 to maintain the speed at the setpoint, thereby providing a robust control scheme.

[0061] It is noted that it may take several minutes to rotate the centrifuge bowl 11 of the separator 10 to a target speed when running the motor at 100% with no flow running through the separator. Bowls may in practice weigh 1000 kg or more. If nothing is done to reduce the load during startup, the motor 13 or separator 10 might be damaged due to overheating or mechanical overload. Thus, suitable operational parameters should be supplied to the VFD 30 for adjusting to this operational mode of the separator 10.

[0062] Further, suitable operational parameters should be supplied to the VFD 30 lowering the torque or speed setpoint just before the flow of the separator is turned off, since turning off the flow drastically reduces the load, which might lead to high speeds and consequently alarms and emergency stops.

[0063] Further, dynamically switching between different operational modes and parameters to be able to control speeds closer to the maximum speed without risking emergency stops caused by a too high bowl speed is advantageous.

[0064] Thus, with the embodiments discussed with reference to Figure 4, in particular the control system 50 enabling both motor speed control and motor torque control, a far more robust control scheme is provided.

[0065] While in Figure 4 the VFD 30 supplies the control system 50 with data indicating that the operational mode of the separator 10 should be adjusted - in this example in the form of a motor load that should be adjusted, it is envisaged in another embodiment that the control system 50 itself internally has access to data indicating that the operational mode of the separator 10 should be adjusted (and hence will not receive the data from the VFD).

[0066] For instance, assuming in an example that the VFD 30 initially is configured with operational parameters suitable for a starting operational mode based on which the motor 13 is controlled.

[0067] The control system 50 may then e.g. after a set time period receive in S104 an internal control message indicating that the starting mode should be ended and in response thereto determine that normal operating mode is to be entered and send an instruction to enter normal operating mode, and updated operational parameters reflecting the normal operating mode, to the VFD in S105.

[0068] Given the specific implementation, operational parameters may be updated anywhere from on a per-second basis to more rarely, such as on an hourly basis.

[0069] Figure 5 illustrates the control system 50 configured to control operation of a centrifugal separator according to an embodiment, where the steps of the method performed by the control system 50 in practice are performed by a processing unit 111 embodied in the form of one or more microprocessors arranged to execute a computer program 112 downloaded to a storage medium 113 associated with the microprocessor, such as a Random Access Memory (RAM), a Flash memory or a hard disk drive. The processing unit 111 is arranged to cause the control system 50 to carry out the method according to embodiments when the appropriate computer program 112 comprising computer-executable instructions is downloaded to the storage medium 113 and executed by the processing unit 111. The storage medium 113 may also be a computer program product comprising the computer program 112. Alternatively, the computer program 112 may be transferred to the storage medium 113 by means of a suitable computer program product, such as a Digital Versatile Disc (DVD) or a memory stick. As a further alternative, the computer program 112 may be downloaded to the storage medium 113 over a network. The processing unit 111 may alternatively be embodied in the form of a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field-programmable gate array (FPGA), a complex programmable logic device (CPLD), etc. The control system 50 further comprises a communication interface 114 (wired and/or wireless) over which the control system 50 is configured to transmit and receive data to a VFD is described hereinabove.

[0070] The aspects of the present disclosure have mainly been described above with reference to a few embodiments and examples thereof. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope of the invention, as defined by the appended patent claims.

[0071] Thus, while various aspects and embodiments have been disclosed herein, other aspects and embodiments will be apparent to those skilled in the art. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

Claims

1. Method of a control system (50) of controlling operation of a centrifugal separator (10), comprising:

   supplying (S101) control signals to a variable frequency drive (30), VFD, configured to control at least one of torque and speed of a motor (13) causing a rotational member (11, 12) of the separator (10) to rotate for separating a fluid mixture into at least a first component and a second component, the VFD (30) controlling (S102) the at least one of torque and speed of the motor (13) based on monitored (S103) operational mode of the separator (10);
   receiving (S104) data indicating that the operational mode of the separator (10) should be adjusted; and
   supplying (S105), in response to the received data indicating that the operational mode of the separator (10) should be adjusted, updated control signals to the VFD (30) for adjusting the operational mode of the separator (10).

2. The method of claim 1, the supplying (S105), in response to the received data indicating that the operational mode of the separator (10) should be adjusted, updated control signals to the VFD (30) for adjusting the operational mode of the separator (10) comprising:
   supplying an updated set (p2, p2', p2") of operational parameters to be applied at the VFD (30) upon the VFD (30) controlling (S102) the at least one of torque and speed of the motor (13).

3. The method of claims 1 or 2, the supplying (S105), in response to the received data indicating that the operational mode of the separator (10) should be adjusted, updated control signals to the VFD (30) for adjusting the operational mode of the separator (10) comprising:
   instructing the VFD (30) to apply either speed control or torque control of the motor (13) of the separator (10).

4. The method of any one of the preceding claims, further comprising, in response to receiving (S104) data indicating that the operational mode of the separator (10) should be adjusted:
   performing diagnostics of the separator (10).

5. The method of any one of the preceding claims, wherein communication between the control system (50) and the VFD (30) is configured to be wireless.

6. A computer program (112) comprising computer-executable instructions for causing a control system (50) to perform steps recited in any one of claims 1-5 when the computer-executable instructions are executed on a processing unit (111) included in the a control system (50).

7. A computer program product comprising a computer readable medium (113), the computer readable medium having

the computer program (112) according to claim 6 embodied thereon.

8. A control system (50) configured to control operation of a centrifugal separator (10), comprising a processing unit (111) and a memory (113), said memory containing instructions (112) executable by said processing unit (111), whereby the control system (50) is operative to:

supply control signals to a variable frequency drive (30), VFD, configured to control at least one of torque and speed of a motor (13) causing a rotational member (11, 12) of the separator (10) to rotate for separating a fluid mixture into at least a first component and a second component, the VFD (30) controlling (S102) the at least one of the torque and speed of the motor (13) based on monitored (S103) the operational mode of the separator (10);
receive data indicating that the operational mode of the separator (10) should be adjusted; and
supply, in response to the received data indicating that the operational mode of the separator (10) should be adjusted, updated control signals to the VFD (30) for adjusting the operational mode of the separator (10).

9. The control system (50) of claim 8, being operative to, when supplying, in response to the received data indicating that the operational mode of the separator (10) should be adjusted, updated control signals to the VFD (30) for adjusting the operational mode of the separator (10):
supply an updated set (p2, p2', p2") of operational parameters to be applied at the VFD (30) upon the VFD (30) controlling (S102) the at least one of the torque and speed of the motor (13).

10. The control system (50) of claims 8 or 9, being operative to, when supplying, in response to the received data indicating that the operational mode of the separator (10) should be adjusted, updated control signals to the VFD (30) for adjusting the operational mode of the separator (10):
instruct the VFD (30) to apply either speed control or torque control of the motor (13) of the separator (10).

11. The control system (50) of any one claims 8-10, further being operative to, in response to receiving (S104) data indicating that the operational mode of the separator (10) should be adjusted:
perform diagnostics of the separator (10).

12. The control system (50) of any one claims 8-11, further being operative to perform wireless communication with the control system (50).

13. A centrifugal separator (10) configured to separate a fluid mixture into at least a first component and a second component; said centrifugal separator (11) comprising

a rotatable centrifuge bowl (11) in which the separation takes place;
a drive motor (13) for causing rotation of the centrifuge bowl (11);
a variable frequency drive (30), VFD, configured to control at least one of torque and speed of the drive motor (13); and
a separator control system (50) configured to perform the method of any one of claims 1-5.

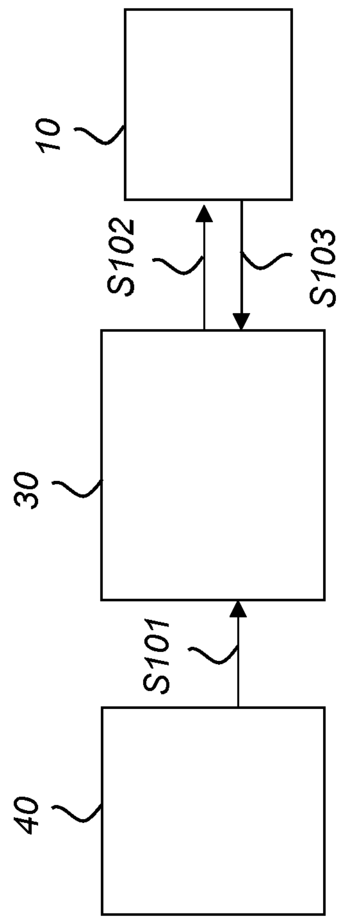

Figure 1

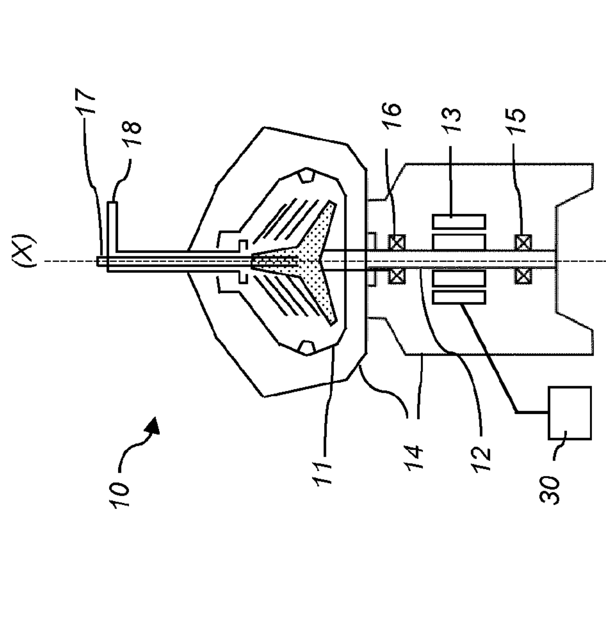

Figure 2

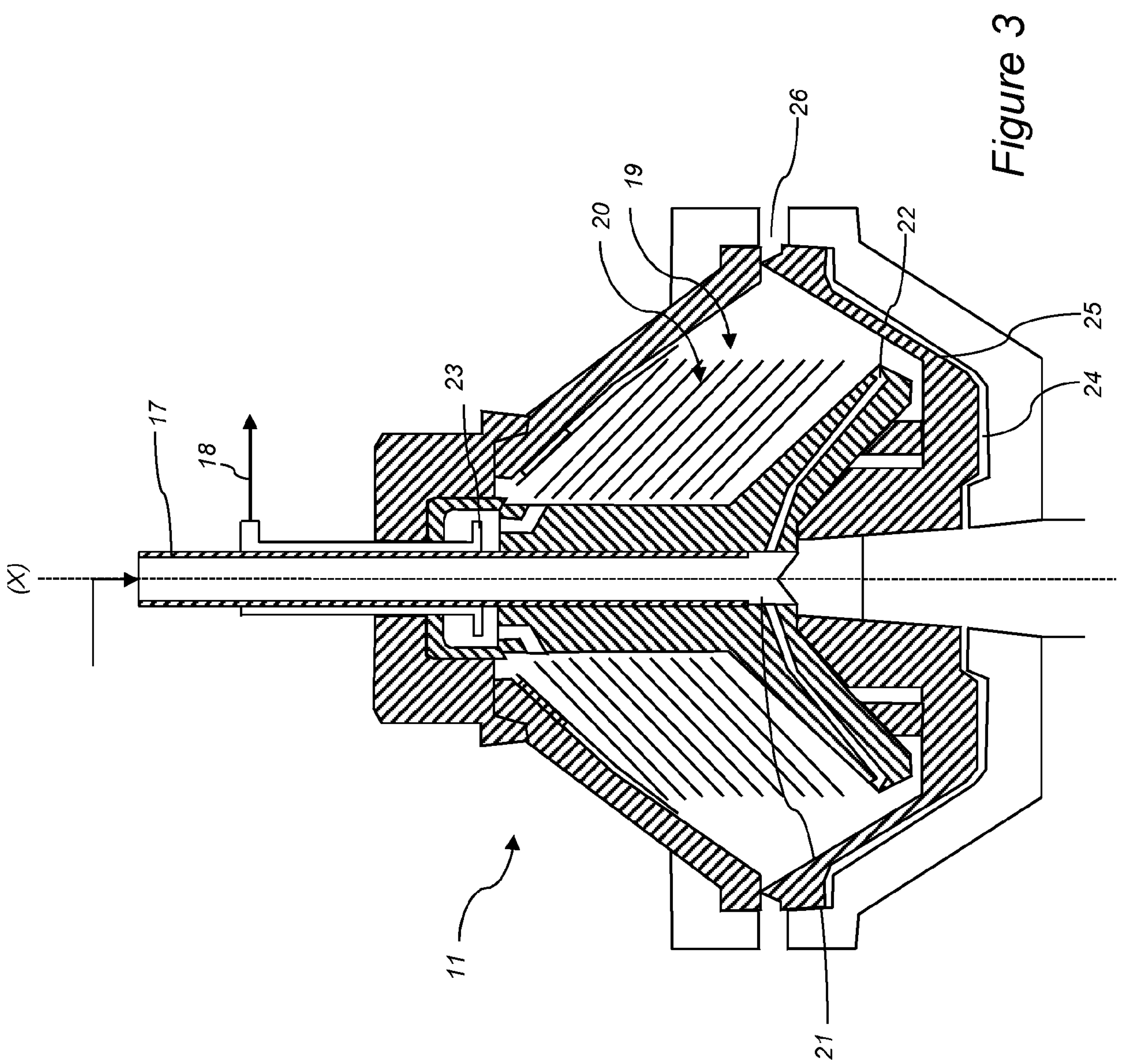

Figure 3

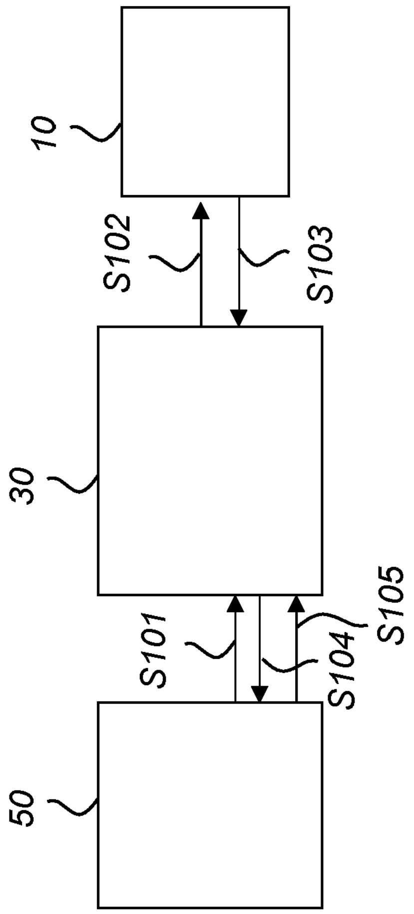

Figure 4

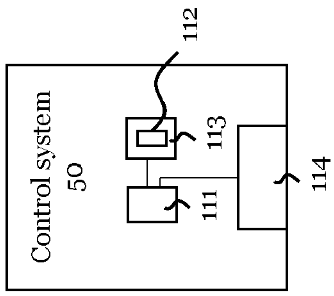

Figure 5

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EUROPEAN SEARCH REPORT

Application Number
EP 23 21 3058

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 5 857 955 A (PHILLIPS VICTOR [US] ET AL) 12 January 1999 (1999-01-12)	1-13	INV. B04B1/08 B04B9/10
Y	* column 1, lines 9-30; figures 1-5 * * column 5, line 58 - column 6, line 4 * * column 6, line 66 - column 7, line 12 * * column 1, line 55 - column 2, line 12 * * column 5, line 7 - line 11 * * column 4, lines 40-45 * * column 8, lines 20-33 * -----	1,13	
X	US 2006/105896 A1 (SMITH GEORGE E [US] ET AL) 18 May 2006 (2006-05-18)	1-13	
Y	* paragraphs [0059], [0061]; figures 1-3 * -----	1,13	
Y	EP 3 287 193 B1 (ALFDEX AB [SE]) 26 May 2021 (2021-05-26) * claim 1; figure 1 * -----	1,13	
			TECHNICAL FIELDS SEARCHED (IPC)
			B04B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	25 March 2024	Pössinger, Tobias

CATEGORY OF CITED DOCUMENTS

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& : member of the same patent family, corresponding document

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25-03-2024

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