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(54) **Control of a pump device**

(57) A method of controlling a pump device for discharging fluid, wherein the method comprises the steps of providing a heat portion adapted to be thermally coupled to the fluid to allow heat transfer therebetween when the fluid is at or above a certain level; monitoring a temperature parameter reflecting a temperature of the heat portion, the temperature parameter including a temperature value of the temperature of the heat portion; calculating a cooling rate value (CRV), the calculation includ-

ing a comparison between at least two temperature values measured at different times; performing a pumping operation analysis including a comparison between a present cooling rate value (CRV) and a reference cooling rate value (ref), the reference cooling rate value representing a specific cooling rate of the heat portion; and initiating pumping operation to discharge the fluid if the cooling rate value is equal to or exceeds the reference cooling rate value.

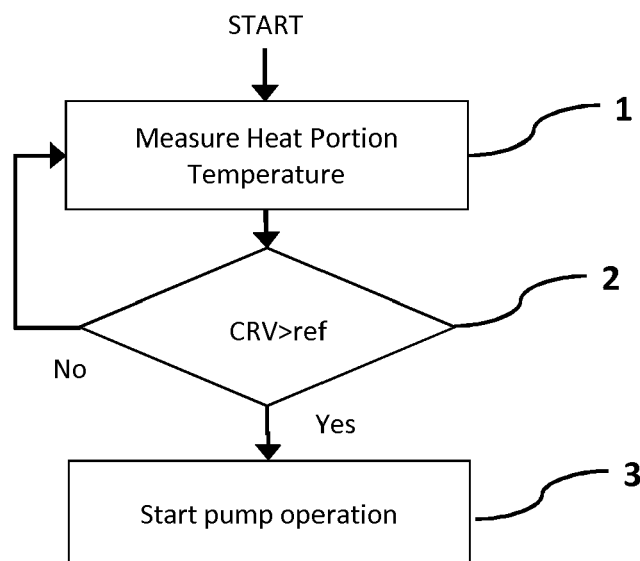


Fig. 1

Description

Technical Field of the Invention

[0001] The invention relates to the field of methods for controlling a pump device for discharging fluid. The invention furthermore relates to the field of devices for controlling a pump device for discharging fluid.

Technical Background

[0002] Pump devices for discharging fluid are used in a large number of applications, for example discharging fluid from fluid tanks or discharging excess fluid from construction sites or sewage pipes. Such pump devices may be of the submersible type, i.e. that the pump device is able to be at least partly submersed in the fluid which the pump device is adapted to discharge. In some applications, e.g. where the fluid level varies, it may be desirable that the pumping operation of the pump device is automatically controlled. For example, it may be desirable to control when the pump device is to be turned on or turned off depending on the fluid level or the variation thereof. Moreover, it may also be desirable to control the speed of the motor or the pumping rate depending on the variation of fluid level. Thus, the pump device is turned off when the fluid level is at or below a predetermined lower level. The pump device may then be arranged to start after a predetermined period of time. Such an automatically controlled pump device is advantageous in order to avoid damages to the pump device due when the pump device is running dry.

[0003] One method of achieving such automatic control is presented in US 6,203,282 where reference values of the electric current driving the pump device motor is stored in a memory and compared with the present electric current in order to determine when the pump is running dry indicated by a decreasing electric current.

[0004] Another method of automatic control of a pump is presented in US 6,481,973. The temperature of the motor driving the pump may be monitored, and the pump may be stopped if the temperature is too high in order to avoid overheating of the pump. Detection of that the pump is starting to pump air instead of fluid, i.e. running dry, may be achieved either by using a level sensor or by detecting a sudden decrease of the motor torque or by detecting a sudden increase of the motor speed. After the pump has been stopped, the pump may be restarted either after a predetermined time or when the motor temperature has decreased to a predetermined value. Waiting a predetermined time before restarting the pump may be problematic due to the risk of flooding if the fluid level would increase rapidly during the predetermined time when the pump is stopped. This problem could be partly alleviated by choosing a very short predetermined time, but on the other hand this would result in an excessive amount of unnecessary starts and operation resulting in wear to the pump. Waiting until the temperature has de-

creased to a predetermined level before restarting the pump may result in similar problems, i.e. the risk of flooding if the temperature limit is set to a too low value or unnecessary starts and dry operation if the temperature limit is set to a too high value.

[0005] Thus, there is a need for an improved method of controlling of a pump device for discharging fluid, and in particular an improved method of controlling starts of a pump device which overcomes the above mentioned drawbacks of the prior art.

Summary of the Invention

[0006] It is an object of the present invention to provide an improved method of controlling a pump device for discharging fluid which achieves a repeatable and accurate detection of an increasing fluid level such that the pump device is reliably started when fluid is needed to be discharged in order to avoid flooding while limiting the number of unnecessary and unwanted starts of the pump device.

[0007] This and other objects are achieved according to the present invention by providing a method having the features defined in the independent claim. Preferred embodiments are defined in the dependent claims.

[0008] According to a first aspect of the present invention, there is provided a method of controlling a pump device for discharging fluid. The method comprises the step of providing a heat portion adapted to be thermally coupled to said fluid to allow heat transfer there between when the fluid is at or above a certain level; monitoring a temperature parameter reflecting a temperature of said heat portion, said temperature parameter including a temperature value of the temperature of said heat portion; calculating a cooling rate value, said calculation including a comparison between at least two temperature values measured at different times; performing a pumping operation analysis including a comparison between a present cooling rate value and a reference cooling rate value, said reference cooling rate value representing a specific cooling rate of said heat portion; and initiating pumping operation to discharge said fluid if said cooling rate value is equal to or exceeds said reference cooling rate value.

[0009] The heat portion may be a portion of a pump device or connectable to the pump device. Also, the cooling rate value is thus based on at least two temperature values measured at different times such that the cooling rate value corresponds to a heat transfer from the heat portion to its surrounding including the thereto thermally coupled fluid, i.e. the degree of cooling of the heat portion. The cooling rate value may otherwise be based on at least two calculated temperature values based on temperature values measured at different times. Particularly, the cooling rate value may be based on two temperature values being mean temperature values of a plurality of temperature values measured at different times. Furthermore, the reference cooling rate value represents a spe-

cific cooling rate that corresponds to fluid level rise of the fluid. Put differently, the rise of the fluid level increases a cooling effect of the heat portion resulting in an increase of the cooling rate. Thus, the reference cooling rate value is selected to represent a specific cooling rate corresponding to a heat transfer from the heat portion reflecting an increase or rise of the fluid level, i.e. an increase of the amount of fluid thermally coupled to the heat portion.

[0010] According to a second aspect of the present invention, there is provided a control device for controlling a pump device for discharging fluid, said device comprising a heat portion adapted to be thermally coupled to said fluid when the fluid is at or above a certain level; a first temperature sensor for monitoring a temperature of said heat portion, said first temperature sensor being adapted to provide a temperature sensor signal representing the temperature of the heat portion; and controller adapted to apply a control signal to a connectable pump device, said controller being further adapted to calculate a cooling rate based on at least two temperature values measured at different times from the first temperature sensor signal at different times; perform a pumping operation analysis including a comparison between a present cooling rate value and a reference cooling rate value, said reference cooling rate value representing a specific cooling rate of said heat portion; and to apply a control signal to a connectable pump device to initiate pumping operation to discharge said fluid if said cooling rate value is equal to or exceeds said reference cooling rate value.

[0011] According to a third aspect of the present invention, there is provided a pump system comprising a pump device and a control device according to the second aspect.

[0012] Consequently, a method of controlling a pump device for discharging fluid is achieved including the start of the pumping operation which may detect an increasing fluid level more robustly and repeatedly compared to the prior art due to the use of reliable temperature measurements instead of using mechanical sensors such as level sensors which may be obstructed by objects in the fluid, e.g. when the fluid is wastewater or other object containing fluid. Furthermore, the method may also rapidly and reliably detect the increasing fluid level due to that the start condition is based on a change or variation of the temperature, more precisely a cooling rate, instead of static temperature values which may easily be affected by a number of sources of errors. Thus, the cooling rate (being calculated from measured heat portion temperature values) responds quickly to an increasing fluid level.

[0013] Put differently, the step of monitoring a temperature parameter reflecting the temperature of a heat portion includes measuring a temperature parameter continuously or at a regular interval or at irregular intervals during at least a part of the time. The interval(s) may be predetermined or adjustable and/or adaptable during operation of the pump device. Put differently, the step of calculating a cooling rate value includes calculating a

cooling rate value based on at least a first temperature value and a second temperature value, wherein the first and second temperature values are measured sequentially or subsequently in time, for example consecutively.

5 The calculation of the cooling rate includes a comparison and/or difference calculation of the at least two temperature values. Put differently, the step of performing a pumping operation analysis may include comparing the calculated cooling rate value with a reference cooling rate value. In other words, the reference cooling rate value is selected to represent a predetermined cooling rate of the heat portion which corresponds to a rate of fluid level increase.

[0014] Thus, the present invention is based on the insight that a rising fluid level of the fluid to be discharged provides a cooling effect and that there is a correlation between a cooling rate and a rise of the fluid level that may be used to monitor the fluid level. Also, there is also an insight that this correlation may be used to detect a rising fluid level when the pump is not in operation. Put differently, the present invention is based on the insight that a reference cooling rate value may be selected to reliably and accurately detect a rising fluid level in order to start the pump device or initiate the pumping operation to discharge fluid when the fluid level rises. Thus, by calculating a cooling rate value and comparing it with a reference cooling rate value a rise of the fluid level may be detected. The cooling rate value is based on temperature measurements of a heat portion being arranged to be thermally coupled to the fluid to allow heat transfer there between. As is understood, the heat portion is arranged with a temperature at least above that of the fluid to allow a cooling of the heat portion in order to provide a cooling rate value. Preferably, the heat portion is arranged with a temperature higher than that of said fluid in order to provide or ensure a temperature difference sufficient to calculate a cooling rate value that represents a rise of the fluid level.

[0015] The reference cooling rate value may, for a given fluid temperature, be selected as an indication of a lower reference fluid level at which the pump device is adapted to initiate pumping operation. In other words, since the cooling rate value may reflect the heat transfer rate between the fluid and the heat portion, the cooling rate value may be correlated to the rate at which the fluid level is increasing. For example, a quick increase of the fluid level results in a large amount of fluid (having a lower temperature than the heat portion) in thermal contact with the heat portion, resulting in a rapid decrease of the heat portion temperature, i.e. a high cooling rate value. A high cooling rate value may thus be correlated to a rapid increase of the fluid level and may thereby be an indication of a high fluid level. Consequently, the reference cooling rate value may be selected as an indication of a user defined or predetermined fluid level at which the pump device is to discharge fluid, i.e. a fluid level at which pumping operation of the pump device is to be initiated. In other words, a reliable and repeatable method for controlling

a pump device for discharging fluid may be achieved which may control the pump device such that pumping operation is initiated at a user defined or predetermined fluid level using a temperature sensor.

[0016] It is understood that the heat portion being thermally coupled to the fluid may refer to that the heat portion arranged to be in thermal contact with the fluid to allow heat transfer when the fluid level is above a predetermined low level above a ground level, floor surface or bottom surface of a space having fluid that needs to be discharged, i.e. the fluid level needs to be above a certain level such that the thermal coupling may be allowed between the heat portion and fluid. The predetermined low level may also correspond to a fluid level above which the pump device is adapted to discharge fluid.

[0017] It is understood that a positive value of the cooling rate corresponds to a decreasing heat portion temperature. It is furthermore understood that the comparison between at least two temperature values measured at different times may comprise a comparison between at least two temperature values measured immediately sequentially after each other in time or measured sequentially in time with a predetermined time or predetermined number of samples of temperature values in between the at least two temperature values used in the comparison. The comparison between at least two temperature values measured at different times may furthermore comprise a comparison of temperature values measured at different, i.e. at least two, positions of the heat portion. The temperature values may also be measured at different positions of the heat portion, temperature values thereby reflecting the temperature of different portions of the heat portion. Put differently, the step of calculating a cooling rate value may include a comparison between at least two temperature values measured at different times and at least two temperature values measured at different positions of the heat portion. This may be advantageous in an embodiment where the heat portion is extending in the direction in which the fluid level is increasing or decreasing. In such an embodiment, advantageous effects may be achieved because a cooling rate may be calculated by comparing at least two temperature values measured at different times and/or comparing at least two temperature values measured at different positions of the heat portion. Thus, the cooling rate value considers changes both in time and space.

[0018] The temperature difference between the heat portion and the fluid, i.e. that the temperature of the heat portion is arranged to be at least a temperature difference above the temperature of the fluid, may be achieved actively or passively. In for example environments where the temperature of the surrounding is sufficiently higher than that of the fluid temperature, the heat portion may have the same temperature as the surrounding temperature. In such a case, the heat portion requires no active heating thereby passively ensuring a sufficient and proper temperature difference.

[0019] In an embodiment of the invention, the method

further comprises a step of heating said heat portion to a certain temperature or temperature difference above the temperature of the fluid. In for example environments where the temperature of the surrounding is near the fluid temperature, the heat portion may require heating to obtain the temperature difference, thereby actively providing a sufficient and proper temperature difference is passively ensured. This is advantageous because a temperature difference between the heat portion and the fluid is achieved which is selected such that an accurate cooling rate value may be calculated in order to mitigate the influence of noise and numerical problems. It is furthermore advantageous because a sufficiently large initial temperature difference between the heat portion and the fluid (after heating the heat portion) may require the step of heating the heat portion to be repeated less frequently.

[0020] In another embodiment of the invention, the method further comprises a step of heating the heat portion if a difference between the temperature value and a reference temperature value is equal to or below a reference difference value. This is advantageous if the pumping device has been standing still, i.e. the pump device is not in pumping operation, for a period of time such that the temperature of the heat portion has decreased to such an extent that the temperature difference between the heat portion and the fluid is not sufficiently large so that the cooling rate may calculated with a small sensitivity for measurement noise and numerical problems. By comparing the difference between the present temperature value of the heat portion and a reference temperature value with a reference difference value, situations when the cooling rate may not be accurately calculated or calculated at all may be avoided or minimized.

[0021] In yet another embodiment of the invention, the method further comprises a step of repeating the step of heating the heat portion if pumping operation has not been initiated after a predetermined time interval. This is advantageous if the pumping device has been standing still, i.e. not performing a pumping operation, for a period of time such that the temperature of the heat portion has decreased to such an extent that the temperature difference between the heat portion and the fluid is not sufficiently large so that the cooling rate may calculated with a small sensitivity for measurement noise and numerical problems. The predetermined time interval may be set to a constant value based on measurements and/or field experience or may be adapted during operation of the pumping device, such that situations when the cooling rate may not be accurately calculated or calculated at all may be avoided or minimized.

[0022] In yet another embodiment of the invention, the method further comprises a step of heating the heat portion comprises electrically heating the heat portion. The heat portion may be electrically heated by means of an electrically heated element being thermally coupled to the heat portion.

[0023] In yet another embodiment of the invention, the method further comprises a step of heating said heat

portion comprises heating the heat portion by a motor adapted to drive the pump arrangement, the motor being thermally coupled to the heat portion. In other words, the step of heating comprises running or by other means heating a motor being thermally coupled to the heat portion such that heat is transferred from the motor to the heat portion, wherein the motor is adapted to drive the pump arrangement. Hereby, the heat portion may be heated by using heat losses from the motor which otherwise would be dissipated to the fluid or surrounding air. The heat portion may be a portion of the motor. This is advantageous because no additional heat portion is required.

[0024] In yet another embodiment of the invention, the heat portion is an electrically heated element. The electrically heated element may be an electrically heated temperature sensor. In yet another embodiment of the invention, the method further comprises a step of monitoring at least one motor load parameter reflecting the load of a motor being arranged for driving the pump arrangement, the load parameter including a motor load value of the motor load of the motor. The method may furthermore comprise a step of interrupting the pumping operation if the motor load value is equal to or below a reference motor load value. The reference motor load value may represent a motor load value at which the pump device is essentially not pumping any liquid, i.e. running dry. Hereby, the motor may be stopped when the pump is or is beginning to run dry due to a low flood level, thereby avoiding damages to the pump device and/or motor.

[0025] In yet another embodiment of the invention, the method further comprises a step of interrupting the step of heating the heat portion and initiating pumping operation if the motor load value is equal to or above the reference motor load value. In other words, the step of heating the heat portion may be interrupted and pumping operation may be initiated if the fluid level has increased substantially indicated by a motor load value being equal to or above the reference motor load value. In for example the case where when the heat portion is being heated while the fluid level starts to increase, it is advantageous to be able to detect this increasing fluid level and interrupt the heating step and initiated pumping operation instead such that flooding is avoided.

[0026] In yet another embodiment of the invention, the motor is an electrical motor.

[0027] The motor load value may be a measure of the supplied power to the motor. In the case of an electric motor, this motor load value may for example be based the cosine of the phase difference between the voltage and the current over an electrical winding of the electric motor. In other embodiments, the motor load value may be the electrical current through an electrical winding of the electrical motor.

[0028] The heat portion may be an electrical winding of the electric motor. This is advantageous because the electrical winding is heated as a side effect when the pump device is operating, i.e. when a current is fed

through the electrical winding. Thereby, the heat portion may assume a higher temperature than the fluid at least when an electrical current is fed through the electrical winding, thereby a cooling rate of the heat portion may be calculated after the pump device has been stopped or after the electrical current is stopped. This is furthermore advantageous in the sense that the temperature sensor which the electrical winding is normally standard equipped with in order to monitor overheating of the winding may be used for monitoring the heat portion temperature, no additional temperature sensor is thus required. In yet another embodiment, the temperature of the heat portion may be measured by measuring the resistance of the electrical winding. This is advantageous because no temperature sensor at all may be required.

[0029] The step of heating said heat portion may include feeding an electric current through the electrical winding of the electric motor. In other words, an electrical current is fed through an electrical winding of the electrical motor of a size such that heat is developed in the winding due to the electrical resistance of the winding. The electrical current may be of a sufficiently small size such that a pump impeller of the pump device being connected to the electric motor and being arranged for discharging said fluid does not rotate. In other words, the electrical current may be of a sufficiently small size such that the electrical winding acts as a heating element only. This is advantageous because no unnecessary wear to the pump device may result from the step of heating the heat portion because neither the pump impeller nor the motor rotates. The electric current may in yet another embodiment be of a size such that the pump impeller of the pump device does rotate, i.e. such that the pump device would discharge fluid if the fluid level were above a minimum level at which the pump device is adapted to discharge fluid. This is advantageous because an increasing fluid level during the step of heating the heat portion may be detected based on a measured current through an electrical winding or a phase difference between the current and voltage over the electrical winding as discussed above.

[0030] In yet another embodiment of the invention, the motor may be an internal combustion engine or any other type of motor. The heat portion may be thermally coupled to the exhaust side of an internal combustion engine such that rapid heating of the heat portion may be achieved.

[0031] In yet another embodiment of the invention, the method further comprises the step of monitoring a fluid temperature parameter reflecting the temperature of the fluid, the fluid temperature parameter including a fluid temperature value of the temperature of the fluid. The method may furthermore comprise the step of adapting at least one of the following parameters in relation to the fluid temperature value: the reference temperature value, the reference difference value, the reference cooling rate value. The step of adapting may include adapting the reference difference value such that it is at a sufficiently high level above the present fluid temperature. This is

advantageous because a sufficiently high temperature difference between the heat portion and the fluid is achieved which may allow calculation of the cooling rate value with a small sensitivity for noise and numerical problems. It is furthermore advantageous because the sufficiently high initial temperature difference between the heat portion and the fluid (after heating the heat portion) may allow the step of heating the heat portion to be repeated less frequently. The step of adapting may include adapting the reference cooling rate value based on the adapted values of the reference temperature and/or the reference difference value and based on the fluid temperature value. Adapting the reference temperature value and/or the cooling rate value is advantageous because pumping operation may be initialized at consistent fluid level increase rates or consistent fluid levels even if the fluid temperature is varying with time.

[0032] The reference cooling rate value may be normalized using the heat portion temperature value and/or the fluid temperature value. Hereby, the comparison between the calculated cooling rate value and the reference cooling rate value may be more robust in a wide range of environments and less sensitive to the absolute values of the present temperatures.

[0033] In yet another embodiment, the reference cooling rate value is a function of the heat portion temperature or a function of a normalized heat portion temperature. The function may for example be an exponential function, a linear function or a polynomial. The step of adapting may include adapting the parameters of the function. The parameters of the function may be adapted such that pumping operation may be initialized at consistent fluid level increase rates or consistent fluid levels even if the fluid temperature is varying with time.

[0034] In yet another embodiment of the invention, the pump device is a submersible pump. A submersible pump may refer to a pump device comprising a pump housing, at least one pump impeller and a motor, wherein the complete pump device is submersible in fluid. The motor of the submersible pump may be cooled by the surrounding fluid during operation. In yet another embodiment, the pump device is a submersible pump of the vertical type, wherein the motor driving the pump impeller is arranged at a vertical distance from the pump impeller which may be substantially above the fluid level.

[0035] In yet another embodiment of the invention, the pump device may be a standalone pump where the pump device is fluidically coupled to the location from where fluid is to be discharged by means of for example a hose or a pipe. In this embodiment, the heat portion may preferably be an electrically heated temperature sensor being arranged for thermal contact with the fluid.

[0036] In yet another embodiment of the invention, the pump device may be a vertical pump where the pump housing and the pump impeller are arranged at a distance from the motor. The pump housing is thus at least partly submersed in fluid, and the motor is not. The pump impeller may be coupled to the motor via for example an

axle. In this embodiment, the heat portion may preferably be a portion of the pump housing.

[0037] In yet another embodiment of the invention, the cooling rate value is a time derivate of the temperature of the heat portion. The time derivate of the temperature of the heat portion may be calculated numerically with for example the backward difference method using the at least two temperature values measured at different times.

[0038] In yet another embodiment of the invention, the cooling rate value is a heat transfer coefficient of said heat portion. In other words the cooling rate value is a heat transfer coefficient indicating the heat transfer rate between the heat portion and the fluid and/or air. The heat transfer coefficient may be calculated from the following expression:

$$T(\tau) = T_{\text{fluid}} - (T(0) - T_{\text{fluid}}) * \exp(-A * h / (m * C_p) * \tau)$$

, where T is the heat portion temperature, τ is the cooling time, T_{fluid} is the fluid temperature, A, $m * C_p$ is the thermal mass of the heat portion (constant), and h is the heat transfer coefficient. The thermal mass $m * C_p$ of the heat portion may be expressed as:

$$m * C_p = \sum (m_i * C_{p_i}),$$

where m_i is the mass of sub portion i of the heat portion and C_{p_i} is the specific heat capacity of sub portion i of the heat portion.

[0039] In yet another embodiment of the invention, the step of monitoring at least one temperature parameter may include storing at least one temperature value in a memory device.

[0040] In an embodiment of the invention, the control device comprises a plurality of temperature sensors for monitoring a temperature of said heat portion. The temperature sensors are adapted to provide a temperature sensor signal representing the temperature of the heat portion. The cooling rate value (CRV) is calculated based on at least two temperature values measured at different times from the temperature sensor signal at different times. The plurality of temperature sensors may be arranged to measure the temperature at various positions around the periphery of the pump housing.

Brief Description of the Drawings

[0041] These and other aspects of the present invention will now be described in more detail, with reference to the appended drawings showing currently preferred embodiments of the invention, wherein:

fig 1 is a flow chart describing an embodiment of the method of controlling a pump device,

fig 2 is a flow chart describing another embodiment of the method of controlling a pump device,
 fig 3 is a flow chart describing yet another embodiment of the method of controlling a pump device,
 fig 4 is a flow chart describing yet another embodiment of the method of controlling a pump device,
 fig 5 is a flow chart describing yet another embodiment of the method of controlling a pump device,
 fig 6 is a flow chart describing yet another embodiment of the method of controlling a pump device,
 fig 7 shows an illustration of a conventional pump cycle,
 fig 8 shows measurement results using the method of controlling a pump device according to an embodiment of the invention,
 fig 9 shows measurement results using the method of controlling a pump device according to an embodiment of the invention,
 fig 10 is an illustration of a submersible pump device.

Detailed Description of a Preferred Embodiment of the Invention

[0042] In the following description, embodiments of the present invention are described.

[0043] Fig 1 is a flow chart describing an embodiment of the method of controlling a pump device. This embodiment of the method is intended to control a pump device, which could be of the submersible type, comprising a pump housing, a pump impeller and an electrical motor having an electrical winding, where the electrical motor is arranged for driving the pump impeller adapted to discharge fluid.

[0044] In a first step 1, a temperature parameter T reflecting the temperature of a heat portion is measured or monitored. The temperature parameter includes a temperature value of the temperature of the heat portion. In other words, the temperature parameter is measured continuously or at a regular interval or at irregular intervals during at least a part of the time. The interval(s) may be predetermined or adjustable and/or adaptable during operation of the pump device. The heat portion is the electrical winding of the motor of the pump device. The heat portion is thermally coupled to the fluid such that the heat portion is in thermal contact with the fluid to allow heat transfer when the fluid level is above a predetermined low level above a ground level, floor surface or bottom surface of a space having fluid that needs to be discharged, i.e. the fluid level needs to be above a certain level such that the thermal coupling may be allowed between the heat portion and fluid. In another embodiment, the predetermined low level may correspond to a fluid level above which the pump device is adapted to discharge fluid.

[0045] In the second step 2, a cooling rate value CRV is calculated. The calculation includes calculating a temperature time derivative using a backward difference numerical method based on two temperature values measured

at different times. It is understood that a positive value of the cooling rate corresponds to a decreasing heat portion temperature. The two temperature values are measured immediately sequentially after each other in time. In other embodiments, two or more temperature values may be used which may be measured immediately sequentially after each other in time or sequentially in time with a predetermined time or predetermined number of samples of temperature values in between the at least two temperature values used in the comparison. In yet other embodiments, the comparison may furthermore comprise a comparison of temperature values measured at different, i.e. at least two, positions of the heat portion. The temperature values may also be measured at different positions of the heat portion, temperature values thereby reflecting the temperature of different portions of the heat portion. Put differently, the step of calculating a cooling rate value may include a comparison between at least two temperature values measured at different times and at least two temperature values measured at different positions of the heat portion. In other embodiments, the cooling rate value is a heat transfer coefficient. The heat transfer coefficient may be calculated from the following expression:

$$T(\tau) = T_{\text{fluid}} - (T(0) - T_{\text{fluid}}) * \exp(-A * h / (m * C_p) * \tau)$$

, where T is the heat portion temperature, τ is the cooling time, T_{fluid} is the fluid temperature, A, m and C_p are constants, and h is the heat transfer coefficient.

[0046] The second step 2 further comprises performing a pumping operation analysis including a comparison between the calculated cooling rate value CRV and a reference cooling rate value ref. The reference cooling rate value is selected to represent a specific cooling rate of the heat portion corresponding to a fluid level rise of said fluid cooling the heat portion. The reference cooling rate value may be selected as an indication of a user defined or predetermined fluid level at which the pump device is to discharge fluid, i.e. a fluid level at which pumping operation of the pump device is to be initiated. If the cooling rate value is above the reference cooling rate value, i.e. if the temperature of the heat portion decreases faster than at a reference rate corresponding to the reference cooling rate value, the method proceeds to the third step 3, otherwise back to the first step 1. It is understood that a positive value of the cooling rate corresponds to a decreasing heat portion temperature.

[0047] In the third step 3, pumping operation is initiated to discharge fluid. In other words, an electric current is provided to the electrical winding of the motor driving the pump device such that pumping operation is initiated.

[0048] Fig 2 is a flow chart describing another embodiment of the method of controlling a pump device. This embodiment of the method is intended to control a pump device, which could be of the submersible type, comprising

ing a pump housing, a pump impeller and an electrical motor having an electrical winding, where the electrical motor is arranged for driving the pump impeller adapted to discharge fluid.

[0049] In a first step 20, pumping operation is initiated to discharge fluid. In other words, an electric current is provided to the electrical winding of the motor driving the pump device such that pumping operation is initiated.

[0050] In a second step 21, a temperature parameter T reflecting the temperature of a heat portion is measured or monitored. The second step 21 corresponds to the first step 1 of the embodiment shown in fig1 and described above.

[0051] In the third step 23, a reference temperature value T_{low} , equalling the current heat portion temperature T , is stored in a memory. The stored reference temperature corresponds to the temperature of the heat portion shortly after pumping operation has been initiated. The reference temperature value T_{low} may be used as an indication or approximation of the fluid temperature.

[0052] In a fourth step 24, a temperature parameter reflecting the temperature of a heat portion is measured or monitored. The fourth step 24 corresponds to the first step 1 of the embodiment shown in fig1.

[0053] In a fifth step 25, a temperature analysis is performed including a comparison between the difference between the temperature value T and a reference temperature value T_{low} , and a reference difference value k . If the difference between the temperature values is above or equal to the reference difference value k , the method proceeds to the sixth step 22, otherwise to the seventh step 26. In other words, the present temperature value of the heat portion is compared with a reference temperature value and a reference difference value, wherein the sum of the latter two preferably is selected to be at a higher level than the fluid temperature, such that situations when the cooling rate may not be accurately calculated or calculated at all may be avoided or minimized. In other embodiments, instead of performing the above described temperature analysis, a time analysis is performed in the fifth step 25 including comparing the time which has elapsed since pumping operation was last interrupted with a predetermined time interval to such that the method proceeds to the sixth step 22 if less time than to has elapsed and to the seventh step 26 otherwise. In yet another embodiment, an alternative temperature analysis is performed, wherein a heating cooling rate value is calculated and compared with a reference heating cooling rate value. When the heating cooling rate value is less than or equal to the reference heating cooling rate value, the method proceeds to the sixth step 22, otherwise to the seventh step 26. In other words, if the heat portion is heated at a rate above a reference value, temperature equilibrium is not yet achieved, and heating should therefore proceed, i.e. the method should proceed to the seventh step.

[0054] In the sixth step 22, a cooling rate value CRV is calculated. The second step 2 further comprises per-

forming a pumping operation analysis including a comparison between the calculated cooling rate value CRV and a reference cooling rate value ref. The sixth step corresponds to the second step 2 of the embodiment shown in fig 1 and described above. If the cooling rate value is above the reference cooling rate value, i.e. if the temperature of the heat portion decreases faster than at a reference rate corresponding to the reference cooling rate value, the method proceeds to the first step 20, otherwise back to the fourth step 24.

[0055] In the seventh step 26, the heat portion is heated by means of feeding an electric current through an electric winding of the motor. The electric current is of a size such that the pump impeller of the pump device rotates. The heat portion is heated by means of heat losses in the electric motor and heat transfer there between. In other embodiments, the electric current may be of a size such that the pump impeller does not rotate. In yet other embodiments, the electric current may be of a type, for example DC, such that the pump impeller does not rotate. In yet other embodiments, the heat portion is heated by a separate heating element which may be an electrical heating element. In yet other embodiments, the heat portion may be an electrically heated temperature sensor. In yet other embodiments, the seventh step may be omitted altogether, typically for example in environments where the temperature of the surrounding is sufficiently higher than that of the fluid temperature, the heat portion may have the same temperature as the surrounding temperature. In such a case, the heat portion requires no active heating thereby passively ensuring a sufficient and proper temperature difference. After the seventh step, the method proceeds to the fourth step 24.

[0056] Fig 3 is a flow chart describing yet another embodiment of the method of controlling a pump device. This embodiment of the method is intended to control a pump device, which could be of the submersible type, comprising a pump housing, a pump impeller and an electrical motor having an electrical winding, where the electrical motor is arranged for driving the pump impeller adapted to discharge fluid.

[0057] In a first step 30, pumping operation is initiated to discharge fluid. In other words, an electric current is provided to the electrical winding of the motor driving the pump device such that pumping operation is initiated.

[0058] In a second step 37, a motor load parameter reflecting the load of the motor of the pump device is measured or monitored (during pumping operation). The load parameter includes a motor load value of the motor load of the motor. The motor load value is a measure of the supplied power to the motor. In the case of an electric motor, this motor load value may for example be the cosine of the phase difference ϕ between the voltage and the current over the electrical winding of the electric motor of the pump device. A low value of the cosine of the phase difference corresponds to a large phase difference between the current and voltage which may be an indication of a low motor load. In other embodiments, the motor

load value may be the electrical current through an electrical winding of the electrical motor.

[0059] In the third step 38, a motor load analysis is performed including a comparison between the motor load value and a reference motor load value. The reference motor load value may represent a motor load value at which the pump device is essentially not pumping any liquid, i.e. running dry. If the motor load value is below the reference motor load value, the method proceeds to the fourth step 39, otherwise back to the second step 37. It is understood that a low motor load value corresponds to a low load of the motor, i.e. that little pumping work is achieved.

[0060] In the fourth step 39, pumping operation is stopped, where after the method proceeds to the fifth step 34.

[0061] In the fifth step 34, a temperature parameter T reflecting the temperature of a heat portion is measured or monitored. The fifth step 34 corresponds to the first step 1 of the embodiment shown in fig1 and described above.

[0062] In the sixth step 32, a cooling rate value CRV is calculated. The sixth step 32 further comprises performing a pumping operation analysis including a comparison between the calculated cooling rate value CRV and a reference cooling rate value ref. The sixth step corresponds to the second step 2 of the embodiment shown in fig 1 and described above. If the cooling rate value is above the reference cooling rate value, i.e. if the temperature of the heat portion decreases faster than at a reference rate corresponding to the reference cooling rate value, the method proceeds to the first step 30, otherwise back to the fifth step 34.

[0063] Fig 4 is a flow chart describing yet another embodiment of the method of controlling a pump device. This embodiment of the method is intended to control a pump device, which could be of the submersible type, comprising a pump housing, a pump impeller and an electrical motor having an electrical winding, where the electrical motor is arranged for driving the pump impeller adapted to discharge fluid.

[0064] In a first step 40, pumping operation is initiated to discharge fluid. In other words, an electric current is provided to the electrical winding of the motor driving the pump device such that pumping operation is initiated.

[0065] In a second step 41, a temperature parameter T reflecting the temperature of a heat portion is measured or monitored. The second step 21 corresponds to the first step 1 of the embodiment shown in fig1 and described above.

[0066] In the third step 43, a reference temperature value T_{low} , equalling the current heat portion temperature T, is stored in a memory. The stored reference temperature value corresponds to the temperature of the heat portion shortly after pumping operation has been initiated. The reference temperature value T_{low} may be used as an indication or approximation of the fluid temperature.

[0067] In a fourth step 47, a motor load parameter re-

flecting the load of the motor of the pump device is measured or monitored (during pumping operation). The fourth step corresponds to the second step 37 of the embodiment shown in fig 3 and described above.

[0068] In a fifth step 48, a motor load analysis is performed including a comparison between the motor load value and a reference motor load value. The reference motor load value may represent a motor load value at which the pump device is essentially not pumping any liquid, i.e. running dry. If the motor load value is below the reference motor load value, the method proceeds to the sixth step 44, otherwise back to the fourth step 47. It is understood that a low motor load value corresponds to a low load of the motor, i.e. that little pumping work is achieved.

[0069] In a sixth step 44, a temperature parameter reflecting the temperature of a heat portion is measured or monitored. The sixth step 44 corresponds to the second step 41.

[0070] In a seventh step 45, a temperature analysis is performed including a comparison between the difference between the temperature value T and a reference temperature value T_{low} and a reference difference value k. If the difference between the temperature values is above the reference difference value k, the method proceeds to the eighth step 49, otherwise to the ninth step 46. In other words, the present temperature value of the heat portion is compared with a reference temperature value and a reference difference value, wherein the sum of the latter two preferably is selected to be at a higher level than the fluid temperature, such that situations when the cooling rate may not be accurately calculated or calculated at all may be avoided or minimized. The reference difference value k may alternatively be a function, for example an exponential, linear or polynomial function, of the temperature value T and/or the reference temperature value T_{low} . In other embodiments, instead of performing the above described temperature analysis, a time analysis is performed in the seventh step 45 including comparing the time which has elapsed since pumping operation was last interrupted with a predetermined time interval to such that the method proceeds to the eighth step 49 if less time than to has elapsed and to the ninth step 46 otherwise. In yet other embodiments, an alternative temperature analysis is performed in the seventh step 45, wherein a heating rate value (HRV) is calculated as a function of the temperature value T and the reference temperature value T_{low} , and the HRV is compared with the reference difference value k which may be a constant or a function, for example an exponential, linear or polynomial function of the temperature value T and/or the reference temperature value T_{low} .

[0071] In the eighth step 49, pumping operation is stopped, where after the method proceeds to the tenth step 410.

[0072] In the ninth step 46, the heat portion is heated by means of feeding an electric current through an electrical winding of the motor. The ninth step 46 corresponds

to the seventh step 26 of the embodiment shown in fig 2 and described above.

[0073] In a tenth step 410, a temperature parameter reflecting the temperature of a heat portion is measured or monitored. The tenth step 410 corresponds to the second step 41.

[0074] In the eleventh step 42, a cooling rate value CRV is calculated. The eleventh step 42 further comprises performing a pumping operation analysis including a comparison between the calculated cooling rate value CRV and a reference cooling rate value ref. The eleventh step corresponds to the second step 2 of the embodiment shown in fig 1 and described above. If the cooling rate value is above the reference cooling rate value, i.e. if the temperature of the heat portion decreases faster than at a reference rate corresponding to the reference cooling rate value, the method proceeds to the first step 40, otherwise back to the tenth step 410.

[0075] Fig 5 is a flow chart describing yet another embodiment of the method of controlling a pump device. This embodiment of the method is intended to control a pump device, which could be of the submersible type, comprising a pump housing, a pump impeller and an electrical motor having an electrical winding, where the electrical motor is arranged for driving the pump impeller adapted to discharge fluid.

[0076] In a first step 50, pumping operation is initiated to discharge fluid. In other words, an electric current is provided to the electrical winding of the motor driving the pump device such that pumping operation is initiated.

[0077] In a second step 51, a temperature parameter T reflecting the temperature of a heat portion is measured or monitored. The second step 51 corresponds to the first step 1 of the embodiment shown in fig1 and described above.

[0078] In the third step 53, a reference temperature value T_{low} , equalling the current heat portion temperature T, is stored in a memory. The stored reference temperature corresponds to the temperature of the heat portion shortly after pumping operation has been initiated. The reference temperature value T_{low} , may be used as an indication or approximation of the fluid temperature.

[0079] In a fourth step 57, a motor load parameter reflecting the load of the motor of the pump device is measured or monitored (during pumping operation). The fourth step corresponds to the second step 37 of the embodiment shown in fig 3 and described above.

[0080] In a fifth step 58, a motor load analysis is performed including a comparison between the motor load value and a reference motor load value. The reference motor load value may represent a motor load value at which the pump device is essentially not pumping any liquid, i.e. running dry. If the motor load value is below the reference motor load value, the method proceeds to the sixth step 511, otherwise back to the fourth step 57. It is understood that a low motor load value corresponds to a low load of the motor, i.e. that little pumping work is achieved.

[0081] In a sixth step 511, a temperature value T_{prev} , equalling the current heat portion temperature T, is stored in a memory.

[0082] In a seventh step 54, a temperature parameter reflecting the temperature of a heat portion is measured or monitored. The seventh step 54 corresponds to the second step 51.

[0083] In an eighth step 55, a temperature analysis is performed including a comparison between the difference between the temperature value T and a reference temperature value T_{low} , and a reference difference value k. If the difference between the temperature values is above the reference difference value k, the method proceeds to the ninth step 59, otherwise to the tenth step 512. In other words, the present temperature value of the heat portion is compared with a reference temperature value and a reference difference value, wherein the sum of the latter two preferably is selected to be at a higher level than the fluid temperature, such that situations when the cooling rate may not be accurately calculated or calculated at all may be avoided or minimized. The reference difference value k may alternatively be a function, for example an exponential, linear or polynomial function, of the temperature value T and/or the reference temperature value T_{low} . In other embodiments, instead of performing the above described temperature analysis, a time analysis is performed in the eighth step 55 including comparing the time which has elapsed since pumping operation was last interrupted with a predetermined time interval to such that the method proceeds to the ninth step 59 if less time than to has elapsed and to the tenth step 512 otherwise. In yet other embodiments, an alternative temperature analysis is performed in the eighth step 55, wherein a heating rate value (HRV) is calculated as a function of the temperature value T and the reference temperature value T_{low} , and the HRV is compared with the reference difference value k which may be a constant or a function as described above.

[0084] In the ninth step 59, pumping operation is stopped, where after the method proceeds to the twelfth step 513.

[0085] In the tenth step 512, a temperature analysis is performed including a comparison between the difference between the temperature value T and the temperature value T_{prev} and a reference difference value m. If the difference between the temperature values is above or equal to the reference difference value m, the method proceeds to the eleventh step 56, otherwise to the ninth step 59. In other words, the present temperature value of the heat portion is compared with a previous temperature value (which has been stored in a memory). If the difference is less than a reference difference value m, the temperature is changing at a slow rate and it is therefore not meaningful to proceed to the heating step 56. Thus, the method proceeds to stop pumping operation instead. The reference difference value m may alternatively be a function, for example an exponential, linear or polynomial function, of the temperature value T and/or

the temperature value T_{prev} . In other embodiments, an alternative temperature analysis is performed in the tenth step 512, wherein a heating rate value (HRV) is calculated as a function of the temperature value T and the temperature value T_{prev} , and the HRV is compared with the reference difference value m which may be a constant or a function as described above.

[0086] In the eleventh step 56, the heat portion is heated by means of feeding an electric current through an electric winding of the motor. The eleventh step 56 corresponds to the seventh step 26 of the embodiment shown in fig 2 and described above.

[0087] In the twelfth step 513, the method waits a predetermined time interval before proceeding to the thirteenth step 510. This wait step is performed to allow the temperature to stabilize after pumping operation has seized, thereby achieving a more predictable pumping operation analysis in the fourteenth step.

[0088] In the thirteenth step 510, a temperature parameter reflecting the temperature of a heat portion is measured or monitored. The thirteenth step 510 corresponds to the second step 51.

[0089] In the fourteenth step 52, a cooling rate value CRV is calculated. The fourteenth step 52 further comprises performing a pumping operation analysis including a comparison between the calculated cooling rate value CRV and a reference cooling rate value ref . The fourteenth step corresponds to the second step 2 of the embodiment shown in fig 1 and described above. If the cooling rate value is above the reference cooling rate value, i.e. if the temperature of the heat portion decreases faster than at a reference rate corresponding to the reference cooling rate value, the method proceeds back to the first step 50, otherwise to the fifteenth step 514.

[0090] In the fifteenth step 514, a temperature analysis is performed including a comparison between the difference between the temperature value T and a reference temperature value T_{low} , and a reference difference value k . If the difference between the temperature values is above the reference difference value k , the method proceeds back to the thirteenth step 510, otherwise to the first step 50. In other words, the present temperature value of the heat portion is compared with a reference temperature value and a reference difference value, wherein the sum of the latter two preferably is selected to be at a higher level than the fluid temperature, such that situations when the cooling rate may not be accurately calculated or calculated at all may be avoided or minimized. In other embodiments, instead of performing the above described temperature analysis, a time analysis is performed in the fifteenth step 514 including comparing the time which has elapsed since pumping operation was last stopped with a predetermined time interval to such that the method proceeds to the thirteenth step 510 if less time than to has elapsed and to the first step 50 otherwise.

[0091] Fig 6 is a flow chart describing yet another embodiment of the method of controlling a pump device.

This embodiment of the method is intended to control a pump device, which could be of the submersible type, comprising a pump housing, a pump impeller and an electrical motor having an electrical winding, where the electrical motor is arranged for driving the pump impeller adapted to discharge fluid.

The embodiment shown in fig 6 is similar to the embodiment in fig 5, except for two details. Firstly, a sixteenth step 517 is included, where a temperature value T_{prev} , equalling the current heat portion temperature T , is stored in a memory. Secondly, the fifteenth step 516 comprises performing a temperature analysis including a comparison between the difference between the temperature value T and the temperature value T_{prev} and a reference difference value m . If the difference between the temperature values is above or equal to the reference difference value m , the method proceeds to the thirteenth step 510, otherwise back to the first step 50. In other words, the present temperature value of the heat portion is compared with a previous temperature value (which has been stored in a memory). If the difference is less than a reference difference value m , the temperature is changing at a slow rate and the method therefore proceeds to stop pumping operation instead. The reference difference value m may alternatively be a function, for example an exponential, linear or polynomial function, of the temperature value T and/or the temperature value T_{prev} . In other embodiments, an alternative temperature analysis is performed in the fifteenth step 516, wherein a heating rate value (HRV) is calculated as a function of the temperature value T and the temperature value T_{prev} , and the HRV is compared with the reference difference value m which may be a constant or a function as described above.

[0092] Fig 7 is an illustration of a conventional pumping cycle. At time $t=0$, the pumping operation is started. The water level starts to decrease at a linear rate and the temperature of the heat portion increases and approaches an equilibrium value of approximately 30 degrees. At time $t=0,052$, the pump starts snoring, i.e. the water has reached a level where the pump is running without water. Due to a lack of water cooling the pump, the temperature of the heat portion starts to increase. At $t=0,068$, pumping operating stops because the temperature of the heat portion has reached an upper limit of 50 degrees. At approximately the same time, the water level starts to increase at a linear rate. When the water has reached a level of 0,30, pumping operation is started again.

[0093] Fig 8 shows the cooling gradient as a function of normalized heat portion temperature for three illustrative examples. The figure also shows an example of a reference cooling rate value function (ref stop condition). The first curve is an example of a fast cooling process, i.e. when the fluid level rises rapidly and/or the fluid temperature is low. When the normalized heat portion temperature has reached 0.92, the gradient crosses the reference cooling rate value curve, and pumping operation may consequently be started. The second curve is an example of a slow cooling process, i.e. when the fluid

level rises slowly and/or the fluid temperature is relatively high. When the normalized heat portion temperature has reached 0.75, the gradient crosses the reference cooling rate value curve, and pumping operation may consequently be started. The third curve is an example of a cooling process involving air only, i.e. when pump device is dry or when there is no thermal contact between the heat portion and the fluid. When the normalized heat portion temperature has reached 0.46, the gradient crosses the reference cooling rate value curve, and pumping operation may consequently be started. It is noted that the normalized temperature when pumping operation is to be started varies greatly with the speed of the cooling process.

[0094] Fig 9 shows the normalized heat portion temperature and the fluid level as a function of time for the same examples illustrated in fig 8. In the example of a fast cooling process, pumping operation is started at a fluid level of approximately 0.25, and in the example of the slow cooling process, pumping operation is started at a fluid level of approximately 0.2. The measurement results thus shows that the pump device may be started at fairly consistent fluid levels using a method according to an embodiment of the invention even though no fluid level sensor is used. It is also understood from these examples that cooling rate is much more strongly correlated to the fluid level than the normalized heat portion temperature. Based on measurement data such as illustrated here, the reference cooling rate value function (as illustrated in fig 8) may be optimized to achieve a low dispersion of the fluid level when pumping operation is to be started. In the example of an air-cooled process, the fluid level is low to begin with, and the fluid level at start of pumping operation (not shown in the figure) is therefore not comparable with the other two examples.

[0095] Fig 10 is a cross section view of an illustration of a submersible pump device 101 according to the second aspect of the present invention. The pump device 101 has an essentially cylindrical shape and is arranged to be vertically aligned in the fluid in which it is submersible. The pump device 101 has an upper pump housing portion 106 and a lower pump housing portion 105. A lower portion of the lower pump housing portion has a perforated outer envelope surface to allow fluid communication between the inlet channels 107 and the fluid surrounding the pump device. Inside the lower pump housing portion 105, a pump impeller 108 is arranged. The pump impeller is coupled to the electrical motor to allow transfer of rotational force there between. On the upper part of the upper pump housing portion 106, a fluid output connection flange 107 is arranged, extending radially from the essentially cylindrical pump housing. The fluid output connection means 107 is fluidically coupled to the interior of the lower pump housing portion 105 via channels in the upper pump housing portion 106 such that fluid may be pumped from surroundings of the pump device, through the perforated outer envelope surface of the lower pump housing portion 105, up through the pump

housing and out from the pump device via the output connection flange. An electrical connection 104 is arranged on the upper surface of the upper pump housing portion 106. The electrical connection is adapted to be coupled to a control unit. The electrical connection also includes wiring to provide an electrical connection between the controller and a temperature sensor which is arranged in the interior of the pump housing. The control unit which is used to control the pump device typically comprises one or more microprocessors or some other device with computing capabilities, e.g. a microcontroller unit (MCU), a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA), a complex programmable logic device (CPLD), etc, while executing appropriate downloadable software stored in a suitable storage area, such as a RAM, a Flash memory or a hard disk. This controller receives signals from the sensors and processes these signals to obtain a control signal to the pump or pump device. The temperature sensor is arranged in thermal contact with the electrical winding 102 of the electrical motor. The electrical winding 102 is partially surrounded by a stator 103. The motor is arranged inside the pump housing at a height from the bottom of the pump device such that the electrical winding is in thermal contact with the fluid (to allow heat transfer there between) when the fluid level is at such a level that it is desirable to start the pump device to discharge fluid. The controller also comprises means for monitoring the motor load by means of measuring the electrical current and voltage over the motor via the electrical connection 104 such that pumping can be interrupted when the motor load is below a reference value indicating that the fluid level is at such a low level that the pump device is essentially running dry.

[0096] Although exemplary embodiments of the present invention have been shown and described, it will be apparent to the person skilled in the art that a number of changes and modifications, or alterations of the invention as described herein may be made. Thus, it is to be understood that the above description of the invention and the accompanying drawing is to be regarded as a non-limiting example thereof and that the scope of the invention is defined in the appended patent claims.

Claims

1. A method of controlling a pump device for discharging fluid, said method comprising the steps of:

- providing a heat portion adapted to be thermally coupled to said fluid to allow heat transfer there between when the fluid is at or above a certain level;
- monitoring a temperature parameter reflecting a temperature of said heat portion, said temperature parameter including a temperature value of the temperature of said heat portion,

- calculating a cooling rate value (CRV), said calculation including a comparison between at least two temperature values measured at different times, with said at least two temperature values being for example mean temperature values, 5
 - performing a pumping operation analysis including a comparison between a present cooling rate value (CRV) and a reference cooling rate value (ref), said reference cooling rate value representing a specific cooling rate of said heat portion; and 10
 - initiating pumping operation to discharge said fluid if said cooling rate value is equal to or exceeds said reference cooling rate value. 15
2. The method according to claim 1, said method further comprising a step of heating said heat portion to a certain temperature or temperature difference above the temperature of said fluid, or of heating said heat portion if a difference between said temperature value and a reference temperature value (T_{low}) is equal to or below a reference difference value (k). 20
 3. The method according to claim 2, said method further comprising a step of repeating said step of heating said heat portion if pumping operation has not been initiated after a predetermined time interval (to). 25
 4. The method according to any one of the claims 2 or 3, wherein said step of heating said heat portion comprises heating said heat portion by a motor adapted to drive said pump device, said motor being thermally coupled to said heat portion, or said heat portion being a portion of said motor, wherein said motor is in particular an electrical motor, with the heat portion being an electrical winding of the electric motor. 30
 5. The method according to any one of the preceding claims, said method further comprising a step of monitoring at least one motor load parameter reflecting the load of a motor being arranged for driving said pump device, said load parameter including an motor load value of the motor load of said motor, wherein said motor is in particular an electrical motor, with said motor load value being based on the cosine of the phase difference (ϕ) between the voltage and the current over an electrical winding of the electric motor. 35
 6. The method according to claim 5, said method further comprising the step of interrupting said pumping operation if said motor load value is below a reference motor load value; 40
 7. The method according to any one of claims 2 to 6, wherein said method further comprises the steps of: 45
 - monitoring a fluid temperature parameter reflecting the temperature of said fluid, said fluid temperature parameter including a fluid temperature value of the temperature of said fluid; and
 - adapting at least one of the following parameters in relation to said fluid temperature value: said reference temperature value (T_{low}), said reference difference value (k), said reference cooling rate value (ref). 50
 8. The method according to any one of the preceding claims, wherein said cooling rate value is a time derivative of said temperature of said heat portion, or wherein said cooling rate value is a heat transfer coefficient of said heat portion. 55
 9. The method according to any one of the preceding claims, wherein said reference cooling rate value is a function of the heat portion temperature or a function of a normalized heat portion temperature, with said function being for example an exponential function.
 10. A control device for controlling a pump device for discharging fluid, said device comprising a heat portion adapted to be thermally coupled to said fluid when the fluid is at or above a certain level; a first temperature sensor for monitoring a temperature of said heat portion, said first temperature sensor being adapted to provide a temperature sensor signal representing the temperature of the heat portion; and a controller adapted to apply a control signal to a connectable pump device, said controller being further adapted to calculate a cooling rate value (CRV) based on at least two temperature values measured at different times from the first temperature sensor signal at different times, with said at least two temperature values being for example mean temperature values, perform a pumping operation analysis including a comparison between a present cooling rate value (CRV) and a reference cooling rate value (ref), said reference cooling rate value representing a specific cooling rate of said heat portion; and to apply a control signal to a connectable pump device to initiate pumping operation to discharge said fluid if said cooling rate value is equal to or exceeds said reference cooling rate value.
 11. The control device according to claim 10, wherein said controller is further adapted to apply a control signal to heating means adapted to heat said heat portion to a certain temperature or temperature difference above the temperature of said fluid resulting in a temperature difference between said heat portion and said fluid, or wherein said controller is further adapted to apply a control signal to the heating

means to heat said heat portion if a difference between said temperature value and a reference temperature value (T_{low}) is equal to or below a reference difference value (k).

12. The control device according to claim 11, wherein said controller is further adapted to resume heating said heat portion if pumping operation has not been initiated after a predetermined time interval (to).

13. The control device according to any one of the claims 11 or 12, wherein the heating means comprises a motor adapted to be thermally coupled to said heat portion such that heat may be transferred to the heat portion during operation of the motor, or wherein said heat portion is a portion of a motor connectable to the control device, wherein said motor is in particular an electrical motor, with said heat portion being in particular at least a portion of an electrical winding of the electric motor.

14. The control device according to any one of the claims 10 to 13, wherein said control device comprises means for monitoring a motor load of a motor connectable to the control device, said motor being adapted to drive said pump device, and wherein said means for monitoring the motor load is adapted to provide a motor load signal representing said motor load, wherein said motor is in particular an electrical motor, with said motor load value being based on the cosine of the phase difference (ϕ) between the voltage and the current over an electrical winding of the electric motor.

15. The control device according to claim 14, wherein said controller is further adapted to apply a control signal to said pump device to interrupt pumping operation if a motor load value from the motor load signal is below a reference motor load value;

16. The control device according to any one of the claims 11 to 15, wherein said device further comprises a second temperature sensor for monitoring a temperature of said fluid, said second temperature sensor being adapted to provide a second temperature sensor signal representing said fluid temperature ; and wherein said controller is further adapted to adapt at least one of the following parameters in relation to a fluid temperature value from the second temperature sensor signal:

said reference temperature value (T_{low}),
said reference difference value (k), and
said reference cooling rate value (ref).

17. The control device according to any one of the claims 10 to 16, wherein said pump device is a submersible pump.

18. A pump system comprising a pump device and a control device according to any one of the claims 10 to 17.

19. The pump system according to claim 18, wherein said control device is integral with said pump device, or said control device is removably connected with said pump device.

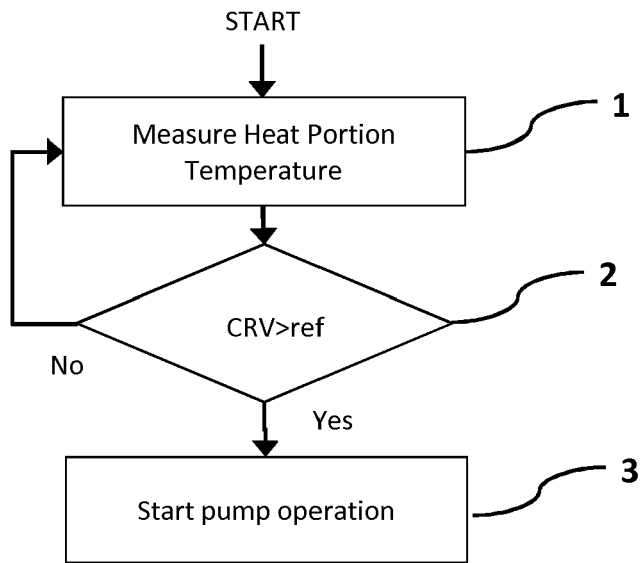


Fig. 1

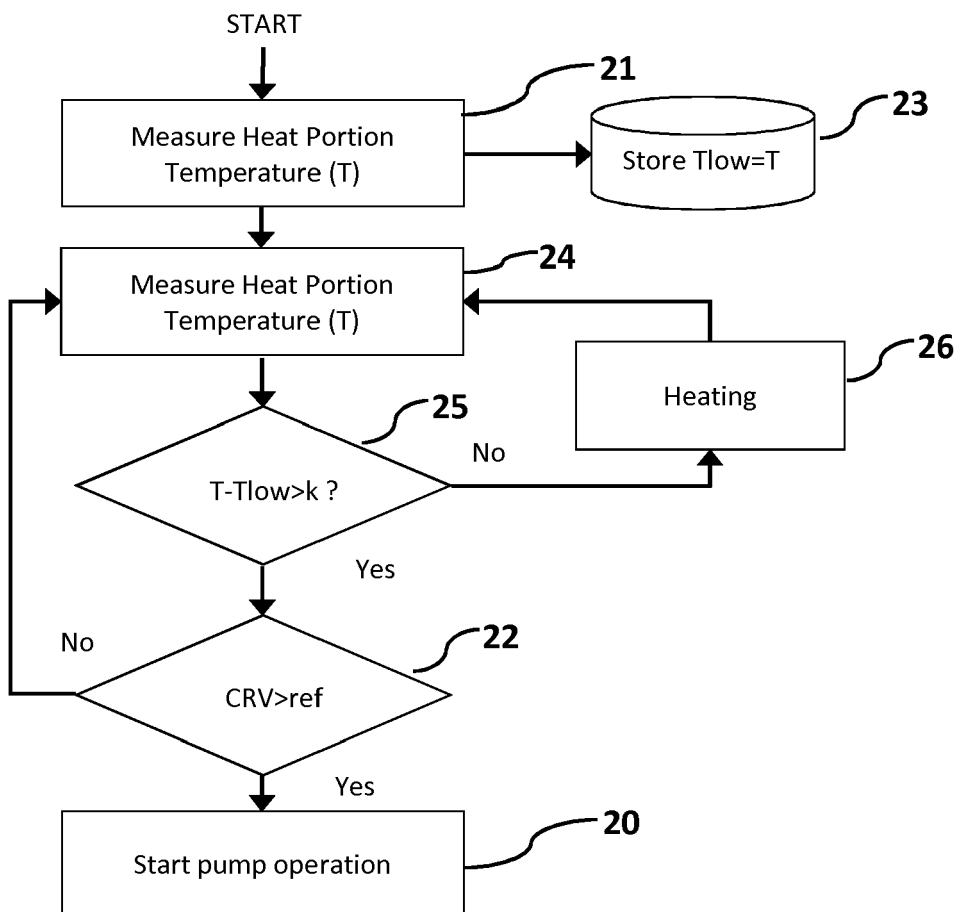
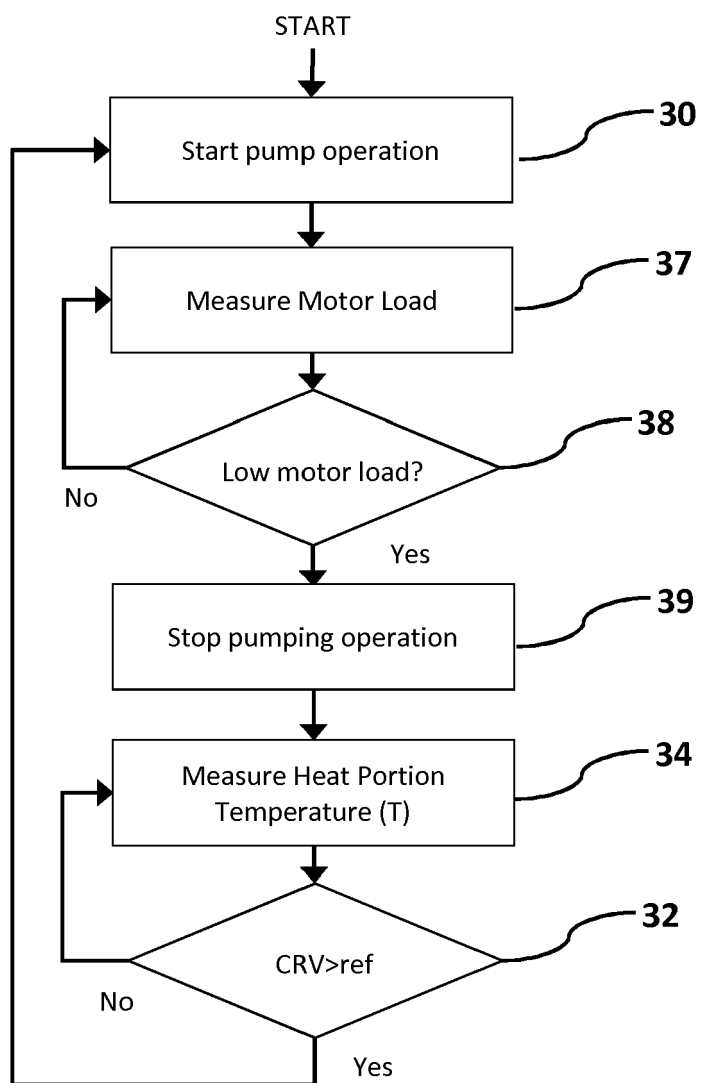


Fig. 2

**Fig. 3**

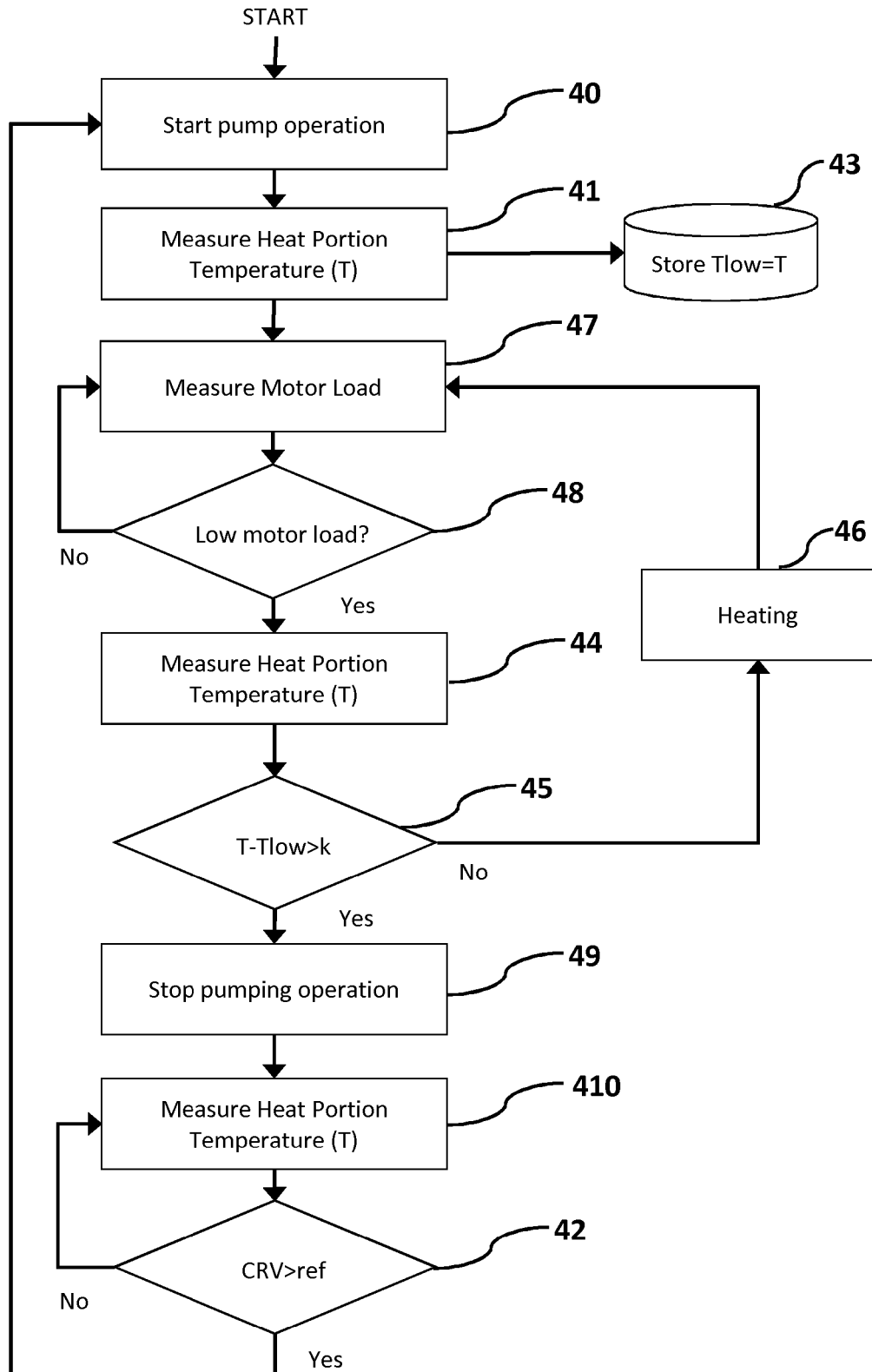


Fig. 4

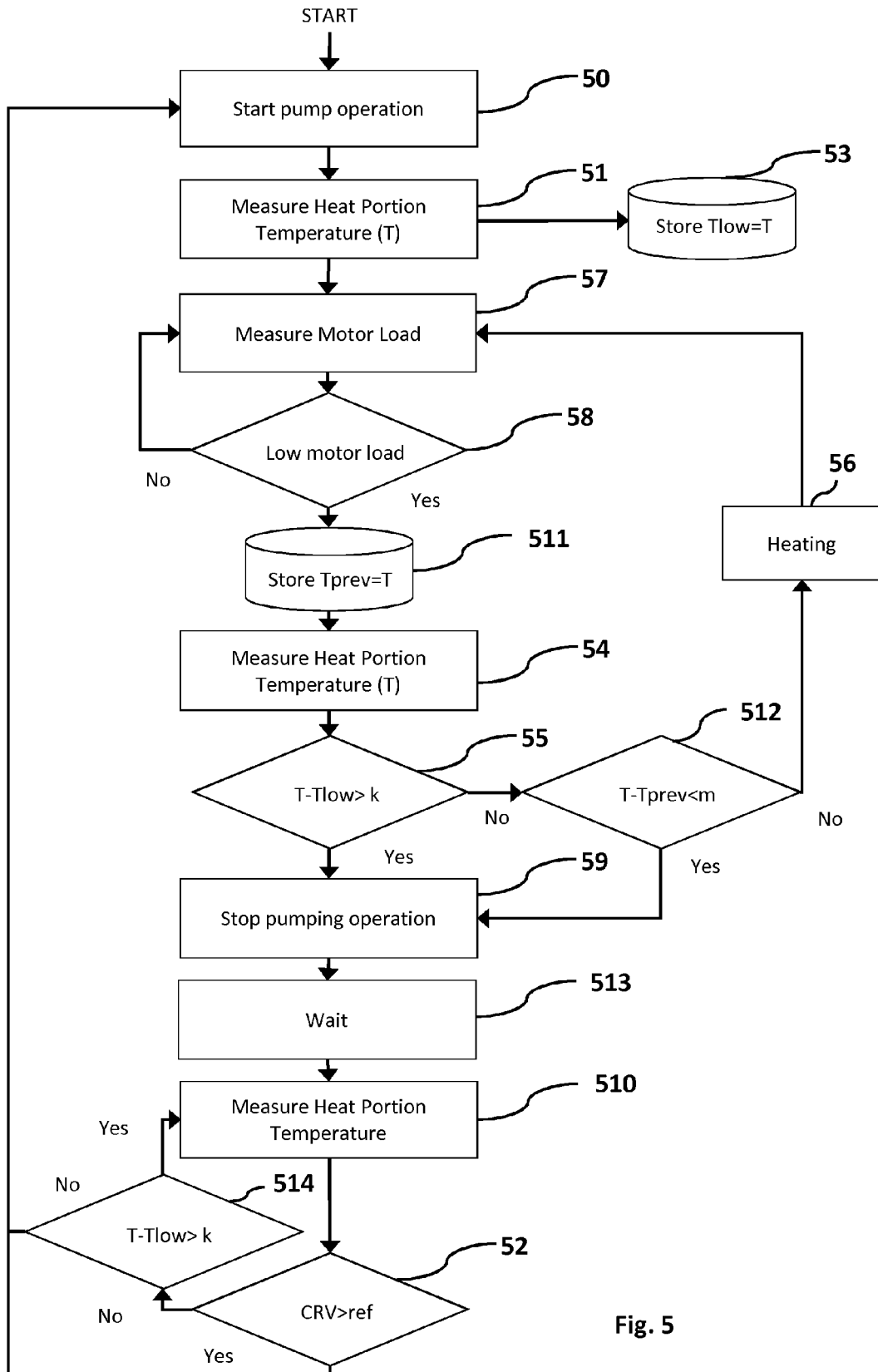


Fig. 5

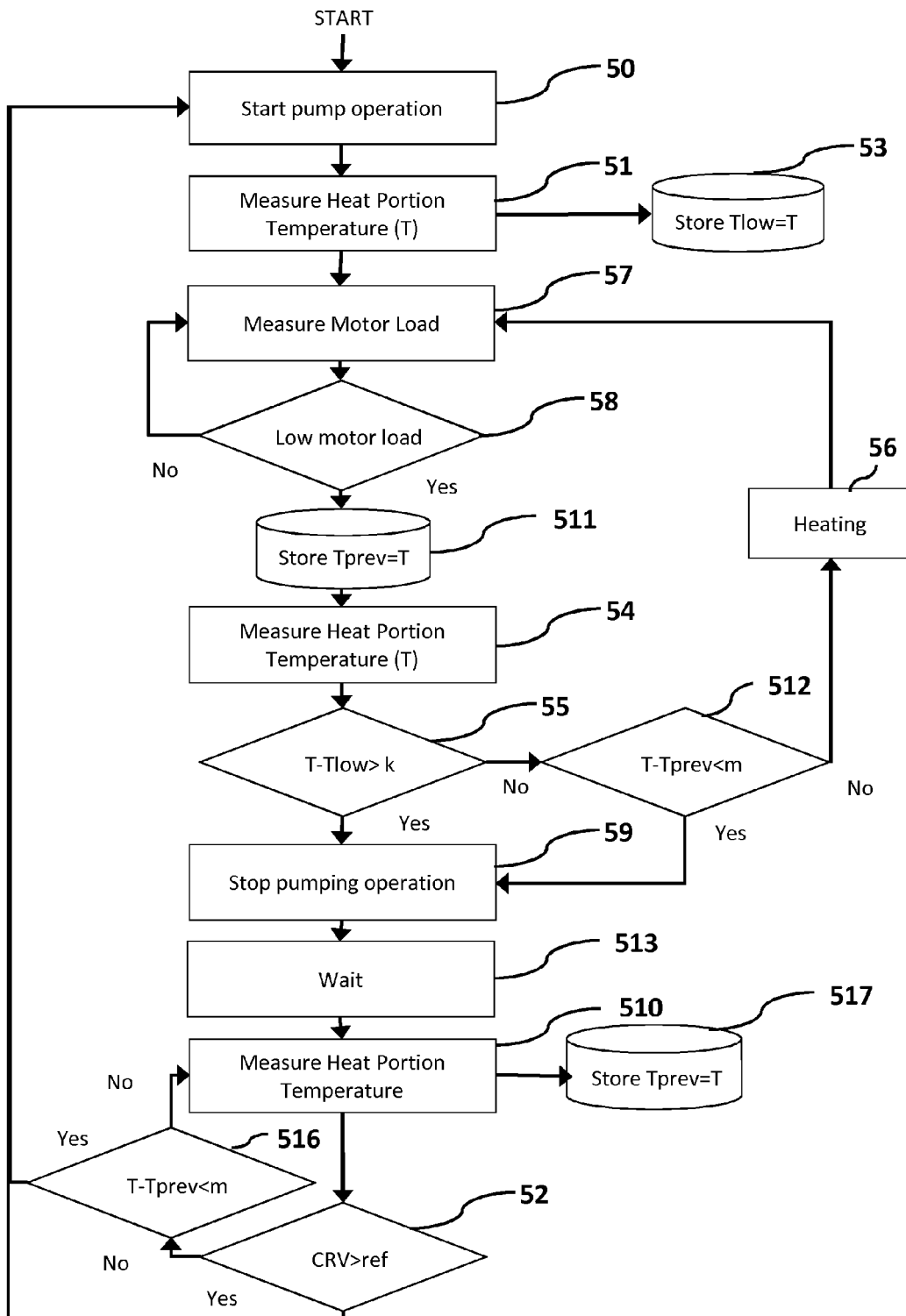


Fig. 6

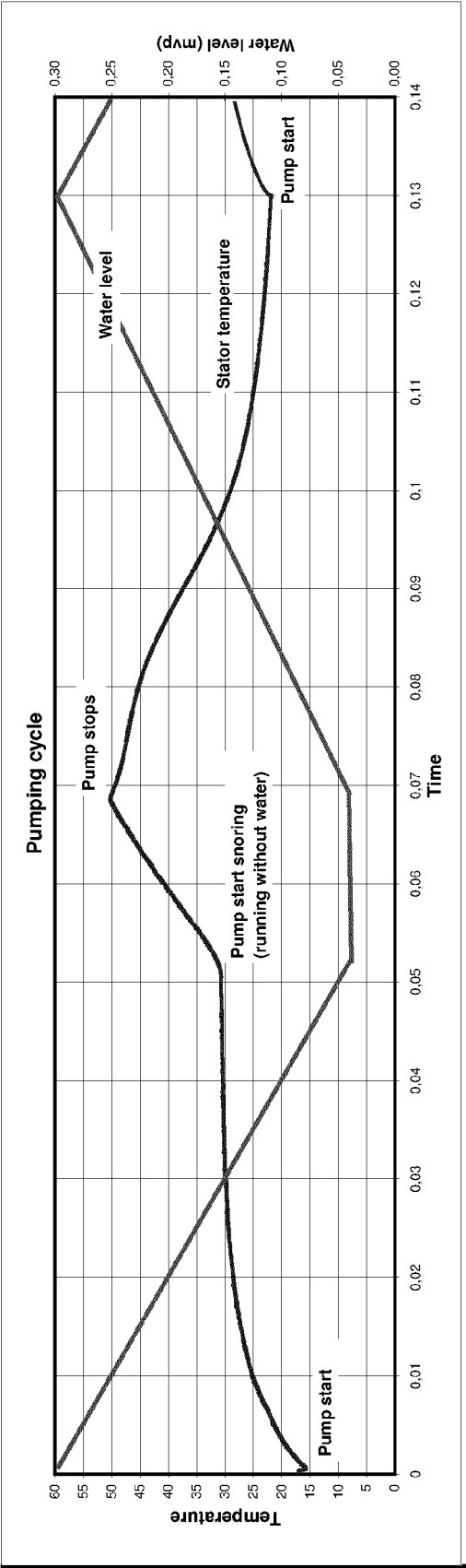


Fig. 7

Fig. 8 Cooling gradient

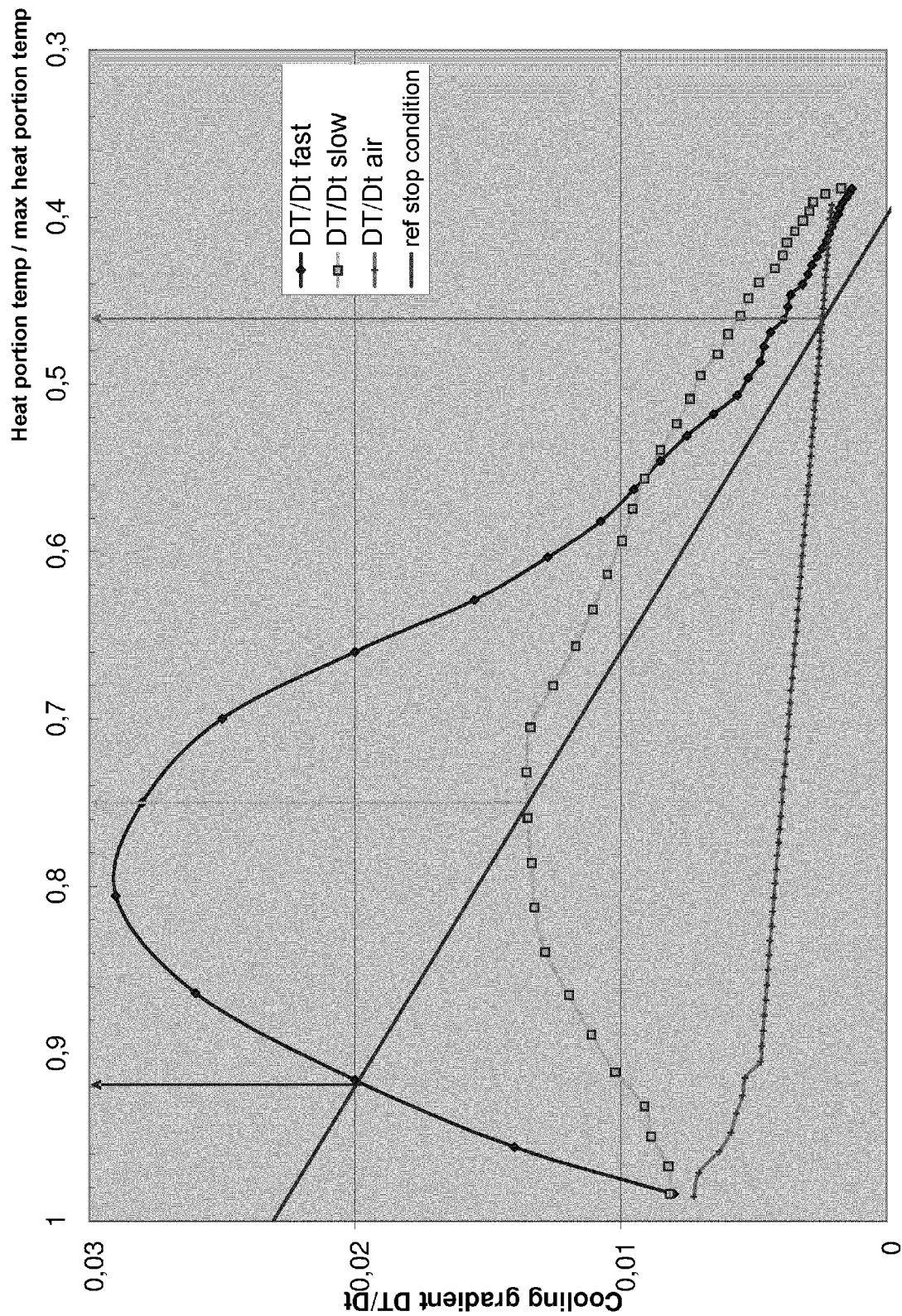
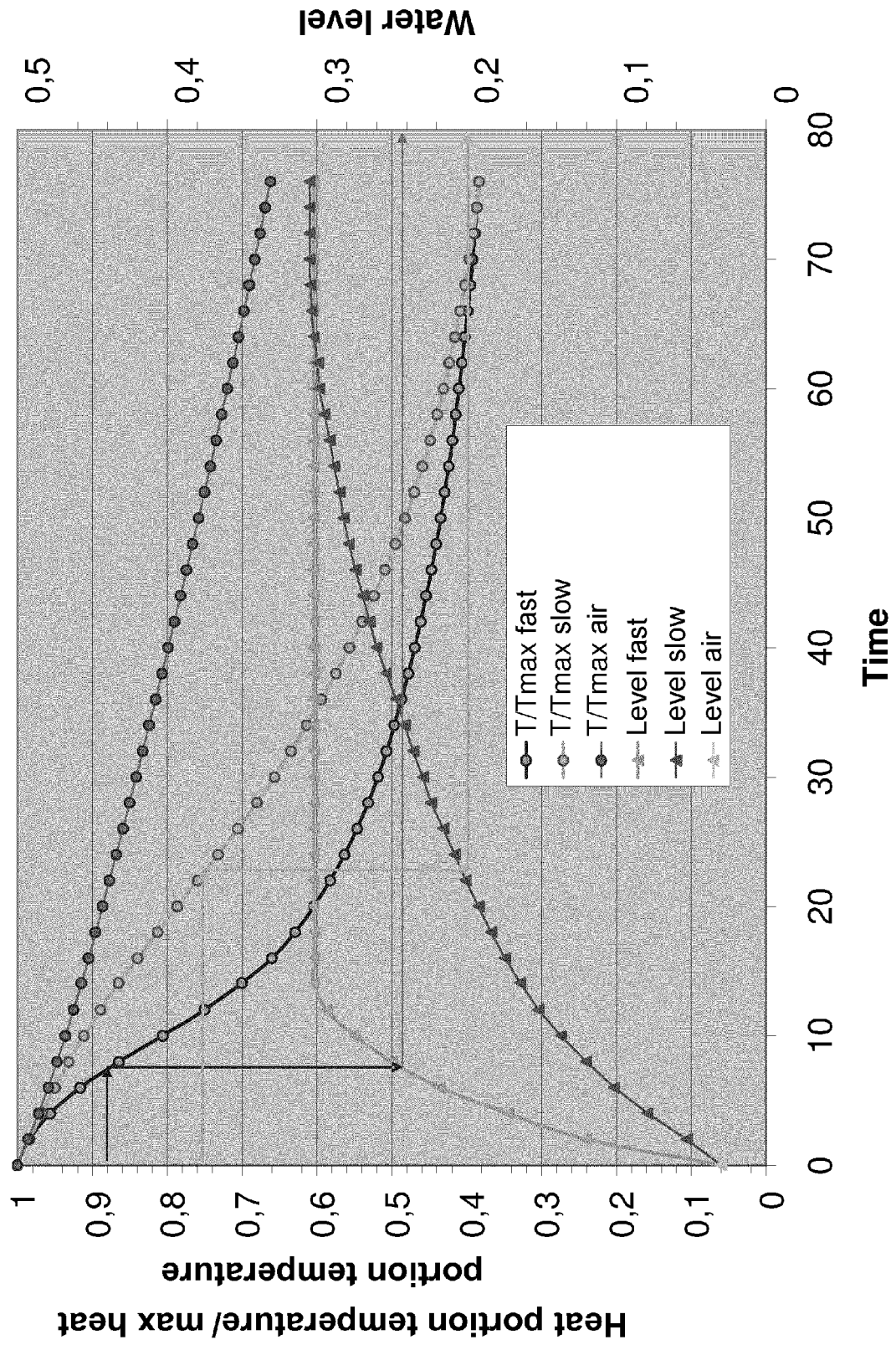


Fig. 9 Cooling of submersible pump



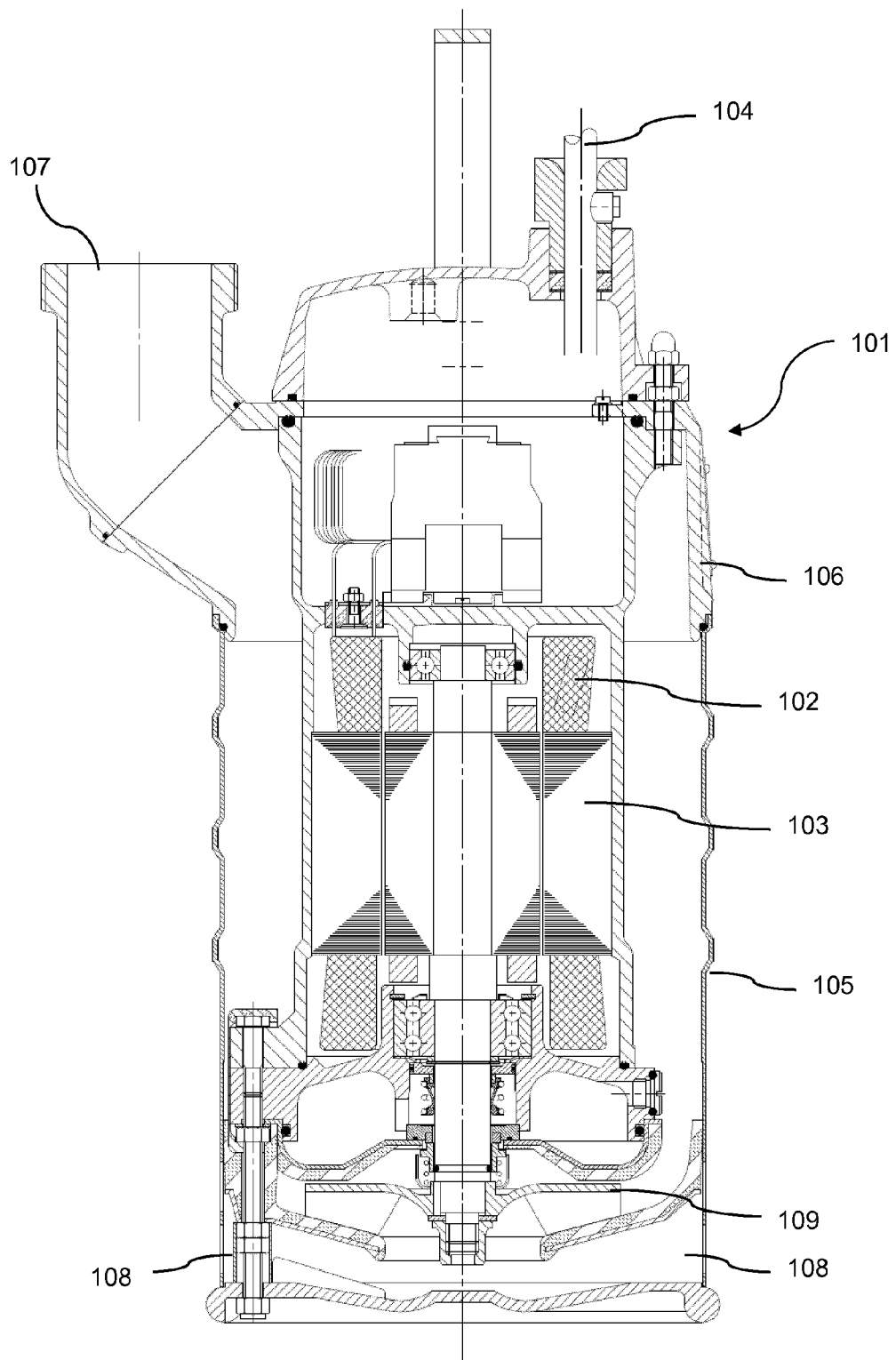


Fig. 10

REFERENCES CITED IN THE DESCRIPTION

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