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***F04B 49/02*** (2006.01) ***F04C 14/06*** (2006.01)

(56) Documents Cited:
**GB 2451876 A** **GB 2447867 A**
**GB 2240819 A** **GB 2197687 A**
**EP 1914427 A** **WO 2008/143859 A**
**US 20090250210 A**

(58) Field of Search:
INT CL **B01D, E03F, F04B, F04C, F04D**
Other: **WPI, EPODOC, TXTE**

(54) Title of the Invention: **Pump control system and method**
Abstract Title: **Pump Control System And Method**

(57) A pump control system 10 comprises a pump 12 having a pump member; a drive means 14 for driving the pump member; and control means 18 for monitoring a load on the pump member and selectively activating or deactivating the drive means 14 based on said load. The load may be a torque load on a motor 14 driving the pump 12 and an inverter 18 determines the torque load and activates or deactivates the pump 12 based on a torque load threshold corresponding to a torque load when pumping sludge or water in a waste treatment plant. Torque load may be calculated from motor current and the threshold may be a minimum load threshold representing sludge rather than water pumping. Used in settlement tanks to ensure that sludge rather than water is pumped to reduce water content in tankers. Rreduces downstream handling costs and is environmentally friendly.

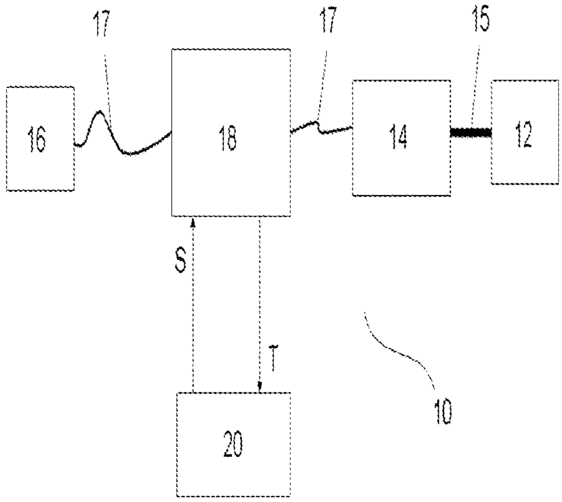


Figure 1

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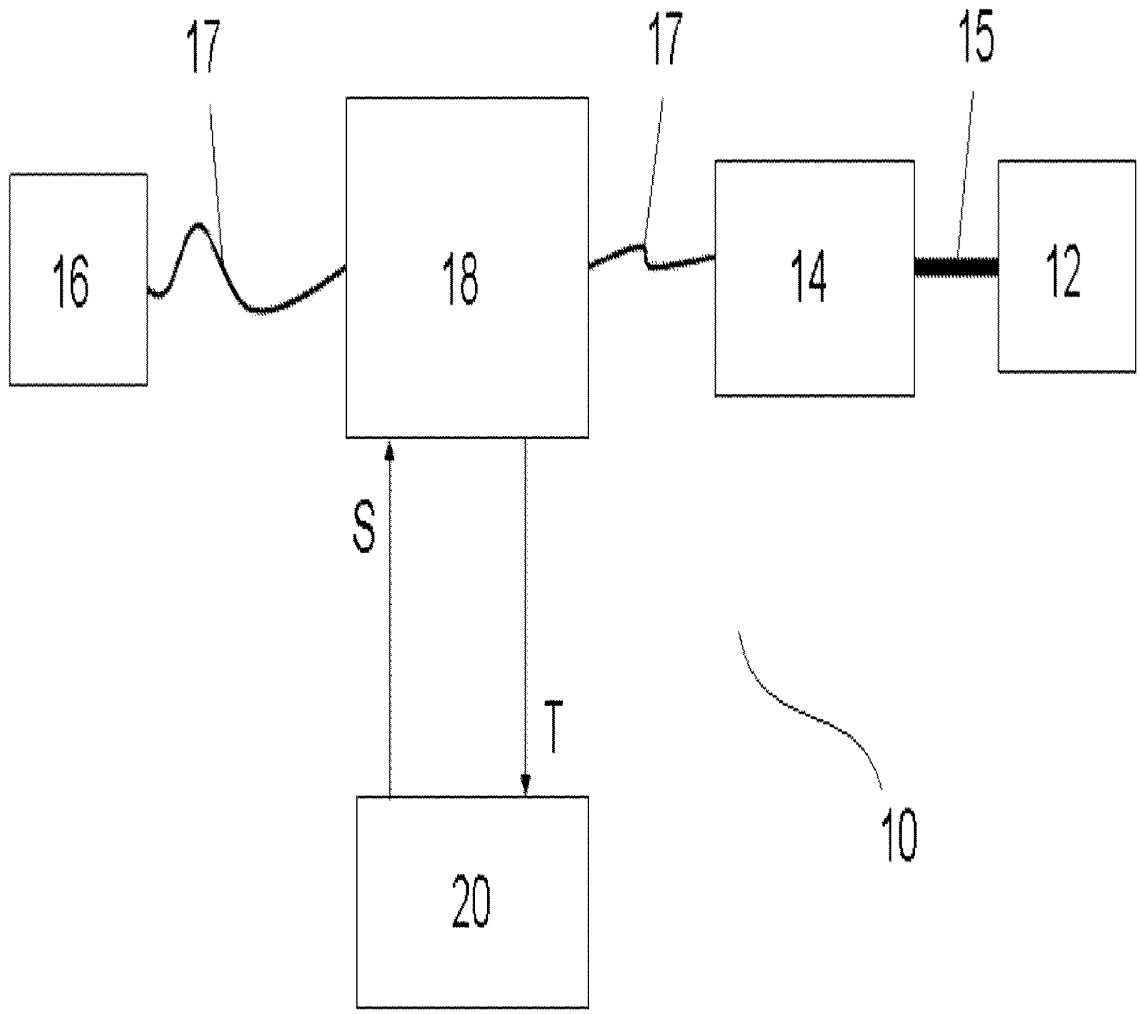
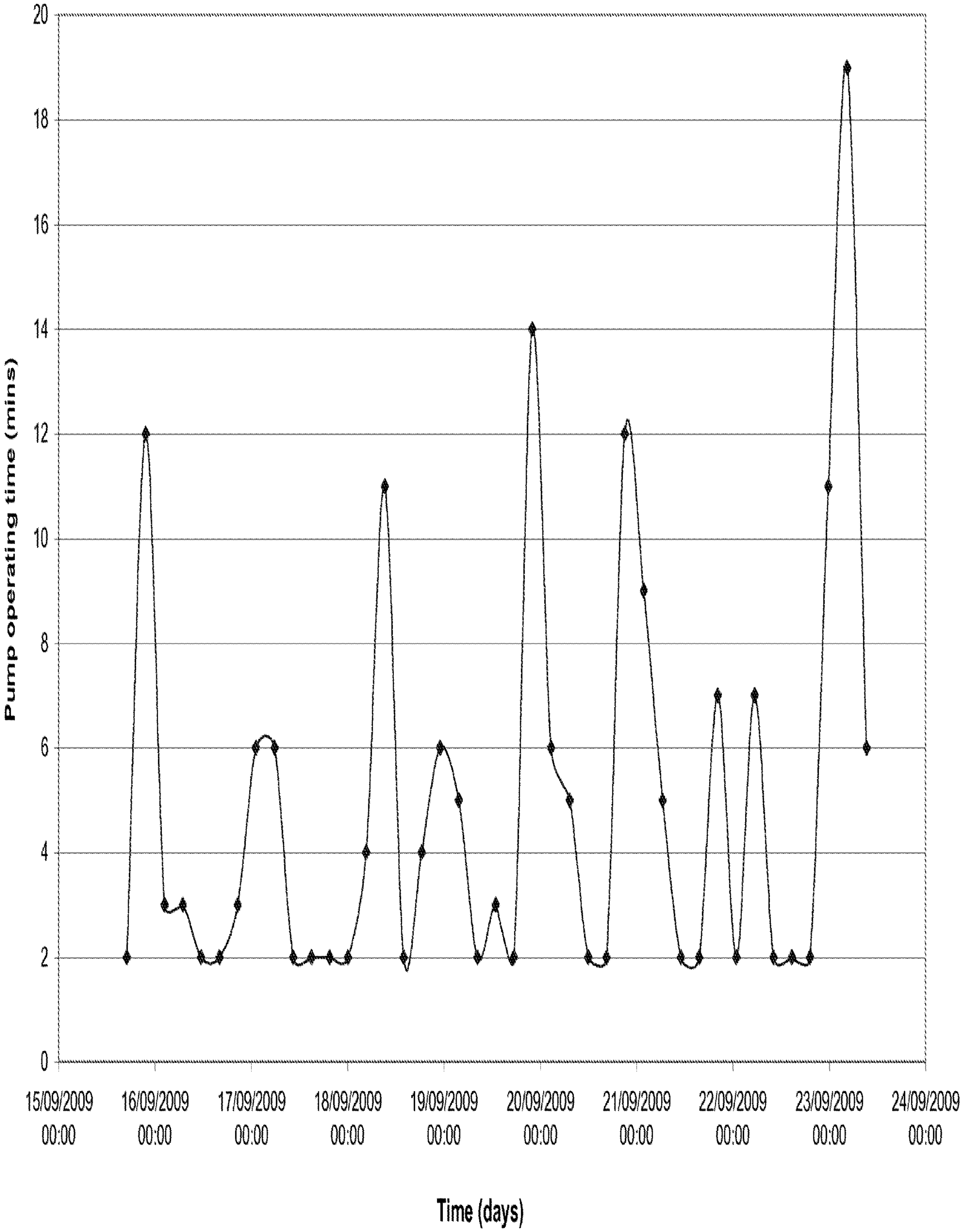



Figure 1



Pump operating time (mins)
0
2
4
6
8
10
12
14
16
18
20
15/09/2009 00:00
16/09/2009 00:00
17/09/2009 00:00
18/09/2009 00:00
19/09/2009 00:00
20/09/2009 00:00
21/09/2009 00:00
22/09/2009 00:00
23/09/2009 00:00
24/09/2009 00:00
Time (days)


Figure 2

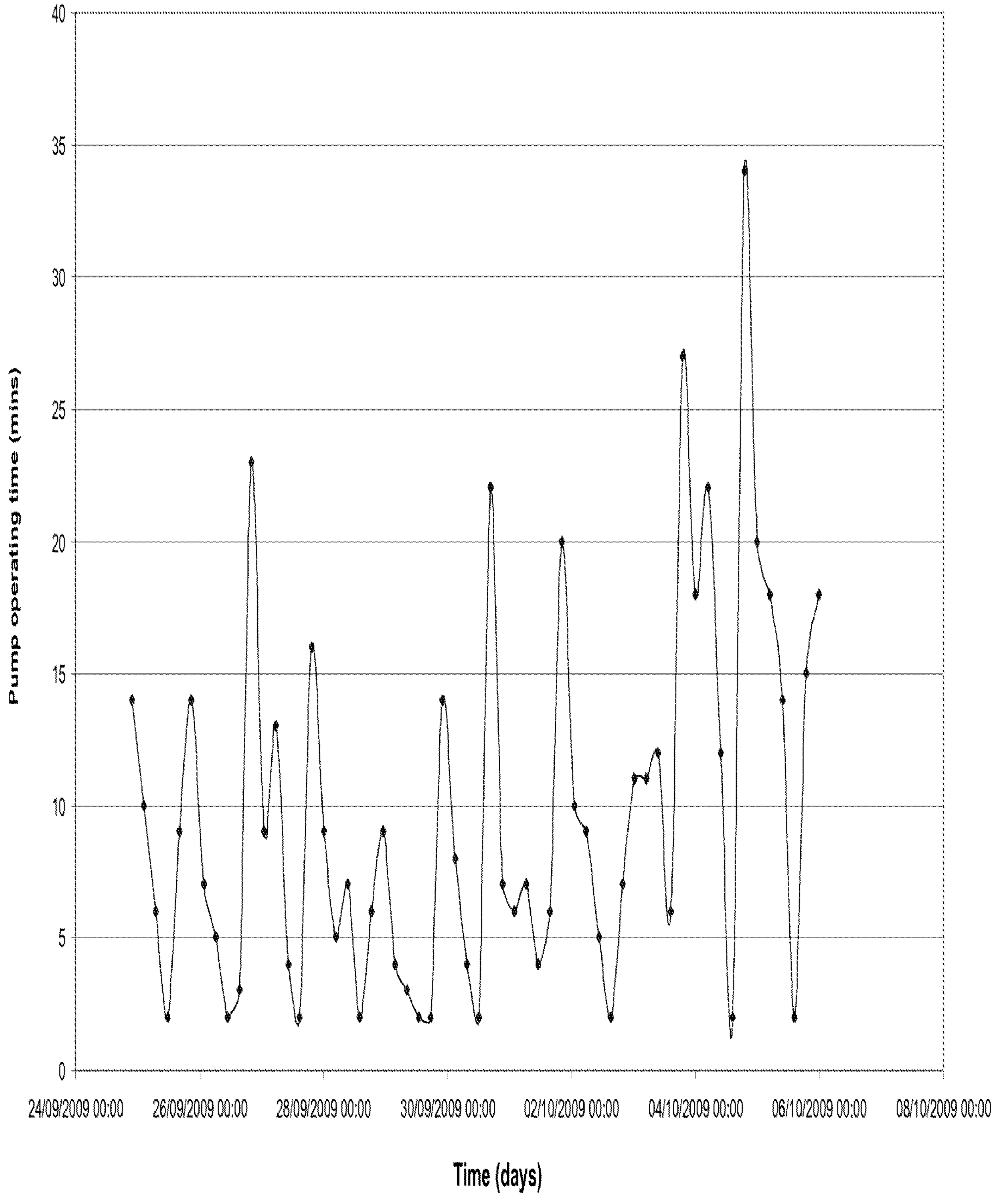

40
35
30
25
20
15
10
5
0
Pump operating time (mins)
24/09/2009 00:00
26/09/2009 00:00
28/09/2009 00:00
30/09/2009 00:00
02/10/2009 00:00
04/10/2009 00:00
06/10/2009 00:00
08/10/2009 00:00
Time (days)

Figure 3

**PUMP CONTROL SYSTEM AND METHOD**

The present invention relates to a pump control system and more specifically to a system for controlling a pump used for discharging solids from a reservoir containing solids and a liquid, such as sludge from a sewerage settling tank.

When fresh sewage or wastewater is added to a settling tank of a sewage treatment plant, approximately 50% of the suspended solid matter will settle out in approximately an hour and a half. This collection of solids is known as raw sludge or primary solids and is said to be "fresh" before anaerobic processes become active. The sludge will become putrescent in a short time once anaerobic bacteria take over and must be removed from the settling tank before this happens.

The fresh semi-solid sludge is continuously extracted from the settling tank by one or more mechanical pumps and passed to separate holding tanks. The sludge is then transferred to tankers which transport the sludge away from the sewage treatment plant to be used on cropland, for example.

Progressive cavity (PC) pumps are typically used for pumping sludge from a settling tank to a holding tank. Such pumps comprise an elongate helical shaped rotor which rotates within a heavy duty rubber sleeve to force sludge up the rubber sleeve towards the holding tank. Such pumps can develop relatively high pressure and relatively low volumes but are susceptible to blockages when pumping solids and are prone to wear.

The pumps are controlled by a timer system to activate and deactivate the pumps for a desired length of time. Typically, the pumps are constantly activated for one minute and deactivated for one minute. However, when activated, the pump may be pumping a high volume of water instead of sludge. When deactivated, a large amount of sludge may be backing up on the pump which could otherwise be being efficiently pumped to the holding tanks. When the pump is activated again for another minute, an amount of sludge which has backed up against the pump will be pumped before an amount of water is undesirably pumped for the remainder of the operating time.

Although the operating time is effectively halved compared with the pump running constantly, a significant amount of the operating time is spent pumping liquid and not sludge. This results in the holding tanks filling up quicker with an undesirable amount of liquid which in turn increases the frequency of tankers to transfer the slurry therefrom. In addition, the tankers themselves are environmentally unfriendly and relatively expensive to run. It can therefore be seen that known methods of pumping sludge from a settling tank to holding tanks is particularly inefficient and expensive. Of course, similar applications other than sludge will be known to suffer from the same problems.

According to a first aspect of the present invention, a pump control system is provided comprising:

- a pump having a pump member;
- a drive means for driving the pump member; and
- control means for monitoring a load on the pump member and selectively activating or deactivating the drive means based on said load.

The term ‘pump member’ will be understood to include all known mechanisms used to pump fluids or solids, such as an impeller, rotor, gear, piston or diaphragm.

Preferably the control means is configured to compare the load against a desired load threshold. Suitably when the load is below the load threshold, the drive means are deactivated or not activated. Likewise, when the load is above the load threshold, the drive means are activated or continue to be activated.

Preferably the load on the pump member is a torque load and the load threshold is a torque threshold. Suitably, for a known speed and torque load on the pump member, the power output of the pump may be determined.

Suitably the drive means comprises an electric motor. The control means is suitably configured to monitor and calculate the torque being subject to the pump member based on current drawn by the motor. For example, the higher the torque load on the pump member, for example when pumping sludge as opposed to water, the harder the motor must work to drive the pump member and thereby demands greater power. The current drawn by the motor is proportional to the power.

Preferably the control means comprises an inverter.

Suitably the torque threshold may correspond to a minimum torque associated with the torque load on the pump member when the pump is pumping sludge. Conveniently, the torque threshold may be set at this torque load so that when the pump member is subject to a torque load which is below the torque threshold, for example when the pump is pumping liquid, the inverter will deactivate the motor and in turn the pump. The pump may be deactivated for a desired period of time to allow a desired amount of sludge to back up against the pump member and then be reactivated to pump predominantly sludge. When the sludge has been transferred downstream of the pump and the pump begins to pump liquid, the torque load on the pump member will drop below the torque threshold and the inverter will deactivate the motor and in turn the pump.

Therefore, the pump is only operated when required and not operated at regular intervals throughout the day when pumping is not required, as is a significant disadvantage of known systems. As a result, the system is significantly more efficient than known control systems, the holding tanks are desirably filled with sludge and the rate of tankers required to transfer the sludge from the holding tanks is significantly reduced. The control system thereby also helps to reduce costs and is environmentally friendly.

Furthermore, the system is sensor-less. In other words, the system does not require load sensors, for example a torque sensor, to monitor the load on the pump member. The control means of the present invention provides this function by being adapted to monitor a load on the pump member and selectively control the pump accordingly. This advantageously reduces the number of system components and associated cost, minimises maintenance and increases the efficiency and reliability of the system.

Furthermore, the control means may suitably act as a safety device and desirably eliminates the need for one or more pressure release valves in the system, for example. Where a blockage occurs in the system, the load on the pump member will increase. In known systems, a pressure release valve is required to automatically open when the pressure in the system exceeds an actuation pressure of the valve. In accordance with the present invention, the control means may be configured to protect the system by deactivating the pump when the load on the pump member meets or exceeds a critical load. This desirably eliminates the need for one or more pressure relief valves which are expensive and require regular maintenance.

Preferably the system further comprises at least one timer to periodically activate the pump to generate a test torque signal. This periodically generated test torque signal is suitably used to determine the torque load on the pump member thereby to determine whether sludge or liquids are backed up against the pump. As described above, if the test torque signal generated is below the torque threshold, liquid is being pumped and the pump is not ready to be activated for an extended period. When sludge is being pumped, the generated test torque signal will be at or above the torque threshold and the control means will continue to activate the drive means accordingly. In this manner, the pump is only activated for an extended period when sludge is being pumped and pumping of liquids is desirably avoided.

Suitably the timer may activate the pump every hour. Preferably the pump is activated every two to six hours, or even longer. Further preferably, the pump is activated every four and a half hours. This period of time has been found to be particularly desirable to correspond with daily life cycles and allows a sufficient amount of sludge to back up against the pump. However, it is envisaged that the pump may only require activating every twelve hours.

Preferably the pump is periodically activated for approximately two minutes to fill the pump system with present pump medium and to generate sufficient data comprising the test torque signal for the control means, such as an inverter, to operate efficiently. If the test torque signal is above the desired torque threshold, the inverter will continue to activate the drive means until the viscosity of the sludge and in turn the torque load on the pump motor falls below the threshold torque when the pump is deactivated.

It has been found that the pump is activated on average for five to ten minutes every four and half hours. This is approximately five to ten percent of the operating time of known pump control systems and as a result the rate of trucks required to empty the holding tanks is equally reduced. Therefore, the control system in accordance with the present invention significantly reduces the operating time of the pump and therefore the power consumption of the system. The holding tanks are desirably filled with sludge and are filled at a significantly slower rate resulting in a reduction in the number of trucks required over a period of time.

Preferably the pump is a positive displacement (PD) pump. Such a pump is less susceptible to blockage than a progressive cavity (PC) pump. Such a pump generates a cyclical, pulsed torque signal.

Preferably the system comprises smoothing means to smooth the pulsed torque signal for monitoring efficiently by the control means. This is particularly desirable where the control means comprises an inverter. Preferably the smoothing means comprises a signal integrator.

A further aspect of the present invention provides a sewage treatment plant comprising a pump control system as described above.

A further aspect of the prevent invention provides a method of controlling a pump having a pump member and drive means for driving the pump member, the method comprising at least the steps of:

- monitoring a load on the pump member;
- comparing the load against a desired load threshold; and
- selectively activating or deactivating the drive means based on said load.

Preferably the method further comprises the periodically generating a test load signal and comparing said test load signal against the load threshold.

Preferably the method further comprises the step of smoothing the load signal for processing by the control means.

An embodiment of the present invention will now be described, by way of example only, with reference to the accompanying figures, in which:

- Figure 1 shows a schematic of a system in accordance with the present invention; and
- Figures 2 and 3 are graphs showing pump operating time in minutes against real time in days.

As shown in Figure 1, the pump control system 10 includes a positive displacement (PD) diaphragm pump 12 mechanically coupled by a suitable means 15 to an electric motor 14 to drive the pump 12. The pump 12 is connected by suitable conduit between a settling tank and a holding tank of a sewerage treatment plant. The pump 12 transfers sludge from the settling tank to the holding tank for tankers to transport to cropland, for example.

The motor 14 is connected by suitable cabling 17 to a mains AC power source 16 and connected between the motor 14 and the power source 16 is an inverter 18. The inverter 18 is configured to monitor the torque load on the diaphragm of the pump 12 based on the current drawn by the motor

14. A suitable inverter 18 is an ABB ACS350 inverter which uses a suitable internal inverter algorithm for such monitoring and processing.

A timer (not shown) is also included in the system 10 so that at regular intervals, the pump 14 is activated so that a test torque signal corresponding to the torque load on the pump 12 is generated and sent to the inverter 18. Based on this test torque signal, the inverter 18 either deactivates the motor 14 and in turn the pump 12 or allows the pump 12 to continue operating at least until the next test torque signal is generated.

The PD pump 12 generates a cyclical, pulsed torque signal T which is a real time torque signal. For the inverter 18 to efficiently process the torque signal T, a signal integrator 20 is also provided to smooth the generated torque signal. The torque load signal T generated from the motor 14 is sent from the inverter 18 to the integrator 20. The smoothed torque signal S is returned to the inverter for processing.

Each time a test torque signal is generated, the inverter 18 compares the torque load with a desired threshold torque load. The threshold torque is predetermined to correspond with a minimum torque load when the pump 12 is pumping sludge. Therefore, when the pump 12 is pumping sludge, the torque load being monitored will be at or above the torque threshold so the inverter 18 will not deactivate the motor 14 and will allow it to continue operating. In a similar manner, a torque load below the threshold torque load indicates the viscosity of the sludge is below a desired amount and the sludge is liquid, i.e. water-like. This is undesirable so the inverter 18 deactivates the pump 12. During the next four and a half hours or other suitable period, a sufficient amount of sludge, if available, is allowed to back up against the pump 12 so that when the next test torque signal is generated, it is at or above the torque load threshold and the pump 12 is activated.

To this effect, the pump control system 10 significantly reduces the operating time of the pump 12 and therefore the power consumption of the system 10. The holding tanks are desirably filled with sludge only and not water and are filled at a significantly slower rate than known systems resulting in a reduction in the number of trucks required over a period of time.

Figures 2 and 3 are graphs of pump operating time against time in days. The graphs show the operating time of the pump over two weeks. The black dots indicate when the pump 12 is being actuated to generate a test torque signal for the inverter 18. These dots occur every four and a half hours, as indicated on the horizontal axis of the graph. It can be seen that at certain times of each day, the pump 12 is actuated for only two minutes. This is because the pump 12 is run for two minutes to generate sufficient data for the inverter 18 to process efficiently and the torque load on the pump 12 is below the torque threshold indicating liquid is upstream of the pump 12 and not sludge. Therefore, the pump 14 is deactivated until the next test torque signal is generated four and a half hours later. Over this period, sufficient sludge can back up against the pump 12 when the settling tanks are at a maximum due to the daily life cycle. The next test torque signal is generated and the torque load is found to be at or over the torque threshold so the pump 12 is allowed to continue operating. The peaks of the graphs indicate this extended period of operation. If the torque load on the pump 12 when the next test torque signal is generated is found to be below the torque threshold, the pump 12 is deactivated but if the torque load is at or above the threshold, the pump 12 is allowed to continue to operate. In this way, the pump 12 only operates for an extended period when sludge is available for pumping. This eradicates the possibility of pumping water and therefore provides a significantly more efficient pump control system.

It can be seen from the graphs that the pump 12 operates for an extended period around the same time each day. This corresponds to daily life when the settling tanks are likely to be at or near a maximum level. The pump 12 is also deactivated at the generally the beginning and end of each day when the settling tanks are likely to be at or near a minimum level. The system therefore automatically adapts its pumping time to meet the amount of solids arriving at a sewerage treatment plant, for example.

**Claims**

1. A pump control system comprising:
   - a pump having a pump member;
   - a drive means for driving the pump member; and
   - control means for monitoring a load on the pump member and selectively activating or deactivating the drive means based on said load.

2. A system according to claim 1, wherein the control means is configured to compare the load against a desired load threshold.

3. A system according to claim 2, wherein the load on the pump member is a torque load and the load threshold is a torque threshold.

4. A system according to claim 3, wherein the torque threshold corresponds to a minimum torque associated with the torque load on the pump member.

5. A system according to any preceding claim, wherein the drive means comprises an electric motor.

6. A system according to claim 5, wherein the control means is configured to monitor and calculate the torque load on the pump member based on current drawn by the motor.

7. A system according to claim 6, wherein the control means comprises an inverter.

8. A system according to any preceding claim, wherein the system is sensor-less.

9. A system according to any preceding claim, further comprising at least one timer to periodically activate the pump to generate a test torque signal.

10. A system according to claim 9, wherein the at least one timer activates the pump every two to six hours or longer.

11. A system according to claim 10, wherein the pump is activated every four and a half hours nominally.

12. A system according to claim 10 or 11, wherein the pump is activated for approximately two minutes to provide a test torque load.

13. A system according to any preceding claim, wherein the pump is a positive displacement pump.

14. A system according to any preceding claim, further comprising smoothing means to smooth a pulsed torque signal from the drive means for the control means to process.

15. A sewage treatment plant comprising a pump control system according to any preceding claim.

16. A method of controlling a pump having a pump member and drive means for driving the pump member, the method comprising at least the steps of:

- monitoring a load on the pump member;

- comparing the load against a desired load threshold; and
- selectively activating or deactivating the drive means based on said load.

17. A method of controlling a pump according to claim 16, further comprising the step of periodically generating a test load signal and comparing said test load signal against the load threshold.

18. A method of controlling a pump according to claim 16 or 17, further comprising the step of smoothing a load signal for processing by the control means.

**Application No:** GB0918625.5 **Examiner:** James Paddock
**Claims searched:** 1-18 **Date of search:** 12 February 2010

## Patents Act 1977: Search Report under Section 17

**Documents considered to be relevant:**

| Category | Relevant to claims | Identity of document and passage or figure of particular relevance |
|---|---|---|
| X | 1-6,13,15,16 | GB2197687 A<br>WATER RESEARCH See the figures and claim 1. Sludge pump control measuring torque and terminating at a minimum value. |
| X | 1-3,5,6,8,13,15,16 | GB2451876 A<br>MONO See Claims 1 and 9. Sewage pump system with upper threshold current cut-off. |
| X | 1,2,5,9-11,13,15-17 | GB2240819 A<br>WILLETT See Claim 1 and page 6, 2nd full para. Sewage tank desludge system with electro-hydraulic PD pump shut down on minimum load threshold reflecting effluent density by inverter based control. Timed reactivation for sampling. |
| X | 1,2,5,8,15,16 | WO2008/143859 A<br>ENVIRONMENT ONE See the Figures. Sewage pump with on/off switching based on motor load. |
| X | 1-3,5,6,8 | EP1914427 A<br>SMITH See paras 11 and 88. Motor current sensing controller deriving torque for switching pump according to condition. |
| X | 1,2,5,8,15,16 | GB2447867 A<br>BYZAK Exemplary sewage pump blockage detection based on a motor current threshold. |
| X | 1-5,16 | US2009/250210 A<br>BAKER HUGHES See Figure 3. Pump control measuring torque and current to determine further activation. |

Categories:

| | | | |
|---|---|---|---|
| X | Document indicating lack of novelty or inventive step | A | Document indicating technological background and/or state of the art. |
| Y | Document indicating lack of inventive step if combined with one or more other documents of same category. | P | Document published on or after the declared priority date but before the filing date of this invention. |
| & | Member of the same patent family | E | Patent document published on or after, but with priority date earlier than, the filing date of this application. |

**Field of Search:**

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC$^{X}$ :

Worldwide search of patent documents classified in the following areas of the IPC

| |
|---|
| B01D; E03F; F04B; F04C; F04D |

The following online and other databases have been used in the preparation of this search report

| |
|---|
| WPI, EPODOC, TXTE |

**International Classification:**

| Subclass | Subgroup | Valid From |
|---|---|---|
| E03F | 0005/22 | 01/01/2006 |
| B01D | 0021/00 | 01/01/2006 |
| F04B | 0049/02 | 01/01/2006 |
| F04C | 0014/06 | 01/01/2006 |