A pump providing fault protection based on a controller receiving sensed pressure values from a pressure sensor included in a cavity of the pump, so as to be integral with the pump.
Fig. 1
Initialize.

21

Monitor pressure, current, time.

22

Perform signal processing

23

Compute fault index value.

24

Fault condition criteria met?

25

No

Update operational mode.

26

Perform fault response: shut down.

27

Update outputs.

28

Yes

26

Fig. 2
INTEGRAL SENSOR AND CONTROL FOR DRY RUN AND FLOW FAULT PROTECTION OF A PUMP

CROSS REFERENCE TO RELATED APPLICATION

[0001] Reference is made to and priority claimed from U.S. provisional application Ser. No. 60/701,607 filed Jul. 21, 2005.

FIELD OF THE INVENTION

[0002] The present invention relates to a pump, and more particularly to a controller or device built into a pump for providing protection for the pump against dry run and flow fault conditions.

BACKGROUND OF THE INVENTION

[0003] Existing pump control devices for providing protection for a smaller-sized water pump against dry run and flow fault conditions typically include a pressure-activated electrical switch that turns off power to the pump when the monitored pressure is too low (or is a vacuum). The pressure-activated switch is installed externally to the pump, in such a way as to monitor the inlet and/or outlet pressure. The control is reflexive, in that a drop in pressure below the threshold of the pressure-activated switch will cause the switch to operate. The pressure-activated switch is typically mechanical or electro-mechanical in construction.

[0004] The pressure sensing components for such pump control devices are typically inserted into the plumbing lines leading into and/or out of the pump. A common method consists in inserting a vacuum-sensing switch into the plumbing line on the supply side of the pump. This creates a risk of leaks in the plumbing, increases the work required for installation, and adds to the physical component count.

[0005] In addition, such pump control devices typically lack input and decision-making flexibility in that they are designed to respond to a single-variable input stimulus (pressure), and they typically lack variable output function-ability since they can only switch the pump to an ON or OFF state. This can be problematic if conditions on the sensed side of the pump are within acceptable operating limits, but conditions on the other side are not. For example, if a pump control device is configured only to respond to vacuum conditions appearing on the supply side of a pump, then no protection is afforded against uncontrolled flows resulting from catastrophic failure of, or damage to, the plumbing system charged by the pump.

SUMMARY

[0006] The invention provides a pump having integral dry run and flow fault protection via a controller using a pressure sensor embedded in either the inlet or outlet cavity of the pump, and the method of operation of the controller. The controller operation is based on the sensed pressure as well as possibly other control parameters that are monitored for protecting the pump from one or more fault conditions. The controller is programmable so that the value, interpretation and response associated with the values of the one or more control parameters—or with trends in the values of the one or more control parameters—may be set and/or changed based on a desired operational performance for the pump.

[0007] The one or more control parameters may include the outlet pressure of the pump, as well as any number of conceivable additional system parameters or control inputs in order to suit the particulars of a given application system or context, such as the inlet pressure, internal or external temperatures, external operational mode signals, supply voltage, electrical current, override commands, emergency shutdown commands, motor RPM, and so on.

[0008] A method of operation of the controller may include one or more steps run as a computer program on a computer processor or other suitable processing device or module that forms part of the controller. Thus, all or part of the operation of a controller according to the invention may be encoded as instructions for execution by a processor, and the instructions may be stored on a storage medium where the processor can execute the instructions such as read-only memory (ROM) or re-writeable program memory such as FLASH. Therefore, the invention also provides a computer program product, i.e. the computer program instructions and the storage medium holding the instructions.

[0009] Alternatively, the logic according to which the controller operates can be encoded and provided as one or more application specific integrated circuits (ASICs). As a further alternative, the full logic by which the controller operates can be provided by a combination of stored computer programs and one or more ASICs.

[0010] In operation, the invention uses a microcontroller (MCU), and one or more computer programs, a pressure sensor integral to the pump, and electrical or electronic power switching components. As such, the invention does not require components external to the pump, nor does it require intrusions into the inlet or outlet plumbing lines, thus avoiding the risk of damage to the plumbing caused by inserting the pressure sensor into the plumbing line, and thus also avoiding the associated burdens of parts and installation.

[0011] However the logic of operation is provided, either via computer programs used by a microcontroller or via ASICs or both, the pump controller operation is interpretive and dynamic and can provide optimized behavior unique to a given application, i.e. the complex logic allows transcending first-order reflexive response behavior. The computer program parameters can be set such that any desired threshold of low pressure, alone or in combination with other monitored parameters, can trigger a corresponding desired response. For example, the pump controller can combine electrical current data with pressure data over time, and then calculate a threat index which in turn is used as a basis for response to the sensed current and pressure data. In particular for example, the pump controller logic can be tailored to incorporate fixed or variable time delays, to operate the pump at single or multiple reduced or increased power levels, to attempt resumption of operation based on any number of decision criteria, to observe configurable discretion and response criteria set at the time of manufacture or in the field, and so on.

[0012] As is known, unusually large fluid flows in a plumbing system may result from failure or damage to the plumbing system. Such “flow faults” (analogous to excessively large electrical current flow in an “electrical fault”) can cause the pressure of the fluid in the system served by the pump to fall to a low value. The pump controller can be
configured (via the computer programs or ASICs) to disregard flow fault pressures, or to act on them in a protective response in conjunction with any of various decision approaches. Thus, the invention not only can protect against dry run conditions (where there is no fluid remaining to be supplied to the fluid system), but also against undesired, unusually large flow conditions, i.e. flow faults.

[0013] An illustrative application of the invention is for a Bag-in-Box beverage syrup dispensing system, where beverage syrups are stored in non-pressureized bags. The syrup is pumped from the bags upon demand, such as to fill a drink container. When the bag is emptied, the described invention senses the drop in system pressure via the integral pressure sensor in the pump, stopping the pump after a pre-determined service time, thus avoiding further operation of the pump sans syrup. Alternatively, an integral pressure sensor can be configured such that it senses vacuum at the pump inlet and/or differential pressure between the inlet and outlet, depending on the particular characteristics of a target system that need be served. The invention may also sense and factor changes in electrical current delivered to the pump motor as electrical current drawn by the pump motor often drops considerably upon depletion of the fluid supply. Finally, the invention can be realized in such a way that the low pressures resulting from flow faults can result in a protective response, such as pump shutdown.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The above and other objects, features and advantages of the invention will become apparent from a consideration of the subsequent detailed description presented in connection with accompanying drawings, in which:

[0015] FIG. 1 is a block diagram/ schematic of an integral pump control typical system diagram according to the present invention.

[0016] FIG. 2 shows an operational flowchart of the steps of operation of a pump controller according to the invention.

DETAILED DESCRIPTION

FIG. 1

[0017] FIG. 1 shows a pump system 10 according to the invention, for pumping a fluid. It includes a pump control module (PCM) 15 serving as a controller for a pump electric motor 16, built into or attached to the pump. An electrical power source 13 (AC or DC), is connected to the PCM 15 by an electrical connection 14.

[0018] The pump system includes a pumping mechanism 18 driven by the pump motor 16 and installed in a plumbing line, so as to have inlet plumbing 11 and outlet plumbing 12. The pumping mechanism includes an inlet cavity and an outlet cavity, and a structure (not shown) such as valve chambers in a positive displacement diaphragm pump, located between the two cavities and driven by the electric motor in a cyclical pattern so as to give rise to a pumping action. A pressure sensor 19 is built into the inlet and/or outlet cavity, and communicatively coupled to the PCM so as to provide to the PCM signals indicative of the fluid pressure in the (inlet or outlet) cavity. The PCM uses the sensor signals to regulate power to the electric motor, i.e. to turn on or off the power to the pump, or to provide more or less electric power to the motor (e.g. by applying more or less voltage to the motor).

[0019] In some embodiments, the PCM 15 is programmable, i.e. it includes an embedded digital computing device, such as a microcontroller or microprocessor, that is able to read a computer program and/or data stored on a non-volatile storage medium or it includes one or more ASICs and/or programmable control parameters, by which operation of the PCM can be configured as desired, and in particular, in case of additional sensed values (e.g. temperature, or current to the motor) provided by other sensors, to provide more than reflective response to the sensed pressure.

[0020] In illustrative operation, in some embodiments the PCM 15 monitors the (inlet or outlet) cavity pressure of the pump over time, reaching decision points and action responses based on operational assumptions, and/or predetermined criteria, and/or adaptive learning behaviors, utilizing individually or in combination, as configured by computer program(s) and/or the logic functions configured into ASICs. The PCM then acts to regulate power to the motor pump via power control electronics, which may include such common devices as transistors or thyristors (TRIAC, SCR, etc.).

[0021] The PCM 15 may also monitor and factor into the decision and response process any number of conceivable additional system parameters or control inputs in order to suit the particulars of a given application system or context, such as the inlet pressure, internal or external temperatures, external operational mode signals, supply voltage, electrical supply current, override commands, emergency shutdown commands, motor RPM, and so on.

[0022] In addition to regulating power to the pump motor 16, the PCM 15 may provide standard or application-specific external alerts (visual alerts, audible alerts, etc.), and a user interface (e.g. a video display) or other hardware (illuminating devices or audio devices) may be provided to enable providing the alerts.

FIG. 2

[0023] FIG. 2 illustrates operation of the pump system 10 shown in FIG. 1, beginning with a step 21 to initialize the PCM. Next, there is a step 22 to monitor selected parameters such as pressure, current and/or other parameters over time. This monitoring can be continues. Then there is a step 23 to perform analog and/or digital signal processing to determine conditioned digital values for the sensed parameters. Then there is a step 24 to compute one or more fault index value(s), i.e. to compute an indicator of whether to shut down or change operational modes, then a step 25 to determine if a fault condition criteria is met (per the computed fault index value(s), by comparison to predetermined threshold value), a step 26 to perform a fault response, such as shut down, if the fault condition criteria is met, and alternatively, if the fault condition criteria is not met, a step 27 to update the operational mode, and a step 28 to update outputs. Logical control is then returned to the step 22 of monitoring pressure.

Possible Applications

[0024] By way of illustration, the invention can be applied to the control of: pressurized water system pumps, such as found in portable and non-portable water systems in vehicles, vessels, structures and modular or mobile platforms; and pressurized fluid system pumps, such as found in beverage dispensers or commercial and industrial fluid systems.
CONCLUSION

[0025] It is to be understood that the above-described arrangements are only illustrative of the application of the principles of the present invention. Numerous modifications and alternative arrangements may be devised by those skilled in the art without departing from the scope of the present invention, and the appended claims are intended to cover such modifications and arrangements.

What is claimed is:

1. A pump system, comprising:
   a pressure sensor, for providing a signal indicative of a sensed pressure;
   a controller, responsive to the signal indicative of a sensed pressure, and also responsive to electrical power, for regulating the electrical power based on at least the sensed pressure; and
   a pump unit, having a pumping mechanism and an electrical motor for driving the pumping mechanism, responsive to the regulated electrical power;
   wherein the pumping mechanism includes an inlet cavity and an outlet cavity on either side of a pumping structure, and the pressure sensor is disposed in the inlet cavity and/or the outlet of the pumping mechanism and is communicatively coupled to the controller.

2. A pump system as in claim 1, wherein the controller uses one or more control parameters that are monitored for protecting the pump unit from one or more fault conditions, and the controller is programmable to provide a different response for different values or different value trends of the one or more control parameters.

3. A pump system as in claim 2, wherein the one or more control parameters include the sensed pressure.

4. A pump system as in claim 2, wherein the one or more control parameters include the sensed pressure and electrical current for the electric motor.

5. A pump system, comprising:
   a pressure sensor, for providing a signal indicative of a sensed pressure;
   means, responsive to the signal indicative of a sensed pressure, and also responsive to electrical power, for regulating the electrical power based on at least the sensed pressure; and
   a pump unit, having a pumping mechanism and an electrical motor for driving the pumping mechanism, responsive to the regulated electrical power;
   wherein the pumping mechanism includes an inlet cavity and an outlet cavity on either side of a pumping structure, and the pressure sensor is disposed in the inlet cavity and/or the outlet of the pumping mechanism and is communicatively coupled to the controller.

6. A pump system as in claim 5, wherein the means for regulating electrical power uses one or more control parameters that are monitored for protecting the pump unit from one or more fault conditions, and is programmable to provide a different response for different values of the one or more control parameters.

7. A method, comprising:
   sensing pressure at either an inlet cavity or an outlet of a pumping mechanism of a pump unit having an electrical motor; and
   regulating electrical power to the electrical motor based on at least the sensed pressure.

8. A method as in claim 7, further comprising monitoring one or more control parameters and using the monitored values for protecting the pump unit from one or more fault conditions.

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