LIQUID-COOLED PUMP CONTROL DEVICE AND FLUID PUMP ASSEMBLY

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Abstract
In a pump control device (1, 1’) comprising a casing (2, 3; 2’, 3’) and a speed controller (20), in particular a frequency converter, arranged in the casing for controlling the rotational speed of an electric drive motor (103; 103’) of a fluid pump (100; 100’), the casing includes a section (3; 3’) of good thermal conductivity in which a cavity (4; 4’) is formed which exhibits connections (5, 6, 7; 5’, 6’) for coupling with the output (102; 102’) of a fluid pump (100; 100’) to be controlled by the pump control device and with pipes so that the cavity (4; 4’) can be passed through by the entire fluid stream delivered by the fluid pump, wherein the speed controller (20) is connected in a heat-conducting manner to the casing portion (3; 3’) of good thermal conductivity.
LIQUID-COOLED PUMP CONTROL DEVICE AND FLUID PUMP ASSEMBLY

[0001] The invention relates to a pump control device comprising a casing and a speed controller, in particular a frequency converter, arranged in the casing for controlling the rotational speed of an electric drive motor of a fluid pump. Furthermore, the invention relates to a fluid pump assembly.

[0002] Speed controllers in pump control devices comprise electronic power components which heat up strongly during operation. In order to protect these power components from burning out, the produced heat must be dissipated. This is effected via heat sinks comprising cooling ribs, ventilating fans or the like in order to release the heat by convection or a forced air stream into the environment. Pumps having a liquid-cooled speed controller are known as well.

[0003] For instance from DE 196 39 098 A1, a motor pump comprising a cooled frequency converter and an electric motor is known, wherein the frequency converter includes a plate as a heat sink on which at least one heat-generating electronic component is mounted, with the plate lying in particular perpendicular to the motor’s axis of rotation and being coolable by a branched-off portion of the delivered medium.

[0004] From EP 0 520 333 A1, a pump unit is in turn known which comprises an electric motor cooled by a partial stream of the delivered fluid and comprising a rotor sealed against the delivered fluid. The electric motor drives a centrifugal pump. A frequency converter for controlling the rotational speed of the pump unit is arranged upstream of the electric motor. The partial stream of the delivered fluid, which has been branched off for cooling the electric motor and the frequency converter, flows through a cooling jacket enclosing the motor on the circumference. The frequency converter, which is arranged in a common casing together with the motor, is mounted in a heat-conducting manner on the outside of said cooling jacket.

[0005] A drawback associated with these known pumps comprising a liquid-cooled frequency converter is, on the one hand, their mechanically complicated design which requires elaborate casing and tubing structures in order to branch off the desired partial stream from the delivered fluid, guiding it toward and away from the heat sink of the frequency converter. A particular problem arises if foreign substances are contained in the delivered fluid, which are easily deposited in the narrow pipes leading to the heat sink and in the channels, respectively, formed in the heat sink and, consequently, might plug them. The purification of the pipes for the partial stream requires a labour-intensive dismantling of the pump. In addition, there is the risk that a plugging of the conduits for conveying the partial stream toward and away from the heat sink of the frequency converter is not noticed in time, since a plugging thereof does not impair the pump’s total flow rate. Thus, it is necessary to electronically monitor a possible overheating of the frequency converter. The known pumps involve the further drawback that, using only a partial stream of the delivered fluid, the cooling capacity is rather low, whereby this partial stream must also cool the pump motor, in addition to the frequency converter. Finally, the known pumps comprising liquid-cooled frequency converters are special constructions which must be developed separately for each pump type. The subsequent retrofitting of existing pumps is not possible with the known solutions.

[0006] The present invention is based on the object of providing a pump control device by means of which the above-described problems of the prior art are avoided.

[0007] According to the invention, this object is achieved by providing a pump control device having the features of claim 1. Advantageous embodiments of the invention are set forth in the dependent claims.

[0008] The pump control device according to the invention has a casing in which a speed controller, for example a frequency converter, is arranged for controlling the rotational speed of an electric drive motor of a fluid pump. The casing includes a section of good thermal conductivity in which a cavity is formed which exhibits connections for coupling with the output of a fluid pump to be controlled by the pump control device, on the one hand, and with pipes, on the other hand, so that the cavity can be passed through by the entire fluid stream delivered by the fluid pump, wherein the speed controller is connected in a heat-conducting manner to the casing portion of good thermal conductivity, i.e. the casing portion of good thermal conductivity serves as a heat sink for the speed controller.

[0009] The advantages of the pump control device according to the invention are diverse. Its versatility must be emphasized, since it can be connected with existing, commercially available uncontrollable fluid pumps in order to subsequently impart control functions to these pumps. The mechanical design of the pump control device according to the invention is simple, solid and robust and thus it can be reliably employed also in harsh operating environments. The high cooling capacity of the pump control device according to the invention must also be specifically emphasized, since the entire delivered fluid stream of a pump controlled by the pump control device is used for cooling the speed controller. Thus, there are sufficient cooling capacity resources under all operating conditions, and an electronic monitoring of the temperature in the pump control device can be omitted. The pump control device according to the invention is maintenance-free and unsusceptible to plugging by foreign substances in the pump throughput, since, using the total stream of delivered fluid, foreign substances possibly provided in the delivered fluid are entrained by the fluid stream and, moreover, there are no bottlenecks in the casing of the pump control device. In fact, using the total stream of delivered fluid for cooling the speed controller, the cavity of the casing portion and the connections are dimensioned in such a large size that a plugging thereof by foreign substances is extremely unlikely. It must be mentioned that the delivered fluid is pressed through the casing of the pump control device under the full pump pressure. The mounting of the pump control device according to the invention on a pump and the removal from the pump, respectively, can be performed with effortless ease and requires neither special tools nor specialized knowledge.

[0010] In an embodiment of the invention, it is provided to have heat-generating components of the speed controller directly adjacent to the casing portion of good thermal conductivity in order to dissipate the heat. A surface section of these components that is as large as possible should rest against the casing portion of good thermal conductivity.
Alternatively or in addition, heat-generating components of the speed controller may be connected to the casing portion of good thermal conductivity via heat conducting means.

[0011] High robustness and tightness of the pump control device is achieved if the casing portion of good thermal conductivity is designed in one piece, preferably as a casting. For reasons of high robustness as well as good thermal conductivity it is preferred to manufacture the casing portion of good thermal conductivity from metal or a metal alloy such as brass.

[0012] Since, during the operation of the pump control device at a pump, the full output pump pressure of the pump prevails in the cavity of the casing portion of good thermal conductivity, said pressure in the cavity may advantageously be used as an actual value for the pump control, for which purpose a passage opening into the cavity is provided for the connection of a sensor.

[0013] In order to be able to cool differently sized electronic components of the speed controller equally well, in a further embodiment of the pump control device according to the invention, it is provided that recesses are formed in the casing portion for receiving large components such as electrolytic capacitors or coils, which recesses project into the cavity or are arranged adjacent to a cavity wall.

[0014] A particularly simple and robust possibility of connecting the pump control device to a pump or pipe, respectively, is provided if the connections of the casing portion of good thermal conductivity are designed as flanges or bushings.

[0015] Pump control devices are usually used in wet surroundings. In order to prevent condensation water from precipitating in the interior of the casing, which might eventually lead to a breakdown of the speed controller, in one embodiment of the pump control device according to the invention it is provided that the casing portion of good thermal conductivity is configured as a casing bottom which can be connected to a casing lid in a fluid-tight manner. Thus, also a high air humidity cannot lead to the formation of condensation water in the interior of the casing.

[0016] Furthermore, the invention comprises a fluid pump assembly comprising a fluid pump and an electric drive motor driving the fluid pump, wherein a pump control device according to the invention controlling the drive motor is connected to the output of the fluid pump. From the prior art it is known to place a frequency converter spaced apart from an electric pump drive motor and to transmit the electric signals of the frequency converter via cables to the electric drive motor. However, this creates problems in terms of the electromagnetic compatibility (EMC) of said known fluid pump assembly, since electromagnetic interference signals are emitted by the control signals of the frequency converter, which lie in the kilohertz range and, in addition, have steep signal edges. An attempt was made to counter these EMC problems by interposing chokes and using shielded cables, which, however, leads to substantial electric losses that are even greater if shielded cables are used since the cable shield produces a capacitive current load. Due to the inventive measure of connecting a pump control device according to the invention to the output of the fluid pump, the cable length between the pump control device and the electric drive motor, via which the control signals are transmitted—and hence the radiation of interference signals—decrease to a minimum.

[0017] In a suitable advancement of the fluid pump assembly according to the invention, the pump control device has a remote operating element which communicates via control lines with the pump control device. Thereby, the use of the pump is substantially facilitated for a user, since the pumps usually have to be installed in poorly accessible places or are even immersed in wells, whereas the operating element may be mounted in a place easily accessible for a user. Long cables between the operating element and the pump control device do not pose a problem here, since the control signals on these cables exhibit only small currents and low voltages.

[0018] In a preferred embodiment of the fluid pump assembly according to the invention, the control lines between the operating element and the pump control device are also used for the supply of electric energy to the pump control device and to the electric drive motor. The electric power supply signals are indeed high-power signals, but they are sinusoidal and exhibit a low mains current frequency of 50-60 Hz, which is why they do not produce any noteworthy interference signals. The control signals, modulated on a carrier frequency, may be superimposed on the supply signals and separated in the pump control device.

[0019] In a particularly preferred embodiment of the fluid pump assembly, the fluid pump is designed as a submersible motor-driven pump. The fluid pump assembly is thereby inserted into a tube well, where it is located in the fluid to be delivered and the pump control device according to the invention is not only cooled by the flow of the entire fluid throughput, but also from the outside, by the fluid located in the tube wall. It is indeed known to install a frequency converter directly in an electric drive motor and to insert it into a tube well, but that have always been single-piece constructions matched with the specific motor which naturally were manufactured only in small quantities and hence were accordingly expensive and uneconomic. However, the solution according to the invention also allows the retrofitting of existing submersible motor-driven pumps, thus enabling a production in large quantities. Moreover, partial streams of the fluid, which had to be branched off somewhere, have always been used in the known drive motors comprising an integrated frequency converter.

[0020] In order that submersible motor-driven pumps can be inserted into casing pipes, they exhibit a casing shape which basically is rotationally symmetrical about a longitudinal axis. In order to increase the insertability of a submersible motor-driven pump assembly according to the invention, it is provided that the pump control device is connected substantially coaxially to the submersible motor-driven pump.

[0021] In a compact embodiment of a fluid pump assembly according to the invention, a pressure sensor used for controlling the pump is integrated in the pump control device. During control, only the additional delivery head resulting from the depth of the positioning of the fluid pump in the fluid to be delivered must be added to the pressure measured by the pressure sensor.

[0022] In the following, the invention is described in further detail by way of a non-limiting exemplary embodiment, with reference to the drawings.
In the drawings, FIG. 1 shows a bottom view of a casing portion of good thermal conductivity of a pump control device according to the invention. FIG. 2 shows a sectional view of the casing portion, taken on the line A-A of FIG. 1. FIG. 3 shows a sectional view of the casing portion, taken on the line B-B of FIG. 3. FIG. 4 shows a perspective view of the casing portion, seen obliquely from above. FIG. 5 shows a perspective view of the casing portion, seen obliquely from below. FIGS. 6 and 7 show perspective views of a first embodiment of a fluid pump assembly according to the invention comprising a pump control device according to the invention placed over a pump. FIG. 8 shows a second embodiment of a fluid pump assembly according to the invention comprising a fluid pump designed as a submersible motor-driven pump, and FIG. 9 shows a cross section of the pump control device used in the fluid pump assembly of FIG. 8.

Initially with reference to FIGS. 6 and 7, a fluid pump assembly comprising a fluid pump 100 is illustrated, which is driven by an electric motor 103. The fluid pump 100 exhibits a fluid inlet 101, into which a fluid stream is sucked (arrow IN), and a fluid outlet 102, from which the fluid stream delivered by the pump is discharged. A pump control device 1 according to the invention is mounted on the fluid outlet 102, which device comprises a casing consisting of a lid 2 and a casing portion 3 configured as a casing bottom, in which a speed controller is incorporated. A display of a manometer 14 is integrated in the casing lid 2. Depending on the type of the electric motor 103, the speed controller can be designed in different ways. If the electric motor 103 is, e.g., a rotary current motor, an electronic frequency converter is used as a speed controller, in case of direct-current motors, a thyristor motor or a voltage control device is used. The pump control device 1 has a connection 7 which is coupled with the fluid outlet 102 of the pump 100 in a fluid-tight manner so that the entire fluid stream delivered by the pump 100 will flow into the connection 7 and will reemerge from a connection 5 formed in the casing portion 3 after having passed through a cavity in the casing portion 3, which cavity is not illustrated (arrow OUT). In FIG. 7, a cable outlet 16 is visible on the casing portion 3, through which control and power-supply cables can be guided from the pump control device 1 to the motor 103.

For the subsequent explanations, FIGS. 1 to 5, which illustrate the casing portion 3 in various views, are also referred to. The casing portion 3 is manufactured as a casing from a metal alloy such as, e.g., brass and therefore has excellent heat conduction properties. It forms a casing bottom in which a speed controlling device 20 (see FIGS. 2 and 3) is incorporated. On the bottom side of the casing portion 3, a cavity 4 is formed which exhibits connections 5, 6, 7. The connections 5, 6, 7 can be configured with flanges or as bushings. Each of these connections 5, 6, 7 can be coupled with the output of a fluid pump to be controlled by the pump control device and can thus function as an input connection or serve as an output connection by being connected to pipes which convey the fluid stream to a consumer. As shown by means of FIGS. 6 and 7, in this exemplary embodiment, the connection 7 designed as a bushing is slid over the fluid outlet 102 of the pump 100 and thus receives the entire fluid stream delivered by the pump 100. The fluid stream flows through the cavity 4 and is discharged at connection 5 of the cavity 4. Thus, the casing portion 3 forms an extremely efficient liquid-cooled heat sink for the speed controller 20 whose electronic power components are connected in a heat-conducting manner to the casing portion 3. As illustrated by means of FIG. 2, some of the heat-generating components 21, 22 of the speed controller 20 are directly adjacent to a wall of the casing portion 3 and are cooled by direct contact, whereby a good heat transfer is provided for the components 21, 22 on the casing portion 3 due to the planar configuration of the bearing surface. As illustrated in FIG. 3, other components 23, 24 of the speed controller 20 are connected to the casing portion 3 via heat conducting means 30. For this purpose, two cup-shaped recesses 8, 9 are formed in the casing portion 3, which extend adjacent to each other toward the cavity 4, wherein the limiting walls of the cavity 4 also form wall sections of the cup-shaped recesses 8, 9. It must be mentioned that the recesses 8, 9 are separated from the cavity 4 in a fluid-tight manner. The components 23, 24, for instance, large-volume components such as electrolytic capacitors or coils, are inserted in the recesses 8, 9 and are sealed by heat conducting means 30 so that between these components and the walls of the recesses 8, 9 there is the best possible thermal conductivity, whereby the fluid flowing through the cavity 4 is used optimally for the cooling of the components 23, 24.

As mentioned, the cavity 4 of the casing portion 3 of the pump control device 1 is passed through by the entire fluid stream delivered by the pump 100, whereby basically the delivery pressure generated by the pump prevails in the cavity 4. This pressure may be used as an actual value for controlling the pump. In the casing portion 3, a passage opening 15 is therefore formed in the wall separating the interior of the casing from the cavity 4. Said passage opening 15 has a thread so that a sensor such as, e.g., a manometer, whose signals are evaluated by the speed controller, can be screwed in in a fluid-tight manner.

Furthermore, passage openings 10, 11, 12, 13 are formed in the casing portion 3, through which cables (not illustrated) for the communication between the speed controller and the pump motor as well as for the power supply of the speed controller can be guided. In order to prevent moisture from reaching the interior of the casing, spouts, bushes etc. can be disposed at the passage openings 10, 11, 12, 13.

FIG. 8 shows a partially sectioned side view of a second embodiment of a fluid pump assembly according to the invention. The fluid pump assembly is housed in a tube well 110. It comprises a fluid pump 100 designed as a submersible motor-driven pump and an electric drive motor 103 driving the fluid pump 100 as well as a pump control device 1' according to the invention which is connected to the output 102 of the fluid pump 100.

FIG. 9 shows a schematic cross section of the pump control device 1', taken on the line A-A in FIG. 8. The pump control device 1' comprises a casing consisting of a cylindrical outer wall 2' and a hollow-cylindrical inner wall 3', in which a speed controller, in particular a frequency converter (not illustrated further), is arranged for controlling the rotational speed of the electric drive motor 103'. The hollow-cylindrical inner wall 3' consists of a material of good thermal conductivity and defines in its interior a cylindrical cavity 4', which—as can be seen in FIG. 8—ex-
hibits connections 5', 6' for coupling with the output 102' of the pump 100' or with a pipe 109, respectively. Due to this design, the cavity 4' is passed through by the entire fluid stream delivered by the fluid pump 100' and hence is cooled in the best possible way. In this exemplary embodiment, the outer jacket of the hollow-cylindrical inner wall 3' has a hexagonal configuration, thereby leaving six planar outer surfaces on which, for the purpose of providing the best possible cooling, electronic power components 21', 22' of the speed controller such as, e.g., thyristors or capacitors can be mounted flatly, for instance, by screwing them on after the insertion of a heat conduction paste. The hollow-cylindrical inner wall 3' may, for example, be a one-piece extruded profile tube made of metal. After mounting the speed controller, in particular the electronic power components 21', 22', onto the hollow-cylindrical inner wall 3', the cylindrical outer wall 2' is placed over this assembly and tightly connected with the inner wall 3'. Suitably, the outer wall 2' also consists of a material of good thermal conductivity.

[0030] Again with reference to FIG. 8, the pump control device 1' has a remote operating element 104 which is installed in a place easily accessible for an operator. The operating element 104 communicates with the pump control device 1' via a control line 106. Furthermore, a power supply cable 105 leads to the operating element 104 and supplies the operating element 104, on the one hand, and also the pump control device 1', on the other hand, with electric current by feeding the electric energy of the power supply cable 105 into the control line 106. The electric energy fed into the control line 106 has a sinusoidal progression (e.g., rotary current signals) and a low mains current frequency of 50-60 Hz. Thus, there is no production of any noteworthy electromagnetic interference signals, even if the control line 106 is very long. The control signals between the operating element 104 and the pump control device 1' are modulated onto a carrier frequency and superposed on the electric supply signals in the control line 106; the separation and demodulation of the control signals takes place in the pump control device 1'. Via the operating element 104, actual values can, for instance, be transmitted which are taken into account by a control circuit in the pump control device 1', and, as a result of the control, electric signals can be produced, which are transmitted via a cable 107 for the purpose of actuating the drive motor 103'. For the control, it is furthermore advantageous if a pressure sensor 14' is directly attached to the pump control device 1' (see FIG. 9). The inner wall 3' thereby exhibits a passage opening 15' into the cavity 4' for the connection of the pressure sensor 14'. During control, only the additional delivery head resulting from the depth position of the fluid pump 100' in the tube well 110 must be added to the pressure measured by the pressure sensor 14'.

[0031] As already mentioned, in the present embodiment of the fluid pump assembly, the fluid pump 100' is configured as a subsurface motor-driven pump and exhibits—just like the drive motor 103'—a casing shape which basically is rotationally symmetrical about a longitudinal axis 108. Thereby, the pump control device 1' is connected coaxially to the subsurface motor-driven pump 100', resulting in a very slim and compact configuration.

1. A pump control device comprising a casing and a speed controller, in particular a frequency converter, arranged in the casing for controlling the rotational speed of an electric drive motor of a fluid pump, wherein the casing includes a section of good thermal conductivity in which a cavity is formed which exhibits connections for coupling with the output of a fluid pump to be controlled by the pump control device and with pipes so that the cavity can be passed through by the entire fluid stream delivered by the fluid pump and that the speed controller is connected in the heat-conducting manner to the casing portion of good thermal conductivity.

2. A pump control device according to claim 1, wherein components of the speed controller are directly adjacent to the casing portion of good thermal conductivity.

3. A pump control device according to claim 1, wherein components of the speed controller are connected to the casing portion of good thermal conductivity via heat conducting means.

4. A pump control device according to claim 1, wherein the casing portion of good thermal conductivity is designed in one piece, preferably as a casting.

5. A pump control device according to claim 4, wherein the casing portion of good thermal conductivity is manufactured from metal or a metal alloy such as brass.

6. A pump control device according to claim 1, wherein the casing portions of good thermal conductivity exhibits a passage opening into the cavity for the connection of a sensor.

7. A pump control device according to claim 1, wherein recesses are formed in the casing portion of good thermal conductivity, which recesses project into the cavity or are arranged adjacent to a cavity wall.

8. A pump control device according to claim 1, wherein the connections of the casing portion of good thermal conductivity comprise flanges or bushings.

9. A pump control device according to claim 1, wherein the casing portion of good thermal conductivity is configured as a casing bottom connectable to a casing lid in a fluid-tight manner.

10. A pump control device according to claim 1, wherein the casing portion of good thermal conductivity is configured as a tubular wall which defines the cavity through which the entire fluid stream delivered by the fluid pump can flow.

11. A fluid pump assembly comprising a fluid pump and an electric drive motor driving the fluid pump, wherein a pump control device according to claim 1, controlling the drive motor, is connected to the output of the fluid pump.

12. A fluid pump assembly according to claim 11, wherein the pump control device has a remote operating element which communicating via control lines with the pump control device.

13. A fluid pump assembly according to claim 12, wherein the control lines have a supply of supply electric energy to the pump control device and to the electric drive motor.

14. A fluid pump assembly according to claim 13, wherein the fluid pump comprises a subsurface motor-driven pump.

15. A fluid pump assembly according to claim 14, wherein the pump control device is connected substantially coaxially to the subsurface motor-driven pump.

16. A fluid pump assembly according to claim 15, wherein a pressure sensor is integrated in the pump control device.