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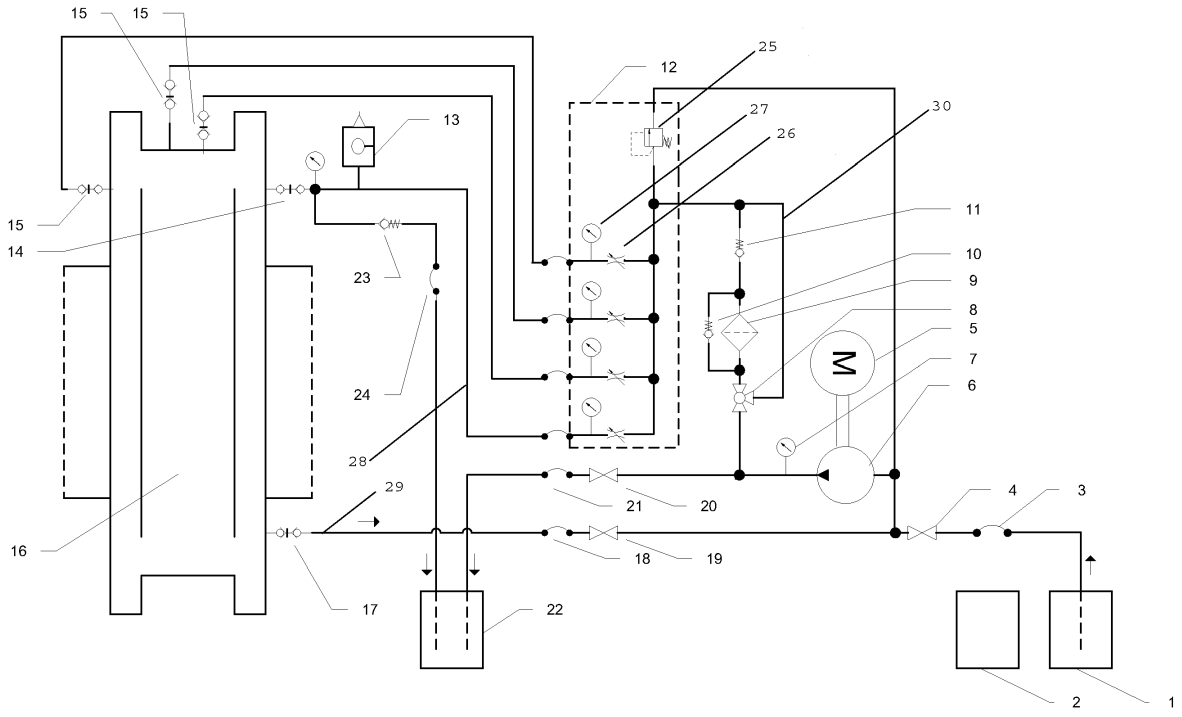
(54) Method and system for purging hardened grease or sludge from a bearing and bearing housing

(57) A method and apparatus for cleaning a bearing, where first, a purging fluid with a high concentration of surfactant is pumped through the bearing in repeated cycles, after which the bearing is flushed, preferably with clean oil, before new grease is provided. The apparatus is compact and comprises preferably a safety valve for preventing overpressure damage to the bearing. The purging fluid contains more than 50% surfactant and contains less than 10% water, and the flushing fluid is oil or contains more than 50% oil.



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Description

FIELD OF THE INVENTION

[0001] The present invention relates to systems and methods for purging hardened grease or sludge from a bearing and bearing housing, for example the bearing and bearing housing a wind turbine generator.

BACKGROUND OF THE INVENTION

[0002] Removal of hardened grease in bearings, tanks and pipes is a general problem and discussed in various prior art documents.

[0003] International patent application WO2007/104102 discloses a method and apparatus using sunflower oil at 50-90°C for cleaning of bearings in railway rolling stock. Rinsing is finally performed at 33°C with a rinsing fluid.

[0004] US5998352 discloses a heavy oil remover that comprises from about 0.1 to about 99 weight percent dipropylene glycol Mono N-butyl ether, from about 1 to about 99 percent of a mixture of methyl cocoate and methyl sunflowerate, from about 0.1 to about 75 weight percent napthenic petroleum distillate solvent, from about 0.1 to about 90 weight percent salt of an alkyl aromatic sulfonic acid, from about 0.05 to about 50 weight percent branched alcohol ethoxylate, from about 0.05 to about 50 weight percent ethoxylated alkyl mercaptan, and the balance, water. Various fluids for oil removal are disclosed in US5814594, US5863881, US6369016, US6310263, US6235698, US6228830, US6090769, US5985816; all containing a certain amount of water.

[0005] WO13017854A1 discloses a method for in-situ cleaning of compressor blades in a gas turbine engine on an aircraft comprises washing said compressor blades by spraying a first liquid composition into the engine, the first liquid composition preferably comprising 50-90% water; and finally rinsing said washed compressor blades by spraying a second liquid composition into the engine, wherein the second liquid composition, has a freezing point of -10 degrees centigrade or below and is non-aqueous and hydrophilic.

[0006] DE102006036268A discloses a method involving bringing a chemical cleaning agent in contact with contaminated surfaces of engine parts e.g. oil pan, and/or in an engine oil chamber, where the cleaning agent has a composition of 15-30 percentage of Butyl-di-glycol and Glycol ether, 5-15 percentage of 2-Amino ethanol and fatty alcohol ethoxylate, 1-5 percentage of Limonene extract, and 5-15 percentage of nonionic Tenside. Oil deposits are dissolved and removed by rinsing off.

[0007] US6093689 discloses an asphalt and heavy oil degreaser comprises a cyclic hydrocarbon solvent, dipropylene glycol mono n-butyl ether, a salt of an alkyl aromatic sulfonic acid, a branched alcohol ethoxylate, and an ethoxylated alkyl mercaptan.

[0008] US6197734B discloses a high wax content heavy oil remover comprises dipropylene glycol mono n-butyl ether, ethoxylated alkyl mercaptan, salt of an alkyl aromatic sulfonic acid, branched alcohol ethoxylate, d-limonene, and white oil.

[0009] Thus, there is a variety of proposed cleaning methods and substanes for removing grease, however, in practice, no satisfactory automated cleaning method and cleaning fluid has found way to the market in connection with bearing for wind turbine generators. Such bearings are typically manually cleaned, which is an expensive and tedious procedure as also explained in US patent application No. 2013/0068253 by Gonzalez et al. For this reason, as an improvement, a method for purging sludge from a bearing and bearing housing of the transmission system a wind turbine generator is disclosed. As explained in US2013/0068253, grease in such bearings has a viscosity that is increasing with time and hardens into highly viscous sludge or even hard particles, all being very difficult to remove. An apparatus is disclosed for removing hardened sludge in a circulating system that is portable. The system comprises an oil reservoir and a heater in order to heat the purging fluid to 130°F (54°C). While the heated purging fluid is pumped through the bearing, the bearing maybe rotated. During circulation of the purging fluid, large particles are strained in a strainer and fine particles are removed in a 10 micron filter. As purging fluid, US2013/0068253 proposes grease or oils or other substances, especially if these cause the bearing or bearing housing to oxidize, such as fluids exhibiting caustic properties. As alternatives, purging fluids without oxidizing properties are mentioned, such as acidic fluids.

[0010] The method in US2013/0068253 has some disadvantages. First of all, the fine filtering of purging fluid results in the 10 micron filter being clogged relatively quickly during the cleaning process, despite the strainer. The increasing viscosity of the purging fluid during dissolution of sludge from the bearing also quickly reduces the flow speed through the 10 micron filter, which in turn increases the cleaning time. Especially, for wind turbine generators, this is not desirable, as the cleaning should be performed quickly without necessary dead time. More severe, though, is the fact that steady increase in viscosity of the purging fluid reduces the flow speed through the bearing, which leads to an unsatisfactory removal of particles from the bearing. Even further, it is pointed out that caustic and acidic fluids, as in US2013/0068253, are preferably not to be used for bearings in wind turbine generators, as there is a risk for damaging the surface of the bearings and, consequently, reducing the lifetime of the bearings.

[0011] Thus in general, there is still need for improvement in the art.

DESCRIPTION / SUMMARY OF THE INVENTION

[0012] It is therefore an objective of the invention to provide an improved system and method for cleaning of bearings, especially bearings in wind turbine generators. This objective is achieved with a system and method as in the following.

[0013] As an improvement, the cleaning process of the bearings, for example bearings of a wind turbine generator, has been separated into multiple steps, where in a first step, purging fluid is circulated through the bearing in order to dissolve sludge, and in a second step, the bearing is flushed with a flushing fluid, where the flushing fluid flushes out remaining particles.

[0014] The term "fluid" is used for the liquids that are employed, because the liquids for purging and flushing will also contains particles during the cleaning process, why not the entire fluid is liquid. The differentiation between the purging fluid and the flushing fluid implies that the liquids are different with respect to their composition. For example, the purging fluid contains a surfactant, whereas the flushing fluid does not. The purging fluid has the task to dissolve sludge, and the flushing fluid has the task to flush out remaining particles, for example metal particles that are in the bearings due to wear in the bearings.

[0015] For example, in order to avoid the problem of clogging of a fine particle filter, the purging fluid is not filtered by a fine particle filter, for example a 10 micron or 5 micron filter. Instead, once the purging fluid has dissolved the sludge and is removed from the bearing, a flushing fluid is pumped through the bearing, the flushing fluid being filtered for removing fine sized particles. As the flushing fluid is not subject to an increase in viscosity, because sludge is already dissolved and removed, the flow speed through the bearing of the flushing fluid can be adjusted easily and kept stable during circulation of the flushing fluid through the bearing. Especially, the flushing speed can be adjusted in relation to the viscosity of the flushing fluid such that a turbulent flow through the bearing can be maintained, which effectively removes particles from the bearing.

[0016] Typically, during the flushing, samples are taken from the flushing fluid in order to check whether the cleanliness of the bearing corresponds to predetermined parameters and criteria, for example the ISO4406 or ISO4407 criteria. The measurement by sampling is an indirect method, because the flushing fluid is only reflecting the state inside the bearings if the flushing is efficient enough to actually flush out the particles that are in the bearing, for example metal particle from wearing of the bearing in the period before cleaning. With reference to the aforementioned US2013/0068253, it would not be possible to check for such highly sensitive criteria by sampling the purging liquid because the dissolution of the sludge in the purging fluid would distort the picture of how the state of cleanliness is inside the bearing. In order of getting a reliable measurement, the state of the flushing fluid has to be stable during the sampling, which is not the case for the dissolving purging fluid in US2013/0068253, as the content of dissolved sludge in the purging fluid increases with time and makes the purging fluid viscous and full of sludge debris.

[0017] It should be made sure that the flushing fluid is compatible with the new grease in the bearing after the cleaning such that no early degradation of the grease is provoked by remnants from the flushing fluid. For example, in most cases, the flushing fluid based on synthetic oil is not optimum if the grease in the bearing is based on mineral oil, as there is a risk for incompatibility. For this reason, it is useful if there, as a step of the method, is performed a compatibility check that the flushing fluid is compatible with the final renewed grease for the bearing.

[0018] As has been found out during study of the problem of dissolving and loosening hardened oil or grease - in the following called sludge - from the bearings, good cleaning results can be achieved by using a purging fluid with a high concentration of surfactant, for example more than 50% or at least 60%, for example at least 70% or 80%. In contrast to typical suggestions in the prior art, where aqueous fluids are used for cleaning, it is preferred to keep the content of water at an absolute minimum. Instead, oil may be used as a diluent of the surfactant. By avoiding water, corrosion is minimized, and by using oil as a diluent for the purging liquid, the surface of the bearings is protected during the cleaning process. This goes against typical teaching, where the bipolar nature of many surfactants is used for binding the hardened grease from the bearings to the non-polar chain end of the surfactant and the water to the opposite end, which is also the typical way of using a surfactant.

[0019] Thus, according to the method, a surfactant is used without adding water. A typical water content of a surfactant is at a level of a few percentages or even less than 1%, why the method comprises using a purging fluid with less than 10% of water, rather less than 5%, 3%, 2%, 1% or less than 0.5% of water. For example, the surfactant is used in a concentrated form. Alternatively, the surfactant is diluted with a non-aqueous substance, for example oil, as already mentioned.

[0020] After using the purging fluid, the bearing is flushed with a flushing liquid. Such flushing liquid should be a non-aqueous substance, for example clean oil, such as hydraulic oil, in order to remove surfactants and remains. After flushing with the flushing liquid, the bearings are greased again with bearing grease.

[0021] Especially in connection with wind turbine generators, a fast and simple cleaning procedure is desired in order to minimize dead time and minimize risk for accidents during quick and sudden weather shifts, which is especially important for offshore wind turbine generators. For this reason, no heating of the purging fluid is desired such that the purging fluid can be used at ambient temperatures. During running of a wind turbine generator, the bearings get warm,

and bearing cleaning can be performed during a relatively short stop of the turbine in order to minimize dead time of the wind turbine generator. In such case, the temperature in the bearing is sufficient to heat the purging fluid in case that ambient temperature is very low, for example near freezing point. A temperature of around 25°C, for example at 20-25°C is typically sufficient for an efficient removal of hardened grease, such that the system does not need a heating element but only uses the possible heat transfer from the bearings to the fluid. This allows the apparatus for performing the cleaning to be provided as a relatively small, compact unit. The compactness is further achieved by providing a circuit with a pump for circulating the purging fluid but avoiding a tank within the circuit other than the volume of the bearings. Thus, the bearings themselves function as the tank during circulation of the purging fluid and the final flushing fluid, for example oil, such as clean low-viscous (15-100 cST) hydraulic oil.

[0022] In order to facilitate the removal of the hardened sludge, the bearing may be rotated during circulation of the purging fluid through the bearing.

[0023] In a concrete embodiment, the following method for purging hardened sludge from a bearing, for example from a bearing of a wind turbine generator, is used in connection with a bearing having a first connection for inlet of purging fluid and a second connection for outlet of cleaning liquid. In this case, an apparatus is attached to the first connection and to the second connection, the apparatus comprises a pump for pumping purging fluid through the bearing, and by the apparatus a purging fluid is circulated through the first connection, through the bearing and through the second connection and back to the first connection in a plurality of circulation cycles. After the plurality of circulation cycles of the purging fluid, the purging fluid is pumped out of the bearing and out of the apparatus. Then, the apparatus circulates a flushing liquid through the bearing through the first connection, through the bearing and through the second connection and back to the first connection by a plurality of circulation cycles. After the plurality of circulation cycles of the flushing fluid, the flushing fluid is pumped out of the bearing and out of the apparatus, and new grease is provided into the bearing as a final step.

[0024] Advantageously, as already mentioned above, a particle filter is provided, the particle filter being configured for only letting particles pass if smaller than a predetermined particle size, for example a particle size of 10 micrometer or 5 micrometer, and filter the larger particles. The method further comprises filtering the flushing fluid with the particle filter. For example, the particle filter is a mechanical filter with a pore size adapted for filtering the particles, for example with an average pore size of 10 micrometer or 5 micrometer. In order not to clog the filter with the debris and sludge from the purging of the bearing, the method advantageously comprises bypassing the particle filter with the purging fluid and only pumping the flushing fluid through the particle filter.

[0025] As a flushing fluid, oil has been found advantageous, especially low-viscous (15-100 cSt) hydraulic oil. Alternatively, a different composition can be used as flushing fluid, however, advantageously, it contains more than 50% oil. Generally, a useful viscosity of the flushing fluid is between 15 and 100 cST. As an example, this is useful when targeting a flushing rate of 5-20 l/min for a bearing having a diameter of 50-80 cm, which are typical dimensions for bearings in wind turbine generators.

[0026] It has been found useful to avoid water or at least reduce the content of water, why the flushing fluid should contain less than 10%, 5%, 3%, 2%, 1% or 0,5% of water.

[0027] For example, the method comprises selecting a flushing fluid with a specific viscosity, for example 15-100 cSt, and adjusting the pumping speed of the flushing fluid through the bearing at a pressure of less than 1 bar over ambient pressure to yield a Reynolds number for the flushing process through the bearing of between 500 and 3000.

[0028] For example, the purging fluid contains more than 50%, 60%, or 70% surfactant and contains less than 10% of water. As alternative to less than 10% of water, it contains less than 5%, 3%, 2%, 1% or 0.5% of water.

[0029] In case of alcohol ethoxylate as a surfactant, this is in contrast to the referenced prior art in the introduction where the content of alcohol ethoxylate is less than 50% and water is added to the formulation.

[0030] In the present invention, it is preferred that no water is added to the purging fluid, such that the water content is very low and, typically, only determined by the mninimum content of water as provided by commercially available surfactants. For example, alcohol ethoxylate surfactant products, typically, contain up to 0.5% water. However, this very small amount of water is acceptable and less damaging than in prior art cases, where substantial amount of water is added.

[0031] In case that the surfactant in the purging fluid shall be diluted, this can advantageously be done with oil, for example such that the oil content is at least 25%. By basically avoiding water and using oil instead, the cleaning of the bearing does not cause unnecessary damage of the bearing surface which would lead to a reduced lifetime of the bearing. The influence of the oil also prevents damage by the small natural content of water in the commercially available surfactant product.

[0032] Such purging fluids and flushing fluids as well as the method and apparatus as described above and below are advantageously used for purging hardened sludge from a bearing, especially of a bearing of a wind turbine generator; however, the described fluids can also be used in other units, such as other type of bearings, tanks or pipes with hardened sludge wherein the purging fluid contains more than 50% surfactant and contains less than 10%, 5%, 3%, 2% or 1% or 0.5% water.

[0033] In order to make efficient use of the fluids, the fluids are repeatedly circulated through the bearing. In case that

the method is performed quickly and with a compact apparatus, the apparatus in some embodiments is not provided with a specific heating unit. Although the pump may slightly raise the temperature of the fluid, this heating is so small that the pump itself cannot be regarded as a heating unit. Especially, in such embodiments, the apparatus has no heating unit that is configured for specifically heating the purging fluid and/or the flushing fluid above 25°C. As described above, if the operation of a wind turbine generator is interrupted for the cleaning process, the bearings would typically have a temperature of 40°C or higher, which is sufficient to heat the fluids even if the surroundings are much colder.

[0034] Examples of an apparatus for purging hardened sludge from a bearing, for example from a bearing of a wind turbine generator, are described in the following.

[0035] The apparatus comprises a pump with an inlet and an outlet for pumping liquid from the inlet to the outlet. It further comprises a first tube connection that is connected to the outlet of the pump and which has a first connecting part configured for connection to a connector of the bearing and a second tube connection that is connected to the inlet of the pump and which has a second connecting part for connecting to a second connector of the bearing. The first tube connection and the second tube connection and the pump are configured together with the bearing, when connected, to function as a circuit for repeated circulation of purging fluid and repeated circulation of flushing fluid from the pump through the first tube connection, through the bearing and through the second tube connection back to the inlet of the pump.

[0036] Advantageously, the apparatus comprises a particle filter configured for only letting particles pass if smaller than a predetermined particle size, for example 10 or 5 micrometer. For example, the apparatus comprises a by-pass flow line that is by-passing the particle filter, and the apparatus comprises a valve system that can toggle between fluid flow through the filter and fluid flow bypassing the filter. With such a system, the apparatus is configured for, in a first step, circulating a purging fluid through the bearing while by-passing the filter and configured, in a subsequent step, circulating a flushing fluid through the bearing while filtering the flushing fluid by the filter. This two step cleaning process has been described above.

[0037] In certain embodiment, the apparatus comprises a safety valve provided in the first tube connection between the outlet of the pump and a connector of the bearing. The safety valve is configured for discharging purging fluid or flushing fluid, respectively, from the apparatus in case that the pressure in the first tube connection is higher than a predetermined pressure level for thereby protecting the bearing from being exposed to overpressure. For example, such overpressure is 0.2, 0.3, 0.5 or even 1 bar above atmospheric pressure. However, typically, it is less than 1 bar over atmospheric pressure.

[0038] Optionally, the apparatus comprises a suction hose having first and second opposite ends, the first end being connected to the inlet of the pump and the second end being configured for selective switching between a connection to a first reservoir with purging fluid for receiving purging fluid by suction from the first reservoir and a second reservoir with flushing fluid for receiving flushing fluid by suction from the second reservoir. The reservoirs are advantageously not part of the apparatus but are only provided for supply the fluids, if it is desired to have a compact apparatus. They may be cans that are part of the commercial product of the fluid.

[0039] Useful for such embodiments, it is if the apparatus comprises a first valve between the inlet of the pump and the second end of the suction hose. The circulation of purging fluid and circulation of flushing fluid in the circuit is thus performed, while the first valve is closed and the first and second reservoir are decoupled from the circuit.

[0040] Optionally, the apparatus comprises a discharge tube with a first discharge tube end and a second discharge tube end, wherein the first discharge tube end is connected to the outlet of the pump and the second discharge tube end is configured for discharge of purging fluid or flushing fluid, respectively, from the apparatus. A discharge valve may be provided between the second discharge tube end and the outlet of the pump for decoupling the discharge tube from the circuit when the purging fluid or flushing fluid, respectively, is circulating in the circuit.

[0041] Useful products as purging fluid have been found among alcohol ethoxylates. An example is an alcohol ethoxylate based on cetyl oleyl alcohol, for example with 2-6 moles of ethylene oxide. Alternatively alcohol ethoxylates based on C13 alcohols have been found useful as well.

SHORT DESCRIPTION OF THE DRAWINGS

[0042] The invention will be explained in more detail with reference to the drawing, which is a schematic illustration of an embodiment of the invention

DETAILED DESCRIPTION / PREFERRED EMBODIMENT

[0043] The drawing is a principle sketch of an embodiment of the invention. It shows an apparatus with a circulating system for purging fluid through a bearing 16. The apparatus comprises a suction hose 3 for selective suction of purging fluid from a purging fluid tank 1 or flushing fluid from a flushing fluid tank 2. The apparatus further comprises connection means 15 for connecting the apparatus to corresponding connectors at the bearing 16. Typically, such bearings have multiple connectors, which are also used in order to increase the flushing speed and increase turbulence for efficient

flushing. The apparatus also comprises a hose 24 for disposing purging fluid and flushing fluid to a waste tank 22.

[0044] Purging fluid from a purging fluid tank 1 is sucked by pump 6 via the suction hose 3 into the circuit of the apparatus, while ball valve 4 is open. The pump 6 is driven by the electric motor 5. Pressure is measured by a pressure gauge 7. The purging fluid is pumped to the three-way valve 8, where it by-passes the filter 9 through check valve 10 and is lead through check valve 11 into valve block 12. Check valve 11 ensures that the fluid does not flow backwards into the filter 9.

[0045] In the valve block 12, the fluid is spilt up into several directions by the four flow control valves 26. Alternatively, the fluid is released from the valve block 12 again through a pressure relief valve 25, from which the fluid flows back to the suction side of the pump 6 if the relief valve 25 gets activated. The fluid is circulated a number of times. It is pointed out that the number of four valves 26 in the valve block 12 is not limiting but only an example.

[0046] Downstream of the four flow control valves 26 there are provided pressure gauges 27. The purging fluid is pumped from the valve block 12 through the flow control valves 26 to the unit 16 to be cleaned, such as a bearing 16 as illustrated in the figure. Typically, the connectors 14, 15 between the bearing 16 and the apparatus comprise quick couplings. It is seen that the purging fluid for the bearing 16 is supplied as various connectors. One return line 29 is connected via a quick coupling to the lower part of the bearing 16.

[0047] One fluid line 28 with connector 14, for example with a quick coupling, is peculiar in having an automatic air vent valve 13, which releases air if in the system, and which is mounted between the valve block 12 and the connector 14. This line 28 should advantageously be at the highest point of the bearing 16.

[0048] Further, a safety pressure check valve 23 is used as a safety function in order to prevent pressure in the circuit and bearing 16 above a predetermined value, which safeguards that no damage is done on the bearing 16 during flushing. The arrangement with the air vent valve 13 and check valve 23 protects the sealing of the bearing 16 against overpressure that accidentally could move the sealing from its seat. In case of overpressure, fluid is guided out of the apparatus via hose 24 and to the waste tank 22.

[0049] When the purging fluid has dissolved the aged grease (old and / or hardened grease) the mix of purging fluid and aged grease is pumped out of the apparatus via hose 21 and into the waste tank 22 by opening the ball valve 20.

[0050] When the purging fluid has been pumped out of the apparatus and the bearing 16, the apparatus is switched to take in flushing liquid from tank 2. Accordingly, ball valves 19 and 20 are closed when starting the pumping process with suction by pump 6 from the flushing liquid tank 2. The process is slightly different than for the purging fluid. Fluid from the flushing fluid tank 2 is suctioned out via the suction hose 3 and through opened ball valve 4 into the pump 6. The flushing fluid is pumped to the three-way valve 8 from which it flows through the filter 9 and via check valve 11 to the valve block 12. If the filter 9 is blocked, the flushing fluid is by-passing the filter 9 via the check valve 10 in order to safeguard a flow. In the valve block 12, the fluid is spilt up into several directions by the four flow control valves 26. Alternatively, the fluid is released from the valve block 12 through a pressure relief valve 25, from which the fluid flows back to the suction side of the pump 6 if the relief valve 25 gets activated. In normal flushing operations, the fluid is circulated a number of times through the bearing 16. Once, the flushing fluid has flushed out contaminants from the bearing 16, the flushing fluid is pumped out with the pump 6 by open the ball valve 20 and via hose 21 into the waste tank 22.

[0051] When the flushing fluid has been pumped out of the bearing 16, the pump is stopped and it is time to inspect / analyse the bearing 16 and re-grease it.

Number list:

1:	Purging fluid Tank (not part of invention)
2:	Flushing fluid Tank (not part of invention)
3:	Suction Hose (symbol for hose in general)
4:	Ball Valve
5:	Electric Motor for pump
6:	Pump
7:	Pressure Gauge
8:	Three Way Valve
9:	Filter
10:	Check Valve
11:	Check Valve
12:	Valve block with 1 relief valve, 4 pieces of flow control valves and 4 pieces of pressures gauges
13:	Air Vent Valve
14:	Connector for fluid supply to the bearing
15:	Connector for fluid supply to the bearing
16:	Unit to be cleaned e.g. bearing unit (not part of invention)

(continued)

17: Connector for fluid drainage from the bearing
18: Hose return to suction side of pump
19: Ball Valve
20: Ball Valve
21: Main Hose to Waste tank
22: Waste Tank (not part of invention)
23: Check Valve
24: Hose to Waste Tank (overflow)
25: Pressure relief valve
26: Flow Control Valves
27: Pressure gauge
28: Special flow line with Air Vent Valve 13
29: Return flow line
30: bypass line around valve 9

Claims

1. A method for purging hardened sludge from a bearing, for example from a bearing of a wind turbine generator, the bearing having a first connection for inlet of liquid and a second connection for outlet of liquid, wherein the method comprises

   - attaching an apparatus to the first connection and to the second connection, the apparatus comprising a pump for pumping purging fluid through the bearing, and by the apparatus circulating a purging fluid through the first connection, through the bearing and through the second connection and back to the first connection by a plurality of circulation cycles;
   - after the plurality of circulation cycles of the purging fluid, pumping the purging fluid out of the bearing;
   - then, by the apparatus circulating a flushing fluid, which is different from the purging fluid, through the bearing through the first connection, through the bearing and through the second connection and back to the first connection by a plurality of circulation cycles;
   - after the plurality of circulation cycles of the flushing fluid, pumping the flushing fluid out of the bearing;
   - providing new grease into the bearing;

2. A method according to claim 1, wherein a particle filter is provided, the particle filter being configured for only letting particles pass if smaller than a predetermined particle size of 10 micrometer, and wherein the method comprises filtering the flushing fluid with the particle filter.

3. A method according to claim 2, wherein the method comprises bypassing the particle filter with the purging fluid and only pumping the flushing fluid through the particle filter.

4. A method according to any preceding claim, wherein the flushing fluid is oil or contains more than 50% oil and less than 10% water.

5. A method according to any preceding claim, wherein the viscosity of the flushing fluid is between 15 and 100 cST.

6. A method according to claim 5, wherein the method comprises adjusting the pumping speed of the flushing fluid through the bearing at a pressure of less than 1 bar over ambient pressure to yield a Reynolds number for the flushing process through the bearing of between 500 and 3000.

7. A method according to claim 5 or 6, wherein the flushing rate is 5-20 l/min for a bearing having a diameter of 50-80 cm.

8. A method according to claim any preceding claim, wherein the purging fluid contains more than 50% surfactant and contains less than 1% water.

9. A method according to claim 8, wherein the surfactant is an alcohol ethoxylate.

10. A method according to claim 8 or 9, wherein the purging fluid contains at least 25% oil.

11. A method according to claim any preceding claim, wherein the method comprises circulating the purging fluid without heating the purging fluid by the apparatus.

12. An apparatus for purging hardened sludge from a bearing, for example from a bearing of a wind turbine generator, wherein the apparatus comprises a pump (6) with an inlet and an outlet for pumping liquid from the inlet to the outlet of the pump (6); the apparatus comprising a first tube connection that is connected to the outlet of the pump (6) and which has a first connecting part configured for connection to a connector (14, 15) of the bearing and a second tube connection (29) connected to the inlet of the pump and which has a second connecting part for connecting to a second connector (17) of the bearing (16), the first tube connection and the second tube connection (29) and the pump (6) being configured with the bearing, when connected, to function as a circuit for repeated circulation of purging fluid and repeated circulation of flushing fluid from the pump (6) through the first tube connection, through the bearing (16) and through the second tube connection (29) back to the inlet of the pump (6), while the first valve (4) is closed and the first and second reservoir (1, 2) are decoupled from the circuit; wherein the apparatus comprises a particle filter (9) configured for only letting particles pass if smaller than a predetermined particle size of 10 micrometer.

13. An apparatus according to claim 12, wherein the apparatus comprises a by-pass flow line (30) that is by-passing the particle filter (9); and wherein the apparatus comprises a valve system (8) that can toggle between fluid flow through the filter and fluid flow bypassing the filter; wherein the apparatus is configured for, in a first step, circulating a purging fluid through the bearing while by-passing the filter (9) and configured, in a subsequent step, circulating a flushing fluid through the bearing while filtering the flushing fluid by the filter.

14. An apparatus according to claim 12 or 13, wherein the apparatus comprises a safety valve (13) provided in the first tube connection between the outlet of the pump (6) and a connector (14) of the bearing (16), the safety valve (13) being configured for discharging purging fluid or flushing fluid, respectively, from the apparatus in case that the pressure in the first tube connection is higher than a predetermined pressure level for thereby protecting the bearing from being exposed to overpressure.

15. An apparatus according to anyone of the claims 12-14, wherein the apparatus comprises a suction hose (3) having first and second opposite ends, the first end being connected to the inlet of the pump (6) and the second being configured for selective switching between a connection to a first reservoir with purging fluid for receiving purging fluid by suction from the first reservoir and a second reservoir with flushing fluid for receiving flushing fluid by suction from the second reservoir; the apparatus comprising a first valve (4) between the inlet of the pump (6) and the second end of the suction hose (3).

16. An apparatus according to any one of the claims 12-15, wherein the apparatus is free from a heating unit capable of heating the oil above 25°C.

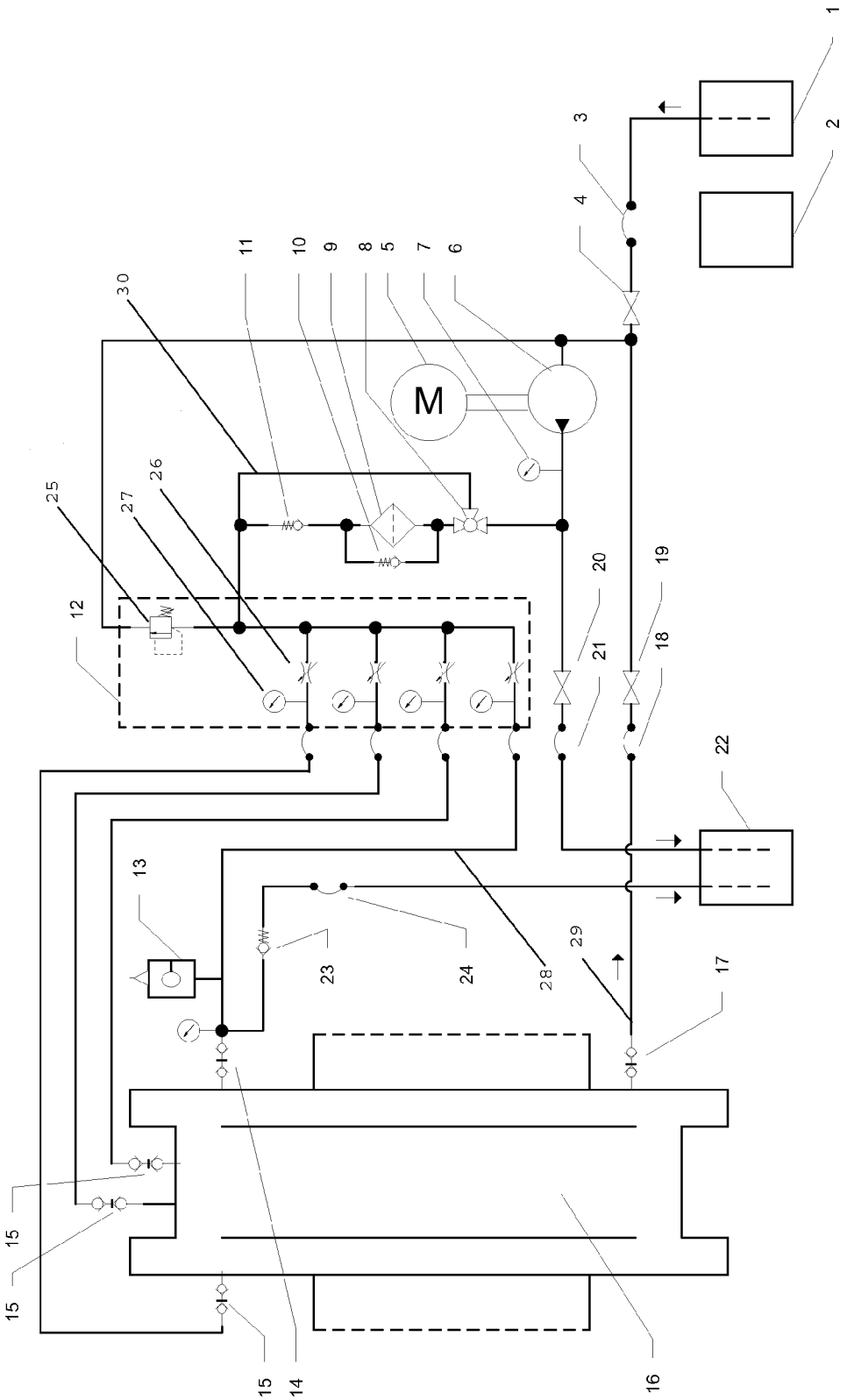
17. An apparatus according to any one of the claims 12-16, wherein the apparatus comprises a discharge tube (21) with a first discharge tube end and a second discharge tube end, wherein the first discharge tube end is connected to the outlet of the pump (6) and the second discharge tube end is configured for discharge of purging fluid or flushing fluid, respectively, from the apparatus; wherein a discharge valve (20) is provided between the second discharge tube end and the outlet of the pump (6) for decoupling the discharge tube (21) from the circuit when the purging fluid or flushing fluid, respectively, is circulating in the circuit.

18. Use of a purging fluid for purging hardened sludge from a bearing of a wind turbine generator, wherein the purging fluid contains more than 50% surfactant and contains less than 10% water.

19. Use according to claim 18, wherein the purging fluid contains more than 50% surfactant and contains less than 10% water and contains at least 25% oil.

20. Use according to claim 18 or 19, wherein the surfactant is an alcohol ethoxylate.

21. Use according to claim 20, wherein the alcohol ethoxylate based on cetyl oleyl alcohol.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Application Number
EP 13 16 9384

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