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MEASURING SYSTEM

The invention relates to a measuring system, comprising: a first pipe branch, through which a medium flows in a predefined flow direction, and a measuring device, which has a predefined nominal diameter, arranged in the first pipe branch and through which the medium flows, for determining and/or monitoring the flow and/or the viscosity of the medium.

Such measuring systems are used, for example, in bunker measuring systems on seagoing vessels, in which the medium is, for example, a lubricating oil provided for lubricating a seagoing vessel motor, which is supplied to the seagoing vessel motor from a bunker tank arranged on the seagoing vessel via the measuring system. Such a bunker system is described, for example, in WO2016/059132. In order to guarantee sufficient lubrication of the motor, it must be ensured that the seagoing vessel motor is supplied with a predefined quantity of lubricating oil. This is documented using the measured values of the flow meter of the measuring system, which must have a predefined accuracy for this.

In the case of flow measuring devices, in particular Coriolis flow measuring devices, this accuracy is essentially determined by the nominal diameter of the measuring device: the smaller the nominal diameter, the greater the accuracy. Due to the accuracy required for the measured value of the flow meter, there is, for example, a predefined, maximum permissible nominal diameter. With large flows, however, small nominal diameters lead to a high pressure loss. As a result, a compromise must be found between the desired accuracy and a reasonable pressure loss. A high pressure loss is also problematic, especially in combination with a high viscosity of the medium, since here, for example, adequate lubrication of the motor is no longer guaranteed.

US 2014/0123742 A1 discloses a measuring system for measuring fuel consumption, by means of which a measuring error of a Coriolis flow measuring device is reduced. To this end, the measuring system has a temperature regulation unit and a pressure-increase unit.

US 2006/0277982 A1 discloses a measuring system for continuously measuring a dynamic fluid consumption of a consumer by means of a continuously operating flow measuring device through which the flow can flow in both directions. This measuring system also has a temperature regulation unit and a pressure increasing unit.

The object of the invention is to reliably determine the flow and/or the viscosity in the measuring system for any nominal diameter (i.e. with any desired level of accuracy) without a high pressure loss and with low reliability at the measuring device.

The object is achieved by a measuring system, having: a first pipe branch, through which a medium flows in a predefined flow direction, a measuring device arranged in the first pipe branch and through which the medium flows, for determining and/or monitoring the flow and/or the viscosity of the medium, wherein the measuring device has a predefined nominal diameter, and a preparation system arranged in the predefined flow direction in the first pipe branch in front of the measuring device. The preparation system has a pressure increasing unit configured to increase the pressure of the medium in the first branch pipe, comprising: a pump arranged in a pump section of the first branch pipe; and a first non-return valve, which is arranged in a first section of the first pipe branch parallel to the pump section, wherein the first non-return valve can be flowed through if a first predefined setpoint pressure is reached and only in a direction opposite to the predefined flow direction. The preparation system also has a temperature regulation unit designed to control the temperature of the medium in the first pipe branch, comprising: at least one heat element, at least one first temperature measuring device and a control/evaluation unit connected to the heat element and the first temperature measuring device.

The pump in the pump section serves, on the one hand, as a booster pump. Due to the fact that the first non-return valve is arranged in a first section of the first pipe branch parallel to the pump section, a proportion of the medium is also conducted by the pump into this section parallel to the pump section. Due to the non-return valve, this parallel first section can only be passed in one direction opposite to the predefined flow direction and only in the event that the pressure of the medium is greater than the first predefined target pressure. Therefore, the medium first flows through the pump in the predefined flow direction, and then flows back against the predefined flow direction through the first section, which is parallel to the pump section, if the predefined target pressure is reached.

The pump section and the first section of the preparation system parallel thereto are connected to one another. When the predefined target pressure is reached, the medium is therefore conveyed in a circuit through these interconnected sections (pump section and the first section parallel thereto). The non-return valve ensures that the pressure increase in the pump section moves within a framework determined by the first setpoint pressure.

The invention preferably relates to media whose dynamic viscosity decreases with increasing temperature. This relationship between dynamic viscosity η and temperature T is often described using the Arrhenius-Andrade relationship, where η_0 is a material constant, R is the gas constant, and E_A is an activation energy:

$$\eta = \eta_0 \cdot \exp\left(\frac{E_A}{R \cdot T}\right)$$

If such a medium is heated by means of the heat element, this leads to a reduction in viscosity.

In a preferred embodiment, the heat element of the temperature regulation unit is arranged in the pump section. As a result, the pressure of the medium is additionally increased due to the heating of the medium in the pump section.

In particular, the heat element is arranged behind the pump in the predefined flow direction.

In the temperature regulation unit, the heat element or its heat output is controlled using the measured value of the first temperature measuring device. The first temperature measuring device can be designed, for example, as a resistance-based thermometer, such as a Pt100 or Pt1000, or as a thermal voltage-based thermometer or thermocouple, or another temperature measuring device known from the prior art.

The measuring system according to the invention thus enables the use of flow measuring devices with small nominal diameters in relation to the flow measured with them, without the problematic pressure drop mentioned at the outset occurring across the measuring device. A further advantage is that a medium which has flowed through the preparation system according to the invention has a reduced viscosity and therefore improved flow properties. Since the preparation system according to the invention influences the viscosity and/or the flow by heating the medium and increasing the pressure, the measuring system according to the invention is therefore suitable for applications in which it must be ensured that a medium with a known viscosity and/or a known flow is present, and that the measured value determined for the known viscosity and/or the known flow has a predefined accuracy. A typical application is the example mentioned above, in which the measuring device is used to monitor the lubrication of a motor.

Determination and/or monitoring by means of the measuring device of, for example, an originally present viscosity, i.e. the viscosity of the medium before it has flowed through the preparation system, is not provided within the scope of the invention due to the targeted influencing of the medium by the preparation system. The same applies to the flow.

The first temperature measuring device is preferably arranged in the first section parallel to the pump section.

According to the invention, the preparation system also has a second non-return valve, which is arranged in a second section of the first pipe branch parallel to the pump section

and which can be flowed through if a second predefined target pressure is reached and only in the flow direction, with the second predefined target pressure being lower than the first predefined target pressure is.
The parallel second section of the preparation system is also connected to the pump section. If, in normal operation, the pressure of the medium in the pump section is increased as intended by means of the working pump, the second non-return valve is not open in this normal operation, since in the parallel second section in the intended flow direction there is always a lower pressure in front of the second non-return valve than behind the second non-return valve. This relationship is reversed only in the event of a failure, for example when the pump is blocked and the medium can no longer flow through the pump section. In this case, the pressure in front of the second flow valve is higher than behind it in the flow direction. In the event that such a blockage of the pump causes a high pressure difference to build up, which is greater than the second predefined setpoint pressure, the second non-return valve opens and the medium can then pass through. A bypass for the pump is thus created by means of the second non-return valve, with which it is ensured that sufficient medium always flows through the first pipe branch. This is e.g. important for reliability in the case of the example mentioned above of lubricating a motor. Therefore, the second predefined setpoint pressure for the second non-return valve should be selected as small as possible. In particular, the predefined second setpoint pressure is lower by at least a factor of 5 than the first predefined setpoint pressure of the first non-return valve.
In a further embodiment of the invention, the pump is a gear pump.
In an advantageous development of the invention, the preparation system and the measuring device have a second pipe branch parallel to the first pipe branch and valves arranged in the first pipe branch and/or the second pipe branch. The first and the second pipe branch are connected to one another. Depending on the setting of the valves, the medium flows either via the first pipe branch or via the second pipe branch in the intended flow direction.
The medium flows via the first pipe branch, in particular during normal operation, whereas the medium flows via the second pipe branch during maintenance or emergency operation. In normal operation, the medium first flows through the preparation system and then through the measuring device. The second pipe branch therefore serves in particular as a bypass for the preparation system and the measuring device, which can be bridged by means of a corresponding setting of the valves, for example in the event of maintenance and/or replacement of components arranged in the first pipe branch. The

valves are designed, for example, as manually operable ball valves.

In an advantageous development of the invention, the temperature regulation unit has a second temperature measuring device connected to the heat element and the control/evaluation unit. The second temperature measuring device and the control/evaluation unit are designed to trigger an alarm in a control unit and/or switch off the heat element when a pre-definable limit temperature is exceeded.

This ensures that the temperature of the medium can continue to be monitored with the temperature regulation unit, for example in the event of a failure of the first temperature measuring device used to control the temperature. In particular, the second temperature measuring device is used to generate alarms and, if necessary, to switch off the heat element. The second temperature measuring device can also be designed, for example, as a resistance-based thermometer, such as a Pt100 or Pt1000, or as a thermal voltage-based thermometer or thermocouple, or another temperature measuring device known from the prior art.

The control unit is, for example, a programmable logic controller (in short, PLC). The control unit can also include a display unit configured to display the alarm, such as a display or flashing LEDs.

In a particularly advantageous embodiment, the measuring device is a Coriolis measuring device for determining the flow and/or the viscosity, which has a nominal diameter smaller than DN 15, preferably smaller than DN 10, as the predefined nominal diameter.

Such measuring devices are manufactured and sold by the applicant in different configurations. A Coriolis measuring device enables the flow or viscosity to be determined very precisely. For a more detailed explanation of the underlying measuring principle of a generic Coriolis measuring device, see DE 10 201 4119427 DE, DE 10 2011 006 971 A1, DE 10 2011 006 919 A1, US 2013/0319134 A1, US 8,281,668 B2 and US 6,415,668 B1.

Particularly with small nominal diameters, very high levels of accuracy can be achieved in the measurement. For example, with a nominal diameter of DN 8, there is an accuracy of 0.5%. With a nominal diameter of DN 15, on the other hand, there is an accuracy of 5%.

In one embodiment of the invention, the temperature regulation unit is designed to regulate the temperature in the first pipe branch to a predefined temperature with an accuracy of at least +/- 9 °C, in particular +/- 5 °C, with the predefined temperature in particular between 30 and 70 °C. This means that there is a maximum deviation of 9 °C from the predefined temperature (i.e. a setpoint temperature) by means of the temperature regulation unit.

In a further embodiment of the invention, the temperature regulation unit is designed to control the temperature in the first pipe branch to a predefined temperature with an accuracy of at least 30%. In the context of this application, unless explicitly stated otherwise, such a relative deviation in temperature is determined in degrees Celsius. In the case of a predefined temperature of 30 °C, the maximum deviation is just +/− 9 °C.

In an advantageous development of the invention, the measuring system has a third temperature measuring device which is arranged in the first pipe branch and is designed to trigger an alarm in the control unit if the temperature measured by the third temperature measuring device exceeds or falls below at least one further specifiable limit temperature. A first further specifiable limit temperature is, for example, an upper limit temperature, so that a “high alarm” is triggered in the control unit if this is exceeded. A second further specifiable limit temperature is, for example, a lower limit temperature, so that a “low alarm” is triggered in the control unit if the temperature falls below this. If both these lower and upper limit temperatures are present, the third temperature measuring device monitors that the temperature of the medium is within a temperature interval defined by the two further limit temperatures that can be predefined. The third temperature measuring device can also be designed, for example, as a resistance-based thermometer, such as a Pt100 or Pt1000, or as a thermal voltage-based thermometer or thermocouple, or another temperature measuring device known from the prior art.

In one embodiment of this advantageous development, the third temperature measuring device is arranged behind the measuring device in the predefined flow direction. Of course, it can also be arranged in front of the measuring device in the flow direction.

In a particularly advantageous development, the measuring system is provided on a seagoing vessel. The measuring system is designed to conduct the medium via the first or the second pipe branch from a bunker tank arranged on the seagoing vessel to a motor arranged on the seagoing vessel. As mentioned above, the measuring system is designed in particular to supply the medium to the motor via the first pipe branch in normal operation, whereas in maintenance or emergency operation the medium is supplied to the motor via the second pipe branch.

In one embodiment of this particularly advantageous development, the bunker tank is arranged above the motor in the vertical position in relation to the motor. As a result, the medium flows essentially due to gravity from the bunker tank to the motor.

Bunker tanks of this type are subject to restrictions, possibly defined in corresponding safety-significant standards, with regard to a minimum vertical distance between the motor or a pump arranged at the inlet of the motor and the level of the medium in the bunker tank. Only by means of the preparation system according to the invention can the requirements defined in the standards for the minimum vertical distance be met for the initially mentioned borderline cases of an initially highly viscous or cold medium and a high flow in this case, so that sufficient lubrication of the motor is guaranteed at the same time.

In a further embodiment of the measuring system according to the invention, the medium is a mineral oil. In particular, the medium is a fuel oil, a motor lubricating oil, or a heating oil.

In one embodiment of the invention, the medium is a motor lubricating oil according to the Society of Automotive Engineers (SAE) classification SAE 15 to SAE 60.

In one embodiment of the invention, the medium upstream of the preparation system has a kinematic viscosity (v) of at most 1880 mm^2/s.

In one embodiment of the invention, the medium upstream of the preparation system has a dynamic viscosity (η) of at most $1760 \cdot 10^{-3}$ Pa·s (millipascal seconds).

Kinematic viscosity (v) is related to dynamic viscosity (η) through density. The kinematic viscosity is usually used for motor lubricating oils.

In one embodiment of the invention, the kinematic viscosity of the medium at a temperature of 40° is between 30 and 400 mm^2/s.

In one embodiment of the invention, the kinematic viscosity of the medium at a temperature of 100 °C is between 5 and 30 mm^2/s.

The invention is explained in more detail with reference to the following figures, which are not true to scale, with the same reference symbols denoting the same features. If it is necessary for clarity or if it appears to make sense in some other way, reference symbols that have already been mentioned are omitted in the following figures. In the figures:

Figure 1: shows an embodiment of the measuring system according to the invention;

Figure 2: shows experimental investigations with the measuring system according to the invention;

Figure 3: shows a seagoing vessel with a measuring system according to the invention.

Figure 1 shows an embodiment of the measuring system 1 according to the invention. A bunker tank 20 with a free-flowing medium 3 contained therein is shown in the upper section. In normal operation, this is fed to a motor 21 in a planned flow direction DR via the first pipe branch 2. The medium 3 is, for example, an SAE 50 motor lubricating oil. In order to monitor the lubrication of the motor 21, a Coriolis flow measuring device 4 with a nominal diameter NW of DN 8 is arranged in the first pipe branch 2. Since such measuring devices 4 through which the medium 3 flows are also suitable for determining

and/or monitoring the viscosity, the invention is in no way limited to the use as a flow measuring device 4 described here and below.
The preparation system and the measuring device 4 can advantageously be bridged via a second pipe branch 15. The first 2 and/or the second pipe branch 15 are designed, for example, as pipelines made of steel. As a result, for example, the components arranged in the first pipe branch 2 can be exchanged and/or serviced during maintenance operations, or the measuring device 4 can be calibrated.
In order to bridge the first pipe branch 2, the ball valve valves 16a, 16b, 16c that can be operated manually in the first pipe branch 2 and in the second pipe branch 15 are arranged here. Depending on the setting, the medium 3 therefore flows in the intended flow direction DR either via the first pipe branch 2 (normal operation) or via the second pipe branch 15 (maintenance or emergency operation) from the bunker tank 20 to the motor 21.
The medium 3 flows through the preparation system 5 according to the invention in the first pipe branch 2 before it flows through the measuring device 4. In the embodiment of the measuring system 1 according to the invention shown here, three mutually parallel and interconnected sections of the first pipe branch 3 are provided in the preparation system 5: namely a pump section 7 through which the medium 3 flows in the previous flow direction DR, a first section 10a parallel to the pump section 7 and a second section 10b parallel to the pump section 7. A gear pump 8 and a heat element 12 are arranged in the pump section 7 in the predefined flow direction DR. The heat element 12 is, for example, a tubular heat element such as that manufactured and sold by the Schniewindt company. The heat element 12 is assigned to a temperature regulation unit 11 in combination with a controller assigned to a control/evaluation unit 14, such as a thyristor controller and a first temperature measuring device 13.
The pump 8 is assigned to a pressure-increasing unit 6 in combination with the first non-return valve 9a arranged in the first section 10a. The first non-return valve 9a permits flow only in the event that a first pressure p1 of 600 mbar is exceeded and only against the intended flow direction DR; this is illustrated by the arrow next to the first non-return valve 9a pointing counter to the predefined flow direction DR. As a result, the medium 3 can flow in a circuit formed by the pump section 7 and the first parallel section 10a. The first predefined pressure p1 of the first non-return valve 9a is used to monitor the increase in pressure in the pump section 7 by the pressure increasing unit 6.
In the event that the pump section 8 cannot flow through in the intended flow direction DR, for example due to a blockage of the pump 8, the medium 3 can alternatively flow through

the second parallel section 10b in the intended flow direction DR (see arrow next to p2). The second non-return valve 9b opens if the medium 3 flows onto the second non-return valve 9b with a pressure difference greater than the second pre-definable pressure p2 (here 20 mbar). This ensures increased reliability, since the permeability of the first pipe branch 2 is still guaranteed in the event of the pump 8 becoming blocked. The first non-return valve 9a and the second non-return valve 9b are designed, for example, as so-called disco non-return valves, in which the first pre-definable pressure p1 and the second pre-definable pressure p2 are set by means of a spring mechanism.

If necessary, in the event of a blockage of the pump 8, a warning is issued to a control unit 18 designed, for example, as a PLC, so that the blockage can then be eliminated. Naturally, the control/evaluation unit 14 of the temperature regulation unit 11 can also be part of this control unit 18.

The control unit 18, in combination with other temperature measuring devices 17, 19, is designed to monitor or issue various alarms, in particular also for temperature monitoring. In the embodiment shown here, at least a second temperature measuring device 17 and a third temperature measuring device 19 are provided for temperature monitoring. The second temperature measuring device 17 is arranged inside the heat element 12 designed as a tubular heat element and is designed to monitor the heat element 12 so that the heat element 12 is switched off if a pre-definable limit temperature T1, for example approx. 60 °C, is exceeded.

The third temperature measuring device 19 is arranged behind the flow measuring device 19 and thus in front of the motor 21 in the predefined flow direction DR and is used to monitor a further limit temperature T2, for example a lower limit temperature T2. This ensures that even after the flow meter 4, the medium 3 exceeds the further lower limit temperature T2 and thus meets the viscosity requirements needed to lubricate the motor 21.

The second temperature measuring device 17 and the third temperature measuring device 19 are designed here as intelligent temperature limit switches with a Pt100 sensor. A failure of the heat element 12, for example the fuse of the heat element 12, and/or a failure of the motor of the pump 8, are given to the control unit 18 as further alarms. The control unit 18 can also include a display unit configured to display the alarms, such as a display or flashing LEDs.

Fig. 2 shows experimental investigations by the applicant, in which the measuring system 1 according to the invention shown in Fig. 1 (see Fig. 2b) is compared with an otherwise identically configured measuring system without a preparation system 5 (Fig. 2a).

The medium 3 and its initial pressure and density are the same in both cases. Shown are the resulting pressure drop over the DN8 Coriolis flow measuring device 4 as unfilled circles (right scale) for mass flows from a range of 0-100 kg/h, as well as the measurement error of the Coriolis flow measuring device 4 (in percent, left scale, filled and unfilled squares). The temperature of the medium 3 is regulated from 20 °C to 55 °C with an accuracy of +/-5 °C by means of the preparation system 5 of the measuring system 1 according to the invention (Fig. 2b). This reduces the viscosity by approximately one order of magnitude. The pressure loss is also reduced by about one order of magnitude (cf. the different right-hand scales in Figs. 2a and 2b). The experimental investigations thus demonstrate the advantageous reduction in pressure loss across the Coriolis measuring device 4 with a simultaneous reduction in viscosity, and thus an improvement in the flow properties of the medium 3.

The measuring system 1 according to the invention is preferably used in a mobile application, for example in the motorized seagoing vessel 22 shown in Fig. 3. Here, the measuring system 1 is used in combination with a bunker tank 20 with lubricating oil for lubricating the motor 21 of the seagoing vessel 22. The bunker tank 20 is arranged elevated in its vertical position in relation to the motor 21, so that the medium 3 flows from the bunker tank 20 to the motor 21 due to gravity.

Irrespective of the fact that the invention was explained in connection with a flow measuring device for determining and/or monitoring the flow, the invention is of course not limited to this exemplary embodiment, but is also applicable to the example of determination and/or viscosity mentioned at the outset, for example the dynamic viscosity η by means of a flow mass meter.

Reference signs and symbols

1	Measuring system
2	First pipe branch
3	Medium
4	Measuring device
5	Preparation system
6	Pressure increase unit
7	Pump section
8	Pump
9a, 9b	First/second non-return valve
10a, 10b	First/second section of the first pipe branch

11	Temperature regulation unit
12	Heat element
13	First temperature measuring device
14	Control/evaluation unit
15	Second pipe branch
16a, 16b, 16c	Valves
17	Second temperature measuring device
18	Control unit
19	Third temperature measuring device
20	Bunker tank
21	Motor
22	Seagoing vessel
DR	Predefined flow direction
NW	Nominal diameter
p1, p2	First/second predefined target pressure
T1	Pre-definable limit temperature
T2, T3	Further pre-definable limit temperatures
η	Dynamic viscosity
ν	Kinematic viscosity

MÅLESYSTEM

Patentkrav

1. Målesystem (1), der omfatter:

   en første ledningsforgrening (2), som et medium (3) strømmer igennem i en fastlagt gennemstrømningsretning (DR),

   et måleapparat (4), der er placeret i den første ledningsforgrening (2) og gennemstrømmes af mediet (3), til bestemmelse og/eller overvågning af mediets (3) gennemstrømning og/eller viskositet, hvor måleapparatet (4) har en fastlagt nominel bredde (NW), og et forberedelsessystem (5), der er placeret i den fastlagte gennemstrømningsretning (DR) i den første ledningsforgrening (2) inden måleapparatet (4),

   - med en trykforøgelsesenhed (6), som er udformet til forøgelse af mediets (3) tryk i den første ledningsforgrening (2), og som omfatter: en pumpe (8), der er placeret i et pumpeafsnit (7) i den første ledningsforgrening (2); og

     en første kontraventil (9a), der er placeret i et første afsnit (10) af den første ledningsforgrening (2), der er parallelt med pumpeafsnittet (7), hvor den første kontraventil (9a) kan gennemstrømmes, hvis der nås et første fastlagt indstillingstryk (p1), og kun i en retning modsat af den fastlagte gennemstrømningsretning (DR); og
   - med en temperaturreguleringsenhed (11), som er udformet til regulering af mediets (3) temperatur i den første ledningsforgrening (2), og som omfatter:

     mindst ét varmeelement (12),

     mindst et første temperaturmåleapparat (13,..) og

     en regulerings-/analyseenhed (14), der er forbundet med varmeelementet (12) og det første temperaturmåleapparat (13), kendetegnet ved, at

   forberedelsessystemet (5) indeholder en anden kontraventil (9b), som er placeret i et andet afsnit (10b) af den første ledningsforgrening (2), der er parallelt med pumpeafsnittet (7), og som kan gennemstrømmes, hvis der nås et andet fastlagt indstillingstryk (p2), og kun i gennemstrømningsretningen (DR), hvor det andet fastlagte indstillingstryk (p2) er mindre end det første fastlagte indstillingstryk (p1), særligt mindst med en faktor 5.

2. Målesystem (1) ifølge krav 1,

hvor pumpen (8) er en tandhjulspumpe.

3. Målesystem (1) ifølge i det mindste et af de foregående krav,
hvor forberedelsessystemet (5) og måleapparatet (4) indeholder en anden ledningsforgrening (15), der er parallel med den første ledningsforgrening (2), og ventiler (16a, 16b, 16c...), der er placeret i den første ledningsforgrening (2) og/eller anden ledningsforgrening (15),
og hvor mediet (3) afhængigt af ventilernes (16a, 16b, 16c…) indstilling enten strømmer via den første ledningsforgrening (2) eller via den anden ledningsforgrening (15) i den planlagte gennemstrømningsretning (DR).

4. Målesystem (1) ifølge i det mindste et af de foregående krav,
hvor temperaturreguleringsenheden (11) indeholder et andet temperaturmåleapparat (17), der er forbundet med varmeelementet (12) og regulerings-/analyseenheden (14), og hvor det andet temperaturmåleapparat (17) og regulerings-/analyseenheden (14) er udformet til i forbindelse med en overskridelse af en grænsetemperatur (T1), der kan fastlægges, at udløse en alarm i en kontrolenhed (18) og/eller frakoble varmeelementet (12).

5. Målesystem (1) ifølge i det mindste et af de foregående krav,
hvor måleapparatet (4) er et Coriolis-måleapparat til bestemmelse af gennemstrømningen og/eller viskositeten, der som fastlagt nominel bredde (NW) har en nominel bredde, der er mindre end DN 15, fortrinsvis mindre end DN 10.

6. Målesystem (1) ifølge i det mindste et af de foregående krav,
hvor temperaturreguleringsenheden (11) er udformet til at regulere temperaturen i den første ledningsforgrening (2) til en fastlagt temperatur med en nøjagtighed på mindst 9 °C, særligt mindst 5 °C,
og hvor den fastlagte temperatur særligt ligger mellem 30 og 70 °C.

7. Målesystem (1) ifølge i det mindste et af de foregående krav,
hvor målesystemet (1) indeholder et tredje temperaturmåleapparat (19), som er placeret i den første ledningsforgrening (2), og som er udformet til at udløse en alarm i kontrolenheden (18), hvis temperaturen, der måles af det tredje temperaturmåleapparat (19), i det mindste over- eller underskrider en yderligere

grænsetemperatur (T2; T3), der kan fastlægges.

8. Målesystem (1) ifølge krav 7,
hvor det tredje temperaturmåleapparat (19) er placeret efter måleapparatet (4) i den fastlagte gennemstrømningsretning (DR).

9. Målesystem (1) ifølge i det mindste et af de foregående krav 3 til 8,
hvor målesystemet (1) er tilvejebragt på et fartøj (22),
og hvor målesystemet (1) er udformet til at føre mediet (3) via den første ledningsforgrening (2) eller den anden ledningsforgrening (15) fra en bunkertank (20), der er placeret på fartøjet (22), til en motor (21), der er placeret på fartøjet.

10. Målesystem ifølge krav 9,
hvor bunkertanken (20) i den vertikale position i forhold til motoren (21) er placeret over motoren (21),
således at mediet (3) i det væsentlige som følge af tyngdekraften strømmer fra bunkertanken (20) til motoren (21).

11. Målesystem ifølge i det mindste et af de foregående krav,
hvor mediet (3) er en mineralolie, særligt en brændstofolie eller en motorsmøreolie.

12. Målesystem ifølge i det mindste et af de foregående krav, hvor mediet (3) inden gennemstrømningen gennem forberedelsessystemet (5) har en dynamisk viskositet (η) på maksimalt $1760*10^{-3}$ Pa·s.

13. Målesystem ifølge i det mindste et af de foregående krav, hvor mediet (3) inden gennemstrømningen gennem forberedelsessystemet (5) har en kinematisk viskositet (ν) på maksimalt 1880 mm^2/s.

14. Målesystem ifølge i det mindste et af de foregående krav, hvor mediets (3) kinematiske viskositet (ν) ved en temperatur på 40 °C ligger på mellem 30 og 400 mm^2/s.

15. Målesystem ifølge i det mindste et af de foregående krav, hvor mediets (3)

kinematiske viskositet (v) ved en temperatur på 100 °C ligger på mellem 5 og 30 mm^2/s.

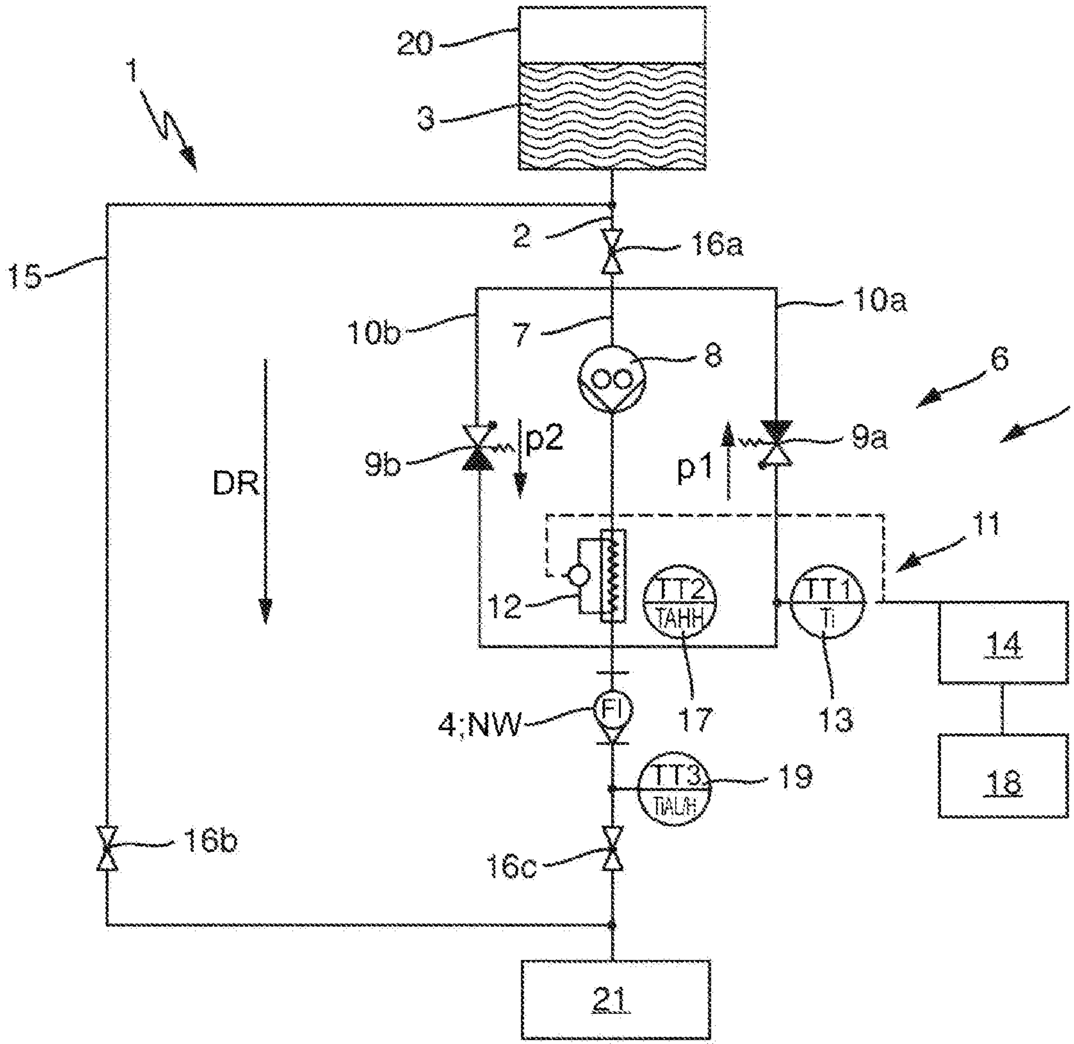
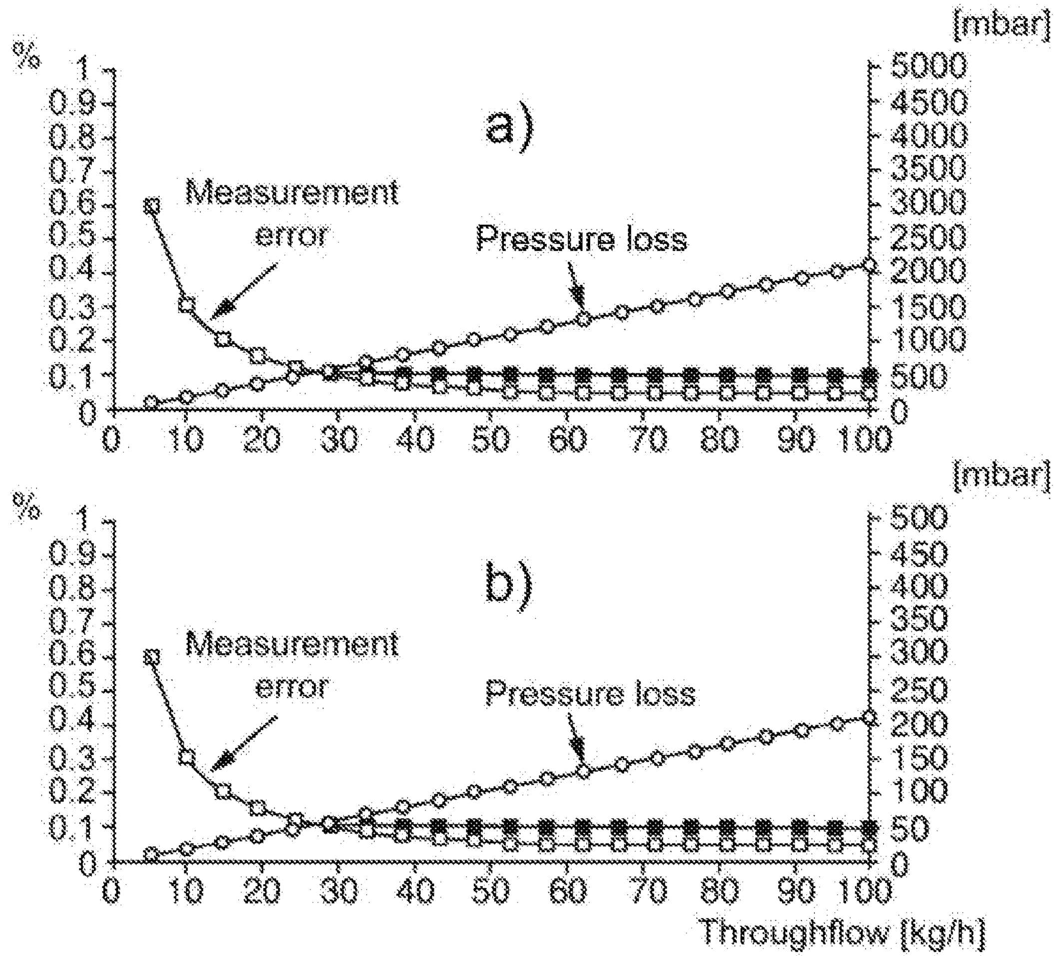
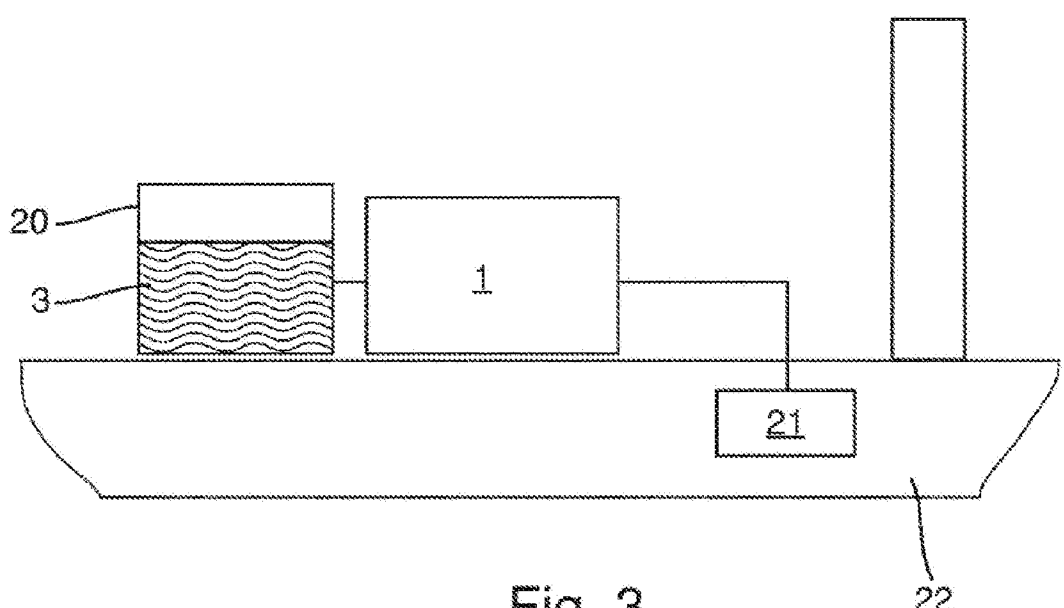

20
3
1
2
16a
15
10b
7
8
10a
6
5
9b
p2
DR
p1
9a
11
12
TT2
TAHH
TT1
Ti
14
4;NW
FI
17
13
18
TT3
19
16b
16c
21

Fig. 1



%
[mbar]
a)
Measurement
error
Pressure loss
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0 10 20 30 40 50 60 70 80 90 100
%
[mbar]
b)
Measurement
error
Pressure loss
500
450
400
350
300
250
200
150
100
50
0
Throughflow [kg/h]

Fig. 2



20
3
1
21
22

Fig. 3