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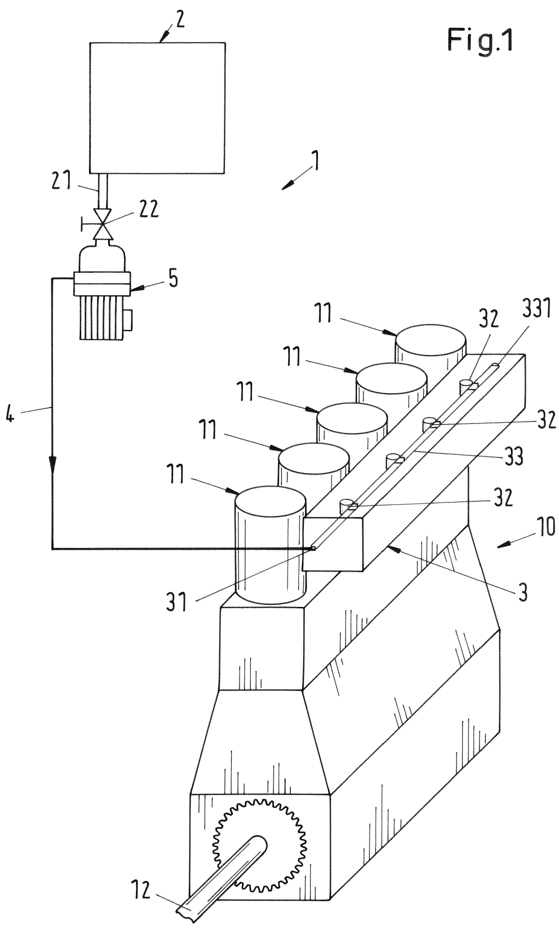
(54) **LUBRICATION ARRANGEMENT FOR A LARGE DIESEL ENGINE**

(57) A lubrication arrangement is proposed for the lubrication of cylinders (11) of a large diesel engine (10), comprising a reservoir (2) for a lubricant, a lubrication device (3) for being mounted to the large diesel engine (10), and a supply line (4) connecting the reservoir (2) with an inlet (31) of the lubrication device (3) for delivering the lubricant from the reservoir (2) to the lubrication device (3), wherein the lubrication device (3) comprises a plurality of injection pumps (32) for delivering the lubricant into the cylinders (11), and wherein a feed pump (5) is provided, which is arranged to pressurize the lubricant in the supply line (4), so that the lubricant is supplied with an overpressure to the inlet (31) of the lubrication device (3). In addition, a combination of a lubrication arrangement and a large diesel engine is proposed.

Fig.1



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Description

[0001] The invention relates to a lubrication arrangement for the lubrication of cylinders of a large diesel engine and a combination of such a lubrication arrangement with a large diesel engine in accordance with the preamble of the independent claim of the respective category.

[0002] Large diesel engines, which can be designed as two-stroke or four-stroke engines, for example as large two-stroke diesel engine with longitudinal scavenging, are often used as main propulsion units for ships or also in stationary operation, for example for driving large generators for the production of electrical power. Here as a rule the engines are in constant operation over a considerable period of time which makes high demands on the operating reliability and availability. For this reason, for the operators, long and predictable intervals between services, low degrees of wear and, an economical use of fuel and operating materials are central criteria for the operation of the engine.

[0003] Especially in view of the growing requirements regarding protection of the environment the operation of large diesel engines becomes more and more demanding. Large diesel engines are mostly operated with heavy oil that requires specific measures with regard to the exhaust resulting from the combustion. In view of the stronger statutory provisions regarding the limitation of exhaust a need exists now for several years for large engines, which can be operated with at least two different fuels. These different fuels may be e.g. two different liquid fuels or a liquid fuel and a gaseous fuel. Such engines are usually called multi-fuel engines and they can be switched during operation from the combustion of one fuel to the combustion of a second, different fuel and vice versa. Liquid or gaseous fuels that may be combusted alternatively in a multi-fuel large diesel engine comprise beside heavy oil, marine diesel or diesel in particular alcohols such as methanol or ethanol, natural gases such as LNG (liquefied natural gas), emulsions or suspensions.

[0004] One example for emulsions that are nowadays used as fuel in large engines is MSAR (multiphase superfine atomised residue). These are essentially emulsions of a heavy hydrocarbon, e.g. bitumen, heavy oil or the like in water, which are produced with special processes. An example for suspensions that are used as fuel for large engines is a suspension of pulverized coal in water.

[0005] A specific type of a multi-fuel engine is an engine that is usually referred to as "dual-fuel engine" or "dual-fuel motor". These are engines that can be operated with two different fuels. In a gas mode a gas, for example natural gas like LNG (liquefied natural gas) or another suited gas for operating an internal combustion engine is used for the combustion in the cylinders. In a liquid mode a suited liquid fuel like gasoline, diesel, marine diesel or heavy oil is used for the combustion in the cylinders of the same engine.

[0006] Within the scope of this application the term "large diesel engine" or the like encompasses also multi-fuel engines, dual-fuel engines and such large engines, which can be operated beside the diesel operation, that is characterized by the self-ignition of the fuel, also in an Otto operation, that is characterized by an external ignition, or in a mixed form of these two operations. More generally the term "large diesel engine" also encompasses large engines, which can be operated alternatively with at least two different fuels, wherein at least one of the fuels is suited to operate the engine according to the diesel method of operation.

[0007] For a reliable, economical and low-wear operation of a large diesel engine the lubrication of the cylinders, more precisely the lubrication between the respective cylinder wall or cylinder liner and the piston moving back and forth along the running surface formed by this cylinder wall or liner, is of utmost importance.

[0008] There are many solutions known in the art to deliver a lubricant to the running surface of a cylinder, whereupon the location and the number of lubrication openings on the running surface and/or the piston, the amount of lubricant that is supplied to the lubrication openings and the timing of the lubrication relative to the working cycle of the piston are important parameters. During operation of the large diesel engine some of these parameters may be changed depending for example on the actual load at which the engine is operated or the actual fuel that is used for the combustion.

[0009] Modern large diesel engines are fully electronically controlled and usually comprise a control system which controls all motor functions, such as the fuel injection, the exhaust valve timing and also the lubrication of the cylinders, in particular the amount of supplied lubricant and/or the timing of the lubrication.

[0010] According to one known solution a lubrication device is provided that is designed as a lubrication rail. The lubrication rail extends along all the cylinders of the engine and comprises a plurality of injection pumps arranged in proximity of the cylinders. For example one separate injection pump is provided for each cylinder, i.e. each cylinder has its own separate injection pump for the lubricant. Quite often each injection pump is configured as a dosing pump for supplying a metered amount of lubricant per lubrication act to the respective cylinder. The outlet of each injection pump is connected to at least one lubrication opening arranged at the running surface (cylinder wall or liner) and/or at the piston of the respective cylinder. Usually each cylinder comprises a plurality, for example 4-10 lubrication opening which are e.g. arranged at different locations of the running surface, and which are all fed by the same injection pump associated with the respective cylinder.

[0011] The respective inlet of each of the injection pumps arranged in the rail is provided with lubricant. To this end the lubrication rail comprises an inlet for the lubricant and this common inlet is in fluid communication with each of the individual injection pumps. The inlet of the lubrication rail is connected by means of a supply line to a reservoir for example a tank for the lubricant.

[0012] In case of large diesel engines used as main propulsion units for ships said reservoir for the lubricant, also referred to as "daily tank" or "service tank" is usually located some distance away from the large diesel engine and supported directly by the ship hull, whereas the lubrication rail constitutes a part of the engine and is directly mounted to the engine. Thus, the reservoir for the lubricant is usually delivered and mounted by the shipyard, whereas the lubrication rail is delivered as part of the engine by the engine manufacturer. After installation of the reservoir for the lubricant at the ship side and installation of the large diesel engine at the engine side, the supply line is mounted to connect the reservoir with the inlet of the lubrication rail.

[0013] It is state of the art that the delivery of the lubricant from the reservoir to the inlet of the lubrication rail is only driven by gravity. This necessitates that the reservoir for the lubricant, more precisely the bottom of this reservoir, has to be located at a level above the level of the inlet of the lubrication rail, i.e. the bottom of the reservoir has to be located higher with respect to the direction of gravity than the inlet of the lubrication rail. As a rule of thumb, in such gravity fed lubrication systems the gravity produces approximately 0.1 bar head pressure per vertical meter. From practice it is known that the inlet pressure of the lubricant at the inlet of the lubrication rail should be approximately 0.3 bar overpressure to enable the operation of the lubrication rail. Consequently, the bottom or the outlet of the reservoir for the lubricant has to be located at an elevation of at least three meters (vertical distance) above the inlet of the lubrication rail. This requires a considerable amount of space and imposes restrictions regarding the location of the reservoir for the lubricant, which is a drawback of such known systems.

[0014] Another problem is the temperature of the lubricant. Lubricants that are used for the cylinder lubrication in large diesel engines are usually high viscosity oils (e.g. SAE 50). Depending for example on the ambient temperature and the actual load at which the engine is operated, the reservoir and/or the lubrication rail are quite cold whereby the lubricant becomes even more viscid. The high viscosity of the lubricant caused by its low temperature may become critical and endanger the proper operation of the lubrication system. A malfunction of the lubrication system or an insufficient lubrication of the cylinders may cause severe damages of the engine. Therefore it is a known measure to provide large supply lines having a considerable diameter. In addition, heating devices are provided at the reservoir for the lubricant and/or at the supply line between the reservoir and the inlet of the lubrication rail in order to increase the temperature of the lubricant and therewith ensure an easy and reliable flow of the lubricant into the injection pumps. As an example, the lubricant is heated to such an extent that it enters the lubrication rail with a temperature of 35°C. However, these heating devices cause additional costs, are an additional potential source for disturbances and - depending on the ambient conditions (such as temperature) cannot always ensure a sufficient heating of the lubricant.

[0015] Starting from this state of the art it is therefore an object of the invention to propose a lubrication arrangement for the lubrication of cylinders of a large diesel engine which is simple and nevertheless ensures a reliable cylinder lubrication for all operational states of the large diesel engine. Furthermore, it is an object of the invention to propose a combination of such a lubrication arrangement with a large diesel engine.

[0016] The subjects of the invention satisfying these objects are characterized by the features of the independent claim of the respective category.

[0017] Thus, in accordance with the invention, a lubrication arrangement is proposed for the lubrication of cylinders of a large diesel engine, comprising a reservoir for a lubricant, a lubrication device for being mounted to the large diesel engine, and a supply line connecting the reservoir with an inlet of the lubrication device for delivering the lubricant from the reservoir to the lubrication device, wherein the lubrication device comprises a plurality of injection pumps for delivering the lubricant into the cylinders, and wherein a feed pump is provided, which is arranged to pressurize the lubricant in the supply line, so that the lubricant is supplied with an overpressure to the inlet of the lubrication device.

[0018] By providing the feed pump to pressurize the lubricant in the supply line between the reservoir and the inlet of the lubrication device the lubricant is always delivered to the inlet of the lubrication device at an overpressure thus ensuring a proper operation of the lubrication device and in particular a sufficient supply of the injection pumps with the lubricant for all operational states of the large diesel engine. The overpressure of the lubricant at the inlet of the lubrication device ensures that the individual injection pumps are always properly filled between each lubrication act or working cycle.

[0019] In addition, since the supply of lubricant to the lubrication device is no longer driven by gravity only, there is no restriction regarding the location of the reservoir. Thus, it is for example possible to locate the reservoir at the same level -with respect to the direction of gravity- as the lubrication device. This results in a considerably space-saving design of the lubrication arrangement and in a larger flexibility regarding the location of the reservoir.

[0020] Furthermore, since the lubricant is delivered to the inlet of the lubrication device at an overpressure the lubrication arrangement becomes considerably less sensitive to the influence of temperature. As a consequence it may become possible to completely dispense with any heating device for the lubricant at the reservoir and/or at the supply line. This results in a much simpler design of the lubrication arrangement and reduces the costs because no heating devices are required.

[0021] In addition, since the lubricant is delivered to the inlet of the lubrication device by means of the feed pump, the influence of the viscosity of the lubricant is considerably reduced, so that the supply line may be designed with a considerably smaller diameter as compared to known devices.

[0022] A further advantage of the lubrication arrangement according to the invention is the simplification when switching from one lubricant to a different lubricant. In particular in multi-fuel or dual-fuel engines the lubricant for the cylinder lubrication may be changed when the engine is switched from the combustion of a first fuel to the combustion to a second, different fuel. Depending on the properties of the respective fuel the change from one fuel to a different one may also require a switch from a first lubricant to a second lubricant to ensure a proper lubrication and as the case may be a neutralization of aggressive components contained in the respective fuel or generated upon combustion of the respective fuel. With the lubrication arrangement according to the invention such a change of the lubricant becomes much simpler.

[0023] According to a preferred design the feed pump is arranged closer to the reservoir than to the inlet of the lubrication device, so that the length of the supply line between the feed pump and the inlet is larger, preferably at least twice as large, as the length of the supply line between the reservoir and the feed pump.

[0024] Arranging the feed pump closer to the reservoir has the advantage that the pressure loss in the supply line is compensated by the feed pump and there is no or nearly no loss of suction pressure for the feed pump. If the feed pump were to be arranged close to the inlet of the lubrication device, the pressure loss caused by the friction of the lubricant in the supply line would reduce the suction pressure of the feed pump.

[0025] Preferably the feed pump is arranged at an outlet of the reservoir. This is a simple possibility to ensure that the entire supply line is always pressurized from the reservoir all the way to the lubrication device.

[0026] According to a preferred design the feed pump is mounted to a wall or to a bottom of the reservoir.

[0027] For a particularly efficient operation of the lubrication arrangement it is preferred that the feed pump is designed for supplying the lubricant to the inlet of the lubrication device with an overpressure of at least 0.5 bar (50 kPa), preferably at least 1 bar (100 kPa). The overpressure of the lubricant at the inlet of the lubrication device does not have to be very high because the overpressure shall only ensure that the injection pumps are always sufficiently provided with lubricant.

[0028] In a preferred embodiment the feed pump is designed for supplying the lubricant to the inlet of the lubrication device with an overpressure of at least 1.5 bar (150 kPa), preferably with an overpressure of approximately 1.5 bar (150 kPa). It has been found that an overpressure of approximately 1.5 bar at the inlet of the lubrication device is completely sufficient to ensure an adequate supply of the injection pumps with lubricant. Thus, the feed pump may be designed as quite a small pump. This is in particular advantageous in view of the costs for the feed pump as well as in view of the energy consumption.

[0029] Furthermore, it is preferred, that the feed pump is designed for supplying the lubricant to the inlet of the lubrication device with an overpressure of at most 3.0 bar (300 kPa), preferably at most 2 bar (200 kPa). This overpressure is sufficient for a reliable supply of lubricant to the lubrication device. Restricting the overpressure to 3 bar or 2 bar respectively has the advantage that the supply line as well as the connection to the lubrication device do not have to be designed as specific high pressure line or connections.

[0030] According to a further preferred measure the reservoir is connected to ambient pressure, so that the lubricant in the reservoir is not yet pressurized but at ambient pressure.

[0031] In view of an economical and energy saving operation it is a preferred measure that the feed pump is designed for a power consumption of at most 500 W, preferably at most 250 W.

[0032] Depending on the specific application or the specific large diesel engine, respectively, it may be preferred that the feed pump is designed for a power consumption of at most 50 W, preferably for a power consumption of approximately 20 W. This renders possible a particularly economic operation of the feed pump without endangering a proper operation of the lubrication arrangement.

[0033] Since a proper cylinder lubrication is crucial to a safe and reliable operation of a large diesel engine, it is preferred as a safety measure that the lubrication arrangement is having a backup feed pump for pressurizing the lubricant in the supply line in case of a failure of the feed pump.

[0034] Preferably the backup feed pump is arranged at the reservoir.

[0035] According to a preferred embodiment the supply line between the reservoir and the inlet of the lubrication device is the sole fluid connection for the lubricant between the reservoir and the lubrication device. Thus, the feed pump has to deliver only such an amount of lubricant which is actually consumed for a reliable cylinder lubrication. In particular, it is preferred that the lubrication arrangement does not comprise any recycling line for recycling any lubricant from the lubrication device back to the reservoir. Therefore, the feed pump has to deliver only the lubricant actually needed for the cylinder lubrication, but the feed pump has not to move any lubricant in a closed cycle or a cycle, i.e. from the reservoir to the lubrication device and then back to the reservoir. This measure considerably reduces the required energy consumption of the feed pump and may also reduce the size of the feed pump as well as the amount of pipework.

[0036] According to a preferred embodiment the lubrication device comprises one separate injection pump for each cylinder of the large diesel engine, i.e. the number of injection pumps equals the number of cylinders in the large diesel engine. This has the advantage that the lubrication of each cylinder may be controlled individually and independently from the other cylinders.

[0037] Furthermore it is preferred, that each injection pump is designed to supply a plurality of lubrication openings, each of which is located at the same cylinder for delivering the lubricant into said cylinder. This measure may improve the lubrication process in the respective cylinder.

[0038] In addition, according to the invention, a combination is proposed of a lubrication arrangement and a large diesel engine having at least one cylinder, in which a piston is arranged for a reciprocating movement between a top dead center and a bottom dead center, wherein the lubrication arrangement for the lubrication of all cylinders is designed according to the invention.

[0039] Preferably the lubrication device is mounted to the large diesel engine and the reservoir is arranged at a support structure different from the large diesel engine, preferably at a hull of a vessel.

[0040] In this configuration the lubrication device may be considered as a component of the large diesel engine, whereas the reservoir for the lubricant does not constitute a component of the large diesel engine but is mounted to a different support structure usually some distance away from the large diesel engine.

[0041] For this combination, where the lubrication device is mounted to the large diesel engine and the reservoir is mounted to a different support structure such as the hull of a vessel, it is preferred that the supply line is the sole fluid connection line between the reservoir and the large diesel engine. In particular, it is preferred that there is no return line for recycling any lubricant or any other fluid, such as system oil, from the large diesel engine to the reservoir. The reservoir contains only unused or fresh lubricant but no lubricant that has been used before for the lubrication of components of the diesel engine.

[0042] According to a preferred embodiment the large diesel engine is a large two-stroke diesel engine, and in particular as a large two-stroke engine with longitudinal scavenging.

[0043] According to a preferred embodiment the large diesel engine is a multi-fuel engine or a dual-fuel engine.

[0044] In particular, the large diesel engine may be designed as a dual fuel engine for the combustion of a liquid fuel, preferably heavy oil, and for the combustion of a gas, wherein it is preferred that the gas is supplied to the cylinder at a low pressure of at most 50 bar, preferably at most 20 bar.

[0045] Further advantageous measures and preferred embodiments of the invention result from the dependent claims.

[0046] The invention will now be explained in more detail with the help of the schematic drawing, which show:

Fig. 1: a schematic illustration of an embodiment of a lubrication arrangement according to the invention for the lubrication of cylinders of a large diesel engine.

[0047] Fig. 1 shows in a schematic representation of an embodiment of a lubrication arrangement according to the invention in combination with a large diesel engine. The lubrication arrangement is designated in its entity with reference numeral 1, and the large diesel engine is designated in its entity with reference numeral 10.

[0048] In the following description reference is made by way of example to an embodiment, wherein the large diesel engine 10 is designed as a large two-stroke diesel engine 10 with longitudinal scavenging. Since these large diesel engines 10 are well known in the art, there is no need for a detailed description. Furthermore, reference is made by way of example to the application that the large diesel engine 10 is the main propulsion unit of a ship or a vessel.

[0049] Of course, the invention is not restricted to this specific type of a large diesel engine 10. In particular, the large diesel engine 10 may be any type of large diesel engine as they are used for example as main propulsion units for ships or also in stationary operation, for example for driving large generators for the production of electrical power. The large diesel engine 10 can be designed as two-stroke or four-stroke engine. In particular, it is also possible that the large diesel engine 10 is designed as a multi-fuel engine for the combustion of a plurality of different liquid and/or gaseous fuels or as a dual fuel engine for the combustion of a liquid fuel and for the combustion of a gas, for example natural gas. The large diesel engine 10 may also be designed for being operated with more than two different fuels.

[0050] The large diesel engine 10 has at least one cylinder 11 but typically more, for example up to fourteen cylinders 11. Since it is sufficient for the understanding of the invention, in Fig. 1 there are shown as an example five cylinders 11. In each cylinder 11 a piston (not shown) is arranged for a reciprocating movement between a top dead center and a bottom dead center. The top side of the piston and a cylinder cover (not shown) together with the cylinder wall or a cylinder liner of the cylinder 11 are delimiting a combustion chamber, in which a fuel is injected for the combustion. Each cylinder 11 further comprises an exhaust valve (not shown) through which the combustion gases are discharged from the combustion chamber to an exhaust gas system (not shown). The movement of the pistons in the cylinders 11 drives the rotation of a crankshaft 12 which is connected to a propeller (not shown) for the propulsion of the ship.

[0051] As it is nowadays state of the art the large diesel engine 10 is operated in a fully electronically controlled manner. An engine control unit (not shown) operates and controls all functions of the large diesel engine 10, for example the operation of the exhaust valves for the gas exchange, the lubrication of the cylinders 11 and the injection process for the fuel, by way of electric or electronic signals and commands. In addition, the engine control unit receives information from several detectors, sensors or measuring devices.

[0052] For the lubrication of the cylinders 11, more precisely for the lubrication between the piston and the cylinder wall or the cylinder liner, respectively, along which the piston moves forth and back in the respective cylinder 11, the lubrication arrangement 1 is provided.

[0053] It has to be noted that the lubrication arrangement 1 is designed only for supplying lubricant to the cylinders 11 for the lubrication of the respective piston when moving along the cylinder wall or the cylinder liner, respectively. The lubrication arrangement 1 is not configured for supplying lubricant or any other fluid, such as a system fluid or a hydraulic oil, to any other component of the diesel engine, e.g. the cross head or hydraulic actuators.

[0054] The lubrication arrangement comprises a reservoir 2 for the lubricant, for example a tank, a lubrication device 3 having an inlet 31 for the lubricant, and a supply line 4 for delivering the lubricant from the reservoir 2 to the inlet 31 of the lubrication device 3.

[0055] The reservoir 2 for the lubricant, which is also referred to as "daily tank", is usually located some distance away from the large diesel engine 10 and for example mounted to or supported by the hull of the vessel. Usually the reservoir 2 is neither mounted to nor directly supported by the large diesel engine 10.

[0056] The reservoir 2 is connected to ambient pressure, i.e. there is at least one opening to the environment, so that the lubricant in the reservoir 2 is at ambient pressure, meaning that the lubricant in the reservoir 2 is not pressurized.

[0057] The reservoir 2 contains only fresh or unused lubricant. In particular, there is no return line nor any other means to recycle any lubricant from the large diesel engine 10 to the reservoir 2. In particular, no used lubricant for example from the crankcase or any other sump of the large diesel engine 10 is supplied to the reservoir 2.

[0058] The lubrication device 3 is configured for being mounted to the large diesel engine. The lubrication device 3 is for example designed as a lubrication rail 3 extending along all cylinders 11 of the large diesel engine 10. The lubrication device 3 comprises a plurality of injection pumps 32 for delivering the lubricant to the cylinders 11, in particular to a plurality of lubrication openings (not shown) provided at the cylinder wall 11 or the cylinder liner, respectively, and/or at the piston of the respective cylinder. The lubricant is conveyed by the injection pumps 32 through the lubrication openings and applied to the respective running surface along which the piston moves forth and back, i.e. the cylinder wall or the cylinder liner, respectively.

[0059] Preferably, the lubrication device 3 comprises exactly one separate injection pump 32 for each cylinder 11, i.e. the number of injection pumps 32 equals the number of the cylinders 11, so that each cylinder 11 has its own injection pump 32.

[0060] As already mentioned each cylinder 11 comprises a plurality of lubricant openings which are for example distributed along the inner circumference of the respective cylinder 11. In addition, it is also possible to arrange lubrication openings at different heights of the cylinder 11 as viewed in the direction of the cylinder axis.

[0061] All the lubrication openings belonging to one cylinder 11 are connected with an outlet of the same injection pump 32, namely that injection pump 32, which is attributed to this cylinder 11. Thus, the respective injection pump 32 attributed to an individual cylinder 11 supplies all the lubrication openings of this cylinder 11 with lubricant.

[0062] The intake of each injection pump 32 is connected to a common lubrication line 33 of the lubrication device 3, wherein the common lubrication line 33 extends from the inlet 31 along all of the injection pumps 32. Thus, each injection pump 32 is supplied with the lubricant flowing from the inlet 31 into the common lubrication line 33.

[0063] The common lubrication line 33 is designed as a stub, i.e. the end 331 of the common lubrication line 33 facing away from the inlet 31 is closed. There is no return line or recycling line for guiding back the lubricant from the lubrication device 3 to the reservoir 2.

[0064] As it is shown in Fig. 1 the lubrication device 3 being designed as a lubrication rail 3 is directly mounted to the cylinders 11 of the large diesel engine 10. Regarding the specific design or the specific configuration of the lubrication device 3 as well as of the injection pumps 32 for delivering the lubricant to the cylinders 11, there are many different embodiments known in the art, so that there is no need for a more detailed explanation.

[0065] According to the invention a feed pump 5 is provided, which is arranged to pressurize the lubricant in the supply line 4, so that the lubricant is supplied with an overpressure to the inlet 31 of the lubrication device 3.

[0066] For pressurizing the entire supply line 4 the feed pump 5 is arranged directly at an outlet 21 of the reservoir 2, so that the feed pump 5 sucks the lubricant directly from the reservoir 2 through the outlet 21. As an alternative it is also possible to arrange the feed pump 5 inside the reservoir 2. Preferably, the feed pump 5 is mounted to a wall or to a bottom of the reservoir 2. At the outlet 21 a valve 22 may be provided for closing the fluid connection between the reservoir 2 and the pump 5. The valve 22 may be advantageous, if a leakage occurs in the lubrication arrangement 1 or if the feed pump 5 has to be changed or when the large diesel engine 10 is operated with a different lubricant that is taken from a different reservoir.

[0067] The feed pump 5 may be designed for example as a centrifugal pump. Since the feed pump 5 has only to provide an overpressure of the lubricant at the inlet 31 of the lubrication device 3, for example an overpressure of 1.5 bar (150 kPa), but has not to generate a circulation of the lubricant from the reservoir 2 to the lubrication device 3 and back to the reservoir 2, both the discharge head and the flow generated by the feed pump 5 are quite low, so that the feed pump 5 may be designed as a small pump. The feed pump 5 has only to deliver such an amount of lubricant, which is really needed or used for the lubrication of the cylinders 11.

[0068] The feed pump 5 shall only ensure that a sufficient amount of lubricant is available in the lubrication device 3, more particular in the common lubrication line 33 of the lubrication device. The feed pump 5 is intentionally not configured for pressurizing the lubricant to a pressure, which is suited for the injection of the lubricant into the respective cylinder 11. Since the feed pump 5 shall only ensure a reliable transport of the lubricant to the lubrication device, the feed pump 5 is preferably designed for supplying the lubricant to the inlet 31 of the lubrication device 3 with an overpressure of at most 3.0 bar (300 kPa) and more preferred with an overpressure of at most 2.0 bar (200 kPa).

[0069] Depending on the specific application the feed pump 5 can for example deliver the lubricant to the inlet 31 at an overpressure of at least 0.5 bar (50 kPa) or at least 1 bar (100 kPa). For many applications an overpressure of approximately 1.5 bar (150 kPa) is suited or sufficient.

[0070] Due to the quite low head and low flow the feed pump 5 has to generate, the feed pump 5 may be designed with a very low energy consumption, for example at most 500 W or at most 250 W. For many applications even a design of the feed pump 5 with an energy consumption of at most 50 W or even with an energy consumption of approximately 20 W is sufficient to ensure a proper lubrication of the cylinders.

[0071] Due to the overpressure of the lubricant at the inlet 31 the influence of the temperature or changes in temperature is considerably reduced, so that the lubrication arrangement 1 may be designed without any heating device for heating the lubricant and/or components of the lubrication arrangement 1.

[0072] Since the cylinder lubrication is a crucial function in the large diesel 10 it is preferred to additionally provide a backup feed pump (not shown) for pressurizing the lubricant in the supply line 4 in case of a malfunction of the feed pump 5. In case the feed pump 5 does not work, for example due to a failure, the backup feed pump is switched on and delivers the lubricant with the overpressure to the inlet 31 of the lubrication device. The backup feed pump may be of the same or a similar design as the feed pump 5 and may have the same or similar properties, e.g. regarding head, flow and energy consumption as the feed pump 5. Preferably, the backup feed pump is also arranged at the reservoir 2 such that it can pressurize the entire supply line 4 between the reservoir 2 and the inlet 31 of the lubrication device 3.

[0073] In particular when the large diesel engine is designed as a dual-fuel or multi-fuel engine, it may be required that two or even more different lubricants are used depending on the specific fuel that is used for the combustion. In such cases a separate reservoir 2 is provided for each of the different lubricants. It goes without saying that in such configurations at each of the different reservoirs a small feed pump 5 may be provided for delivering the respective lubricant with overpressure to the inlet 31 of the lubrication device 3.

Claims

1. A lubrication arrangement for the lubrication of cylinders (11) of a large diesel engine (10), comprising a reservoir (2) for a lubricant, a lubrication device (3) for being mounted to the large diesel engine (10), and a supply line (4) connecting the reservoir (2) with an inlet (31) of the lubrication device (3) for delivering the lubricant from the reservoir (2) to the lubrication device (3), wherein the lubrication device (3) comprises a plurality of injection pumps (32) for delivering the lubricant into the cylinders (11), **characterized in that** a feed pump (5) is provided, which is arranged to pressurize the lubricant in the supply line (4), so that the lubricant is supplied with an overpressure to the inlet (31) of the lubrication device (3).

2. A lubrication arrangement in accordance with claim 1, wherein the feed pump (5) is arranged closer to the reservoir (2) than to the inlet (31) of the lubrication device (3), so that the length of the supply line (4) between the feed pump (5) and the inlet (31) is larger, preferably at least twice as large, as the length of the supply line (4) between the reservoir (2) and the feed pump (5).

3. A lubrication arrangement in accordance with any one of the preceding claims, wherein the feed pump (5) is arranged at an outlet (21) of the reservoir (2).

4. A lubrication arrangement in accordance with any one of the preceding claims, wherein the feed pump (5) is mounted to a wall or to a bottom of the reservoir (2).

5. A lubrication arrangement in accordance with any one of the preceding claims, wherein the feed pump (5) is designed for supplying the lubricant to the inlet (31) of the lubrication device (3) with an overpressure of at least 0.5 bar (50 kPa), preferably at least 1 bar (100 kPa).

6. A lubrication arrangement in accordance with any one of the preceding claims, wherein the feed pump (5) is designed for supplying the lubricant to the inlet (31) of the lubrication device (3) with an overpressure of at least 1.5 bar (150 kPa), preferably with an overpressure of approximately 1.5 bar (150 kPa).

7. A lubrication arrangement in accordance with any one of the preceding claims, wherein the feed pump (5) is designed for supplying the lubricant to the inlet (31) of the lubrication device (3) with an overpressure

of at most 3.0 bar (300 kPa), preferably at most 2 bar (200 kPa).

8. A lubrication arrangement in accordance with any one of the preceding claims, wherein the reservoir is connected to ambient pressure.

9. A lubrication arrangement in accordance with any one of the preceding claims, wherein the supply line (4) between the reservoir (2) and the inlet (31) of the lubrication device (3) is the sole fluid connection for the lubricant between the reservoir (2) and the lubrication device (3).

10. A lubrication arrangement in accordance with any one of the preceding claims, wherein the lubrication device (3) comprises one separate injection pump (32) for each cylinder (11) of the large diesel engine (10).

11. A combination of a lubrication arrangement and a large diesel engine having at least one cylinder (11), in which a piston is arranged for a reciprocating movement between a top dead center and a bottom dead center, **characterized in that** the lubrication arrangement (1) for the lubrication of all cylinders (11) is designed according to anyone of the preceding claims.

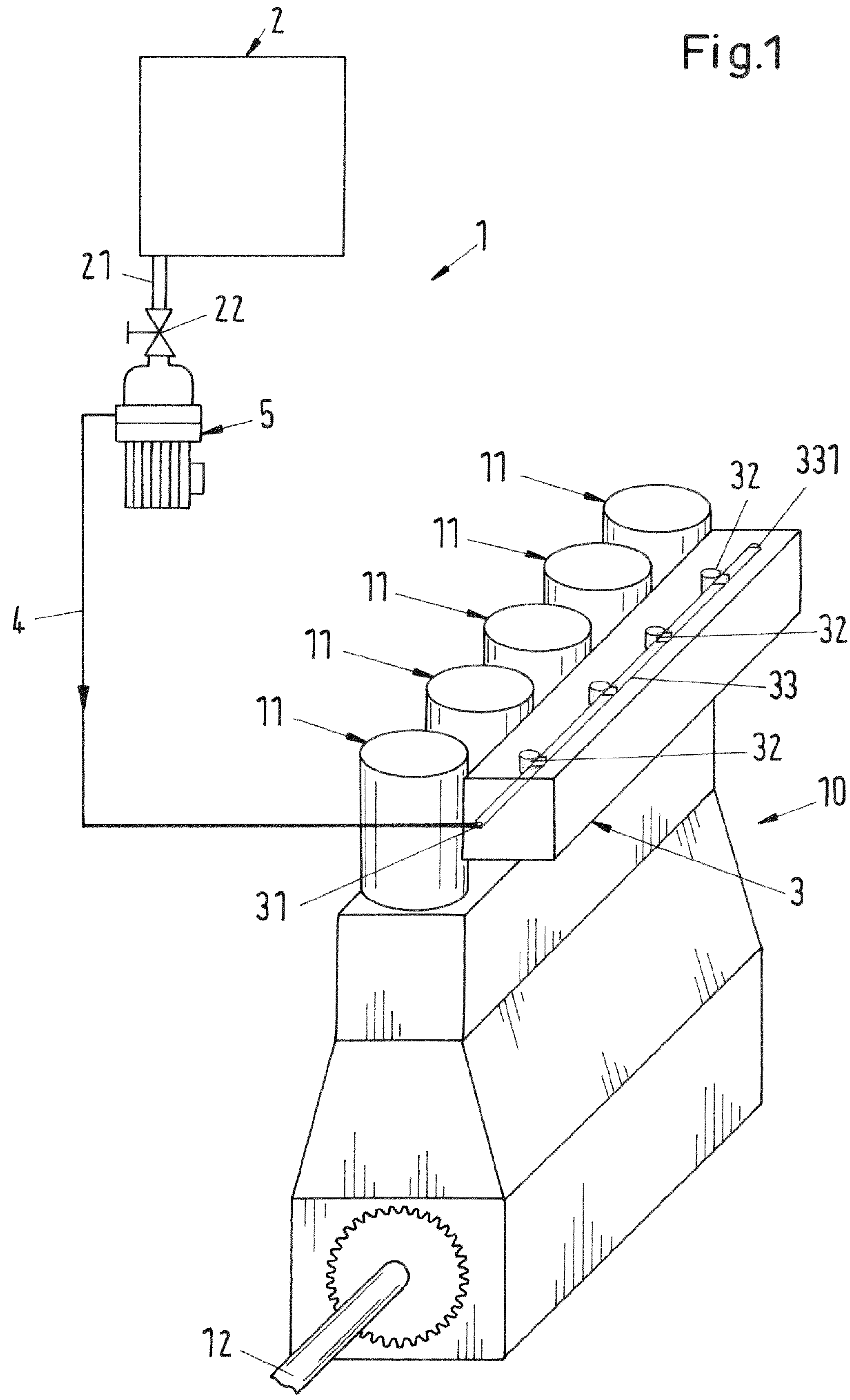
12. A combination in accordance with claim 13, wherein the lubrication device (3) is mounted to the large diesel engine (10), and wherein the reservoir (2) is arranged at a support structure different from the large diesel engine (10), preferably at a hull of a vessel.

13. A combination in accordance with claim 14, wherein the supply line (4) is the sole fluid connection line between the reservoir and the large diesel engine (10).

14. A combination in accordance with claim 13, wherein the large diesel engine (10) is a large two-stroke diesel engine.

15. A combination in accordance with any one of claims 13-14, wherein the large diesel engine (10) is a multi-fuel engine or a dual-fuel engine.

Fig.1



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EUROPEAN SEARCH REPORT

Application Number
EP 18 20 1514

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 101 24 476 A1 (MAN B&W DIESEL A/S) 5 December 2002 (2002-12-05) * abstract *; figures * * paragraph [0016] * -----	1-15	INV. F01M1/02
X A	WO 2017/067561 A1 (A P MØLLER - MAERSK A/S) 27 April 2017 (2017-04-27) * abstract *; figures * * page 9, lines 9-12 * * page 16, line 6 - page 18, line 2 * -----	1-9, 11-15 10	
X	WO 2007/057027 A1 (HANS JENSEN LUBRICATORS A/S; AAMAND JAN) 24 May 2007 (2007-05-24) * abstract *; figures * * page 13, line 22 - page 16, line 4 * -----	1-15	
X	DE 199 59 300 A1 (MAN B & W DIESEL A/S) 21 June 2001 (2001-06-21) * abstract *; figures * * paragraphs [0021] - [0042] * -----	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

F01M
F02B
F02D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	1 March 2019	Döring, Marcus

CATEGORY OF CITED DOCUMENTS

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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01-03-2019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 10124476 A1	05-12-2002	CN 1387000 A	25-12-2002
		DE 10124476 A1	05-12-2002
		JP 2003013721 A	15-01-2003
		JP 2009062999 A	26-03-2009
		KR 20020089142 A	29-11-2002
WO 2017067561 A1	27-04-2017	DK 201500647 A1	08-05-2017
		EP 3365539 A1	29-08-2018
		WO 2017067561 A1	27-04-2017
WO 2007057027 A1	24-05-2007	AT 540199 T	15-01-2012
		CN 101356342 A	28-01-2009
		DK 176366 B1	01-10-2007
		DK 1951995 T3	23-04-2012
		EP 1951995 A1	06-08-2008
		JP 5129150 B2	23-01-2013
		JP 2009516795 A	23-04-2009
		KR 20080069704 A	28-07-2008
		WO 2007057027 A1	24-05-2007
DE 19959300 A1	21-06-2001	CN 1299004 A	13-06-2001
		DE 19959300 A1	21-06-2001
		DK 176424 B1	04-02-2008
		JP 2001193430 A	17-07-2001
		KR 20010070286 A	25-07-2001

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