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(54) LUBRICATING OIL SYSTEM

(57) The lubricating oil system for a piston engine, where lubricating oil is supplied to the pistons of the engine via a crankshaft (22) and connecting rods (2) comprises a lubricating oil pump (1), a lubricating oil line (4) supplying lubricating oil from the lubricating oil pump (1) to the connecting rods (2), and a damping pipe (5) that is arranged in fluid communication with the lubricating oil line (4) and configured to damp pressure pulsations in the lubricating oil system.

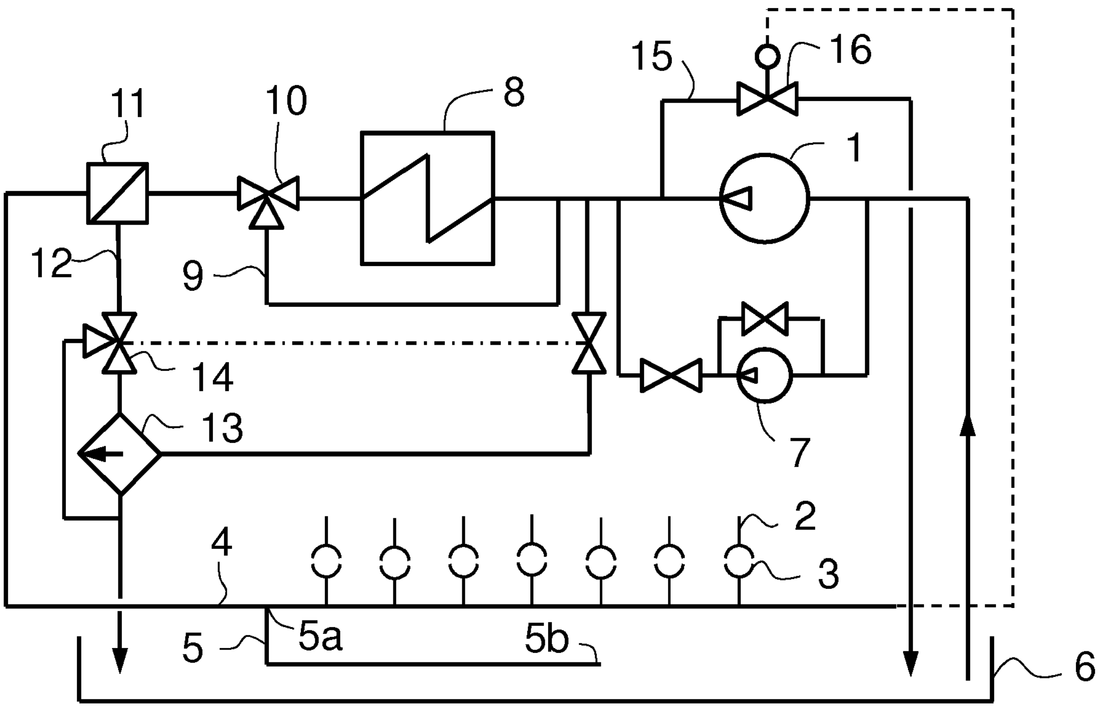

FIG. 1

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Description

Technical field of the invention

[0001] The present invention relates to a lubricating oil system for a piston engine in accordance with the preamble of claim 1.

Background of the invention

[0002] The pistons of a piston engine are connected to a crankshaft via connecting rods. In large four-stroke piston engines, such as in ship or power plant engines, the connecting rods are commonly used for conducting pressurized lubricating oil to the piston, where it can be used both for lubricating the piston rings and for cooling the piston crown. The crankpins of the crankshaft are provided with lubrication oil outlets, which communicate with lubrication oil inlets that are arranged in the big ends of the connecting rods. Because of this arrangement, the inlets of the connecting rods are in fluid communication with the outlets of the crankshaft only at certain intervals. When the inlets of a connecting rod open, the pressure in the lubricating oil line that supplies lubricating oil to the connecting rods decreases. When the fluid communication between the lubricating oil line and the connecting rod is cut, a pressure peak occurs in the lubricating oil line. The sequential opening and closing of the lubrication oil inlets leads to pressure pulsations and in the worst case to cavitation in the connecting rod bearings.

Summary of the invention

[0003] An object of the present invention is to provide an improved lubricating oil system for a piston engine, where lubricating oil is supplied to the pistons of the engine via a crankshaft and connecting rods. The characterizing features of the lubricating oil system according to the invention are given in the characterizing part of claim 1.

[0004] The lubricating oil system according to the invention comprises a lubricating oil pump, a lubricating oil line supplying lubricating oil from the lubricating oil pump to the connecting rods, and a damping pipe that is arranged in fluid communication with the lubricating oil line and configured to damp pressure pulsations in the lubricating oil system.

[0005] Because of the damping pipe, pressure oscillations in the lubricating oil system are effectively reduced. Cavitation risk in the connecting rod bearings is therefore reduced and oil pressure can be lowered. Consequently, a smaller oil pump can be used and energy is saved. The damping pipe does not need service.

[0006] According to an embodiment of the invention, the damping pipe has a first end, which is connected to the lubricating oil line between the lubricating oil pump and the bearings that connect the connecting rods to the crankshaft, and a second end, which is closed. The damping pipe can be arranged inside an oil sump.

[0007] The length of the damping pipe can be selected using formula $LT = a/(4*f)$, where LT is the length of the damping pipe, a is the speed of sound in the damping pipe and f is the opening frequency of the flow path to the connecting rods.

Brief description of the drawings

[0008] Embodiments of the invention are described below in more detail with reference to the accompanying drawings, in which

Fig. 1 shows schematically a lubricating oil system of a piston engine, and

Fig. 2 shows a cross-sectional view of a connecting rod of the engine.

Description of embodiments of the invention

[0009] In figure 1 is shown a lubricating oil system of a piston engine. The engine is a large internal combustion engine, such as a main or an auxiliary engine of a ship or an engine that is used at a power plant for producing electricity. The cylinder bore of the engine is at least 150 mm. The rated power of the engine is at least 150 kW per cylinder. In the embodiment of figure 1, the engine comprises seven cylinders that are arranged in line, but the engine can comprise any reasonable number of cylinders. The cylinders could also be arranged for example in a V-configuration. The lubricating oil system is configured to deliver lubricating oil to components of the engine for lubrication and/or cooling purposes. The lubricating oil system supplies lubricating oil at least to connecting rods 2 of the engine, but the lubricating oil can be supplied also to various other places. The lubricating oil is supplied inside the connecting rods 2 to the pistons of the engine, where the lubricating oil is used for lubricating the piston rings and/or for cooling the piston.

[0010] The lubricating oil system comprises an oil pump 1, which pressurizes the lubricating oil and feeds it into a lubricating oil line 4, in which the lubricating oil is conducted to the components where the lubricating oil is used. The lubricating oil is taken from an oil reservoir 6. In the embodiment of figure 1, the oil reservoir is a wet oil sump 6. However, the engine could also be provided with a dry oil sump, in which case the oil would be taken from a separate tank, into which the oil is introduced from the dry sump. The oil pump 1 is driven by the engine. However, the oil pump 1 could also be driven by some other power source, such as an electric motor. The oil pump 1 can be for example a screw pump. The lubricating oil system is also provided with a prelubricating pump 7, which ensures that lubricating oil flow is available also when the engine is started. The prelubricating pump 7 is arranged in parallel with the oil pump 1. The prelubricating pump 7 is electrically driven.

[0011] An oil cooler 8 is arranged downstream from the oil pump 1 for cooling the pressurized lubricating oil. A by-pass duct 9 is arranged in parallel with the oil cooler 8 for allowing bypassing of the oil cooler 8 when the lubricating oil temperature is low, for instance when the engine is started. A by-pass valve 10 connects the by-pass line 9 to the lubricating oil line 4 on the downstream side of the oil cooler 8. The by-pass valve 10 is used for selectively guiding the lubricating oil flow from the oil pump 1 either through the oil cooler 8 or through the by-pass line 9. The by-pass valve 10 can be temperature-controlled for automatically keeping the lubricating oil temperature within the appropriate temperature range.

[0012] A filter 11 is arranged downstream from the by-pass valve 10. The filter 11 is an automatic backflushing filter, which is connected to a backflushing line 12. Automatic backflushing of the filter 11 ensures proper functioning of the filter 11 and minimizes the need for maintenance. The backflushing line 12 is provided with a centrifugal filter 13, which removes particles from the lubricating oil before the oil is returned to the oil sump 6. The backflushing line 11 is further provided with a three-port valve 14, which allows bypassing of the centrifugal filter 13 when needed.

[0013] A pressure release line 15 is connected to the lubricating oil line 4 between the oil pump 1 and the oil cooler 8. The pressure release line 15 is provided with a pressure regulating valve 16, which is controlled on the basis of the pressure that is measured from the lubricating oil line 4. When the pressure in the lubricating oil line 4 exceeds a predetermined limit value, the pressure regulating valve 16 opens and allows lubricating oil flow from the lubricating oil line 4 into the oil sump 6 reducing thus the pressure in the lubricating oil line 4.

[0014] In figure 2 is shown a simplified cross-sectional view of a connecting rod 2 of the engine. The connecting rod 2 is attached to the crankshaft 22 of the engine. In figure 2 can be seen a crank web 17 of the crankshaft 22, a counterweight 18 that is attached to the web 17 and a crankpin 19. The big end of the connecting rod 2 is arranged around the crankpin 19. A lubricating oil channel 20 is arranged inside the crankpin 19. In the example of figure 2, the lubricating oil channel 20 extends across the crankpin 19 in the longitudinal direction of the crank web 17 of the crankshaft 22. Both ends of the lubricating oil channel 20 open onto the outer surface of the crankpin 19. The ends of the lubricating oil channel 20 form outlets 20b, 20c, through which the lubricating oil is introduced into the connecting rod 2. The lubricating oil is introduced into the lubricating oil channel 20 via an inlet 20a. The lubricating oil channel 20 inside the crankpin 19 could be arranged in many other ways, and the crankpin 19 could be provided with two or more lubricating oil channels 20. The crankpin 19 could thus comprise more than two outlets for lubricating oil. Alternatively, there could be only one outlet for the lubricating oil in the crankpin 19. The lubricating oil can be introduced into the lubricating oil channel 20 via a main bearing of the crankshaft 22.

[0015] Also the connecting rod 2 is provided with a lubricating oil channel 21. The lubricating oil channel 21 of the connecting rod 2 extends from the big end of the connecting rod 2 to the small end and the lubricating oil channel 21 is open at both ends. The lower end of the lubricating oil channel 21 forms an inlet 21 a, through which the lubricating oil is introduced into the connecting rod 2. The connecting rod 2 could be provided with two or more inlets for the lubricating oil. For instance, the lower end of the cooling oil channel 21 could be branched.

[0016] As the crankshaft 22 rotates, the inlet 21 a of the lubricating oil channel 21 of the connecting rod 2 becomes aligned with an outlet 20b, 20c of the lubricating oil channel 20 of the crankpin 19 twice during each rotation of the crankshaft 22. When the inlet 21 a of the connecting rod 2 is aligned with an outlet 20b, 20c of the crankpin 19, lubricating oil flow into the connecting rod 2 is allowed. When the inlet 21 a and the outlets 20b, 20c are not aligned, flow into the connecting rod 2 is not allowed. The fluid communication between the crankpin 19 and the connecting rod 2 is thus alternately opened and closed. The opening and closing frequency depends on how the lubricating oil channels 20, 21 of the crankpin 19 and the connecting rod 2 are arranged. If the connecting rod 2 is provided with two or more inlets, the inlets can be arranged to be in fluid communication with the outlets of the crankpin 19 either sequentially or at the same time. When an inlet 21 a is opened, the pressure in the lubricating oil line 4 decreases and when the inlet 21 a is closed, the pressure increases. The opening and closing of the fluid communication into the connecting rod 2 therefore causes pressure pulsations in the lubricating oil system.

[0017] Each crankpin 19 and connecting rod 2 of the engine is provided with a similar lubricating oil arrangement. Since the pistons in different cylinders of the engine are in different phases, the fluid communication into each connecting rod 2 opens at a different time. The frequency of the pressure pulsations depends on how the lubricating oil channels 20, 21 of the crankpin 19 and the connecting rod 2 are arranged and on the number of cylinders of the engine. In the embodiment of the figures, the engine comprises 7 cylinders and in each cylinder the fluid communication into the connecting rod 2 opens twice during each rotation of the engine. The fluid communication into the connecting rods 2 is thus opened and closed 14 times during each rotation. If the rotation speed of the engine is 1000 revolutions per minute, the opening and closing frequency of the fluid communication into the connecting rods 2 is approximately 233 Hz.

[0018] For damping the pressure pulsations, the lubricating oil system is provided with a damping pipe 5, which is arranged in fluid communication with the lubricating oil line 4 and configured to damp the pressure pulsations. The damping pipe 5 can be connected to the lubricating oil line 4 at any point between the filter 11 and the bearings 3 that connect the connecting rods 2 to the crankshaft 22, i.e. the big end bearings. In the embodiment of figure 1, the damping pipe 5 is connected to the lubricating oil line 4 close to the crankshaft 22. The damping pipe 5 is arranged inside the oil sump 6. The damping pipe 5 has a first end 5a that is connected to the lubricating oil line 4 and a second end 5b, which is closed. The second end 5b of the damping pipe 5 can be provided with a flange, which is for instance bolted or welded to the damping pipe 5.

[0019] The length of the damping pipe 5 is selected using the following formula:

$$LT = a/(4*f)), \qquad (1)$$

where
LT is the length of the pipe [m],
a is the speed of sound in the pipe [m/s], and
f is the frequency at which the fluid communication from the lubricating oil line to any of the connecting rods opens [1/s].

[0020] The speed of sound in the damping pipe 5 can be calculated by the following formula:

$$a = (1/(\rho*(1/k+d\phi/tE)))\text{^}1/2, \qquad (2)$$

where
p is the density of the fuel [kg/m3],
k is the bulk modulus of the fuel [N/m2],
d is the inner diameter of the pipe [m],
ϕ is a pipe restraint factor,
t is the thickness of the pipe [m], and
E is the Young's Modulus of the pipe [N/m2].

[0021] The damping pipe 5 can be a straight pipe or it can be provided with bends. A suitable inner diameter for the damping pipe 5 is 30 to 200 percent of the inner diameter of the lubricating oil line 4.

[0022] It will be appreciated by a person skilled in the art that the invention is not limited to the embodiments described above, but may vary within the scope of the appended claims.

Claims

1. A lubricating oil system for a piston engine, where lubricating oil is supplied to the pistons of the engine via a crankshaft (22) and connecting rods (2), the lubricating oil system comprising a lubricating oil pump (1) and a lubricating oil line (4) supplying lubricating oil from the lubricating oil pump (1) to the connecting rods (2), **characterized in that** the lubricating oil system comprises a damping pipe (5) that is arranged in fluid communication with the lubricating oil line (4) and configured to damp pressure pulsations in the lubricating oil system.

2. A lubricating oil system according to claim 1, wherein the damping pipe (5) has a first end (5a), which is connected to the lubricating oil line (4) between the lubricating oil pump (1) and the bearings (3) that connect the connecting rods (2) to the crankshaft (22), and a second end (5b), which is closed.

3. A lubricating oil system according to claim 1 or 2, wherein the damping pipe (5) is arranged inside an oil sump (6).

4. A lubricating oil system according to any of claims 1 to 3, wherein the length of the damping pipe (5) is selected using formula LT = a/(4*f), where LT is the length of the damping pipe (5), a is the speed of sound in the damping pipe (5) and f is the opening frequency of the flow path to the connecting rods (2).

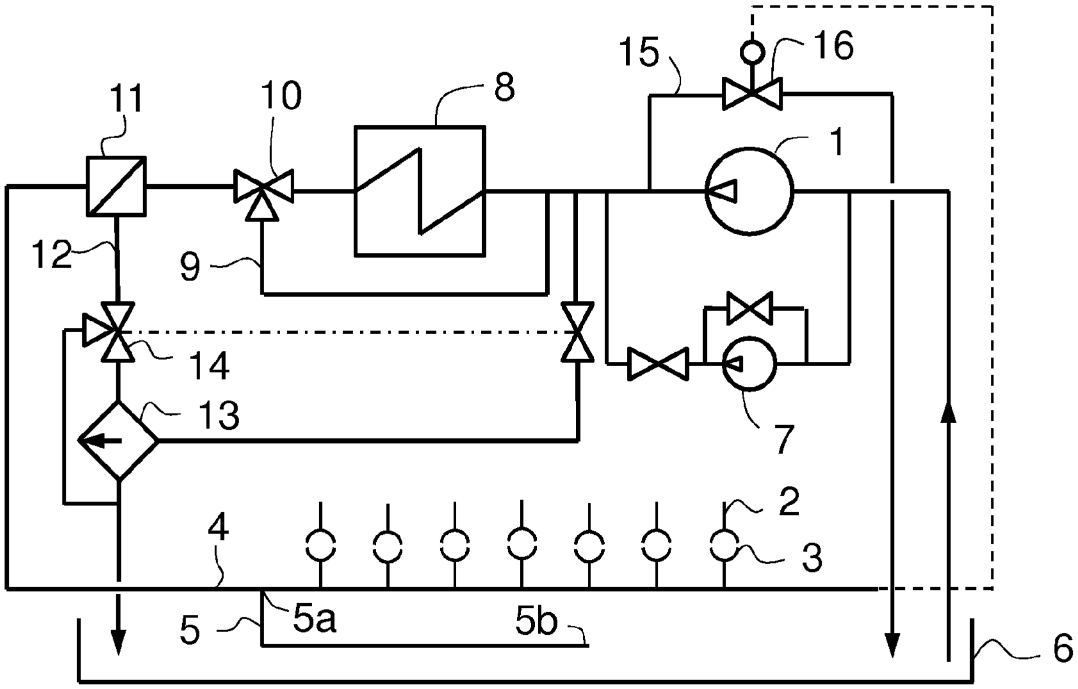
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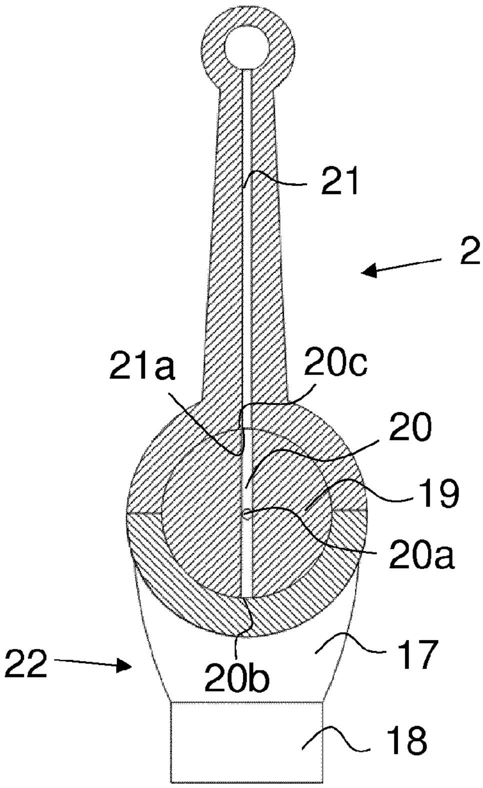
FIG. 1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20c
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FIG. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 15 16 7835

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F01M

The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
The Hague	6 November 2015	Van Zoest, Peter

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