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Description

[0001] This invention relates to a cylinder lubrication device for a large engine, in particular a large size diesel engine.

[0002] Various types of cylinder lubrication devices have been constructed for internal combustion engines used in the automotive sector or for large engines.

[0003] Large engines, in particular in the version as large diesel engines which can be designed as two-stroke or as four-stroke internal combustion engines, are frequently used as drive units for ships or also in stationary operation, e.g. for the drive of large generators for the generation of electrical energy. In this respect, the large engines as a rule run over a considerable time period, which sets a high demand on the operating safety and on the availability of such an engine. In particular long service intervals, low wear and an economic handling of the operating supply items are therefore central criteria.

[0004] When the engine runs, the piston slides along the surface of the wall of the cylinder. The cylinder serves as the running surface and is designed usually in the form of a cylinder liner. A cylinder lubrication and/or piston lubrication can be provided for the piston reciprocating in the cylinder liner. On the one hand, the piston has to slide as smoothly as possible, that is without impediment, in the cylinder; on the other hand, the piston must seal the working space as much as possible to ensure an efficient conversion of the energy released in the combustion process performed in the working space.

[0005] A lubricant, e.g. a lubrication oil is therefore usually introduced onto the inner surface of the cylinder liner during the operation of the large engine to achieve good running properties of the piston and to keep the wear of the running surface, of the piston and of the piston rings as small as possible as shown for instance in WO 2004/038189. The lubricant furthermore helps to neutralize aggressive combustion products contributes to avoid corrosion. Due to these numerous demands, high quality substances are used frequently as the lubricant, which are consequently expensive. It is therefore required to work with lubrication rates, which are as small as possible with respect to a particularly efficient and economic operation of the engine.

[0006] In large engines, however not only in these, the lubrication of each piston moving to and fro in its respective cylinder is undertaken by lubrication devices foreseen in the reciprocating piston or in the wall of the cylinder liner. The lubricant is applied to the running surface in order to minimize the friction between the piston and the running surface and thus to reduce the wear of the running surface and the piston rings. In the case of modern engines, such as for example Wärtsilä's RTA engines, the wear of the running surface is less than 0.05 mm for an operating time of 1000 hours. The quantity of lubricant being transported is about 1.3 g/kWh or less and should be reduced further, not least for reasons of cost. At the same time wear should be minimised.

[0007] Totally different solutions are known for lubrication systems for lubricating the running surfaces, not only with regard to the actual operation of the lubrication devices themselves but also with respect to the method of lubrication. According to a known solution, the lubricant is applied to the pistons running past at the lubricant openings through a plurality of lubricant openings, which are accommodated in the cylinder wall in circumferential direction, with the lubricant being distributed by the piston rings not only in the circumferential direction but also in the axial direction.

[0008] A proven method is the so-called internal lubrication in which the lubricant, typically a lubrication oil, is conveyed through the interior of the piston and is then applied from the piston interior onto the piston or onto the cylinder running surface via one or more lubrication sites which are provided on the surface of the piston. Such a method is disclosed, for example, in EP-A-0 903 473.

[0009] In addition to the manner in which the lubricant is applied to the running surface of the cylinder liner, the dosage of the lubricant is to be taken care of to ensure that the correct amount of lubricant arrives at each lubrication point. For this purpose, a large variety of different oil dosage pumps are known form the state of the art. In order to ensure an even oil distribution to the lubricating quills of the cylinder of an internal combustion engine, known oil dosage pumps include an actuating piston driving a certain number of dosage plungers being attached or connected to the actuating piston. The dosage plungers are movably arranged in a dosing space so as to reciprocate to perform a delivery and a return stroke along a working path which usually extends in the direction of the plunger axis. During the return stroke, a pre-settable amount of lubrication oil is filled into the dosing space on top of the plunger. On receiving an injection signal, the actuating piston starts to move and the lubrication oil is pressurized by the plungers driven by the actuating piston and the lubrication oil is supplied from each dosing space to the respective lubricating quill. Such known cylinder oil dosage pumps as for example disclosed in CH 673 506, DE 197 43 955 B4, or EP 1 386 063 A1 which all are very complex in construction resulting in a comparably high price for the pumps.

[0010] Two-stroke marine diesel engines require an accurately timed, metered and independently delivered pulsed lubricant flow to multiple points at the periphery of each engine cylinder. As each engine cylinder requires its own pump, such a pump is to be produced at the lowest possible cost whilst being as simple and reliable as possible.
In order to meet these demands, other pump proposals use only a single piston to deliver multiple flows, but in that case it is not possible to guarantee individual flows to each injection site on the engine cylinder. Due to the fact, that the lubricant may be an oil of a high viscosity such a pump may not be sufficient to provide the optimal dosage of lubricant to the lubrication site. In particular, if the engine is cold, the amount of lubricant delivered to each lubrication site may be insufficient.

[0011] It is an object of the invention to improve the dosage of lubricant for any operating condition of the engine.

[0012] The object of the invention is achieved by heating the lubricant locally in the vicinity of the lubrication site.

[0013] Certainly, it has been contemplated in the prior art to take the viscosity of a fluid into account when metering a precise volume thereof. Such a device has been disclosed for instance in US4252097 for fuel injection. The viscosity of the fuel

determines the time required to meter the desired volume of liquid fuel. An electronic fuel injector which injects fuel into a cylinder of an internal combustion engine is controlled by a metering solenoid, which controls the amount of liquid fuel flowing through a metering valve. The longer the metering solenoid is actuated, the greater the amount of fuel which flows through the metering valve of the fuel injector. Given a fixed period of time, a smaller amount of fuel having a high viscosity will flow through the metering valve than the amount of fuel having a lower viscosity.
However, this solution is not applicable for lubricant injection for the reason, that the time for metering the lubricant may not be changed as the lubricant has to be metered at a given crank angle, thus a given position of the piston in the cylinder liner.

[0014] It has been also contemplated to preheat the fuel injected into the intake manifold or cylinders of automotive engines, as disclosed in US6109543. For mostly economical reasons, fuel injectors have been optimized so as to provide a fuel of optimal temperature and pressure to minimize fuel consumption.
However, lubricant consumption is in automotive engines a minor concern due to the fact that the lubricant is usually provided in an oil reservoir from which it is distributed by the piston onto the cylinder wall. The lubricant is collected again in the oil reservoir and usually refilled periodically. An oil filter may be provided to filter any solid particles from the lubricant resulting from wear and abrasion of the piston or cylinder surface.

[0015] However, this concept would not apply to large engines such as large size diesel engines used primarily for marine applications. For a piston having a diameter of at least 600 mm, the use of an oil reservoir had severe disadvantageous due to the fact of the long distance the lubricant has to travel from the reservoir to the site requiring lubrication. Consequently, such concept would result in a very high lubricant consumption. The running surface requiring lubrication can amount to a couple of square meters for large engines. Due to the fact, that for this particular application, lubricant consumption is of a considerable concern, such a concept would lead to a far too high lubricant consumption.

[0016] The lubricant is to be delivered in the precise amount at a definite point in time for a definite time period to the respective lubrication site. The lubricant is supplied by lubricant pumps to the respective lubrication site from where it is released onto the inner surface of the cylinder liner. A lubrication site can be provided on at least one of the piston or on the inner surface of the cylinder liner.

[0017] At the lubrication site, the lubricant is delivered as liquid through openings nurturing a liquid film spreading over the cylinder liner surface or as a spray into the working space or the scavenging space. By working space it is intended the space extending between the piston, cylinder head and cylinder liner, which contains the fuel and gases to be compressed and burnt. Under scavenging space it is intended the space extending from the underside of the piston to the crankcase. The cylinder liner in the scavenging space contains scavenging slots and at least a portion of the piston rod. It can be advantageous to deliver the lubricant into this scavenging space. It is not exposed to the combustion process. Therefore, any contamination due to residues resulting from a lubricant may be avoided, which may have entered the combustion space. Due to the fact, that the lubricant may contain additives, which can cause hot gas corrosion under combustion conditions in the cylinder head, in particular the exhaust valves or the fuel injection system, the presence of any lubricant in the combustion space should be avoided.

[0018] The fuel viscosity is between four and five times the viscosity of the lubricant. Typically the fuel viscosity is in the range of 700-1000 cst at 50℃, whereas the viscosity of the lubricant is typically at most 500 cst, preferably at most 300 cst, in particular from 15 cst to around 220 cst at 40℃. In case of fuel injection, the injection temperature is usually kept constant which is the most suitable for ensuring the correct flow rate the fuel through the injection system resulting in the appropriate amount of fuel sprayed into the combustion chamber.

[0019] However, in the case of lubricant injection the conditions are different as the flow rate is much smaller compared to fuel injection. Typically the volume of lubricant delivered per piston stroke is at most 1 g per quill, thus per lubrication site, preferably at most 500 mg per quill, particularly preferred at most 300 mg per quill. A plurality of quills can be provided on the cylinder liner and/or on the piston. According to a particularly preferred embodiment, 8 quills are provided per cylinder liner. The very limited amount of lubricant employed for the purpose of cylinder liner lubrication makes the cylinder liner surface to be covered by lubricant very sensitive to the spray pattern. Furthermore the amount of lubricant depends mainly on the conditions in the working space at various loads and on the viscosity of the lubricant during injection. Adjusting the viscosity of the lubricant at various loads can thus unexpectedly improve the oil distribution over the cylinder liner surface depending on the engine operation and injectors design.

[0020] For all of the reasons mentioned previously, the lubricant has to be introduced with utmost precision into the working space or also the scavenging space. The amount of lubricant has to be adjusted, such, that it is avoided that any lubricant is present in the working space during combustion. However, sufficient lubricant is to be present at any portion of the piston stroke to ensure sufficient lubrication.

[0021] The performance of the lubricant injection device thus depends on the viscosity of the lubricant during injection. In particular, the pre-heating in the lubrication system of a marine large bore diesel engine has the purpose to increase the fluidity of the lubricant. Increased fluidity helps to improve the transportation of the lubricant and facilitates pumping of the lubricant through the conduit leading to the lubrication site, for instance a quill on a cylinder liner. If the temperature of the lubricant is increased by the pre-heating system, a reduced viscosity of the lubricant will result, thereby facilitating its distribution through the conduit to the lubrication site. At the lubrication site, the lubricant enters the lubrication space. Advantageously the lubricant is sprayed onto the surface to be lubricated in order to cover the largest possible area of this surface for a given amount of lubricant, thus minimizing the demand of lubricant for the specific lubrication purpose. Conveniently a spay nozzle is provided for spraying the lubricant onto the surface to be lubricated. Such a spray nozzle forms part of a lubricant injection device.

[0022] It is unlikely that the lubricant present at the position of the spray nozzle has the correct viscosity to ensure a uniform lubricant spray ensuring the coverage of the surface to be lubricated. The viscosity of the lubricant has thus a considerable influence on the spray pattern and thus on the actual surface covered by the lubricant. If the viscosity deviates from the designed viscosity, the area of the surface

covered may be considerably smaller than the area of the surface which could be covered under ideal conditions. Consequently, a portion of the surface may not be exposed to lubricant or to an amount of lubricant inferior to the amount ensuring an optimal lubrication. Therefore the viscosity of the lubricant at the position of the spray nozzle has to be accurately controlled.
Due to the fact, that the viscosity of the lubricant is correlated with its temperature, the temperature of the lubricant at the position of the spray nozzle has to be monitored and controlled.

[0023] The lubricant temperature is also affected by the heat release through the pipe system leading to the lubrication site and strongly depends on the cylinder liner temperature at the position of the lubricant distribution element of the lubricant injection device. Consequently the working space or the scavenging space, where the distribution system is located, and the engine operation conditions like the cylinder liner wall temperature, the engine load, the efficiency of the cylinder liner cooling system all contribute to change the viscosity of the lubricant at the injection time with negative effects on the performance of the lubrication system.

[0024] Accordingly, it is a further object of the invention to provide a lubricant injection device for a large engine, in particular a large size diesel engine.
It is another object of the invention to provide a lubricant injection device, which is easy to install also by mounting the lubricant injection device into conventional engines already in operation by way of retrofitting.

[0025] Therefore, a lubricant injection device for an internal combustion engine comprises a lubricant distribution element and a passage for supplying lubricant to the lubricant distribution element and an inlet opening for receiving lubricant from a lubricant supply device. The lubricant distribution element comprises an opening for distributing the lubricant onto the surface of a cylinder liner or piston, said opening being closable by a closing element for interrupting the lubricant supply. Said lubricant injection device contains a lubricant heating element for heating the lubricant in the passage.
The lubricant distribution element, the opening, the closing element and the passage are arranged in a fuel injection device body forming a housing for these elements. The heating element can also be arranged in the housing but may also be arranged on the circumference of the housing.
The lubricant injection device is also suitable for the lubrication from the piston towards the liner surface as disclosed in EP 2133 520 A1. Furthermore it is possible to atomize the lubricant leaving a nozzle located on the piston surface. The lubricant is dispersed in the form of droplets into the space between the piston and cylinder liner by controlling the viscosity with the heating element, e.g. a thermal needle inside the injector body.

[0026] The average diameter of the passage is advantageously at least 5 mm, preferably at least 10 mm, particularly preferred at least 15 mm. A diameter of at least 10 mm results in a lower pressure drop for the lubricant when flowing through the passage. Therefore the demand for power of the lubricant supply device may be reduced.

[0027] The desired diameter is also depending on the required speed of the lubricant in the passage aiming to optimize the heat transfer between the heating element and the lubricant flowing through the injector body such that the required temperature of the lubricant is achieved.

[0028] The viscosity of the lubricant at the lubrication site is less than 500 cst, preferably less than 400 cst, particularly preferred in the range of 15 cst up to and including 220 cst. The injector design and the boundary condition of the injection are the basis to define the proper viscosity to be set.

[0029] According to an embodiment the passage for transporting a lubricant has a passage wall delimiting the passage, the passage wall containing the heating element. The passage wall is part of the injector body. The heating element can comprise at least one of an electrical resistor or a heat exchanger. According to an advantageous variant, the heat exchanger contains a heating fluid. The heating fluid may be a fluid, which has been directly or indirectly heated by the combustion process performed when the fuel is burnt in the working space.

[0030] According to an alternative embodiment, the passage for transporting the lubricant contains the heating element. The heating element can be an elongate element, such as a rod or stub extending over at least a portion of the passage. Advantageously, the elongate element contains at least one of a resistor, a passage for circulation of a heating fluid or a heat generation element. The lubricant passage may be arranged circumferentially around the heating element. In particular, the lubricant passage may spiral shaped, thus be of the shape of a helix. The helix extends between an inlet opening, by which the lubricant enters the passage and an outlet opening, by which the lubricant leaves the passage to be injected at the lubrication site. In particular a nozzle may be formed in the passage leading to the outlet opening, the nozzle may be advantageously be configured as a spray nozzle.

[0031] The lubricant injection device in accordance with any one of the preceding embodiments may be part of a large engine. The large engine can in particular be configured as a large size diesel engine.
The large engine has at least one cylinder liner and/or piston comprising a lubricant injection device in accordance with any of the preceding embodiments.

[0032] Furthermore, the invention is concerned with a method for lubricating an inner surface of a cylinder liner comprising a lubricant injection device in accordance with any one of the preceding embodiments. The method comprises the steps of filling a lubricant passage with lubricant and opening the outlet opening to discharge said lubricant from said passage when the lubricant has reached its lubrication temperature.

[0033] Advantageously, the lubricant passage is closed after a time period corresponding to the injection of a predetermined volume of lubricant.

[0034] The lubricant injection device according to a particularly preferred embodiment is thus equipped with means to control the temperature of the lubricant precisely at the time of injection directly at the lubricant site. The lubricant leaves the lubricant injection device at the lubrication site through the outlet opening which contains a spray nozzle.
The temperature of the lubricant is controlled in order to guarantee the proper viscosity of the lubricant during the injection to achieve a required spray pattern

independently from any other environmental and operational conditions. The lubricant injection device according to the particularly preferred embodiment is disposed with a heating element to modify the viscosity of the lubricant directly and quickly. Herewith, the injection conditions in terms of penetration, break-up of the spray and distribution over the cylinder liner circumference are optimized. The optimization results in a balancing of the different boundary conditions that can derive from the engine operation such as low or high load conditions. By changing viscosity of the lubricant, the spray pattern may also be adapted to different engine load conditions. For instance, the injection duration may be adapted as a function of the speed of the piston. In an embodiment, the lubricant injection device is equipped with an elongate element in the shape of a rod, which is preferably shaped as a needle. The temperature of the needle may be changed by the heat release of a thermal resistor and the lubricant temperature can be kept controlled until the injection starts and even during the injection period guaranteeing a stable lubricant spray entering into the working space or combustion chamber. The injector body is disposed with a spiral shaped passage that encircles the needle. The length of the spiral shaped passage is such to ensure that the lubricant flows for a sufficient time through the spiral shaped passage to obtain the required temperature and viscosity. A spiral shaped passage helps makes the lubricant injection device more compact. The residence time of the lubricant is determined by the length of the lubricant passage. By providing a spiral shaped passage, the length of the lubricant passage can be increased without requiring an increase in the length of the injector body. A winding is defined as a portion of the length of the lubricant passage which extends over an angle of 360°. Advantageously the number of windings is at least 3, preferably at least 5, particularly preferred at least 10.

[0035] The temperature of the needle is controlled by an external power supply so to be changeable and the required temperature of the lubricant is kept under control and adjusted to obtain the required viscosity for a proper injection quality.

[0036] These and other objects and advantages of the invention will become more apparent from the following detailed description, taken in conjunction with the accompanying drawings wherein:

Fig. 1 illustrates a section of a large engine;

Fig. 2 illustrates a section through the working space and a fuel injection element according to a first embodiment of the invention

Fig. 3 is a diagram of the forces acting on the crank shaft

Fig. 4 illustrates a section through a portion of a second embodiment of a lubricant injection device according to the invention

Fig. 5 illustrates a section through a portion of a third embodiment of a lubricant injection device according to the invention

[0037] Fig. 1 shows in a schematic representation a cylinder 3 of a large engine comprising a cylinder head designated in the following with the reference numeral 1. The cylinder head 1 is in particular suitable for large size diesel engines which are

mostly designed as two-stroke diesel combustion engines with uniflow scavenging. The substantial components of large engines, which as a rule have a plurality of cylinders 3, are known per se.
The cylinder head 1 includes a roof area 5 and a side area 6, which bound the combustion chamber 7 of the cylinder 3 in the mounted state, as shown in Fig. 1. In this connection, the roof area 5 of the cylinder head 1 in the mounted state forms the bounding surface of the combustion chamber 7 which is disposed opposite the piston end face 41 and lies perpendicular to an axis A - A of the cylinder head 1 as shown in Fig. 2. The side area 6 adjoins the roof area 5 and its upper part in accordance with the illustration, which opens into the roof area 5, extends obliquely to the axis A - A of the cylinder head 1 so that the side area 6 opens at an obtuse angle into the roof area 5. A piston 4 is arranged movable to and fro along the axis A - A in the cylinder 3. The cylinder head 1 has a mounting opening, which can be arranged substantially centrally in the roof area 5 for receiving a fuel injection nozzle or also in the side area 6 as shown in Fig. 2. The fuel injection nozzle 9 is connected via a fuel line 91 to an injection apparatus (not shown) which introduces the fuel into the working space 7 of the cylinder 3 through the injection nozzle 9. An outlet opening 10 is arranged in the roof area 5 or the side area 6 of the cylinder head 1 for receiving a valve 11. The valve 11 opens and closes a fluid exchange passage, for feeding air and discharging exhaust gases of the combustion process performed in the working space 7 upon completion of the compression stroke of the piston 4. The valve drive unit 12 is shown schematically in Fig. 2.

[0038] The work performed by the expanding gases during the combustion process let the piston 4 perform an expansion stroke. In Fig. 1 the piston moves downwardly during the expansion stroke. In the lower region of the cylinder 2, scavenging openings 14 are provided, which form a passage from the working space 7 into a cylinder space 15 when the piston 4 is located at the bottom dead centre or in the vicinity thereof. Therefore, fresh air can be fed into the working space 7 after the piston has performed its expansion stroke.

[0039] The piston is connected within an engine chamber or crankcase 16 to a piston rod 17. The piston rod 17 transmits the to and fro movement of the piston in the cylinder 2 to a cross-head 18 and to a connecting rod 19, which is connected to a cam mounted on a crank shaft 20 during operation of the diesel engine. The crankshaft 20 rotates with an angular velocity ω around an angle denoted α. The cross-head 18 has a crosshead pin 21 having sliding shoes 22 which run up and down on rails 23.

[0040] The connecting rod 19 acts on a crank journal 24 with a force S, which is made up of a force K exerted by the piston and a reaction force exerted by the rail, a not illustrated normal force on the guide. The force K is the product of the loaded surface A of the piston 4 and the excess pressure in the working space 7. $K = A * (p - p_0)$ with p being the pressure in the working space 7 and p_0 the environmental pressure. As the force ratios illustrated in Fig. 1 present at the crankshaft 20 show, a rotational force T is produced using the lever arm r of the crank from which an effective torque Mt results corresponding to the pair of forces +S, -S what is shown in Fig. 3. This effective torque Mt has a magnitude which is equal to the area spanned by the pair of forces +S, -S. The effective torque Mt disappears when the piston has arrived in a dead point centre position (i.e. for $\alpha = 0°$ or 180°). The effective torque Mt can be measured and entered into a control system.

The control system can generate from this information an indication on the load of the engine, which is correlated to the magnitude of the maximal torque and can also generate the time behaviour of the torque. Based on this information a precise timing of the lubricant injection can be determined. Alternatively, the lubricant injection time may be correlated to the crankshaft angle.

[0041] In Fig. 2 a lubricant injection device 30 is shown, which is not drawn to scale to make the essential features thereof more apparent. The lubricant injection device 30 comprises a lubricant distribution element 31 and a passage 32 for supplying lubricant to the lubricant distribution element 31. Furthermore the lubricant injection device has an inlet opening 33 for receiving lubricant from a lubricant supply device 34. The lubricant distribution element 31 comprises an opening 35 for distributing the lubricant onto the surface of a cylinder liner 8 or piston ring 13. The opening 35 is closable by a closing element 36 for interrupting the lubricant supply, **characterized in that** said lubricant injection device contains a lubricant heating element 38 for heating the lubricant in the passage 32. The heating element 38 is designed as a skirt, which is heated by applying an electrical current thereto. The skirt works as a resistor for the electrical current passing there through. The current supplied my stem form an alternate current supply or also a direct current supply.

[0042] Fig. 4 is a lubricant injection device according to a second embodiment of the invention. The lubricant injection device 60 comprises a lubricant distribution element 61 and a passage 62 for supplying lubricant to the lubricant distribution element 61. The lubricant distribution element 61 has at least one outlet opening 81 for injection of the lubricant into the working space.

[0043] Furthermore, the lubricant injection device has an inlet opening 63 for receiving lubricant from a lubricant supply device 64. The lubricant distribution element 61 comprises an opening 65 for distributing the lubricant onto the surface of a cylinder liner 8 or piston ring 13 of Fig. 2. The opening 65 is closable by a closing element 66 for interrupting the lubricant supply. The closing element 66 is configured as a stub, which is moveable along the axis A-A of the lubricant injection device. The stub can comprise a first section 71 which has a diameter, which matches the diameter of the opening 65 and a second section 72, which receives a spring 73 for directing the stub to a position in which the head of the first section 71 closes the opening 65.
The spring 73 is placed into a bore 74. The bore may be filled with an actuating fluid entering and leaving the bore via a passage 75. The bore is to be sealed from the lubricant passages if the actuating fluid and the lubricant should not come into contact with each other.

[0044] Normally the actuating fluid will be of a sufficient pressure so that the opening 65 is held in a closed position by the combined forces of the spring and the actuating fluid in the bore 74. If the control system indicates a demand for lubrication, the actuating fluid may be depressurized by opening a valve in the actuating fluid circuit, which allows the actuating fluid to flow to a reservoir. The heated lubricant present in the lubricant space 76 exerts a pressure onto the second section 72 and is capable of lifting the head of the first section 71, when the force of the spring is overcome by sufficient lubricant pressure. Under these conditions, the lubricant pressure is also suitable for providing an accurate injection profile when leaving through the outlet opening 81 or a plurality of these outlet openings.

[0045] The lubricant injection device 60 contains a lubricant heating element 68 for heating the lubricant in the passage 62. The heating element 68 has a body 69, which contains a passage 70 for a heating fluid. The body 69 is heated by the heating fluid circulating through the passage 70. The heating fluid is supplied to passage 70 from heating fluid space 77. The body 69 is mounted onto the lubricant injection device body 78 shown in part in Fig. 4 by screwing, press-fitting and/or welding. The passage 70 in the body 69 is sealed from the lubricant passage 62 and the lubricant space 76 so as to preclude any contamination of the lubricant with the heating fluid or vice versa. The heating fluid can be supplied to the heating fluid space 77 by a separate passage in the lubricant injection device body 78, which is not shown in Fig. 4.

[0046] As an alternative or in addition to the heating element provided in the body 69, a heating element may be provided in the stub, which is not shown in the figures. The heating element may also be configured as a passage for a heating fluid, but may alternatively or in addition thereto be disposed with an electrically heated means. In particular, the heating element may comprise a resistor.

[0047] Fig. 5 is a lubricant injection device according to a third embodiment of the invention. The lubricant injection device 130 comprises a lubricant distribution element 131 and a passage 132 for supplying lubricant to the lubricant distribution element 131. The lubricant distribution element 131 has at least one outlet opening 151 for injection of the lubricant into the working space 7.

[0048] Furthermore, the lubricant injection device has an inlet opening 133 for receiving lubricant from a lubricant supply device 134. The lubricant distribution element 131 comprises an opening 135 for distributing the lubricant onto the surface of a cylinder liner 8 or piston ring 13 of Fig. 2. The opening 135 is closable by a closing element 136 for interrupting the lubricant supply. The closing element 136 is configured as a rod, which is moveable along the axis A-A of the lubricant injection device. The rod can comprise a heating element 138. The rod has a first section 141 having a head for closing the opening 135 and a second section 142, which receives a spring 143 for directing the rod to a position in which the head of the first section 141 closes the opening 135.
The spring 143 is placed into a bore 144. The bore may be filled with an actuating fluid entering and leaving the bore via a passage 145. The bore is to be sealed from the lubricant passages if the actuating fluid and the lubricant should not come into contact with each other.

[0049] The second section of the rod is connected via a connection element 149 to a power supply 150. A temperature measurement device 155 may be provided for the lubricant entering the lubricant injection device. The output of the temperature measurement device 155 may be fed into a control unit 156. The control unit can send a signal to the power supply 150 to operate the heating element 138 until the desired temperature is measured by the temperature measurement device 155.
The control unit may also open or close a valve 158 for the supply of actuating fluid and/or supply energy to a solenoid 160. The solenoid 160 may be used alternatively or in addition to the spring 143 for moving the rod into an open position, which allows the lubricant to pass through the passage 132 to the liquid distribution element 131 and to the outlet opening 151 to be injected into the working space 7.

[0050] The wall element shown in Fig. 4 may be part of a cylinder liner 8 or a piston 4. The lubricant injection device may be fixed to said wall element by welding, soldering, a screw connection or by a connection obtained by a press-fit.

[0051] The invention thus provides a lubricant injection device, which can be easily installed and be operated safely over a long time without requiring maintenance. Any piston or cylinder liner of a large engine may be equipped with a lubricant injection device according to any of the embodiments disclosed.
The invention further provides several embodiments of a heating element of the lubricant injection device. These features serve to reduce the costs of installation/operation thereby reducing the lubricant consumption. By means of the lubricant injection device according to the invention, the large engine can be operated more cost effectively than an engine being equipped with a conventional lubricant supply device.

PATENTKRAV

1. Stor dieselmotor, der omfatter en smøremiddelindsprøjtningsindretning (30, 60, 130), et smøremiddelfordelingselement (31, 61, 131) og en passage (32, 62, 132) til levering af smøremiddel til smøremiddelfordelingselementet (31, 61, 131) og en indløbsåbning (33, 63, 133) til modtagelse af smøremiddel fra en smøremiddelforsyningsindretning (34, 64, 134), hvor smøremiddelfordelingselementet (31, 61, 131) omfatter en åbning (35, 65, 135) til fordeling af smøremidlet på overfladen af en cylinderforing (8) eller et stempel (4), hvor åbningen (35, 65, 135) kan lukkes af et lukkeelement (36, 66, 136) til afbrydelse af smøremiddelleveringen, **kendetegnet ved, at** smøremiddelindsprøjtningsindretningen indeholder et smøremiddelvarmeelement (38, 68, 138) til opvarmning af smøremidlet i passagen (32, 62, 132).

2. Stor dieselmotor ifølge krav 1, hvor passagen (32, 62, 132) til transport af et smøremiddel har en passagevæg, der afgrænser passagen, og hvor passagevæggen indeholder varmeelementet (38, 68, 138).

3. Stor dieselmotor ifølge krav 2, hvor varmeelementet (38, 68, 138) omfatter en elektrisk modstand.

4. Stor dieselmotor ifølge krav 2, hvor varmeelementet (38, 68, 138) omfatter en varmeveksler.

5. Stor dieselmotor ifølge krav 4, hvor varmeveksleren indeholder en opvarmningsfluid.

6. Stor dieselmotor ifølge et hvilket som helst af de foregående krav, hvor passagen (32, 62, 132) til transport af smøremidlet indeholder varmeelementet (38, 68, 138).

7. Stor dieselmotor ifølge krav 6, hvor varmeelementet (38, 68, 138) er et langstrakt element, der strækker sig over i det mindste en del af passagen (32, 62, 132).

8. Stor dieselmotor ifølge krav 6, hvor det langstrakte element indeholder en modstand.

9. Stor dieselmotor ifølge krav 6, hvor det langstrakte element indeholder en passage (32, 62, 132) til cirkulation af en opvarmningsfluid eller et varmefrembringelseselement.

10. Stor dieselmotor ifølge et hvilket som helst af de foregående krav, hvor passagen (32, 62, 132) er anbragt langs omkredsen omkring varmeelementet (38, 68, 138).

11. Fremgangsmåde til smøring af en indre overflade af en cylinderforing (8) i en stor dieselmotor ifølge et hvilket som helst af de foregående krav 1 til 10, omfattende trinene at fylde en passage (32, 62, 132) med smøremiddel og at åbne udløbsåbningen til afgivelse af smøremidlet fra passagen (32, 62, 132), når smøremidlet har nået sin smøretemperatur.

12. Fremgangsmåde ifølge krav 11, hvor passagen (32, 62, 132) lukkes efter en tidsperiode svarende til indsprøjtningen af et forudbestemt smøremiddelvolumen.

Fig.1

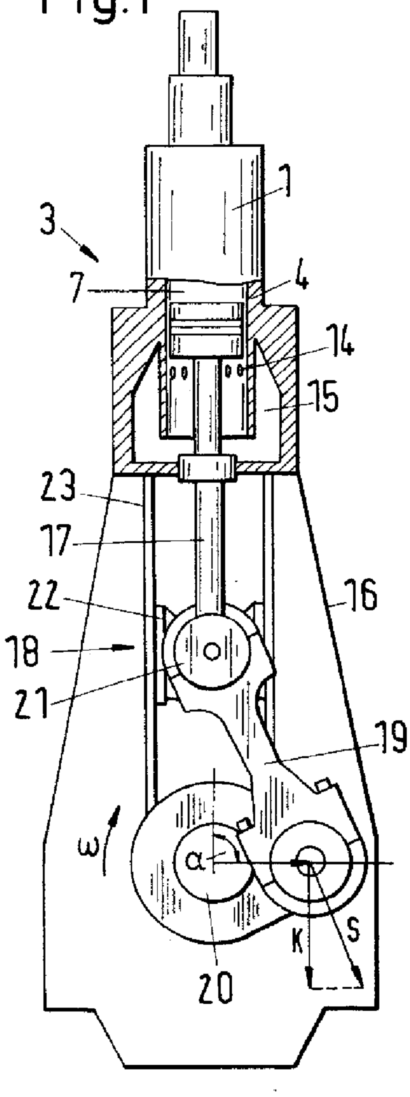

Fig.2

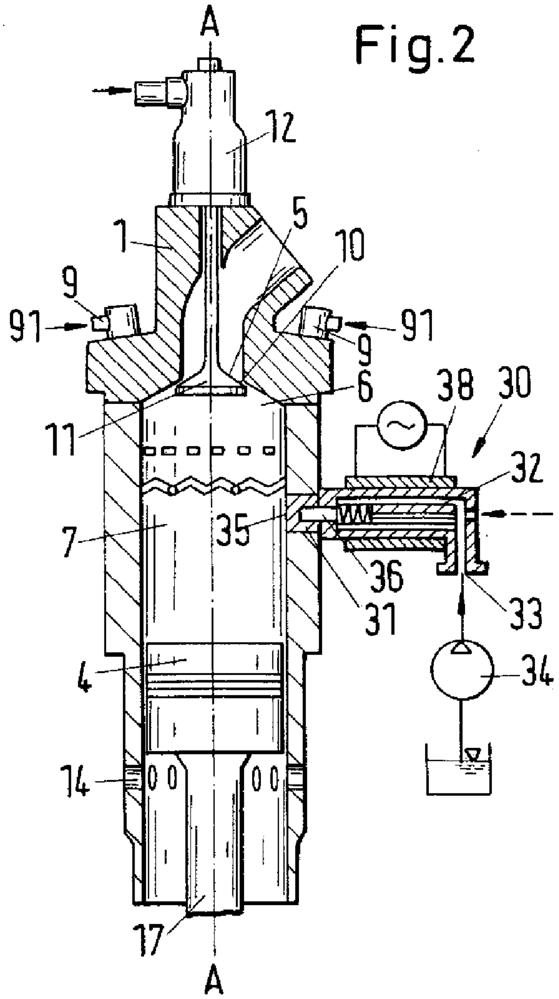

Fig.3

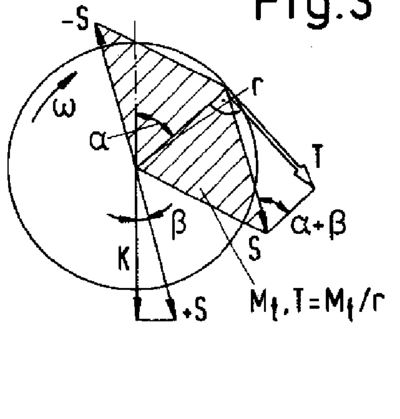

Fig.4

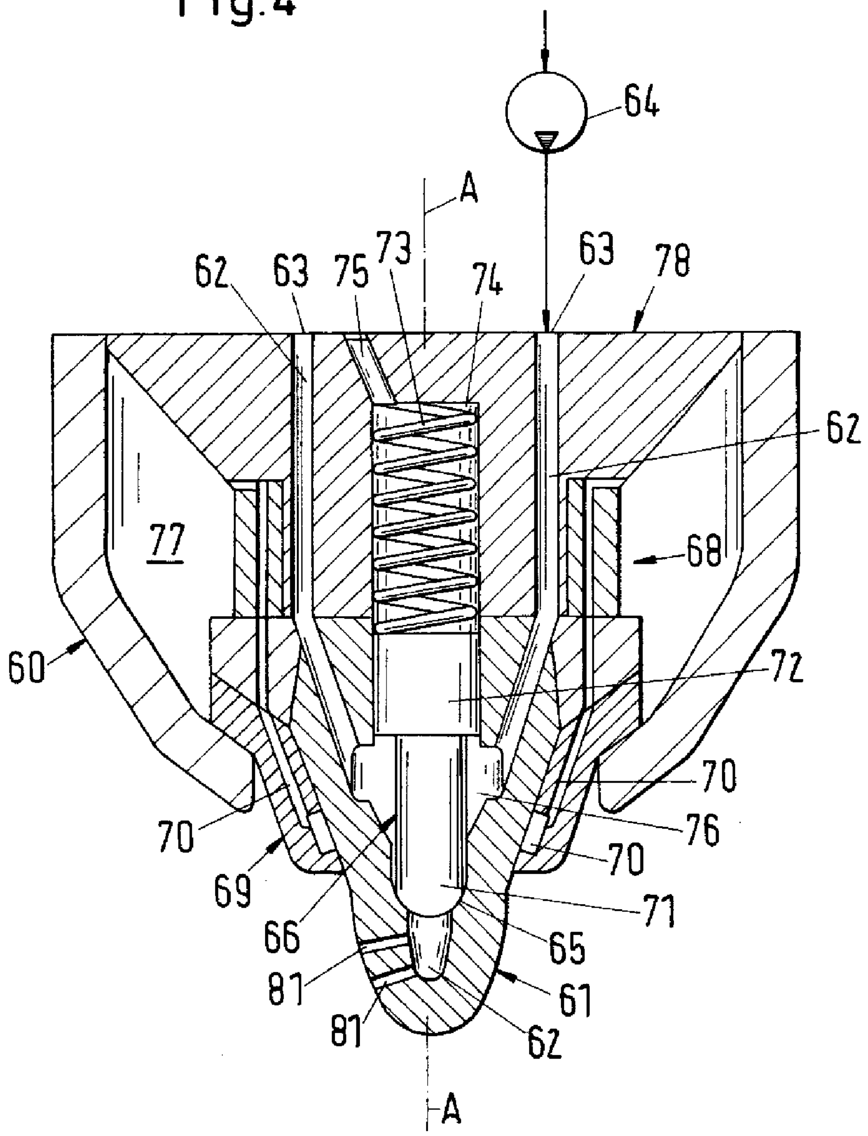
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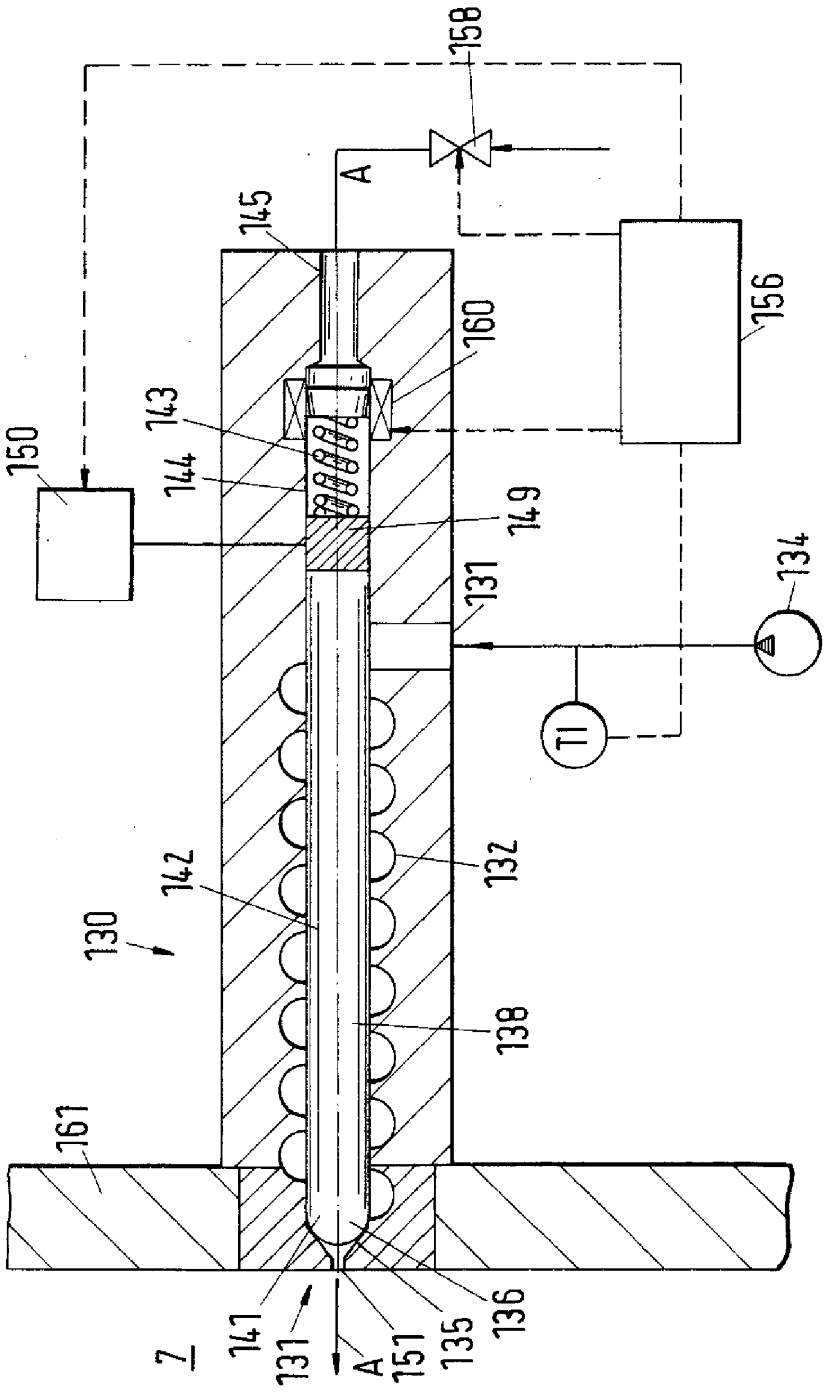
Fig.5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