CLAIMS

1. A method of improving the lubrication system of a large slow running engine,

wherein the engine comprises a cylinder (1) with a reciprocal piston inside and with a plurality of lubricant injectors (4) distributed along a perimeter of the cylinder (1) for injection of lubricant into the cylinder (1) at various positions on the perimeter during injection phases;

wherein the lubrication system is configured for providing lubricant to the injectors (4) in the injection phases; wherein the lubrication system comprises a lubricator (11) pipe-connected to each injector (4) by a lubricant feed conduit (9) for providing pressurized lubricant to each injector (4) through the lubricant feed conduit (9) in the injection phases;

wherein the lubricator (11) comprises a housing (101) in which a hydraulic-driven actuator piston (123) is arranged reciprocal along a stroke length,

wherein the housing (101) further contains a plurality of injection plungers (119) and a corresponding plurality of dosing channels (115) as well as non-return valves (102), one for each dosing channel (115), each injection plunger (119) being slidingly arranged in one of the dosing channels (115), wherein the injection plungers (119) are coupled to the actuator piston (123) in order to be moved in common by the actuator piston (123) over the stroke length and as a consequence pressurize lubricant in the dosing channels (115) over a dosing channel distance for expelling the pressurized lubricant from each dosing channel (115) through the corresponding non-return valve (102) for injection of the lubricant into the engine cylinder (1); wherein the dosing channel distance defines the volume of lubricant expelled from the dosing channel (115) through the non-return valve (102) during the injection phase;

wherein each non-return valve (102) is provided in a corresponding valve-chamber (102') in the housing (11) and comprises a valve-member (23) pre-stressed against a lubricator valve-seat (24) by the load of a spring (25);

characterized in that the method comprises the steps of:

- removing the spring (25) and valve member (23) from the valve chamber (102') and

- substituting the lubricator valve seat (24) by inserting an insert (26) into the valve-chamber (102'), the insert (26) fitting tightly to the valve chamber (102') and comprising an insert valve-seat (29) that is different to the lubricator valve seat (24);
- providing the insert valve seat (29) with higher dimensional precision than the lubricator valve seat (24) by providing the insert valve seat (29) with a circular symmetric shape wherein the circular symmetry varies by less than 0.2 mm when measured across the insert valve seat (29); and
- providing the insert valve seat (29) with a surface roughness smaller than the surface roughness of the lubricator valve seat (24) by providing a surface roughness of the insert valve seat (29) of less than 12.5µm; and
- subsequently operating the lubricator (11) in the lubrication system of the engine with the insert valve-seat (29).

~~2. A method according to claim 1, wherein the method comprises providing the insert valve seat (29) with higher dimensional precision than the lubricator valve seat (24).~~

~~3. A method according to claim 2, wherein the method comprises providing the insert valve seat (29) with a circular symmetric shape wherein the circular symmetry varies by less than 0.2 mm when measured across the insert valve seat (29).~~

~~4. A method according to claim 1, wherein method comprises providing the insert valve seat (29) with a surface roughness smaller than the surface roughness of the lubricator valve seat (24).~~

~~5. A method according to claim 4, wherein the method comprises providing a surface roughness of the insert valve seat (29) of less than 12.5µm.~~

~~6.~~2. ~~A~~ The method according to claim 1, wherein method comprises providing the insert valve seat (29) concave with a first radius of curvature, and the valve member (23) convex with a second radius of curvature equal to or smaller than the first radius of curvature; wherein the first and second radius of curvature is measured orthogonal to the insert valve seat (29).

~~7.~~3. The ~~A~~ method according to claims 1~~5~~, wherein the first radius of curvature is 5-50% larger than the second radius of curvature.

~~8.~~4. The ~~A~~ method according to claim 1, wherein the method comprises operating the lubricator (11) in the lubrication system for at least 100,000 lubrication injection cycles prior to the modification, and continuing operation of the lubrication system with the lubricator (11) and the insert valve-seat (29) after the modification.

~~9.~~5. The ~~A~~ method according to claim 1, wherein the method comprises operating the lubrication system by feeding lubricant to the injectors with the modified lubricator (11) at a lubricant pressure in the range of 20-100 bar and injecting a mist of atomized droplets of lubricant by the injectors into swirling scavenging air inside the engine cylinder and distributing the droplets onto the cylinder wall during transport of the droplets by swirling motion towards the top dead centre, TDC, of the cylinder.

~~10.~~6. A method of improving a lubricator (11) for a large slow running engine, the engine comprising a cylinder (1) with a reciprocal piston inside and with a plurality of lubricant injectors (4) distributed along a perimeter of the cylinder (1) for injection of lubricant into the cylinder (1) at various positions on the perimeter during injection phases; wherein the lubricator (11) is configured for providing pressurized lubricant to the injectors (4) in the injection phases;

wherein the lubricator (11) comprises a housing (101) in which a hydraulic-driven actuator piston (123) is arranged reciprocal along a stroke length,

wherein the housing (101) further contains a plurality of injection plungers (119) and a corresponding plurality of dosing channels (115) as well as non-return valves (102), one for each dosing channel (115), each injection plunger (119) being slidingly arranged in one of the dosing channels (115), wherein the injection plungers (119) are coupled to the actuator piston (123) in order to be moved in common by the actuator piston (123) over the stroke length and as a consequence pressurize lubricant in the dosing channels (115) over a dosing channel distance for expelling the pressurized lubricant from each dosing channels (115) through the corresponding non-return valve (102) for injection of the lubricant into the engine cylinder (1); wherein the dosing channel distance defines the volume of lubricant expelled from

the dosing channel (115) through the non-return valve (102) during the injection phase;

wherein each non-return valve (102) is provided in a corresponding valve-chamber (102') in the housing (11) and comprises a valve-member (23) pre-stressed against a lubricator valve-seat (24) by the load of a spring (25);

characterized in that the method comprises the steps of:

- removing the spring (25) and valve member (23) from the valve chamber (102') and

- substituting the lubricator valve seat (24) by inserting an insert (26) into the valve-chamber (102'), the insert (26) fitting tightly to the valve chamber (102') and comprising an insert valve-seat (29) that is different to the lubricator valve seat (24);

- providing the insert valve seat (29) with higher dimensional precision than the lubricator valve seat (24) by providing the insert valve seat (29) with a circular symmetric shape wherein the circular symmetry varies by less than 0.2 mm when measured across the insert valve seat (29); and

- providing the insert valve seat (29) with a surface roughness smaller than the surface roughness of the lubricator valve seat (24) by providing a surface roughness of the insert valve seat (29) of less than 12.5µm; and

- subsequently operating the lubricator (11) in the lubrication system of the engine with the insert valve-seat (29).

~~11. A method according to claim 10, wherein the method comprises providing the insert valve seat (29) with higher dimensional precision than the lubricator valve seat (24).~~

~~12. A method according to claim 11, wherein the method comprises providing the insert valve seat (29) with a circular symmetric shape wherein the circular symmetry varies by less than 0.1 mm when measured across the different valve seat (24).~~

~~13. A method according to claim 10, wherein method comprises providing the insert valve seat (29) with a surface roughness smaller than the surface roughness of the lubricator valve seat (24).~~

~~14. A method according to claim 13, wherein the method comprises providing a surface roughness of the insert valve seat (29) of less than 12.5µm.~~

~~15.~~7. The ~~A~~ method according to claim 6~~10~~, wherein method comprises providing the insert valve seat (29) concave with a first radius of curvature, and the valve member (23) convex with a second radius of curvature equal to or smaller than the first radius of curvature; wherein the first and second radius of curvature is measured orthogonal to the insert valve seat (29).

~~16.~~8. The ~~A~~ method according to claims 7~~15~~, wherein the first radius of curvature is 5-50% larger than the second radius of curvature.

~~17.~~9. A lubricator (11) for a large slow running engine, the engine comprising a cylinder (1) with a reciprocal piston inside and with a plurality of lubricant injectors (4) distributed along a perimeter of the cylinder (1) for injection of lubricant into the cylinder (1) at various positions on the perimeter during injection phases; wherein the lubricator (11) is configured for providing pressurized lubricant to the injectors (4) in the injection phases;

wherein the lubricator (11) comprises a housing (101) in which a hydraulic-driven actuator piston (123) is arranged reciprocal along a stroke length,

wherein the housing (101) further contains a plurality of injection plungers (119) and a corresponding plurality of dosing channels (115) as well as non-return valves (102), one for each dosing channel (115), each injection plunger (119) being slidingly arranged in one of the dosing channels (115), wherein the injection plungers (119) are coupled to the actuator piston (123) in order to be moved in common by the actuator piston (123) over the stroke length and as a consequence pressurize lubricant in the dosing channels (115) over a dosing channel distance for expelling the pressurized lubricant from each dosing channels (115) through the corresponding non-return valve (102) for injection of the lubricant into the engine cylinder (1); wherein the dosing channel distance defines the volume of lubricant expelled from the dosing channel (115) through the non-return valve (102) during the injection phase;

wherein each non-return valve (102) is provided in a corresponding valve-chamber (102') in the housing (11) and comprises a spherical valve-member (23) pre-stressed against a valve-seat (29) by the load of a spring (25);

wherein the valve seat has a diameter of 3 to 10 mm;

wherein the thickness of the ring-formed contact surface between the valve member and the valve seat is in the range of 0.01 mm to 0.5 mm,

characterized in that the valve-seat (29) is part of an insert (26) that is contained in the valve-chamber (102') as a part separable from the valve chamber (102'), that the insert valve seat (29) is provided with a circular symmetric shape wherein the circular symmetry varies by less than 0.2 mm when measured across the insert valve seat (29); and

that the insert valve seat (29) is provided with a surface roughness of less than 12.5µm.

~~18. A lubricator according to claim 17, wherein the insert valve seat (29) has a circular symmetric shape wherein the circular symmetry varies by less than 0.2 mm when measured across the insert valve seat (29).~~

~~19. A lubricator according to claim 17 or 18, wherein the insert valve seat (29) has a surface roughness less than 12.5µm.~~

~~20.~~10. The ~~A~~ lubricator according to claim 9~~17~~, wherein the insert (26) comprises a double valve system with two serially arranged insert valve seats (29, 30) for two serially arranged non-return valves (21, 22).

~~21.~~11. The ~~A~~ lubricator according to claim 10~~20~~, wherein the two insert valve seats (29, 30) arranged serially as an upstream insert valve seat (30) and a downstream insert valve seat (29), wherein the upstream insert valve seat (30) is smaller than the downstream insert valve seat (29), and the upstream valve member (23') on the upstream insert valve seat (30) is smaller than the downstream valve member (23) on the downstream insert valve seat (29).

~~22.~~12. The ~~A~~ lubricator according to claim 11~~21~~, wherein the upstream valve member (23') is pre-stressed against the upstream insert valve seat (30) by a spring (25')

resting against the downstream valve member (23), which in turn is pre-stressed against the downstream insert valve seat (29) by ~~(29)~~ a further and stronger spring (25) in order for the further spring (25) to provide sufficient force for pre-stressing both valve members (23, 23') against their respective seats (29, 30).

~~23.~~13. The ~~A~~ lubricator according to claim 9~~17~~, wherein the valve seat (29) in the insert (26) is concave with a first radius of curvature, and the valve member (23) in the insert (26) is convex with a second radius of curvature equal to or smaller than the first radius of curvature; wherein the first and second radius of curvature is measured orthogonal to the insert valve seat (29).

~~24.~~14. The ~~A~~ lubricator according to claim 13~~23~~, wherein the first radius of curvature is 5-50% larger than the second radius of curvature.

~~25.~~15. The ~~A~~ lubricator according to claim 9~~17~~, wherein the insert (26) comprises an assembly of a first insert part (~~26A~~26B) and a second insert part (~~26B~~26A) that are interconnected and configured for insertion of the valve-member (23) and the spring (25) only prior to assembly of the first insert part (~~26A~~26B) with the second insert part (~~26B~~26A), wherein the first insert part (~~26A~~26B) comprises the valve seat (30) and the second insert part (~~26B~~26A) comprises a downstream outlet (32) for lubricant and a shoulder (33) at the outlet (32), wherein the shoulder (33) after assembly presses against the spring (25) in order to keep it pre-stressed against the valve member (23).