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(71) Applicant: WÄRTSILÄ FINLAND OY [FI/FI]; Tarhaajantie 2, FI-65380 Vaasa (FI).

(72) Inventors: SCIUTO, Giacomo; c/o Wärtsilä Italia S.p.A., Bagnoli della Rosandra, 334, San Dorligo della Valle, IT-34018 Trieste (IT). MOSCA, Francesco; c/o Wärtsilä Italia S.p.A., Bagnoli della Rosandra, 334, San Dorligo della Valle, IT-34018 Trieste (IT). ZUANIGH, Luca; c/o Wärtsilä Italia S.p.A., Bagnoli della Rosandra, 334, San Dorligo della Valle, IT-34018 Trieste (IT).

(74) Agent: GENIP OY; Heikinkatu 7, FI-48100 Kotka (FI).

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(54) Title: A METHOD IN A STARTING PROCEDURE OF AN INTERNAL COMBUSTION PISTON ENGINE PROVIDED WITH A COMMON-RAIL INJECTION SYSTEM

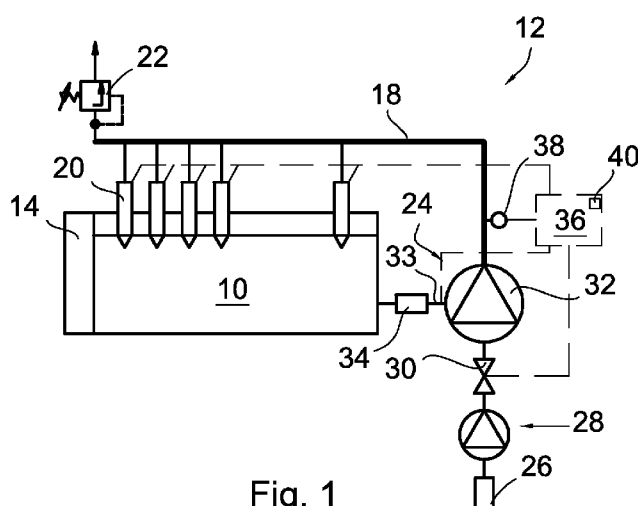


Fig. 1

(57) Abstract: A method in a starting procedure of an internal combustion piston engine (10) is disclosed, wherein the engine is cranked by means of a starting system (14) and fuel is pumped into in a common rail (18) of a fuel system (12) of the engine and/or pressure of the fuel is increased in the common rail system of the engine by operating a high pressure pump (32) of the common rail (18) by cranking of the engine such that the speed of the pump is directly proportional to the speed of the engine (10). The performance set value information is determined to comprise instructions of setting allowed pressure range based on the speed of the engine, and the output obtained from the high pressure pump is controlled making use of the performance set value information by controlling a flow control valve (28) arranged to the inlet side of the high pressure pump (32).

A METHOD IN A STARTING PROCEDURE OF AN INTERNAL COMBUSTION PISTON ENGINE PROVIDED WITH A COMMON-RAIL INJECTION SYSTEM

5 Technical field

[001] The present invention relates to method in a starting procedure of an internal combustion piston engine according to the preamble of claim 1.

10 Background art

[002] Large bore reciprocating internal combustion piston engines, having the bore size more than 200 mm are commonly used as prime movers in marine vessels and power plants.

[003] Large bore reciprocating internal combustion engines working in dual fuel application are provided with three fuel systems. Firstly the engine is provided with a main liquid fuel system which is a liquid fuel introduction system using heavy fuel oil and/or light fuel oil during diesel mode operation of the engine.

[004] Secondly the engine is provided with a gaseous fuel system which is a gaseous fuel introduction system. The gaseous fuel introduction system comprises gas admission valves that allow the gas to enter the cylinder via a manifold during operating the engine in gas mode.

[005] Thirdly the engine is provided with a pilot fuel system which is a liquid fuel introduction system. The pilot fuel system is used for injecting the amount of fuel used for ignition of gaseous fuel in the gas mode operation of the engine and also during the diesel mode operation of the engine only for keeping nozzle holes clean.

[006] Typically the pilot fuel system is a so called common rail system which comprises as its main components a pressure accumulator i.e. a common rail, a number of fuel injectors connected to the pressure accumulator and a high pressure pump adapted to feed fuel to the pressure accumulator and maintain a predetermined high pressure in the accumulator. In such a large bore engines the high pressure pump is typically a piston pump arranged to be driven directly by the engine via a gear system.

[007] During starting phase of a large bore engine the combination of the pressure in the common rail which is acting on the high pressure pump pistons and engine speed i.e. the pump speed is a very critical and if not correct that may damage the pump, and impair the complete common rail fuel system with worn material particles.

[008] An object of the invention is to provide method in a starting procedure of an internal combustion piston engine in which the performance is considerably improved compared to the prior art solutions.

Disclosure of the Invention

[009] The objects of the invention can be met substantially as is disclosed in the independent claim and in the other claims describing more details of different embodiments of the invention.

[0010] According to the invention during a starting procedure of an internal combustion piston engine the engine is cranked by means of a starting system and fuel is pumped into in a common rail of a fuel system of the engine and/or pressure of the fuel is increased in the common rail system of the engine by operating a high pressure pump of the common rail system by cranking of the engine such that the speed of the pump is directly proportional to the speed of the engine. In the method perfor-

mance set value information is determined, which comprises instructions of setting allowed pressure range in the common rail based on the speed behaviour of the engine. Since the pump is directly driven by the engine the speed of the pump is directly proportional to the speed of the engine
5 and thus instructions of setting allowed pressure range in the common rail is also based on the speed of the high pressure pump.

[0011] The output obtained from the high pressure pump is controlled making use of the performance set value information such that forces
10 generated by the fuel onto the pump is within a specific range i.e. no damages on the piston and on the lubricating system of pump is caused and, on the other hand, it is ensured that amount of pressure in the system is sufficient to support fuel injection into the cylinders of the with specific injection duration. During starting phase the control unit regu-
15 lates the common rail system pressure, and by utilizing a feedback signal of measurement of the rail pressure the control unit operates the flow control valve.

[0012] The output obtained from the high pressure pump is controlled by
20 controlling a flow control valve arranged to the inlet side of the high pressure pump such that the output is in conformity with the performance set value information.

[0013] Controlling the flow control valve arranged to the inlet side of the
25 high pressure pump effects on the inlet pressure of high pressure pump which is controlled to obtain a desired pre-set output pressure of the high pressure pump set as a function of the engine or pump speed.

[0014] According to an embodiment of the invention the inlet pressure of
30 high pressure pump is controlled to obtain a desired pre-set output pressure of the high pressure pump set as a function of time derivative of the engine speed.

[0015] According to an embodiment of the invention fuel is delivered to the high pressure pump by a dedicated transfer pump arranged to the fuel system upstream the high pressure pump and the output obtained from the high pressure pump is controlled by operating a flow control
5 valve arranged between the outlet of the transfer pump and the inlet of the high pressure pump.

[0016] According to an embodiment of the invention the pressure of the fuel is measured in outlet side of the high pressure pump and the output
10 obtained from the high pressure pump is controlled making use of the performance set value information and the pressure of the fuel.

[0017] According to an embodiment of the invention the performance set value information comprises a lookup table including maximum allowed
15 pressure and minimum required pressure for a number of distinct speed value of the engine.

[0018] According to an embodiment of the invention the performance set value information comprises executable instructions to calculate maxi-
20 mum allowed pressure and minimum required pressure as a function of the speed value of the engine.

[0019] According to an embodiment of the invention the performance set value information is determined such that that the stresses generated by
25 the fuel pressure to the pump is within a specific predetermined range.

[0020] According to an embodiment of the invention the performance set value information is determined such that that the force generated by the fuel pressure to the pump's pistons is within a specific predetermined
30 range.

[0021] According to an embodiment of the invention the performance set value information is determined such that that the force generated by the

fuel pressure to the pump's bearings is within a specific predetermined range.

[0022] By means of the invention it is possible to provide a specific combination and/or setup of starting settings such as pump drive train gear ratio, engine starting ramp and common rail fuel pressure, that allows the engine and the high pressure pump to be started in a safe manner avoiding any failure of the involved components.

[0023] Invention provides several advantages. Optimised pressure system during starting phase: pressure within the fuel high pressure system, during transient phase, is kept within a range that ensures the correct operating conditions without any damage to the involved components. Secondly, reduction of component wear is obtained because due to optimised pressure level during starting phase the involved components operates in safe condition e.g. lubricating status in the pump will be completely developed when maximum pressure is reached in steady condition, and no dangerous or harmful conditions are reached.

20

Brief Description of Drawings

[0024] In the following, the invention will be described with reference to the accompanying exemplary, schematic drawing, in which
Figure 1 illustrates a common rail fuel system of an internal combustion piston engine according to the invention.

Detailed Description of Drawings

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[0025] Figure 1 depicts schematically an internal combustion piston engine 10. There is shown a fuel system 12 of the engine but only to the

extent necessary for understanding the invention and the operation thereof. The fuel system 12 is of a common rail fuel system type. It should be noted that the fuel system 12 described here may represent a sole fuel system of the engine or it may also be a subsystem of a larger fuel arrangement. According to a specific embodiment the fuel system 12 is a part of a fuel system of a so called gas engine in which the fuel system 12 may be used a pilot fuel injection system for igniting the charge in the cylinder. Thus other possible additional and/or parallel fuel systems are not shown here. The fuel system shown here comprises a so called common rail 18 i.e. a pressure accumulator which is arranged in flow connection with fuel injectors 20 of the engine such that the fuel pressure in the common rail 18 is continuously effected in the injectors 20 and control of the fuel admission is accomplished separated by means known as such (not shown). The common rail 18 is also provided with a safety valve 22 allowing fuel to escape from the common rail in case the pressure exceeds a certain predetermined set value.

[0026] Additionally the fuel system 12 is provided with a fuel supply system 24. The fuel supply system comprises a source of fuel 26 and a means for transferring the fuel from the source of fuel 26 to the engine, which may include a transfer pump 28 and other auxiliary devices such as filters etc. Fuel is delivered to the high pressure pump 32 by a dedicated transfer pump arranged to the fuel system upstream the high pressure pump. The fuel supply system 24 comprises also a high pressure pump 32 the inlet side of which is in connection with an outlet side of the transfer pump 24. There is a flow control valve 30 arranged between the transfer pump 28 and the high pressure pump 32. The high pressure pump 32 is mechanically connected to and driven by the engine 10 via a drivetrain 33. There may be a gear system 34 arranged in the drivetrain 33 between the engine 10 and the pump 32 by means of which the gear ratio may be set suitably. In any case, the drivetrain result in the effect

that the pump rotates with a speed which is directly proportional to the engine speed.

[0027] The fuel system 12 is provided with a control unit 36. The control unit 36 may be a dedicated control unit for the fuel system or an integral part of a general engine control system (not shown). The control unit 36 shown in the figure or the general engine control system is arranged to control the operation of each injector 20 of the engine. Particularly, the control system 36 control the injection duration of each injector based on e.g. information stored in one or more a look-up table. There is a pressure probe 38 arranged to common rail 18 or a conduit leading from the high pressure pump 32 the common rail. The pressure probe is adapted to communicate with the control unit 36 such that the measure pressure prevailing in the common rail is available to the control unit 36 for further processing. The control unit 36 is adapted to communicate with the flow control valve 30 such that the flow control effect obtained by the valve 30 is controllable by the control unit 36. Thus the pressure of the fuel is measured in outlet side of the high pressure pump 32. The output obtained from the high pressure pump is controlled making use of the performance set value information and the pressure of the fuel.

[0028] The engine is also provided with a starting system 14, which is depicted here in extremely schematic manner. In large bore engines the starting system is typically an air start system using high pressure compressed air. The air is admitted into the cylinders when the piston is just past top dead center and continued until just before the exhaust valve opens.

[0029] Now, the invention relates specifically to transient operation of the fuel system during the starting procedure of the engine 10. During the starting procedure of the internal combustion piston engine 10 the engine is cranked by means of the starting system 14. At this stage the high

pressure pump 32 starts to deliver the fuel in to the common rail 18 and increase the fuel pressure simultaneously. The acceleration ramp of the pump 32 follows the acceleration ramp of the engine 10 due to the fixed drivetrain between the engine 10 and the pump 32. In other words the speed of the pump is directly proportional to the speed of the engine.

[0030] According to the invention the control unit 36 is provided with or is provided with access to performance set value information unit 40. The performance set value information unit 40 comprises the performance instructions set to the high pressure pump 32. More specifically the performance set value information comprises instructions to set allowed output, or pressure raise obtained by the pump 32 based on the speed behaviour of the engine, such as the actual speed or time derivative of the speed of the engine. The control unit 36 is adapted to control the output obtained from the high pressure pump 32 making use of the performance set value information 40. Since the pressure of the fuel is measured the output obtained from the high pressure pump is controlled making use of the performance set value information and the measured pressure of the fuel.

[0031] Advantageously the output obtained from the high pressure pump is controlled by controlling a flow control valve arranged to the inlet side of the high pressure pump 32. This way the inlet pressure of high pressure pump 32 is controlled to obtain a desired pre-set output pressure of the high pressure pump 32 set as a function of the engine speed.

[0032] Since the characteristics of the high pressure pump i.e. so called pump curve is known it may be also feasible to modify the invention such that that the pressure of the fuel is measured at inlet side of the high pressure pump but after the flow control valve 30 and the output obtained from the high pressure pump is controlled making use of the performance set value information and the pressure of the fuel.

[0033] According to an embodiment of the invention the performance set value information comprises a lookup table including maximum allowed pressure and minimum required pressure for a number of distinct speed value of the engine. According to another embodiment of the invention the performance set value information comprises executable instructions to calculate maximum allowed pressure and minimum required pressure as a function of the speed value of the engine.

[0034] According to an embodiment of the invention the performance set value information is determined such that that the stresses generated by the fuel pressure to the pump is within a specific predetermined range and/or the performance set value information is determined such that that the force generated by the fuel pressure to the pump's pistons is within a specific predetermined range and/or the performance set value information is determined such that that the force generated by the fuel pressure to the pump's bearings is within a specific predetermined range.

[0035] While the invention has been described herein by way of examples in connection with what are, at present, considered to be the most preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but is intended to cover various combinations or modifications of its features, and several other applications included within the scope of the invention, as defined in the appended claims. The details mentioned in connection with any embodiment above may be used in connection with another embodiment when such combination is technically feasible.

Claims

1. A method in a starting procedure of an internal combustion piston
5 engine (10), in which method the engine is cranked by means of a start-
ing system (14) and fuel is pumped into in a common rail (18) of a fuel
system (12) of the engine and/or pressure of the fuel is increased in the
common rail system of the engine by operating a high pressure pump
(32) of the common rail (18) by cranking of the engine such that the
10 speed of the pump is directly proportional to the speed of the engine
(10), **characterized** in that performance set value information is deter-
mined to comprise instructions of setting allowed pressure range based
on speed behaviour of the engine, and the output obtained from the high
pressure pump is controlled making use of the performance set value
15 information by controlling a flow control valve (28) arranged to the inlet
side of the high pressure pump (32).

2. A method in a starting procedure of an internal combustion piston
engine according to claim 1, **characterized** in that the inlet pressure of
high pressure pump (32) is controlled to obtain a desired pre-set output
20 pressure of the high pressure pump (32) set as a function of the engine
speed.

3. A method in a starting procedure of an internal combustion piston
engine according to claim 1, **characterized** in that the inlet pressure of
high pressure pump (32) is controlled to obtain a desired pre-set output
25 pressure of the high pressure pump (32) set as a function of time deriva-
tive of the engine speed.

4. A method in a starting procedure of an internal combustion piston
engine according to claim 2 or 3, **characterized** in that fuel is delivered
to the high pressure pump (32) by a dedicated transfer pump (28) ar-
30 ranged to the fuel system upstream the high pressure pump and the out-

put obtained from the high pressure pump is controlled by operating a flow control valve (30) arranged between to outlet of the transfer pump (28) and the inlet of the high pressure pump (38).

5. A method in a starting procedure of an internal combustion piston engine according to claim 1, **characterized** in that the pressure of the fuel is measured in outlet side of the high pressure pump (32) and the output obtained from the high pressure pump is controlled making use of the performance set value information (40) and the pressure of the fuel (38).
6. A method in a starting procedure of an internal combustion piston engine according to claim 1, **characterized** in that the performance set value information (40) comprises a lookup table including maximum allowed pressure and minimum required pressure for a number of distinct speed value of the engine.
7. A method in a starting procedure of an internal combustion piston engine according to claim 1, **characterized** in that the performance set value information (40) comprises executable instructions to calculate maximum allowed pressure and minimum required pressure as a function of the speed value of the engine.
8. A method in a starting procedure of an internal combustion piston engine according to claim 1, **characterized** in that the performance set value information (40) is determined such that that the stresses generated by the fuel pressure to the pump is within a specific predetermined range.
9. A method in a starting procedure of an internal combustion piston engine according to claim 7, **characterized** in that the performance set value information (40) is determined such that that the force generated by the fuel pressure to the pump's pistons is within a specific predetermined range.

10. A method in a starting procedure of an internal combustion piston engine according to claim 7, **characterized** in that the performance set value information (40) is determined such that that the force generated by the fuel pressure to the pump's bearings is within a specific predetermined range.
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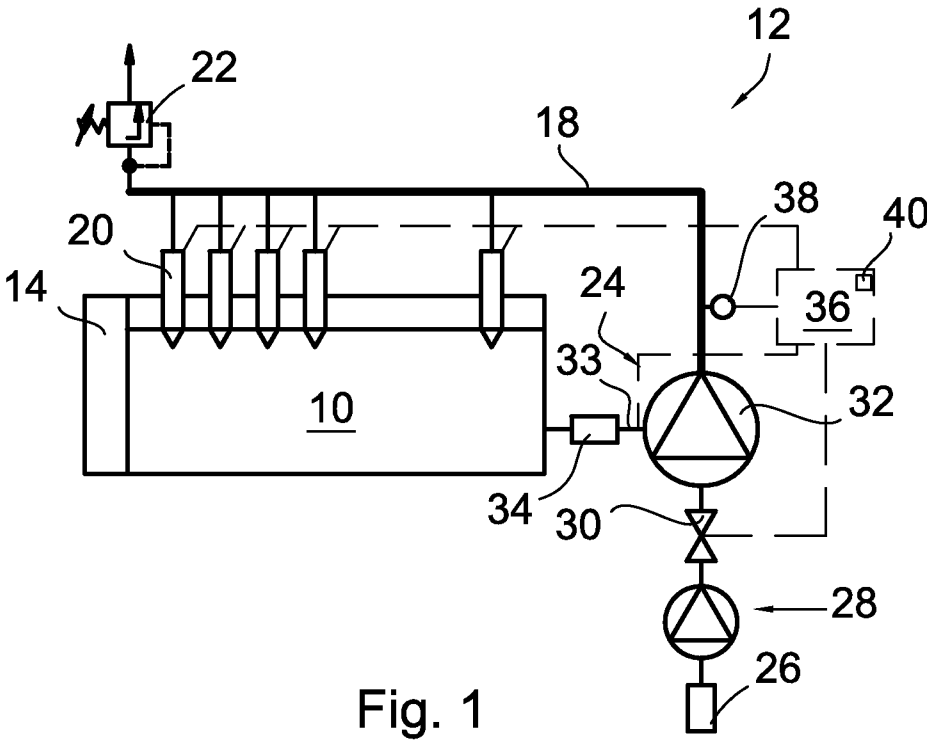


Fig. 1

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER

INV. F02D41/06 F02D41/38 F02M59/36
ADD. F02D19/10 F02D41/00 F02M43/04 F02M63/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F02D F02M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	DE 10 2013 218838 A1 (BOSCH GMBH ROBERT [DE]) 19 March 2015 (2015-03-19) paragraphs [0002] - [0005], [0009], [0014]; figure 1 -----	1,4,5, 8-10
X	EP 1 529 940 A2 (DENSO CORP [JP]) 11 May 2005 (2005-05-11) abstract; figures 1-9 ----- -/-	1,2,4,5, 8-10



Further documents are listed in the continuation of Box C.



See patent family annex.

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European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Mineau, Christophe

INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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Information on patent family members

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