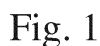


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trical auxiliary pump (AP) arranged to feed oil to said second group of oil consumers (NZ); the system being arranged, during engine brake operation, to command an interconnection of said main and auxiliary circuits, to control said main pump to provide for a relative maximum oil flow and to control said auxiliary pump to extract energy from said oil flow provided by said main pump, thereby generating electric energy.



Description

PRIORITY CLAIM

[0001] *This application claims priority from Italian Patent Application No. 102017000034652 filed on 29/03/2017.*

Field of the invention

[0002] The present invention relates to the field of the cooling and lubricating systems of the internal combustion engines.

Description of the prior art

[0003] The engine oil circuit has two different tasks to cool certain components, to lubricate other components and to lubricate and cool further components.

[0004] The engine pistons belong to the first of the above categories, being components that, as such, request only cooling. Instead, all the piston connections: the piston pin, the piston pin bore, the conrod small end, etc.. need lubrication more than cooling. WO2010002293 discloses the possibility to separate the piston oil cooling circuit from the others oil consumers by means of a separate pump.

[0005] Thus a separate oil circuit to cool the engine piston (s) with a corresponding separate pump, with respect to the remaining and "traditional" engine lubricating circuit arranged to lubricate all the internal combustion engine components requiring lubrication from the engine oil such as the crankshaft bearings, the valves system including the camshaft and rocker bearings and possibly also the actuators to command/switch the valves timing, for example to operate the engine braking, or an Atkinson/Miller cycle and so on. According to the present description, with "auxiliary oil circuit" is intended the above separate oil circuit to cool the engine piston(s), with respect to the main one, including an auxiliary pump sucking the engine oil from a common engine oil sump/tank and optionally an auxiliary cooler capable to cool the oil sucked by the auxiliary pump and at least one nozzle affixed to an engine wall so as to hit on opening of a cooling passage realized in the body piston.

[0006] Therefore, the secondary pump is controlled in order to supply a correct oil flow to the pistons.

Summary of the invention

[0007] The main object of the present invention is to provide a cooling circuit comprising two groups of engine oil consumers and two oil pumps arranged to independently supply oil to said groups of oil consumers capable to improve the engine efficiency at engine braking operation. The engine brake operation is well known and consists of the inhibition of the fuel injection in the engine cylinder(s) and a sudden compressed air releasing when

the piston is close to the top dead center.

[0008] Several engine brake operations are known, therefore such details are not relevant for the understanding of the present invention.

5 **[0009]** During engine brake operation it is also known to increase the load applied to the internal combustion engine, for example, by throttling the exhaust gas line of the internal combustion engine in order to increase its back pressure. These strategies are also known and thus such details are not relevant for the understanding of the present invention.

10 **[0010]** The main principle of the present invention is that during engine braking, the two independent oil circuits are interconnected, the main pump is operated in order to supply its maximum oil flow, while the auxiliary pump, electric type, is controlled in order to generate electric energy from the oil flow supplied by the main pump. Preferably, during electric generation, provision of oil for piston cooling is ensured.

15 **[0011]** Therefore, a portion of the oil flow pumped by the main pump reaches at least the first group of oil consumers and preferably also the second group of oil consumers, and another portion of the oil flow reaches the auxiliary pump which extracts electric energy from this another portion of oil flow. Then all the oil portions fall in the oil sump. The main pump is driven directly by the internal combustion engine, thus, the operation of the main pump, in order to supply its maximum oil flow, offers the higher load to the combustion engine. The main pump can have a variable and controllable displacement or can have a fixed displacement coupled with a controllable bypass circuit capable to control the oil flow. It is clear that also in the latter case the maximum - or rated - flow can be obtained by closing the main pump bypass circuit, leading to increase of the hydraulic load seen by the main pump and thus by the internal combustion engine. In this context, a join directly connects an engine PTO with the pump shaft. According to a preferred embodiment of the invention, a section of the circuit connecting the auxiliary pump with its own oil consumers is throttled, even not completely, in order to maximize the load seen by the main pump and the electric energy harvested by the auxiliary pump.

20 **[0012]** When the second group of oil consumers includes also bearings, the auxiliary oil circuit can comprise an auxiliary filter in order to avoid bearings damaging.

25 **[0013]** According to a further embodiment of the invention, only the piston nozzles are served by the auxiliary oil circuit and when the engine brake actuation is commanded, first the oil is diverted from the auxiliary circuit to the main circuit in order to suddenly pressurize the main gallery of the main circuit and obtain a prompt valve timing operation shifting, then the auxiliary pump is controlled to generate electric energy that is conveyed in the vehicle electric grid to which the vehicular battery is connected.

30 **[0014]** This sudden pressurization helps the main circuit to better serve switching means operating on the

camshaft/rocker arms and eventually further components in order to actuate said engine brake. The same diversion can be exploited also for actuating another valve timing strategy, however only during engine brake operation the main pump is controlled to develop its maximum oil flow and the auxiliary pump to work as an electric generator.

[0015] The main lubricating circuit can be pressurized by the auxiliary pump also before the engine cranking, namely when the main pump driven by the crankshaft is still. Thus, the auxiliary pump is switched on and the diverting means are activated before engine cranking by helping the lubrication of bearings and of other components in a condition where, usually, such components are stressed due to the lack of oil pressurization. Preferably, at cranking the activation of the auxiliary pump and of the diverting means is contemporary with or consequence of the on-board services activation, such as the fuel pump.

[0016] With the exception of the above temporary interconnection between main and auxiliary circuits through an interconnecting valve, the sole point in common between the main and auxiliary circuits is the oil sump or the oil tank in case the lubricating circuit is of the dry type.

[0017] It is clear that immediately after the circuits interconnection the pumping of oil by the main pump and the extraction of energy by the auxiliary pump are simultaneous actions.

[0018] These and further objects are achieved by means of the attached claims, which describe preferred embodiments of the invention, forming an integral part of the present description.

Brief description of the drawings

[0019] The invention will become fully clear from the following detailed description, given by way of a mere exemplifying and non-limiting example, to be read with reference to the attached drawing figures, wherein:

- Fig. 1 shows schematically an example of implementation of the present invention,

[0020] The same reference numerals and letters in the figures designate the same or functionally equivalent parts. According to the present invention, the term "second element" does not imply the presence of a "first element", first, second, etc.. are used only for improving the clarity of the description and they should not be interpreted in a limiting way.

Detailed description of the preferred embodiments

[0021] The present invention is here described with the help of figure 1.

[0022] An internal combustion engine, as usual, comprises a piston reciprocated with a respective cylinder.

[0023] A lubricating and cooling system is implemented to both cool the pistons and lubricate other "oil consumers". After its work, the oil, as usual, falls in an oil sump OS where the oil is collected or in case of dry oil circuit, the oil is collected in a dedicated oil tank.

[0024] According to the present invention, an auxiliary oil circuit with an electric auxiliary pump AP sucks oil from the oil sump/tank to feed only the piston nozzles NZ cooling the engine piston or optionally also other oil consumers, while a main oil circuit with a respective main pump MP sucks oil from the same oil sump/tank to feed oil to the first group of engine oil consumers CB-RA, CM, CR with the exception of the second group of engine oil consumers served by the auxiliary circuit.

[0025] Therefore, the oil consumers can be considered as divided into a first and a second group, wherein the first group is served by the main pump/circuit and second group by the auxiliary pump/circuit and wherein the second group comprises only or at least said oil piston nozzles NZ. According to the invention, the main pump is of a variable flow pump or, alternatively, the main pump MP is not controllable, namely fixed, but is provided with a bypass pipe connecting the main pump inlet with the main pump outlet through a controllable main valve MCV, so as the oil flow is handled through said controllable auxiliary valve MCV. Being both solutions equivalent, a reference to a variable flow pump includes also a fixed flow pump provided with said bypass means.

[0026] According to the invention, the controllable interconnecting valve SW connects the main circuit with the auxiliary circuit and the main pump is driven to provide its maximum oil flow and pressure, and in order to offer the maximum possible - namely rated - load to the internal combustion engine driving the main pump; at the same time the auxiliary pump, electric type, extracts energy from the oil provided by the main pump to generate electric energy supplied to the vehicular electric grid.

[0027] Preferably, when the timing switching means are activated, the controllable interconnecting valve SW interconnects both the circuits and the auxiliary pump cooperate with the main pump in pressurizing the switching means SM, namely those hydraulic actuators capable to change the engine valve timing. After the valve timing is changed into engine brake, the auxiliary pump switches from pumping oil into extracting energy from oil.

[0028] In other words, in a first phase the auxiliary pump cooperates with the main pump, and in a second subsequent phase, the auxiliary pump becomes an electric generator, when the engine turns in engine brake operation.

[0029] In those timing valve switching, leading to a different strategy from engine braking, such as Atkinson/Miller strategy or internal EGR, after said first phase of cooperation of both the pumps/circuits, the interconnecting valve SW disconnects the circuits and both the pumps pump oil according their respective requirements.

[0030] Preferably, the main circuit comprises a main cooler MC. Preferably, the auxiliary circuit comprises an

auxiliary cooler AC separated and thermally independent from the main cooler.

[0031] Preferably, the auxiliary cooler is refreshed by the ambient air directly or indirectly through an intermediate vectoring medium. According to figure 1, the auxiliary cooler AC is a thermal exchanger between the engine oil directed to the piston nozzles and an intermediate vectoring medium circulating in a secondary circuit, where the heat is released to the ambient through the vectoring medium/ambient air exchanger SAC. However, an indirect cooling of the oil circulating in the auxiliary circuit is not mandatory.

[0032] The engine oil consumers, are mainly the followings:

- Command means CM including camshaft bearings CB and rocker arms RA, and switching means SM for varying cylinder valve timing actuation,
- eventually idler gear bearings
- air compressor bearings
- turbocharger bearings
- gears
- PTO (Power Take Off)
- Piston nozzle NZ.

[0033] Preferably, if the second oil consumers group comprises only piston nozzles, the auxiliary circuit is not provided of an oil filter, because the cooling of the piston does not necessarily require oil filtration.

[0034] Preferably, a throttling valve V is arranged on the auxiliary circuit between the interconnection valve SW and the oil piston nozzles NZ.

[0035] According to another preferred embodiment that can be combined with the above ones, the auxiliary circuit comprises an auxiliary pressure sensor PS arranged between an outlet of the auxiliary pump and the piston nozzles NZ, and a control unit, preferably the engine control unit, controls the auxiliary pump on the basis of a pressure signal generated by the auxiliary pressure sensor, when the engine is fired.

[0036] According to another preferred embodiment of the invention, even combinable with the others herewith described, during engine firing operation the control unit controls the pumps so that the oil fed by the auxiliary pump is proportional to the power delivered by the respective combustion engine and/or the oil fed by main pump is proportional to the engine speed.

[0037] Preferably, such controls are actuated by varying the target pressures within the respective main galleries of the main and auxiliary circuits.

[0038] Preferably, during timing valve switching, the piston nozzles are shut off, due to the throttling valve V, for a short time interval just before the activation of switching means SM capable to vary the activation of the engine valves, for example for engine brake or internal EGR, and so on. Such short time is, for example, less than 1 second and in general depends on the engine operating point. Therefore, the above oil diversion in connection

with the throttling of the piston nozzles, leads oil pressure to increase suddenly within the main oil circuit, by making faster the dynamics of the switching means. Immediately after the activation of the engine control means CM, the piston cooling is restored, thus the oil circulated by the auxiliary circuit is driven to the piston oil jets.

[0039] With command means CM are intended, in general, the devices controlling the cylinder valves, such as rocker arms/finger follower, camshaft, etc. and the relative switching means SM are those, per se known components, capable to vary the timing of the valve actuation according to an auxiliary strategy, such as engine brake or internal EGR, Atkinson, Miller, and so on.

[0040] This strategy leads to energy savings since the load offered to the internal combustion engine is harvested recharging vehicle batteries.

[0041] According to a preferred embodiment of the invention, also this "oil diversion" from the auxiliary circuit to the main circuit is actuated for a short time when the engine brake function or the internal EGR or other similar strategies are commanded to be activated or deactivated, namely during transition between two or more valve operating strategy. The time interval duration of the oil diversion depends on the dynamics of the switching means SM involved in the switching operation, however said time duration <1 second should be enough.

[0042] A nozzle NZ is fixed with an internal part of the engine body in a lower position in order not to interfere with the piston travel.

[0043] The nozzle ejects engine lubricating oil towards the inlet opening of a passage realized under the piston skirt.

[0044] Many changes, modifications, variations and other uses and applications of the subject invention will become apparent to those skilled in the art after considering the specification and the accompanying drawings which disclose preferred embodiments thereof. All such changes, modifications, variations and other uses and applications which do not depart from the scope of the invention are deemed to be covered by this invention.

[0045] It should be understood that all the single features and/or embodiments can be combined between each other. In addition, the features disclosed in the prior art background are introduced only in order to better understand the invention and not as a declaration about the existence of known prior art. Therefore, also the features described in the prior art background can be considered in combination with those mentioned in each embodiment of the detailed description. Further implementation details will not be described, as the man skilled in the art is able to carry out the invention starting from the teaching of the above description.

Claims

1. Lubricating and cooling system for an internal combustion engine, the combustion engine comprising

a piston suitable to reciprocate with a respective cylinder, the system comprising a multitude of oil consumers grouped into a first and a second group, wherein said second group comprises at least one piston nozzle(s) (NZ) arranged in order to refresh said piston, the system comprising

- a main oil circuit with a respective main pump (MP), comprising connecting means for being directly driven by said internal combustion engine, wherein said main pump is a controllable variable flow pump arranged to feed oil to said first group of oil consumers (CB-RA, CM, CR);
- an auxiliary oil circuit with a respective electrical auxiliary pump (AP) arranged to feed oil to said second group of oil consumers (NZ),
- an interconnecting valve (SW) capable to selectively operatively interconnect said first and second circuits, the system being arranged, during engine brake operation,
- to command said interconnecting valve (SW) to operatively interconnect said main and auxiliary circuits, and then
- to control said main pump to provide for a relative maximum oil flow, and
- to control said auxiliary pump to extract energy from said oil flow provided by said main pump, thereby generating electric energy.

2. System according to claim 1, further arranged in such a way, during a valve timing switching,

- to command said interconnecting valve to interconnect said main and auxiliary circuits,
- to control said main pump to provide for a relative maximum oil flow,
- to control said auxiliary pump to cooperate with said main pump to build up pressure in the main circuit to speed up said valve timing switching.

3. System according to claim 2, wherein, when after said valve timing switching, said engine is fired, the system is arranged

- to command said interconnecting valve to disconnect said main and auxiliary circuits,
- to control said main pump to provide for a relative predetermined oil flow,
- to control said auxiliary pump to provide for a relative predetermined oil flow.

4. System according to any one of claims from 1 to 3, wherein said main circuit comprises a main cooler (MC) and said auxiliary circuit comprises an auxiliary cooler (AC) separated and thermally independent from said main cooler.

5. System according to any of previous claims, wherein

said engine oil consumers (CB-RA, CM, CR), comprise said piston nozzle (NZ) and at least one of the following oil consumers:

- Command means (CM) including camshaft bearings (CB), rocker arms (RA), and switching means (SM) for vary cylinder valve timing actuation,
- eventually idler gears
- air compressor bearings
- turbocharger bearings
- gears
- PTO (Power Take Off).

6. System according to any of the previous claims, wherein when said second group consist of said piston nozzle (NZ), said auxiliary oil circuit is filter-less.

7. System according to any of the previous claims, wherein said main pump (MP) has a variable geometry or is provided with a bypass pipe connecting a main pump inlet with a main pump outlet and a relative main throttling valve (MCV), to control said oil flow.

8. Combustion engine comprising a piston reciprocated with a respective cylinder, and cooling system according to any of previous claims 1 to 7.

9. Terrestrial vehicle or fixed installation provided with the combustion engine according to claim 8.

10. Method of managing an engine brake operation in an internal combustion engine provided with a piston reciprocated with a respective cylinder and with a lubricating and cooling system comprising a multitude of engine oil consumers grouped into a first and a second group, wherein said second group comprises at least one piston nozzle(s) (NZ) arranged in order to refresh said piston, wherein the system comprises a main oil circuit with a respective main pump (MP), comprising connecting means for being directly driven by said internal combustion engine, wherein said main pump is a controllable variable flow pump arranged to feed oil to said first group of oil consumers (CB-RA, CM, CR) and an auxiliary oil circuit with a respective electrical auxiliary pump (AP) arranged to feed oil to said second group of oil consumers (NZ), the method comprising the following steps:

- (i) operative interconnection of said first and second circuits, and then
- (ii) controlling said main pump to provide for a relative maximum oil flow, and
- (iii) controlling said auxiliary pump to extract energy from said oil flow provided by said main pump, thereby generating electric energy.

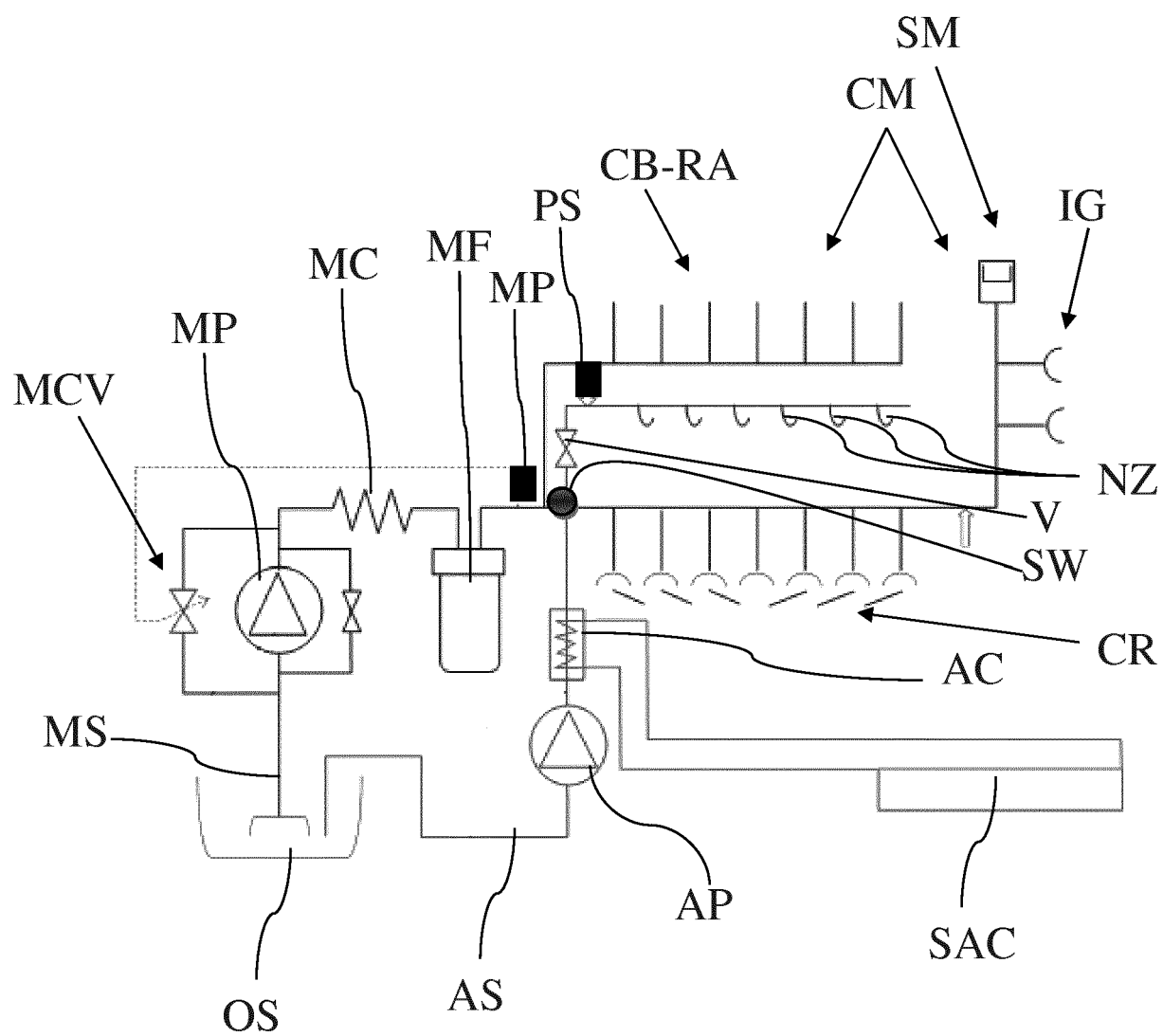


Fig. 1



EUROPEAN SEARCH REPORT

Application Number
EP 18 16 5241

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	JP 2004 218468 A (TOYOTA MOTOR CORP; AISIN SEIKI) 5 August 2004 (2004-08-05) * abstract; figures 1-10 * -----	1-10	INV. F01M1/16 F04C28/04
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			F01M F04C
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 5 June 2018	Examiner Flamme, Emmanuel
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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