(51) International Patent Classification:
    FOIL 1/255 (2006.01) FOIL 1/00 (2006.01)

(21) International Application Number:
PCT/FI2009/050626

(22) International Filing Date:
15 July 2009 (15.07.2009)

(25) Filing Language:
English

(26) Publication Language:
English

(30) Priority Data:
20085756 31 July 2008 (31.07.2008) FI

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(84) Designated States (unless otherwise indicated, for every kind of regional protection available): AIPRIO (BW, BH, GM, KE, LS, MW, MZ, NA, SD, SL, NZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW).

(54) Title: A CONTROL ARRANGEMENT IN A PISTON ENGINE

(57) Abstract: The invention relates to a control arrangement for gas exchange in a piston engine adapted between a cam device (5) of a camshaft (4) of the engine (1) and an inlet valve (3) arranged to open and close the inlet valve (3) in association with a cylinder of the engine, which control arrangement (7) comprises a body part (8), in which a piston device (9) is movably arranged to be in force transmission connection with the camshaft (4) and the valve mechanism (6). The cam device (5) includes a cam profile (5') having a portion (5c) arranged under a base circle (5a) of the cam profile (5'). Said portion (5c) of the cam profile (5') is arranged to control gas exchange through the inlet valve (3), specifically for providing a delay in the closing of the inlet valve (3).
A CONTROL ARRANGEMENT IN A PISTON ENGINE

Technical field

The invention relates to a control arrangement for gas exchange in a piston engine in accordance with the preamble of claim 1.

Background art

There are situations in the operation of a four stroke internal combustion engine in which the cylinders are not provided with enough air for self-ignition to happen during the compression stroke. This is specifically true as regards engines charged by high pressure such as two-stage turbo charged engines during engine start and during load variations. In engines of this kind higher pressures in combination with sharper or shorter cam nose forms are utilised resulting in charging action taking place in shorter time respectively. Hence, the opening times of the inlet valves under normal load of the engine are not long enough for such special situations.

On the other hand in order to minimise emissions from a diesel engine the timing of the inlet valves needs to be such that the inlet valve is closed early before the bottom dead centre of the piston, while the boost pressure is raised accordingly so as to get a sufficient amount of air to the cylinder. This kind of arrangement is, however, problematic with low engine loads, when the boost pressure of the turbocharger is still relatively low.

One solution could be intensified supply of inlet air during the opening phase of the inlet valve under such special situations. Another solution is to provide for a delay in the closing of the inlet valve for prolonging the opening time of the inlet valve when needed. One solution for such a variable inlet valve closure (VIC) is disclosed in patent publication WO 2008/000899.
An object of the invention is to provide a further improved control arrangement for gas exchange in a piston engine, which is particularly applicable in two-stage turbo charged engines and solves the above mentioned problems apparent in such engines when operated under low engine loads and during start of the engine.

**Disclosure of the invention**

The objects of the invention can be met substantially as is disclosed in claim 1 and in the other claims. According to the invention the cam device includes a cam profile having a portion arranged under a base circle of the cam profile, whereby said portion of the cam profile is arranged to control gas exchange through the inlet valve. Hereby a constructionally simple and reliable way of control can be provided so that the deficit of air specifically under low load situations and start of the engine can be compensated. When sharp cam nose forms are utilised it is of advantage to provide for effective delaying of the closing movement of the inlet valve early during the closing phase thereof under said special situations. Then the invention can with advantage be availed of by arranging the form of the cam profile to determine the ending of the delaying effect.

The portion of the cam profile under the base circle is with advantage arranged to be utilised for increasing the supply of air through the inlet valve. In case such an auxiliary boost of air is supplied it may not be necessary to increase the total opening time of the inlet valve. In this case, however, it may be necessary to provide a separate cam device with cam profile operating independent on the one arranged for lifting the inlet valve.

The piston device is in force transmission connection with the cam shaft at least in the direction for opening the inlet valve. The body part and the piston device together define a first chamber, into which hydraulic medium can be selectively fed for providing a delay in the closing of the inlet valve. In this case the portion
of the cam profile under the base circle can with advantage be arranged to be utilised for controlling the releasing of pressure in said first chamber.

The first chamber can then be connected to a second chamber via a duct, whereby the opening of the duct into the second chamber is selectively controlled by a guide member arranged in said second chamber between the cam device and the piston device.

The guide member is arranged to directly act on the piston device only in the direction for opening the inlet valve. Hereby the return movement of the piston device may with advantage be utilised for proving the delay function.

In a practical embodiment the guide member includes a releasing groove in the mantle surface thereof. By arranging the releasing groove at the position of the opening of the duct by means of said portion of the cam profile located under the base circle the pressure in said first chamber can be released.

The guide member is spring loaded towards the cam device. Hereby a reliable cooperation between the cam profile of the cam device and the valve lifting means can be ensured.

The first chamber includes with advantage a stopper surface defining the lowermost position of the piston device, said position being selected so that a gap is left between the piston device and the guide member when guided by the portion of the cam profile under the base circle. Hereby the mutual contact between the piston device and the guide member can be re-established slowly so as to ensure smooth operation thereof. On the other hand in case the variable inlet valve closure (VIC) function is not utilised the stopper surface makes sure that the piston device does not follow the cam profile at the position of the portion of the cam profile under the base circle so that the cooperation between the piston device and the guide member remains the same under all circumstances.

Brief Description of Drawings
In the following the invention is described in more detail, by way of example only, with reference to the accompanying drawings, in which

- Figure 1 shows a piston engine and a skeleton diagram of its valve mechanism, and

- Figures 2 - 6 show an embodiment of a control arrangement according to the invention in separate consecutive stages of operation.

**Detailed Description of Drawings**

Figure 1 shows a schematic view of a piston engine 1 as far as it is relevant to the understanding of the invention. The gas exchange of the cylinders (not shown) in the piston engine 1 is carried out under the control of gas exchange valves, i.e. inlet valves and exhaust valves, located on a cylinder head 2. Only inlet valves 3 are shown and they are operated by means of valve mechanisms 6 which are typically guided by cam profiles 5' of cam devices 5 arranged on a camshaft 4 of the engine. The force transmission connection between each valve mechanism 6 and the corresponding cam device 5 is realised by a control arrangement 7.

The control arrangement 7 is shown in more detail in Figures 2 - 6, of which Figure 2 shows it in an unoperated state, whereby the inlet valve 3 in connection therewith is closed. The control arrangement 7 comprises a body part 8, which is typically attached to the engine body. A piston device 9 is movably arranged within the body part 8. The upper end of the piston device 9 is arranged in force transmission connection with the valve mechanism 6 (not shown closer). This connection may be mechanical or hydraulic. The movements of the piston device 9 are controlled by a guide member 10 arranged at the lower end of the piston device within the body part 8. The guide member 10 is in engagement with and urged by a spring 11 towards a roller 12, which receives its guidance from the cam profile 5' of the cam device 5. Thus, when the cam shaft 4 rotates, in figures 2 - 6 counter-clockwise, the roller 12 follows the cam profile 5'
of the cam device 5, and the changes in the cam profile 5' are transmitted so as to affect the opening and closing of the inlet valve 3.

The cam profile 5' has a base circle 5a with radius R. A nose 5b extends from the base circle and is arranged to move the piston device 8 upwards in the figures for providing opening of the inlet valve 3. In addition the cam profile 5' includes a portion 5c arranged under the base circle 5a of the cam profile 5' having thus radius smaller than the radius R. Naturally, the portion 5c need not have a constant radius. The effect of the portion 5c to the operation of the control arrangement 7 and the inlet valve 3 will be explained more in detail below.

The body part 8 and the piston device 9 together define a first chamber 13, into which hydraulic medium can be selectively fed for providing a delay in the closing of the inlet valve 3. The feed line is provided with a shut-off valve 14 and a non-return valve 15. By means of the shut-off valve 14 the feed line to the first chamber 13 may be connected or disconnected, depending on whether or not the aim is to use the delay function for the delayed closing of the inlet valve 3. Due to the non-return valve 15 the control arrangement cannot cause any pulsations in the source of hydraulic medium. This is of importance when lubricating oil is used as a hydraulic medium.

The body part 8 is additionally provided with a duct 16 by means of which the first chamber 13 can be connected with a second chamber 17, which is defined by the body part 8 and the guide member 10 and in which the lower end of the piston device 9 is located. Also the spring 11 is located in this second chamber 17.

So in figure 2 the control arrangement 7 is in an unoperated state and the roller is located on the base circle 5a of the cam profile 5'. In figure 3 the cam device 5 has rotated counter-clockwise so that the nose 5b has lifted the roller 12 upwards in the figure. Thus, also the guide member 12 and the piston device 9 have moved upwards and as a consequence the corresponding inlet valve 3 (not shown) has opened. Simultaneously the first chamber 13 is filled with hydraulic medium.
In figure 4 the roller 12 has returned on the base circle 5a. Due to the hydraulic medium in the first chamber 13 the piston device 9 remains in its top position thereby keeping the inlet valve also open. As can be seen in figure 4 the engagement between the piston device 9 and the guide member 10 is hereby disconnected.

In figure 5 the cam device 5 has rotated further counter-clockwise so that the roller 12 has entered the portion 5c which is located under the base circle 5a of the cam profile 5'. As a consequence the guide element 10 has moved downwards in the figure as well so that a releasing groove 10a in the mantle surface of the guiding member 10 has moved at the position of the duct 16 connecting the first and the second chambers 13 resp. 17. Hereby also the pressure in the first chamber 13 is released and the piston device 9 starts to move downwards in the figure thereby allowing also the inlet valve to close. The releasing groove 10a is in connection (not shown) with the second chamber 17 which for its part is connected with ducts 18 to an oil sump providing lubrication for the camshaft and the parts connected therewith. Thus, in accordance with the invention the portion 5c of the cam profile 5' is arranged to control gas exchange through the inlet valve by providing releasing of pressure for ending the delay function relating to prolonged opening of the inlet valve.

In figure 6, finally, the roller 12 still being on the portion 5c of the cam profile 5' the releasing of pressure in the first chamber 13 has allowed the piston device 9 to move downwards to a position defined by a stopper surface 13a arranged in the first chamber 13. As can be seen the piston device 9 and the guide member 10 are still disconnected. Only when the roller 12 is returned to the base circle 5a of the cam profile 5' on further rotation of the cam shaft 4 the roller 12 together with the guide element 10 will move slowly against the piston device 9 guided by the suitably designed cam profile and the situation disclosed in figure 2 will follow and the cycle will restart. The stopper surface 13a is of importance for smooth operation and re-establishing of the contact between the piston device 9 and the guide member 10. In addition, in case the variable inlet valve closure (VIC) function related to the chamber 13 is not utilised the stopper surface 13a makes sure that the piston device does not follow the cam profile at the po-
sition of the portion of the cam profile under the base circle. Although the movement of the piston device 9 is stopped by the stopper surface 13a the movement of the guiding member 10 together with the releasing groove 10a is continued ensuring that communication between the chamber 13 with the chamber 17 is established in a normal way.

By means of the invention the deficit of air under low load situations and start of the engine, which is largely due to cam nose form extending in the direction of rotation of the cam shaft substantially less than conventionally thereby shortening the opening time of the inlet valve availed of in large two-stage turbo engines, can be compensated. Large internal combustion engines refer here to such engines that are used, for example, as main propulsion engines or auxiliary engines in ships or in power plants for the production of heat and/or electricity.

It is clear that the invention is not limited to the examples mentioned above but can be implemented in many other different embodiments within the scope of the inventive idea.
Claims

1. A control arrangement for gas exchange in a piston engine adapted between a cam device (5) of a camshaft (4) of the engine (1) and an inlet valve mechanism (6) arranged to open and close the inlet valve (3) in association with a cylinder of the engine, which control arrangement (7) comprises a body part (8), in which a piston device (9) is movably arranged, the body part (8) and the piston device (9) together defining a first chamber (13), into which hydraulic medium can be selectively fed for providing a delay in the closing of the inlet valve (3), the cam device (5) including a cam profile (5') having a portion (5c) arranged under a base circle (5a) of the cam profile (5'), said portion (5c) of the cam profile (5') under the base circle (5a) being arranged to be utilised for controlling the releasing of pressure in said first chamber (13), characterised in that the piston device (9) is arranged to be in force transmission connection with the camshaft (4) at least in the direction for opening the inlet valve (9) and that the first chamber (13) is connected to a second chamber (17) via a duct (16) and the opening of the duct (16) into the second chamber (17) is selectively controlled by a guide member (10) arranged in said second chamber (17) between the cam device (5) and the piston device (9).

2. A control arrangement according to claim 1, characterised in that the guide member (10) is arranged to directly act on the piston device (9) only in the direction for opening the inlet valve (3).

3. A control arrangement according to claim 1 or 2, characterised in that the guide member (10) includes a releasing groove (10a) in the mantle surface thereof and that the releasing groove (10a) is arranged at the position of the opening of the duct (16) by means of said portion (5c) of the cam profile (5') located under the base circle (5a) for releasing of the pressure in said first chamber (13).

4. A control arrangement according to any one of the preceding claims, characterised in that the guide member (10) is spring loaded (11) towards the cam device (5).
5. A control arrangement according to any one of the preceding claims, characterised in that the first chamber (13) includes a stopper surface (13a) defining the lowermost position of the piston device (9), said position being selected so that a gap is left between the piston device (9) and the guide member (10) when guided by the portion (5c) of the cam profile (5') under the base circle (5a).
### INTERNATIONAL SEARCH REPORT

**International application No**

PCT/FI2009/050626

### A. CLASSIFICATION OF SUBJECT MATTER

INV. F01L1/255  F01L1/08  F01L13/00

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)

**FOIL**

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 practical, search terms used)

EPO-Internal  , WPI Data

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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### Date of the actual completion of the international search

20 October 2009

### Date of mailing of the international search report

28/10/2009

Name and mailing address of the ISA/

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Authorized officer

de Mateo Garcia, I
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