Title: OIL PUMP CONTROL SYSTEM

Abstract: An oil pump control system (200; 400) comprising an oil pump (100; 300) and a primary lubrication circuit (101; 301). The control system (200; 400) is characterised in that it envisages a secondary circuit (102; 302) comprising, in turn, a solenoid valve (114; 303) whose opening/closing is controlled by an electronic control unit. The secondary circuit (102; 302) achieves the adjustment between two values (P*, P**) of the delivery pressure in the primary lubrication circuit (101; 301) to save pumping energy.
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
OIL PUMP CONTROL SYSTEM

TECHNICAL FIELD

The present invention relates to an oil pump control system.

BACKGROUND ART

As known, both gear pumps and variable displacement vane pumps (VOP) adjust delivery pressure to only one setting. This means that the pump, especially at high rpm, conveys oil at pressure exceeding, also by a high degree, that actually required by the endothermic engine.

Figure 1 shows the usual pattern of an engine demand curve (a) compared against the pattern of a curve (b) related to a traditional gear pump, and of a curve (c) referred to a traditional variable displacement vane pump (VOP), respectively.

In figure 1, the engine (and pump) rpm is shown on the abscissa while the corresponding pressures are shown on the ordinate.

Obviously, the subtended areas of the various curves (a) (b) (c) represent the energies corresponding to endothermic engine demand, to the demand of a traditional gear pump (curve (b)) mechanically connected to the endothermic engine itself, and to the needs of a variable displacement vane pump (VOP) (curve (c)), respectively.

Furthermore, as shown in figure 1, area A1 comprised
between curve (a) and curve (b) represents the lost energy with respect to that strictly needed for pumping lubricant oil towards the endothermic engine by means of a gear oil pump.

Similarly, area $A_1$ comprised between curve (a) and curve (b) represents the lost energy with respect to that strictly needed to pump lubricant oil towards the endothermic engine by means of a variable displacement vane pump (VOP).

Indeed, in ideal conditions, by means of ideal continuous adjustments, curve (b) and curve (c) respectively should essentially coincide with curve (a).

In practice, devices are made for performing essentially continuous adjustments.

However, in order to obtain this, the oil pumps must be adjusted by means of complicated hydraulic systems and controlled by electronic control units which make production cost thereof very high.

**DISCLOSURE OF INVENTION**

Therefore, it is the object of the present invention to give an easily implementable and low-cost solution adapted to decrease the surface of areas $A_1$ or $A_2$ as much as possible.

Therefore, the present invention aims to make a two-level pressure adjustment system by means of which, especially at low speed and low temperature, the actual
pump-related curves do not exceed the endothermic engine curve (a) very much. In this way, a system for dissipating less energy is made.

Therefore, according to the present invention, an oil pump control system is obtained according to the attached claims.

**BRIEF DESCRIPTION OF THE DRAWINGS**

The present invention will now be described with reference to the accompanying drawings illustrating two non-limitative embodiments thereof, in which:

- figure 2 shows a first configuration of a first embodiment of a gear oil pump control system according to the present invention;

- figure 3 shows a second configuration of the first embodiment of a gear oil pump control system according to the present invention;

- figure 4 shows a first configuration of a second embodiment of a variable displacement vane pump (VOP) control system according to the present invention;

- figure 5 shows a second configuration of the second embodiment of a variable displacement vane pump (VOP) control system according to the present invention; and

- figure 6 shows the usual pattern of the engine demand curve (a) compared against the pattern of a gear pump-related curve (b*) for a system according to the
present invention, and, respectively, against the pattern of a curve (c*) related to a variable displacement vane pump (VOP) for a system according to the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

In figure 2, number 100 indicates a gear pump belonging to a control system 200 object of the present invention.

In known way, the gear pump 100 conveys oil at a certain pressure P through a primary hydraulic circuit 101 towards an endothermic engine (not shown) for lubricating it.

As shown again in figure 2, from the primary circuit 101 departs a secondary circuit 102 provided with a shutter device 103.

Device 103 is provided with a chamber 104, which envisages an oil inlet 105 and an oil outlet 106 from the primary circuit 101. The oil released from output 106 is conveyed towards a first drain SC1.

Within the chamber 104, there is a shutter 107 subjected to the elastic forces exerted by a spring 108.

The shutter 107 comprises, in turn, a piston 109 and a plunger 110 reciprocally connected by a stem 111.

The bottom of the chamber 104 is provided with a further outlet 112 from which departs a conduit 113 that leads to a second drain SC2.
Furthermore, the conduit 113 is provided with a solenoid valve 114 which is closed in the configuration shown in figure 1.

The plunger 110 splits chamber 104 into a first portion 104a comprised between a lower surface 109a of piston 109 and an upper surface 110a of plunger 110, and a second portion 104b defined by a lower surface 110b of the piston 110 and a bottom 115 of chamber 104.

Both the first portion 104a and a second portion 104b (with solenoid valve 114 closed) (figure 2) are full of oil.

As explained above, at low rpm (figure 6), solenoid valve 114 is closed and controlled by an electronic control unit (not shown) which takes rpm and temperature of the endothermic engine into account. In this way, the pressures on the surfaces 110a and 110b of the plunger 110 balance and the resulting pressure acts only on surface 109a of piston 109 (highlighted in bold).

As shown in figure 6, when the endothermic engine rpm increases and reaches a value $N^*$, with solenoid valve 114 closed, the pressure $P^*$ of the oil in the portion 104a of chamber 104 is such to apply a force on the surface 109a (highlighted in bold) which raises the shutter 107 in a direction and sense defined by an arrow $F_1$ (figure 2).

From this point on, despite the increase of rpm,
pressure $P^*$ in the primary hydraulic circuit 101 remains the same because outlet 106 is not closed by shutter 107 and the oil existing in the portion 104a is conveyed towards the first drain SC1.

Once reached the rpm $N^{**}$, the electronic control unit (not shown) controls the opening of the solenoid valve 114 so that the system 200 assumes the configuration shown in figure 3.

If solenoid valve 114 is open (figure 3), the working force of the oil existing in portion 104a which acts on the piston 109 is that generated by the pressure of the oil itself acting on portions 116 (highlighted in bold in figure 3) of surface 109a. Evidently, the other forces which act on the rest of the surface 109a will be balanced by those acting on surface 110a.

The shutter 107 will therefore be lowered in a direction and sense defined by an arrow F2 (figure 3).

All this allows a slight leakage of oil through outlet 106 thus returning curve $(b^*)$ (figure 6) to a pattern equal to that of curve $(b)$ shown in figure 1.

As shown in figure 6, by making the gear pump 100 work between two pressure values $P^*$ and $P^{**}$ the energy saving shown by area A3 is obtained, thus reaching the prearranged object. In other words, there is a change from area A1 in figure 1 to an area A1* in figure 6.

Figures 4 and 5 show a second embodiment of the
present invention in which a variable displacement vane pump 300 is used.

Pump 300 is integrated in a control system 400.

System 400 envisages, in a way entirely similar to that seen for the first embodiment shown in figures 2 and 3, a primary lubrication circuit 301 from which a secondary circuit 302 that leads to a drain SC3 departs.

In turn, the secondary circuit 302 envisages a solenoid valve 303 which is open in the configuration shown in figure 4 and therefore the secondary circuit 302 drains into drain SC3.

The adjustment system of the pump 300 by means of the primary circuit 301 will not be explained in greater detail because it is widely known in literature.

In the configuration shown in figure 4 (with solenoid valve 303 open), the secondary circuit 302 discharges oil into a chamber 304. In this way, when the rpm of the endothermic engine increases and reaches a value N* corresponding to a pressure p*, with solenoid valve 303 open, the pump displacement 300 is adjusted by the oil pressure existing in a chamber 305 and by the stiffness of a spring 306 which is found in chamber 304.

When the rpm exceeds a certain value N**(figure 6), the solenoid valve 303, controlled by the electronic control unit, closes the secondary circuit 302, the chamber 304 is filled with oil which may be only
discharged through the primary circuit 301 towards a shutter device 307. In this way, the displacement of the pump 300 is adjusted by the stiffness of a spring 308, which acts on a shutter 309, by the pressure of the oil in the chamber 304 and in chamber 305, as in variable displacement vane pumps of the traditional type.

Also in this case, an energy saving shown by area A3 in figure 6 is obtained. In other words, there is a shift from area A2 shown in figure 1 to an area A2* shown in figure 6.
CLAIMS

1.- A control system (200; 400) for oil pumps comprising an oil pump (100; 300) and a primary lubrication circuit (101; 301); control system (200; 400) characterised in that a secondary circuit (102; 302) comprises a solenoid valve (114; 303) whose opening/closing is controlled by an electronic control unit; said secondary circuit (102; 302) making possible the adjustment between two values (P*, P**) of the delivery pressure in said primary lubrication circuit (101; 301) to save pumping energy.

2.- A control system (200; 400) as claimed in claim 1, characterised in that said oil pump (100) is a gear pump (100).

3.- A control system (200; 400) as claimed in claim 1, characterised in that said oil pump (300) is a variable displacement vane pump (300).

4.- A control system (200; 400) as claimed in any of the preceding claims, characterised in that said secondary circuit (102; 302) envisages a shutter device (103; 307) for adjusting the flow of pressurised oil.

5.- A control system (200) as claimed in claim 2 and in claim 4, characterised in that said shutter device (103) is hydraulically connected with said solenoid valve (114).
Fig. 1

Prior art gear pump
VOP 1 level p
Engine request

Fig. 6

Prior art gear pump
VOP 2 level p
Engine request
Gear pump 2 levels p
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

INV. F01M1/16 F04C14/22 F04C14/24

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)

F04C

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, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
</table>

X

JP 09 088533 A (TOKYO BUHIN KOGYO KK)
31 March 1997 (1997-03-31)
figures 1-3
-& PATENT ABSTRACTS OF JAPAN
vol. 1997, no. 07,
31 July 1997 (1997-07-31)
& JP 09 088533 A (TOKYO BUHIN KOGYO KK),
31 March 1997 (1997-03-31)
abstract

X

DE 102 39 364 A1 (DR.ING.H.C. F. PORSCHE
Ag) 18 March 2004 (2004-03-18)
figures 1-3
paragraphs [0001], [0002], [0005]

1,2,4,5

1,3-5

Further documents are listed in the continuation of Box C.

X See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"I" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"X" later document published after the international filing date of priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"Y" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Z" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"S" document member of the same patent family

Date of the actual completion of the international search

4 October 2006

Date of mailing of the international search report

17/10/2006

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL-2280 Hl Rijswijk
Tel. (+31-70) 340-2040, Fax. 340-9016

Authorized officer

Biloen, David
<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>US 5 339 776 A (REGUEIRO ET AL) 23 August 1994 (1994-08-23) figures 1,4,5 column 2, lines 47-51 column 2, lines 65-69</td>
<td>1,2,4,5</td>
</tr>
<tr>
<td>X</td>
<td>US 2002/172604 A1 (BERGER ALVIN HENRY) 21 November 2002 (2002-11-21) figure 1</td>
<td>1,2</td>
</tr>
<tr>
<td>X</td>
<td>EP 1 043 504 A (BAYERISCHE MOTOREN WERKE AKTIENGESELLSCHAFT) 11 October 2000 (2000-10-11) figure 2</td>
<td>1,3</td>
</tr>
<tr>
<td>P,A</td>
<td>DE 10 2004 049029 A1 (AUDI AG) 20 April 2006 (2006-04-20) figures 2,3</td>
<td>1,2,4,5</td>
</tr>
<tr>
<td>A</td>
<td>US 5 690 479 A (LEHMANN ET AL) 25 November 1997 (1997-11-25) figure 2 column 2, lines 33-43 column 2, line 46 - line 53</td>
<td>1-5</td>
</tr>
<tr>
<td>Patent document cited in search report</td>
<td>Publication date</td>
<td>Patent family member(s)</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>-----------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>DE 10239364</td>
<td>18-03-2004</td>
<td>WO 2004020831 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP 1537335 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 2005520096 T</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 2005232785 A1</td>
</tr>
<tr>
<td>US 5339776</td>
<td>23-08-1994</td>
<td>NONE</td>
</tr>
<tr>
<td>JP 62248812</td>
<td>29-10-1987</td>
<td>NONE</td>
</tr>
<tr>
<td>DE 102004049029 A1</td>
<td>20-04-2006</td>
<td>NONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 9429595 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 9500432 T</td>
</tr>
</tbody>
</table>