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(54) **Variable displacement lubricant vane pump**

(57) A variable displacement lubricant vane pump (10) is provided with a pump rotor (20) rotating around a rotor axis (21) and with a rotor body (24) provided with vane slits (25) wherein shiftable rotor vanes (26) are arranged. A shiftable control ring (30) is provided wherein the slidable vanes (26) are rotating, the control ring (30) being actuated to control the eccentricity of the control ring (30) with respect to the rotor axis (21). A metal pump housing (12) including two parallel sidewalls (16, 17) is provided which axially cover the rotor body (24), the rotor vanes (26) and the control ring (30).

The control ring (30; 30') is provided with a control ring body (31; 31') made out of the same plastic material with a thermal expansion coefficient a_P of 65% to 150% of the thermal expansion coefficient a_M of the housing metal.

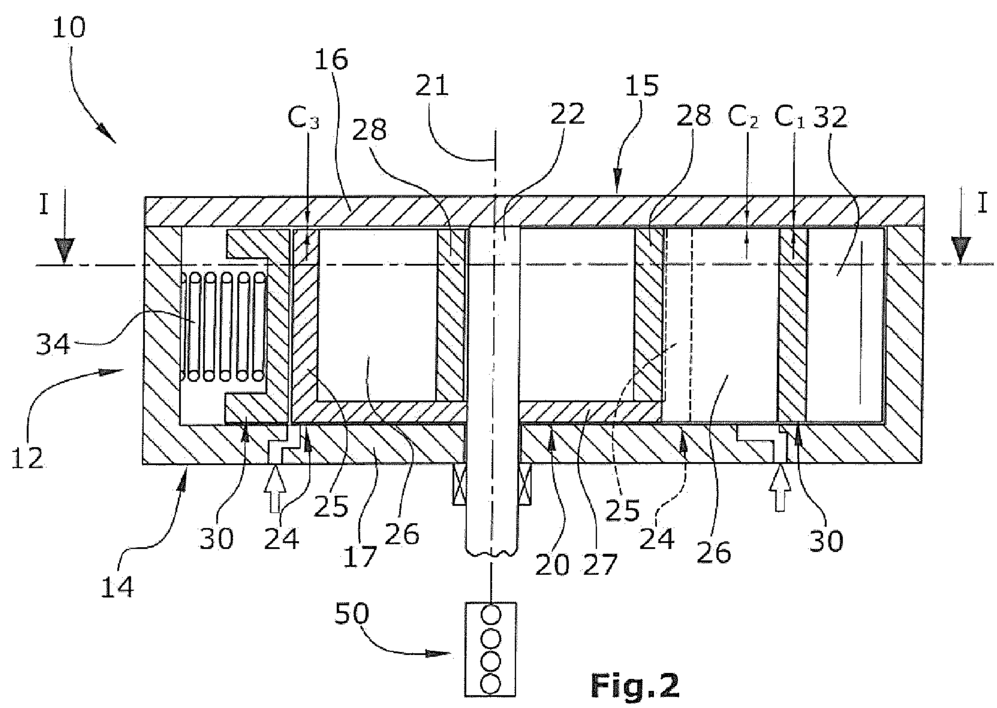

Fig.2

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Description

[0001] The present invention refers to a mechanical variable displacement lubricant vane pump for providing pressurized lubricant for an internal combustion engine.

[0002] The mechanical lubricant pump is directly driven by the engine and comprises a pump rotor rotating around a rotor axis. The pump rotor is provided with a rotor body with radial vane slits wherein numerous shiftable rotor vanes are provided. A shiftable control ring is provided which radially surrounds the pumping cavity which is separated by the vanes into numerous rotating pumping chambers. The control ring is actuated so that the control ring can be shifted in a radial direction to control the eccentricity of the control ring with respect to the rotor axis. By controlling the control ring eccentricity the volumetric performance of the pump can be varied without changing the rotational speed of the pump. A pump housing is provided including two parallel sidewalls which are axially covering the rotor body, the rotor vanes and the control ring.

[0003] The hydraulic efficiency of the pump is highly dependent on the hydraulic leakage of the pumping chambers which is dependent on the axial clearances between the static housing sidewalls of the pump housing on one side and the rotor body, the vanes and the control ring at the other side. Mechanical lubricant pumps of the state of the art use aluminium for the pump housing and steel or sintered steel for the control ring, the vanes and the rotor body. Since the thermal expansion coefficient of the these materials are different, the axial clearances between the housing at one side and the control ring, the vanes and the rotor body on the other side increase up to 100 μm and more at typical lubricant working temperatures of combustion engines of 100°C and more. These clearances lead to serious hydraulic leakage and backflow which cause a reduced hydraulic efficiency of the pump. Additionally, very tight and precise mechanical clearances are to be realized in production of the mechanical lubricant pump which causes relatively high production cost.

[0004] Before this background, it is an object of the invention to provide a variable lubricant vane pump with high hydraulic efficiency and reduced production cost.

[0005] This object is solved with a variable lubricant vane pump with the features of claim 1.

[0006] According to main claim 1, the control ring body is made out of a plastic material, whereby the complete pump housing is made out of steel or metal, and preferably is made of aluminium. The thermal expansion coefficient a_P of the control ring plastic material is between 65% and 150% of the thermal expansion coefficient a_M of the housing metal, steel or aluminium. The difference of the thermal expansion coefficients of the control ring material and the pump housing material is significant lower than the thermal expansion difference between steel and aluminium or can even be close to zero so that the increase/decrease of the axial clearance between the pump housing and the control ring caused by a temperature increase/increase is much lower than in the state of the art material pairings, or can even be close to zero.

[0007] As a result, the axial clearance between the sidewalls of the pump housing at one side and the control ring at the other side is reduced significantly, especially at common lubricant working temperatures of, in practice, 100°C and more. The axial clearance at a working temperatures of around 100°C can be reduced to, for example, less than 100 μm so that the hydraulic efficiency of the pump can be increased significantly especially at lubricant working temperature. As another result, the mechanical clearances to be realized in the production of the pump could be higher so that the production cost can be reduced significantly.

[0008] Preferably, the control ring is provided with a separate sliding ring at the inner circumferential of the control ring body, whereby the sliding ring material is different of the control ring body material. The control ring body material can be selected to provide a low thermal expansion coefficient difference with the metal pump housing material. The sliding ring material is chosen to provide good mechanical properties to provide good lubricational and frictional conditions. The sliding ring material could be plastic with a low friction coefficient with respect to the material of the vane head. Preferably, the sliding ring material is metal which provides a low-friction pairing with the vane heads and provides high wear resistance. The axial extension of the sliding ring can be different, and preferably can be less than the axial extension of the control ring body which guarantees a small clearance between the control ring body and the pump housing.

[0009] The sliding ring can be rotationally fixed to the control ring on body, for example by overmolding, pressfitting, clamping etc. According to a preferred embodiment, the sliding bearing is provided with a radial distance to the control ring body so that the sliding ring is rotatable around the center of the control ring so that the sliding bearing can rotate together with the pump rotor vanes.

[0010] Preferably, the shiftable rotor vanes are made of plastic, preferably of the same plastic as the control ring body. The vane plastic is chosen to provide a relatively low difference between the thermal expansion coefficient of the vane material and the thermal expansion coefficient of the housing metal. This constitution allows a relatively small axial clearance between the vanes and the pump housing so that the hydraulic efficiency of the pump is improved due to a reduced backflow between the rotating pump chambers defined by the control ring, the pump housing, the pump rotor and the rotor vanes.

[0011] According to a preferred embodiment of the invention, also the rotor body is made out a same plastic material, and preferably made out of the same plastic material as the control ring and the vanes. The rotor body supports the rotor vanes and, if given, a support ring which axially supports the inner radial end of the vanes. Also the axial clearance of the rotor body with respect to the sidewalls of the pump housing has a relevant impact on the backflow and on the hydraulic pump efficiency. Using the same plastic material for the rotor body therefore also increases the hydraulic efficiency of the pump and can help to reduce production costs.

[0012] Preferably, the plastic material of the control ring, the vanes and, if given, the rotor body is fiber-reinforced plastic material. A fiber-reinforced plastic material has good mechanical characteristics, has low weight and provides a good long term mechanical stability.

[0013] The following is a detailed description of an embodiment of the invention with reference to the drawings, wherein

figure 1 shows a cross section in a transversal plane I-I of a variable displacement lubricant pump,

figure 2 shows a longitudinal cross-section in a complex longitudinal plane II-II of the pump of figure 1, and

figure 3 shows a second embodiment of a control ring of the variable displacement lubricant pump of figure 1.

[0014] Figures 1 and 2 show a variable mechanical displacement lubricant vane pump 10 which is directly driven by an internal combustion engine 50 so that the rotational speed of the pump 10 is always proportional to the rotational speed of the engine 50.

[0015] The pump 10 comprises a pump housing 12 consisting of a housing body 14 and a housing cover lid 15. All parts of the pump housing 12 including the housing body 14 and the housing cover lid 15 are made out of aluminium. As can be seen in figure 1, a rotor 20 is arranged inside the housing 12. The rotor 20 consists of a metal rotor shaft 22, a ringlike rotor body 24 holding numerous rotor vanes 26, a circular base disk 27 and a shiftable support ring 28. The ringlike rotor body 24 and the base disc 27 are integral with each other and are made of a fiber-reinforced plastic material. The rotor 20 rotates around a rotor axis 21. The rotor body 24 is provided with numerous radial slits 25 in which the rotor vanes 26 are provided radially shiftable with respect to the rotor body 24. The vanes 26 are made of the same fiber-reinforced plastic material as the rotor body 24.

[0016] The pump rotor 20 including the vanes 26 is radially surrounded by a shiftable control ring 30 which is not rotatable but is radially shiftable with respect to the pump housing 12. In the embodiment shown in figures 1 and 2, the control ring 30 is defined by a single monolithic control ring body 31 which is made of the same fiber-reinforced plastic material as the rotor body 24.

[0017] The pump housing 12 provides two parallel sidewalls 16, 17 which axially close and cover the pump cavity defined by the rotor body 24 and the control ring 30. Inside the pump cavity, the rotor body 24, the rotor vanes 26 and the control ring 30 together define numerous rotating pumping chambers which are rotating in anti-clockwise direction in figure 1. One sidewall 17 is provided with an inlet opening 18 and with an outlet opening 19 through which the lubricant flows into the rotating pumping chambers and flows out of the rotating pumping chambers, respectively. A control chamber 40 is hydraulically connected to the outlet opening 19 and pushes the control ring 30 via a control ring plunger 32 against the spring force of a counter-acting preload spring 34 into a low pumping volume position/direction of the pump.

[0018] The thermal expansion coefficient a_P of the fiber-reinforced plastic material of the rotor body 24, the vanes 26 and the control ring 30 is very close to or even almost identical with the thermal expansion coefficient a_M of the aluminium of the pump housing 12. As a result, the axial control ring clearances C_1 between the control ring 30 and the respective sidewalls 16, 17, the axial vane clearances C_2 between the vanes 26 and the respective sidewalls 16, 17 and the axial rotor body clearances C_3 between the rotor body 24 and the sidewalls 16, 17 is not changing significantly over a temperature range between -30°C and up to 140°C. Even at a temperature of 100°C the clearances C1 to C3 remain below 100 μm.

[0019] In figure 3, an alternative embodiment of the control ring 30' is shown, whereby the control ring 30' is defined by a control ring body 31' made out of a fiber reinforced plastic material and a separate metal sliding ring 29. The sliding ring 29 is rotationally fixed to the control ring body 31' by overmolding, press-fitting or clamping. Alternatively, the sliding ring 29 could also be provided rotatable with respect to the control ring body 31'.

Claims

1. A variable displacement lubricant vane pump (10) for providing pressurized lubricant for an internal combustion engine (50), comprising
   a pump rotor (20) rotating around a rotor axis (21) and being provided with a rotor body (24) provided with vane slits (25) wherein shiftable rotor vanes (26) are provided,
   a shiftable control ring (30; 30') wherein the slidable vanes (26) are rotating, the control ring (30) being actuated to control the eccentricity of the control ring (30) with respect to the rotor axis (21), and
   a metal pump housing (12) including two parallel sidewalls (16, 17) axially covering the rotor body (24), the rotor vanes (26) and the control ring (30; 30'),
   whereby the control ring (30; 30') is provided with a control ring body (31; 31') made out of a plastic material with a thermal expansion coefficient a_P of 65% to 150% of the thermal expansion coefficient a_M of the housing metal.

2. The variable displacement lubricant vane pump (10)

of claim 1, whereby the control ring (30') is provided with a separate sliding ring (29) at the inner circumference of the control ring body (31'), the sliding ring material being different of the control ring body material.

3. The variable displacement lubricant vane pump (10) of claim 2, whereby the sliding ring material is a metal.

4. The variable displacement lubricant vane pump (10) of claim 2, whereby the sliding ring material is a plastic material.

5. The variable displacement lubricant vane pump (10) of one of the preceding claims 2-4, whereby the sliding ring (29) is rotable with respect to the control ring body (31').

6. The variable displacement lubricant vane pump (10) of one of the preceding claims, whereby the vanes (26) are made of plastic, preferably of the same plastic as the control ring body (31).

7. The variable displacement lubricant vane pump (10) of one of the preceding claims, whereby the rotor body (24) is made of plastic, preferably of the same plastic as the control ring body (31).

8. The variable displacement lubricant vane pump (10) of one of the preceding claims, whereby the complete pump housing (12) is made of aluminium.

9. The variable displacement lubricant vane pump (10) of one of the preceding claims, whereby the plastic material of the control ring (30) and the vanes (26) is a fiber-reinforced plastic material.

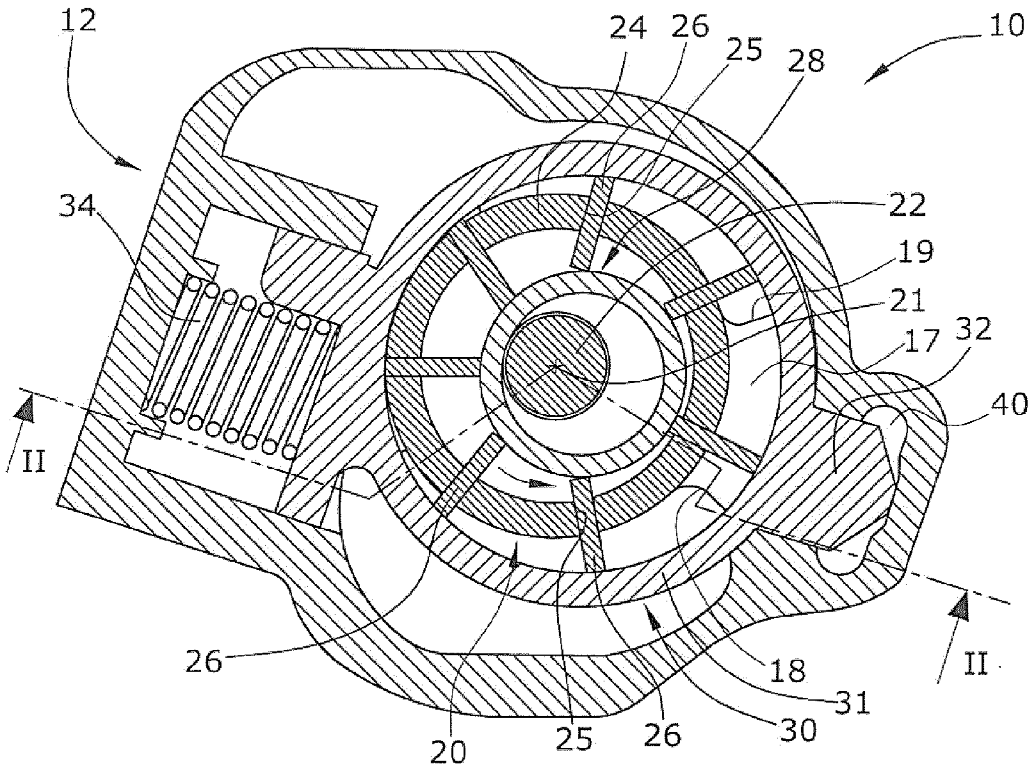
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Fig.1

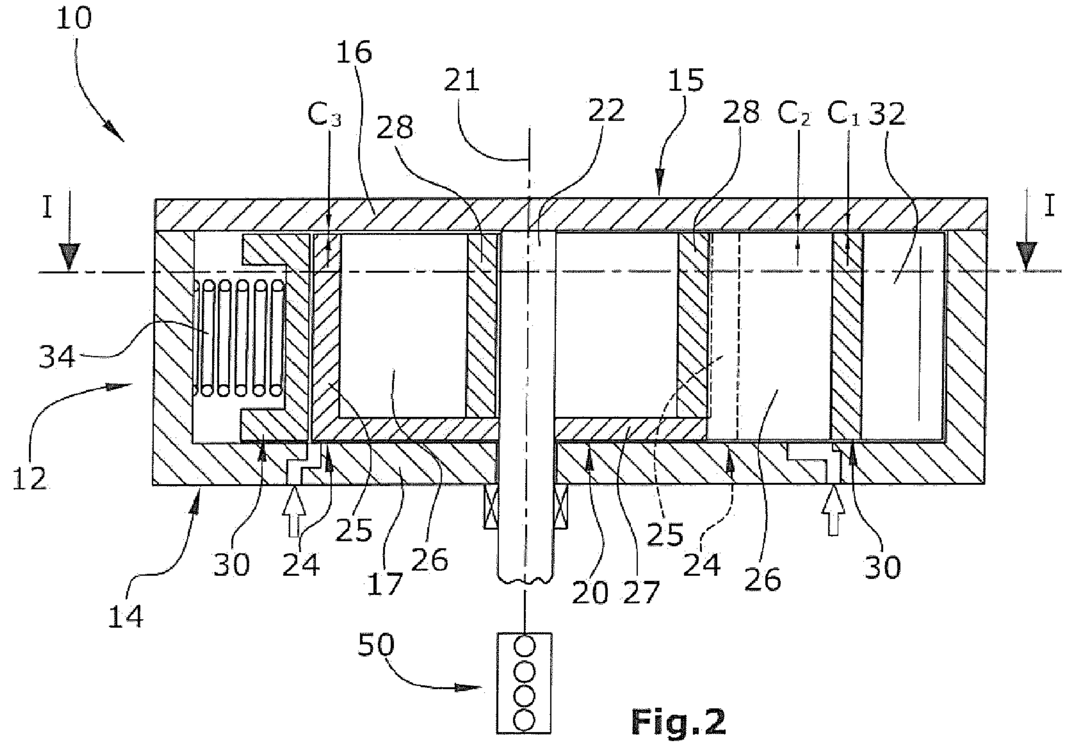
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Fig.2

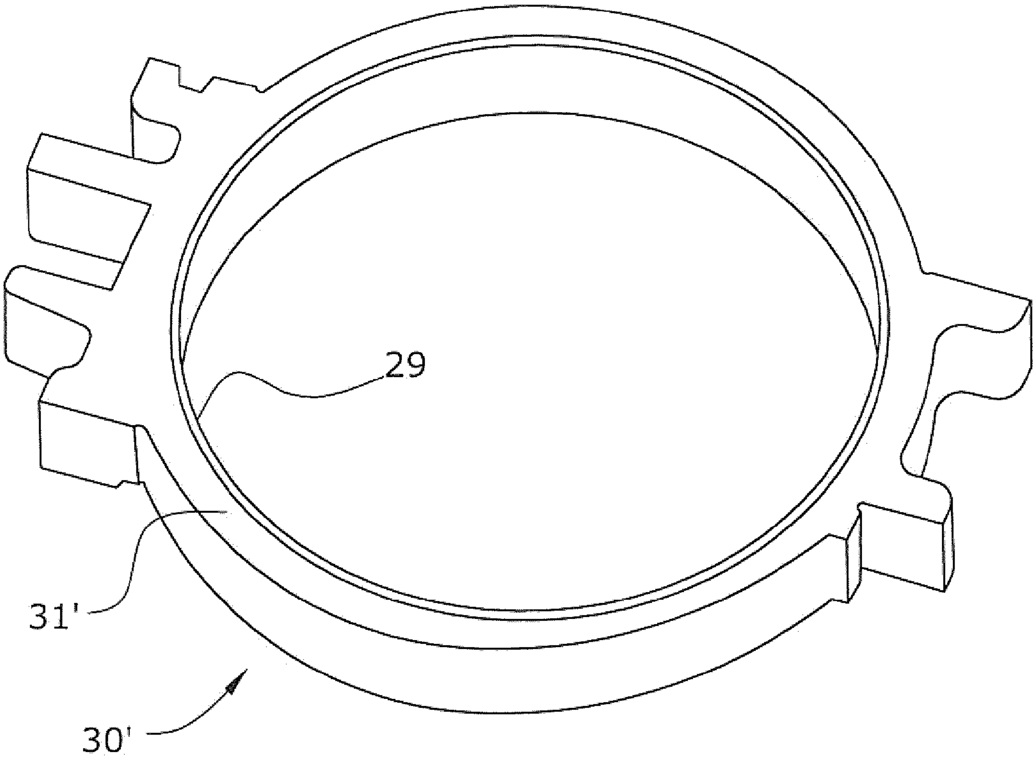

Fig.3

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EUROPEAN SEARCH REPORT

Application Number
EP 12 19 4435

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 10 2011 014591 A1 (VOLKSWAGEN AG [DE]) 27 September 2012 (2012-09-27) * abstract; claims 1-3; figure 1 * -----	1-9	INV. F04C2/348 F04C14/22
A	US 2004/136853 A1 (CLEMENTS MARTIN A [US] ET AL) 15 July 2004 (2004-07-15) * abstract; figure 1 * -----	1-9	
A	US 5 876 192 A (FOLLMER WILLIAM CALVIN [US]) 2 March 1999 (1999-03-02) * abstract; claim 10; figure 1 * -----	1-9	
A	DE 33 33 647 A1 (GLYCO ANTRIEBSTECHNIK GMBH [DE]) 24 May 1984 (1984-05-24) * page 9, line 18 - line 28; figure 1 * -----	1-9	

TECHNICAL FIELDS SEARCHED (IPC)

F04C

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	24 April 2013	Descoubes, Pierre

CATEGORY OF CITED DOCUMENTS

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