Abstract: A non-contact positive displacement fuel pump for an LPG vehicle with a lubricant separation system, according to an embodiment of the present invention, includes a pump body mounted with an inlet and an outlet at one side thereof, a piston axially mounted to the pump body to generate pressure to the pump body, a linear motor connected to a piston rod to move the piston in a reciprocating motion, and bearings disposed at both sides of the linear motor to fix the piston reciprocating in the pump body at a predetermined position by securely supporting the piston rod in radial directions.
before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments
Description

NON-CONTACT POSITIVE DISPLACEMENT FUEL PUMP
FOR LPG VEHICLE WITH LUBRICANT SEPARATION
SYSTEM

Technical Field

The present invention relates to a non-contact positive displacement fuel pump for an LPG vehicle, capable of preventing deterioration of the pump efficiency caused by deterioration of pressure due to friction abrasion, and other troubles such as internal damage of mechanic parts resulting from vibration and noise resulting by cavitation, which is a problem of a turbo pump.

Background Art

In general, fuel pumps for a liquefied petroleum gas (LPG) vehicle can be classified largely into a positive displacement pump and a non-positive displacement pump so called a turbo pump, a centrifugal pump or a regenerative pump.

Differently from general gasoline or diesel oil, the LPG has very low viscosity and steam pressure.

Therefore, when using a positive displacement fuel pump with the LPG, leakage of fuel may be caused due to friction abrasion. Furthermore, as the pressure gradually decreases, flux, pressure, efficiency and performance of the fuel pump are greatly deteriorated.

Even when using the turbo pump, the pressure is decreased at an entry of the pump owing to a low steam pressure, thereby causing cavitation. Accordingly, not only vibration and noise are increased but also mechanic parts may be damaged by internal corrosion.

As a consequence, control of fuel supply for the vehicle cannot be properly achieved, thereby deteriorating the output of the LPG vehicle.

Disclosure of Invention

Technical Problem

Therefore, the present invention has been made in view of the above problems, and it is an object of the present invention to provide a non-contact positive displacement fuel pump for an LPG vehicle, capable of achieving an excellent pumping performance without generating cavitation as a positive displacement, and generating uniform pressure by preventing friction abrasion, which is a problem of conventional LPG fuel pumps, and thereby improving durability and reliability as a non-contact fuel pump.
Technical Solution

In accordance with the present invention, the above and other objects can be accomplished by the provision of a non-contact positive displacement fuel pump for an LPG vehicle comprising a pump body mounted with an inlet and an outlet at one side thereof, a piston axially mounted to the pump body to generate pressure to the pump body, a linear motor connected to a piston rod to move the piston in a reciprocating motion, and bearings disposed at both sides of the linear motor to fix the piston reciprocating in the pump body at a predetermined position by securely supporting the piston rod in radial directions.

In accordance with another aspect of the present invention, there is provided a non-contact positive displacement fuel pump comprising a pump body mounted with an inlet and an outlet in the middle part thereof, pistons axially mounted to both sides of the pump body to generate pressure to the pump body, linear motors connected to piston rods of the respective pistons to move the piston in a reciprocating motion, and bearings mounted to both sides of each linear motor to fix the piston reciprocating in the pump body at a predetermined position by securely supporting the piston rod in radial directions.

The piston may be mounted non-contactingly with respect to the pump body, forming a micro gap. Preferably, a plurality of sealing recesses may be additionally formed along an outer circumference of the piston so as to prevent LPG fuel being supplied into the pump body from leaking through a rear end of the piston.

The piston rod may be axially mounted to a mover of the linear motor.

The bearing may be implemented with a linear flexure bearing for supplying flexibility to the piston rod, and comprise a diaphragm which includes a hub having an annular shape with a hole in the center, a plurality of hub arms radially extended from an outer circumference of the hub, forming uniform angular intervals with respect to the center of the hub, a rim having an annular shape disposed to surround the hub and the hub arms, being disposed adjacent to outer ends of the respective hub arms, a plurality of rim arms provided in the same number as the hub arms and radially extended from an inner circumference of the rim to be adjacent to one edge of the respective hub arms, forming uniform angular intervals with respect to the center of the hub, and a plurality of flexure blades each having an arch shape with a predetermined width and disposed between one side of the hub arms and one side of the rim arms, the sides which are distanced, thereby interconnecting the hub arms and the rim arms, an inner spacer fixed corresponding to the shape of the hub, including a hub spacer having the same size and shape as the hub, a plurality of hub spacer arms arranged on an outer circumference of the hub spacer in the same positions and shapes as the hub arms, a
supporting protrusion formed on one side of the hub spacer arms, corresponding to one side of the hub arms in connection with the flexure blades, and an outer spacer fixed corresponding to the shape of the rim, including a rim spacer having the same size and shape as the rim, a plurality of rim spacer arms arranged on an inner circumference of the rim spacer to be in the same positions and shapes as the rim arm, and a supporting protrusion formed on one side of the rim spacer arms corresponding to one side of the rim arms in connection with the flexure blades.

Brief Description of the Drawings

The above and other objects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a structural sectional view of a non-contact positive displacement fuel pump for an LPG vehicle, according to an embodiment of the present invention;

FIG. 2 is a view showing the operational state of the non-contact positive displacement fuel pump for an LPG vehicle, according to the embodiment of the present invention;

FIG. 3 is a plan view extractingly showing a diaphragm of a linear flexure bearing of the non-contact positive displacement fuel pump of FIG. 1;

FIG. 4 is a plan view of inner and outer spacers of the linear flexure bearing of the non-contact positive displacement fuel pump of FIG. 1;

FIG. 5 is a plan view of the linear flexure bearing constructed by the diaphragm and the inner and outer spacers of FIG. 3;

FIG. 6 is a structural sectional view of a non-contact positive displacement fuel pump for an LPG vehicle, according to another embodiment of the present invention; and

FIG. 7 shows the operational state of the non-contact positive displacement fuel pump according to the another embodiment.

Best Mode for Carrying Out the Invention

Hereinafter, exemplary embodiments of the present invention will be described in detail with reference to the accompanying drawings.

FIG. 1 is a structural sectional view of a non-contact positive displacement fuel pump 1000 for an LPG vehicle, according to an embodiment of the present invention. FIG. 2 shows the operational state of the non-contact positive displacement fuel pump 1000.

Referring to FIG. 1, first, the non-contact positive displacement fuel pump 1000 is structured to pump LPG fuel in non-contacting manner so as to generate uniform pressure by preventing friction abrasion between a piston and a pump body, which has
been a problem of conventional LPG fuel pumps.

[27] The non-contact positive displacement fuel pump 1000 is constituted mainly by four parts, that is, a pump body 200, a piston 300 axially mounted in the pump body 200, a linear motor 400 moving the piston 300 in a reciprocating motion, and a bearing supporting the piston 300.

[28] In this embodiment, the fuel pump 1000 is structured such that a single piston 300 is axially mounted inside the pump body 200 to generate pressure.

[29] Here, the piston 300 is mounted out of contact with the pump body 200. Prior to this, an outer diameter of the piston 300 should be determined to form a micro gap with the pump body 200 in order to minimize loss of the pressure.

[30] Additionally, an inlet 210 and an outlet 220 are provided at one side of the pump body 200 to take in and take out the LPG fuel, respectively, through suction and exhaustion operations in accordance with the reciprocating motion of the piston 300. Being connected with check valves 211 and 221, respectively, the inlet 210 and the outlet 220 are intermittently operated according to compressing and pulling motions of the piston 300.

[31] The linear motor 400 is also mounted to the piston 300 so that the piston 300 can reciprocate within the pump body 200.

[32] The mounting structure will be described in detail. Referring to FIG. 2, a stator 420 of the linear motor 400 is fixed to the pump body 200 whereas a mover 410 of the linear motor 400 is connected to a piston rod 320 extended from the piston 300. As the mover 410 is reciprocated by a magnetic field formed with respect to the stator 420, the piston rod 320 inserted in the mover 410 is accordingly moved along with the mover 410.

[33] Meanwhile, the bearing is disposed at both sides of the linear motor 400 to strongly support the piston rod 320 in radial directions such that the piston 300 reciprocating in the pump body 200 can be fixed at a predetermined position.

[34] The bearing may be a linear flexure bearing 100 having high stiffness in radial directions but low stiffness in an axial direction, and being relatively less affected by torsional stress. The linear flexure bearing 100 supplements flexibility of the piston 300 which is reciprocating.

[35] More specifically, the linear flexure bearing 100 connected with the piston rod 320 is reciprocated along with the piston rod 320 in accordance with the reciprocating motion of the piston 300.

[36] Therefore, even while the piston 300 is reciprocating through the linear flexure bearing 100, the micro gap G formed between the piston 300 and the pump body 200 can be stably maintained.

[37] Here, the piston 300 is non-contactingly operated, forming the micro gap G with
respect to the pump body 200, and equipped with a plurality of sealing recesses 310 formed along an outer circumference. The sealing recesses 310 prevent leakage of the LPG fuel flowing into the pump body 200 through a rear end of the piston.

That is, such a structure of the piston 300 is a labyrinth-type seal, that is, a non-contacting seal. According to this structure, as the LPG fuel flows in through the micro gap G and passes through the plurality of sealing recesses 310, the pressure of the LPG fuel is gradually reduced. Therefore, the LPG fuel can be prevented by the sealing recesses 310 from flowing in through the rear end of the piston.

Since the "linear flexure bearing" was filed by the present applicant on August 25, 2002 and published on December 23, 2004, the structure thereof will be briefly explained hereinafter with the accompanying drawings.

FIG. 3 is a plan view extractingly showing a diaphragm of the linear flexure bearing from FIG. 1. FIG. 4 is a plan view of inner and outer spacers of the linear flexure bearing of the non-contact positive displacement fuel pump of FIG. 1. FIG. 5 is a plan view of the linear flexure bearing constructed by the diaphragm and the inner and outer spacers of FIG. 3.

Referring to FIG. 3, first, the diaphragm 10 of the linear flexure bearing 100 comprises a hub 12, a rim 16, and a plurality of flexure blades 21, 23 and 25, which are all coplanarly connected. The hub 12 includes hub arms 14a, 14b and 14c radially extended from an outer circumference thereof such that the flexure blades 21, 23 and 25 can be connected with the hub 12 and the rim 16. Additionally, rim arms 18a, 18b and 18c are radially extended from an inner circumference of the rim 16.

The hub 12 has an annular shape having a circular hole in the center. A plurality of rivet points 13 are formed on the hub 12 at uniform intervals. Since a supporting shaft will be inserted in the center hole of the hub 12, the size of the hole of the hub 12 may vary depending on a diameter of the shaft to be applied.

The hub arms 14a, 14b and 14c are arranged in radial directions from the outer circumference of the hub 12 at the same angular intervals with respect to the center of the hub 12. According to this embodiment, three hub arms 14a, 14b and 14c are integrally formed with the hub 12, being arranged at 120 intervals from one another with respect to the center of the hub 12.

Each of the hub arms 14a, 14b and 14c includes at least one rivet point 15.

The rim 16 having an annular shape is disposed to surround the hub 12 and the hub arms 14a, 14b and 14c. Preferably, the rim 16 has the size such that an inner circumference thereof is disposed adjacently to outer ends of the respective hub arms 14a, 14b and 14c at a predetermined interval. A plurality of rivet points 19 are also formed on the rim 16 at uniform intervals.

The rim arms 18a, 18b and 18c are formed in the same number as the hub arms 14a,
14b and 14c, and radially extended from the inner circumference of the rim 16 forming the same angular intervals with respect to the center of the hub 12.

According to this embodiment, three rim arms 18a, 18b and 18c are integrally formed with the rim 16, being arranged at 120 intervals from one another with respect to the center of the hub 12. Each of the rim arms 18a, 18b and 18c includes at least one rivet point 17.

The plurality of flexure blades 21, 23 and 25 are formed each in an arch shape having a predetermined width, and disposed between one side of the hub arms 14a, 14b and 14c and one side of the rim arms 18a, 18b and 18c, the sides which are distanced from each other, accordingly interconnecting the hub arms 14a, 14b and 14c and the rim arms 18a, 18b and 18c. According to the embodiment of the present invention, respectively three flexure blades 21, 23 and 25 arranged side by side at predetermined intervals adjacent to one another are disposed between the hub arms 14a, 14b and 14c and the rim arms 18a, 18b and 18c.

The width of the flexure blades 21, 23 and 25 is decreased as going toward the center of the hub 12.

Referring to FIG. 4, an inner spacer 30 comprises a hub spacer 32 and hub spacer arms 34a, 34b and 34c. An outer spacer 40 comprises a rim spacer 41 and rim spacer arms 43a, 43b and 43c.

The hub spacer 32 has the same size and shape as the hub 12 of the diaphragm 10.

The hub spacer arms 34a, 34b and 34c are provided in a plural number and arranged on an outer circumference of the hub spacer 32 to be in the same positions and shapes as the hub arms 14a, 14b and 14c.

In addition, a supporting protrusion 36 is formed on one side of the hub spacer arms 34a, 34b and 34c, corresponding to one side of the hub arms 14a, 14b and 14c in connection with the flexure blades 21, 23 and 25.

The supporting protrusion 36 has a teeth form and is formed to correspond to the respective flexure blades 21, 23 and 25 disposed between the distanced sides of the hub arms 14a, 14b and 14c and the rim arms 18a, 18b and 18c. Each tooth of the supporting protrusion 36 includes a long side 36a and a short side 36b. Here, it is preferred that the short side 36b is corresponded to an outer circumferential edge of the respective flexure blades 21, 23 and 25 when the inner spacer 30 is connected with the diaphragm 10, whereas the long side 36a forms a predetermined acute angle \( \alpha \) with respect to the short side 36b.

In the inner spacer 30 according to a first embodiment of the present invention, the acute angle \( \alpha \) formed between the long side 36a and the short side 36b of the supporting protrusion 36 is 52°.

The rim spacer 41 has the same size and shape as the rim 16 of the diaphragm 10.
In addition, the rim spacer arms 43a, 43b and 43c are provided in a plural number and arranged on an inner circumference of the rim spacer 41 to be in the same positions and shapes as the rim arms 18a, 18b and 18c.

In addition, a supporting protrusion 45 is formed on one side of the rim spacer arms 43a, 43b and 43c corresponding to one side of the rim arms 18a, 18b and 18c in connection with the flexure blades 21, 23 and 25.

The supporting protrusion 45 has a teeth form and is formed to correspond to the respective flexure blades 21, 23 and 25 disposed between the distanced sides of the hub arms 14a, 14b and 14c and the rim arms 18a, 18b and 18c. More specifically, each tooth of the supporting protrusion 45 includes a long side 45a and a short side 45b. Here, as shown in FIG. 5, it is preferred that the short side 45b is corresponded to an outer circumferential edge of the respective flexure blades 21, 23 and 25 when the outer spacer 40 is connected with the diaphragm 10. The long side 45a forms a predetermined acute angle \( \beta \) with respect to the short side 45b.

Referring to FIG. 5, in the outer spacer 40 according to this embodiment, the acute angle \( \beta \) formed between the long side 45a and the short side 45b of the supporting protrusion 45 is 50°.

The above-structured inner spacer 30 and the outer spacer 40 are provided with rivet points 31, 35, 42 and 46 disposed corresponding to the rivet points 13, 15, 17 and 19 formed at the diaphragm 10. Through the rivet points 31, 35, 42 and 46, the spacers 30 and 40 can be connected with the diaphragm 10 and also fixed to a shaft or a housing mounted at the inside and the outside of the bearing 100.

As a result of measurement about stiffness in the axial direction and stiffness and fatigue life in radial directions by a computer modeling analysis, the linear flexure bearing 100 has high stiffness in radial directions and low stiffness in an axial direction, and relatively low torsional stress.

Therefore, while supplying flexibility to the piston rod 320, the linear flexure bearing 100 is capable of stably maintaining the micro gap \( G \) between the piston 300 and the pump body 200.

FIG. 6 is a structural sectional view of a non-contact positive displacement fuel pump for an LPG vehicle, according to another embodiment of the present invention. FIG. 7 shows the operational state of the non-contact positive displacement fuel pump according to the another embodiment.

As shown in FIG. 6, differently from the previous embodiment, the non-contact positive displacement fuel pump 1000 according to the another embodiment of the present invention comprises two pistons 300 disposed at both sides in the pump body 200.

Accordingly, the inlet 210 and the outlet 220 are formed in the middle part of the
pump body 200. Here, in order to improve the LPG pumping efficiency through the inlet 210 and the outlet 220, a predetermined space needs to be formed in the middle part when the both pistons 300 are compressed.

Therefore, as shown in FIG. 7, the fuel pump 1000 according to the another embodiment is capable of not only doubling the pumping efficiency using the two pistons 300 but also restraining vibration through the symmetrical structure.

Here, the pistons 300 are each equipped with the linear motor 400 and a pair of the linear flexure bearings 100.

Industrial Applicability

The above-described non-contact positive displacement fuel pump for an LPG vehicle can be applied not only to the fuel pump of the LPG vehicle but also to other types of vehicles using dimethyl ether (DME), gasoline and so on.

As can be appreciated from the above description, the non-contact positive displacement fuel pump for an LPG vehicle, according to any of the above embodiments of the present invention, is capable of preventing the pumping performance from being deteriorated due to a decreased pressure by friction abrasion. Thus, since the pressure can be stably maintained, reliability and durability can be enhanced.

Furthermore, through a linear flexure bearing, friction between a piston and a pump body by weight of the piston, the pumping load and external impacts can be prevented.

Although the preferred embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.
Claims

[1] A non-contact positive displacement fuel pump for an LPG vehicle with a lubricant separation system, comprising:
a pump body mounted with an inlet and an outlet at one side thereof;
a piston axially mounted to the pump body to generate pressure to the pump body;
a linear motor connected to a piston rod to move the piston in a reciprocating motion; and
bearings disposed at both sides of the linear motor to fix the piston reciprocating in the pump body at a predetermined position by securely supporting the piston rod in radial directions.

[2] A non-contact positive displacement fuel pump for an LPG vehicle, with a lubricant separation system, comprising:
a pump body mounted with an inlet and an outlet in the middle part thereof;
pistons axially mounted to both sides of the pump body to generate pressure to the pump body;
linear motors connected to piston rods of the respective pistons to move the piston in a reciprocating motion; and
bearings mounted to both sides of each linear motor to fix the piston reciprocating in the pump body at a predetermined position by securely supporting the piston rod in radial directions.

[3] The non-contact positive displacement fuel pump according to claim 1 or claim 2, wherein the piston is mounted non-contactingly with respect to the pump body to form a micro gap, and comprises a plurality of sealing recesses formed along an outer circumference thereof to prevent LPG fuel being supplied into the pump body from leaking through a rear end of the piston.

[4] The non-contact positive displacement fuel pump according to claim 1 or claim 2, wherein the piston rod is axially mounted to a mover of the linear motor.

[5] The non-contact positive displacement fuel pump according to claim 1 or claim 2, wherein the bearing is implemented with a linear flexure bearing for supplying flexibility to the piston rod, and comprises:
a diaphragm which includes a hub having an annular shape with a hole in the center, a plurality of hub arms radially extended from an outer circumference of the hub, forming uniform angular intervals with respect to the center of the hub, a rim having an annular shape disposed to surround the hub and the hub arms, being disposed adjacent to outer ends of the respective hub arms, a plurality of rim arms provided in the same number as the hub arms and radially extended
from an inner circumference of the rim to be adjacent to one edge of the respective hub arms, forming uniform angular intervals with respect to the center of the hub, and a plurality of flexure blades each having an arch shape with a predetermined width and disposed between one side of the hub arms and one side of the rim arms, the sides which are distanced, thereby interconnecting the hub arms and the rim arms;
an inner spacer fixed corresponding to the shape of the hub, including a hub spacer having the same size and shape as the hub, a plurality of hub spacer arms arranged on an outer circumference of the hub spacer in the same positions and shapes as the hub arms, a supporting protrusion formed on one side of the hub spacer arms, corresponding to one side of the hub arms in connection with the flexure blades; and
an outer spacer fixed corresponding to the shape of the rim, including a rim spacer having the same size and shape as the rim, a plurality of rim spacer arms arranged on an inner circumference of the rim spacer to be in the same positions and shapes as the rim arm, and a supporting protrusion formed on one side of the rim spacer arms corresponding to one side of the rim arms in connection with the flexure blades.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

F02M 37/04(2006.01)1

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)

IPC 8 F02M37/04

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

Korean utility models and applications for utility models since 1975

Japanese utility models and applications for utility models since 1975

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

eKIPASS (KIPO Internal) & Keywords "linear pump", "axleure bearing", "piston" and "liquid"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
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<td>JP 2001-3041 12 A (DAIKIN IND LTD) 31 October 2001 See Paragraphs 0091 - 0178, Figures 4,6</td>
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<td>Y</td>
<td>See Paragraphs 0010 - 0090, Figures 2-7</td>
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<td>KR 10-0462996 B1 (KOREA INSTITUTE OF MACHINERY &amp; MATERIALS) 13 December 2004 See Page 3, line 8 - Page 5, line 1, Figures 1-7</td>
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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
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X 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

Y 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

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Date of the actual completion of the international search

12 JANUARY 2009 (12.01.2009)

Date of mailing of the international search report

12 JANUARY 2009 (12.01.2009)

Name and mailing address of the ISA/KR

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Telephone No 82-42-481-5478

Form PCT/ISA/210 (second sheet) (July 2008)
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