ROTOR OIL SEALING ARRANGEMENT FOR A ROTARY INTERNAL COMBUSTION ENGINE

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ABSTRACT

Oil sealing rings disposed between an eccentric shaft and a rotor to contain cooling oil in a rotor center cavity, which are biased to an operative position by blow-by gas pressure, and a valve arrangement to maintain the blow-by gas pressure between atmospheric pressure and a higher predetermined value.

5 Claims, 3 Drawing Figures
ROTOR OIL SEALING ARRANGEMENT FOR A ROTARY INTERNAL COMBUSTION ENGINE

The present invention relates to an oil sealing arrangement for a rotary internal combustion engine, and more particularly to a rotor center cavity cooling oil sealing arrangement of a type which includes oil sealing rings disposed between an eccentric shaft and a rotor for containing oil in the rotor center cavity. More particularly, the present invention relates to a rotor center cavity cooling oil sealing arrangement in which the oil sealing rings are sealingly pressed against faces of grooves in which they are carried throughout varying operating conditions of the engine.

Rotary internal combustion engines under consideration comprise a housing having spaced end walls with substantially flat internal surfaces and a peripheral wall interconnecting the end walls to define therein a cavity having an axis along which the end walls are spaced. A rotor is received within the housing cavity and journalled on an eccentric portion of an eccentric shaft, which in turn is journalled in bearings received in bores formed in the end walls. The rotor has substantially flat end faces adjacent to the internal surfaces of the end walls of the housing. The rotor also has a peripheral face with a plurality of circumferentially spaced apex portions sealingly slidable on the inner peripheral surface of the housing to form a plurality of working chambers which vary in volume upon rotation of the rotor relative to the housing.

In a rotary internal combustion engine of the above type, the rotor is cooled with oil which passes into a rotor center cavity from the bearings on which the rotor is journalled, or directly from a passageway formed in the eccentric shaft. The oil is swirled around inside the rotor and is consequently forced out by centrifugal forces set up by motion of the rotor.

The rotor end faces are usually provided with annular grooves in which annular oil seals are received for sealing engagement with the adjacent internal surfaces of the end walls of the housing. Gas between the eccentric shaft and portions of the rotor are sealed by sealing rings fitted in circumferential grooves formed in the eccentric shaft. Spaces are provided adjacent to the sealing rings into which are supplied blow-by gas, to bias the sealing rings into sealing positions.

A problem is encountered with this sealing arrangement in that the pressure of the blow-by gas acting on the sealing rings is reduced when the engine is subjected to a light load, such as when the engine is driven during deceleration, and thus it is difficult to press the sealing rings into effective sealing engagement. This may result in leakage of oil out of the rotor center cavity.

Therefore, the present invention contemplates to solve this problem encountered in the above described rotor oil sealing arrangement of a rotary internal combustion engine.

It is an object of the present invention to provide a rotor oil sealing arrangement which ensures satisfactory sealing effectiveness throughout varying operating conditions of the engine.

It is another object of the present invention to provide means for maintaining the blow-by gas pressure supplied to sealing rings at a sufficient level throughout varying operating conditions of the engine.

These and other objects, features, and advantages of the present invention will become more apparent from the following description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a fragmentary sectional view of a multior rotor rotary internal combustion engine and a rotor oil sealing arrangement according to one embodiment of the present invention;

FIG. 2 is an enlarged diagrammatic view of the oil sealing arrangement shown in FIG. 1; and

FIG. 3 is an enlarged diagrammatic view of a rotor oil sealing arrangement according to another embodiment of the present invention.

In FIGS. 1 and 2, a rotary internal combustion engine comprises a housing 10 comprising an axially spaced end wall 12 and an intermediate or end wall 14, both having substantially flat internal surfaces, and a peripheral wall 16 disposed between and interconnecting the end walls 12 and 14 to form a cavity (no numeral) therebetween. The inner surface of the peripheral wall 16 has an epitrochoidal profile.

A rotor 20 is operatively disposed in the cavity of the housing 10, and is journalled by a bearing 22 on an eccentric portion 24 of an eccentric shaft 26. The eccentric shaft 26 extends axially through bores (no numerals) formed in the end walls 12 and 14 of the housing 10, and are journalled therein as may readily be appreciated. The rotor 20 has axially spaced end faces 28 and 30 disposed adjacent to the internal surfaces of the end walls 12 and 14, respectively, and has a peripheral face (no numeral) interconnecting the end faces 28 and 30. The rotor 20 has a plurality of circumferentially spaced apex portions in which are disposed apex seals, only one apex seal being shown and designated by a reference numeral 32. The apex seals 32 are in gas sealing contact with and slidable on the inner surface of the peripheral wall 16 to form a plurality of working chambers, only one of which is shown and designated by a reference numeral 34, upon rotation of the rotor 20 relative to the housing 10.

Proper rotation of the rotor 20 relative to the housing 10 is assured by an internal gear 36 secured to the rotor 20 and an external gear 38 secured to the end wall 12, the internal gear 36 being in mesh with the external gear 38.

Each working chamber 34 must be sealed from the adjacent chambers, and for this purpose the apex seals 32 are disposed in the apex portions and side seals 40 and 42 are disposed in the end faces of the rotor 20.

Axially extending through the eccentric shaft 26 is an oil passageway 44 communicating with a source of oil (not shown) in a conventional manner. Radially extending bores 46 are formed in the eccentric shaft 26, and communicate with the oil passageway 44 for delivering oil to a bearing 23 by which the eccentric shaft 26 is journalled in the end wall 12. Formed in the eccentric portion 24 is a radial bore 48, communicating with the oil passageway 44 for delivering oil to the bearing 22. Formed also in the eccentric portion 26 is a radial bore 50 communicating with the oil passageway 44 for supplying oil into a center cavity 52 formed in the rotor 20. Thus, the rotor 20 is cooled with oil which passes into the rotor center cavity 52 from the radial bore 50 and also from the bearing 22.

As is clearly shown in FIG. 2, oil seals 54 and 56 are fitted in grooves 57 and 59 formed in the end faces 28 and 30 of the rotor 20, in a conventional manner. As
will be seen, the annular grooves 57 and 59 are disposed radially outward of apertures 58 and 60 formed in the end faces 28 and 30 respectively.

In order to keep cooling oil within the rotor center cavity 52, it is necessary to seal the annular gap between the circumferential surface of the eccentric portion 24 and the aperture 60, and to seal the gap between the circumferential surface of the eccentric shaft 26 and the aperture 58. For this purpose, a sealing ring 62 is disposed in a groove 64 formed in the circumferential surface of the eccentric portion 24, and another sealing ring 66 is disposed in a groove 68 formed in a rotating member 70 fixed to the eccentric portion 24. The rotating member 70 comprises an annular portion 72, a cylindrical portion 74 extending axially from the annular portion 72 into the bore formed in the end wall 12, and a hub portion 76 extending from the annular portion 72 and fixed to the eccentric portion 24 in a conventional manner. Formed in the circumferential surface of the annular portion 72 of the rotating member 70 is the groove 68 for receiving the sealing ring 66, the sealing ring 66 being in sealing contact with a right face 69 of the groove 68 as shown. Formed in the circumferential surface of the cylindrical portion 74 is a groove 78 for receiving a sealing ring 80, which is in sealing contact with a left face 79 of the groove 78 as shown. A space or blow-by gas chamber 82 is formed between the rotating member 70 and the internal surface of the end wall 12, and another blow-by gas chamber 84 is formed between the end face 30 of the rotor 20 and the internal surface of the end wall 14. The blow-by gas chambers 82 and 84 communicate with each other by means of a passageway 86 formed in the eccentric portion 24 and the rotating member 70.

Now it will be understood that if gas under pressure is supplied into the blow-by gas chambers 82 and 84, the sealing ring 66 is pressed against the right-hand face 69 of the groove 68, the sealing ring 80 against the left hand face 79 of the groove 78, and the sealing ring 62 against a left hand face 65 of the groove 64, as best seen in FIG. 2.

Since the rotor oil sealing arrangement described above is conventional and well known in the art, further detailed description of its construction will be omitted.

The blow-by gas chamber 84 communicates with a passageway 88 formed in the end wall 14, the passageway 88 being communicable with an atmospheric chamber 90 through a relief valve 92. The atmospheric chamber 90 communicates through an air passageway 94 and an air cleaner (not shown) with the atmosphere.

The relief valve 92 is designed such that it permits communication between the passageway 88 and the atmospheric chamber 90 when the pressure in the passageway 88 is above a predetermined level of, for example, 100mmHg. The relief valve 92 includes a ball 95 normally biased by a compression spring 96 to block communication between the passageway 88 and the atmospheric chamber 90. The stiffness of the compression spring 96 for biasing the ball 95 can be adjusted by turning an adjustment screw 98. A branch passageway 100 is formed in the end wall 14, and communicates with the passageway 88 at one end. The other end of the branch passageway 100 is communicable with the atmosphere via the air cleaner through a pressure control valve 102. The pressure control valve 102 is operable to permit communication between the atmosphere and the passageway 88 when the pressure in the passageway 88 falls below atmospheric pressure to prevent the pressure in the blow-by gas chambers 82 and 84 from dropping below atmospheric pressure. The control valve 102 includes a hollow valve housing 104 tightly fitted into the passageway 100. The control valve 102 also includes a valve element 106 normally biased to a closed position by a compression spring 108. The spring 108 is so designed to permit the valve element 106 to move to an open position when the pressure in the passageway 88 falls below atmospheric pressure.

During the operation of the engine, cooling of the rotor 20 is carried out by supplying oil into the center cavity 52 of the rotor 20 from the source of cooling oil through the oil passageway 44 and the radial bore 50 formed in the eccentric portion 24. Depending on the speed of rotation of the rotor 20, cooling oil supplied into the rotor cavity 52 is swirled around inside the rotor 20 and consequently forced out. When the engine is subjected to a medium or heavy load during operation, a considerably high level of blow-by gas pressure exists in the blow-by gas chambers 82 and 84, and thus the pressure within the chambers 82 and 84 will be maintained around but below 100mmHg under the control of the relief valve 92, which opens if the pressure in the passageway 88 is above 100mmHg. In this engine operating condition the sealing rings 62, 66 and 80 are pressed against the faces 65, 69 and 79, respectively, due to the pressure in the blow-by gas chambers 82 and 84, preventing oil loss from the rotor center cavity 52. The control valve 102 is closed in this engine operating condition. When the engine is subjected to a light load, i.e. when the engine is braked during deceleration, the blow-by gas pressure is relatively low, and the pressure in the blow-by gas chambers 82 and 84 may fall below atmospheric pressure. In this engine operating condition the control valve 102 remains closed, and communication between the passageway 100 and the atmosphere, thus introducing substantially atmospheric pressure into the blow-by gas chambers 82 and 84. Hence, the sealing rings 62, 66 and 80 are kept pressed against the faces 65, 69 and 79 respectively, due to the atmospheric pressure in the blow-by gas chambers 82 and 84. In this engine operating condition the relief valve 92 is closed.

Referring now to FIG. 3, there is shown another embodiment of a rotor oil sealing arrangement of the present invention. With the exception of a design feature which will be described below in detail, the configuration and operation of this embodiment is substantially identical with that of the embodiment shown in FIGS. 1 and 2, and like reference numerals denote like components and parts in both cases.

This embodiment of the present invention differs from the previously described embodiment in that the relief valve 92 and the control valve 102 of the previous embodiment are replaced herein by one control valve 110, which permits communication between the passageway 88 and the passageway 94 when the pressure within the passageway 88 exceeds for example 100mmHg, and also permits communication between the passageway 88 and the passageway 94 via a bypass passageway 112 when the pressure in the passageway 88 falls below atmospheric pressure. Moreover, the branch passageway 100 of the previous embodiment is replaced herein by the bypass passageway 112 which
communicates with the passageway 94 and a valve chamber 114 of the control valve 110.

The control valve 110 as shown in FIG. 3 includes a hollow valve member 116 cooperating with a valve seat 118 to allow or block communication between the passageway 88 and the passageway 94. The hollow valve member 116 is biased toward the valve seat 118 by a compression spring 120, which is designed to permit the hollow valve member 116 to disengage from the valve seat 118 when the pressure in the passageway 88 exceeds 100mmHg. The hollow valve member 116 has formed therethrough a bore 119 which is open to the valve chamber 114, and has formed therein a valve seat 122 which cooperates with a valve element 124 biased toward the valve seat 122 by another compression spring 126, which is designed to permit the valve element 124 to disengage from the valve seat 122 and allow communication between the passageway 88 and the passageway 94 via the bypass passageway 112 when the pressure in the passageway 88 falls below atmospheric pressure.

It will now be appreciated from the foregoing description that a rotor oil sealing arrangement of the present invention is capable of effectively preventing cooling oil from leaking out of the rotor center cavity irrespective of engine operating conditions. Thus, according to the present invention, oil loss can be considerably reduced.

It will be understood that the above embodiments of a rotor oil sealing arrangement of the present invention are by means of example only, and that considerable modification may be made without departing from the scope of the present invention.

What is claimed is:

1. A rotary internal combustion engine comprising:
   a housing having spaced end walls and a peripheral wall connecting said end walls, defining therein a cavity having an axis along which said end walls are spaced;
   a shaft co-axial with said cavity and having an eccentric portion, said eccentric portion having formed therein circumferential grooves, said shaft extending through bores formed in said end walls; a rotor received within said cavity of said housing, journaled on said eccentric portion for relative rotation with respect to said housing and having a center cavity therein, said rotor having end faces disposed adjacent to said housing end walls and having a peripheral face cooperating with said housing peripheral wall to define a plurality of working chambers therebetween, the end faces of said rotor having formed therein apertures co-axial with said eccentric portion of said shaft; said rotor having annular grooves formed in the end faces thereof co-axial with and outwardly spaced from said apertures; oil sealing rings mounted in said annular grooves for sealing engagement with said adjacent end walls; sealing rings received in said circumferential grooves for sealing engagement with adjacent portions of said apertures; said rotor and said end walls defining therebetween blow-by gas chambers, said blow-by gas chambers being disposed axially outward from said sealing rings and radially inward from said oil sealing rings and being communicable with a source of blow-by gas and communicative with each other; and at least one valve for permitting communication between said blow-by gas chambers and the atmosphere when the pressure in said blow-by gas chambers exceeds a high predetermined value, and for permitting communication between said blow-by gas chambers and the atmosphere when the pressure in said blow-by gas chambers falls below a low predetermined value, and for blocking said communication under all other conditions.

2. A rotary internal combustion engine as claimed in claim 1, wherein said at least one valve comprises a passageway communicating with said blow-by gas chambers; an air passageway communicating with the atmosphere and communicable with said passageway; a control valve including a valve chamber communicative with said air passageway, a hollow valve member permitting communication between said passageway and said valve chamber, a valve element accommodated within said hollow valve member, a spring for biasing said valve element toward a position such as to block communication between said passageway and said valve chamber when the pressure in said passageway is above said low predetermined value, and permitting said valve element to move to a position such as to permit communication between said passageway and said valve chamber when the pressure in said passageway is below said low predetermined value; a second spring for biasing said hollow valve member toward a position such as to block communication between said passageway and said air passageway when the pressure in said passageway is below said high predetermined value, and to allow said hollow valve member to move to a position such as to permit communication between said passageway and said air passageway when the pressure in said passageway is above said high predetermined value.

3. A rotary internal combustion engine as claimed in claim 1, wherein said at least one valve comprises a passageway communicating with said blow-by gas chambers and communicable with the atmosphere; a branch passageway branched off from said passageway and communicable with the atmosphere; a relief valve provided in said passageway and operable to permit said passageway to communicate with the atmosphere when the pressure in said passageway exceeds said high predetermined value; and a pressure control valve provided in said branch passageway and operable to permit said branch passageway to communicate with the atmosphere when the pressure in said passageway falls below said low predetermined value, and to block said communication under all other conditions.

4. A rotary internal combustion engine as claimed in claim 3, wherein said relief valve comprises a ball biassed by a compression spring toward a position such as to close said passageway.

5. A rotary internal combustion engine as claimed in claim 3, wherein said pressure control valve includes a hollow valve housing fitted in said branch passageway; and a valve element biased by a compression spring toward a position such as to close said branch passageway.

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