

FACE SEAL FOR RELATIVELY ROTATABLE MEMBERS.

This invention relates to face seals for opposing fluid leakage between relatively rotatable members.

The invention is applied to a face seal of the kind comprising a rigid sealing ring carried by a free end of a coaxial resiliently deformable sleeve having means at its other end for mounting the sleeve fluid-tight on one member so as to present the sealing ring to bear axially against a counterface on another, relatively rotatable, member.

It is known in such a seal, which may be referred to as "a face seal of the kind defined", to provide for the effect on the seal of the pressure of fluid to be sealed to be more or less balanced, such as by the provision of oppositely axially directed surfaces of appropriate area exposed to the fluid pressure, so as to achieve a required resultant bearing load of the sealing ring against its counterface, taking into account inherent resilient or applied spring-loading of the sealing ring.

The present invention provides a balanced face seal of the kind defined which is of simple construction, in terms of the shape and only a few parts, is particularly suitable for low fluid pressures, such as exist in the cooling water systems of internal combustion engines, and enables a fluid pressure balancing and required sealing ring loading effect to be achieved simply by the shape and proportions of the resiliently deformable sleeve.

According to the invention, in a face seal of the kind defined, the resiliently deformable sleeve is a moulded elastomeric sleeve which is geometrically equivalent to an

axially opposed pair of frusto-conical parts joined pivotally together at their larger diameter, the larger diameter portions of the frusto-conical parts of the sleeve forming a circumferential flexible junction with a circumferential groove in which is seated a garter spring, the smaller diameter rims forming respectively the free end of the sleeve to carry the sealing ring and the other end of the sleeve having the mounting means, and the sleeve forming a toggle system which, in use, is exposed to the pressure of fluid to be sealed and exerts on the sealing ring an axial bearing load having a value dependent on the angles of conicity and the axial lengths of the frusto-conical parts and the ratio of the diameters of the free end and mounting end of the sleeve.

The lengths and conicity of the frusto-conical parts of the sleeve determine the leverage of the toggle system and the ratio of the diameters of the ends of the sleeve, which determines the line of operation of the toggle system, can be selected to give a desired relationship between the toggle system and the axis of the seal. By design of the sleeve to achieve equivalence with a calculated toggle system, the effect of sealed fluid pressure on the sleeve can be balanced as required to obtain a required bearing load of the sealing ring on its counterface.

The sleeve can also be designed to utilise the inherent resilience of its elastomeric material for residual loading of the sealing ring, augmented by the garter spring, and also the frusto-conical shape of the free end of the spring has the practical advantage that it can be made simply to grip fast and seal around a shouldered back of the sealing ring.

The invention will be further described, by way of example, with reference to the accompanying drawings, in

which:-

Fig. 1 is an axial section of a face seal in accordance with the invention in place in a circulating water pump of the cooling system of an internal combustion engine,

Fig. 2 is a partly axially sectioned side elevation of the sleeve and mounting cup of the seal of Fig. 1, before the sealing ring is fitted,

Fig. 3 is an axial fragmentary section showing an optional detail of the sleeve and sealing ring fitting, and

Figs. 4 to 7 are explanatory diagrams of the toggle system which the seal sleeve embodies.

As shown by Figs. 1 to 3, the face seal consists simply of a rigid sealing ring 1, made of carbon or a like material as known for face seals, carried by the free end of a moulded elastomeric sleeve 2, such as of a nitrile rubber, moulded on to the inner peripheral rim of an annular mounting cup 3, of pressed sheet metal or moulded plastics material, which fits fluid-tight into a stepped bore 4 of the body 5 of a cooling water circulating pump.

The sealing ring 1 has on its front face 6 an annular land 7 which bears axially as a relatively rotatable seal fluid-tight against a plane counterface 8 on the boss of an impeller 9 carried by a rotor shaft 10 which passes with a running clearance through the sealing ring and is journaled in a bearing 11 in the pump body 5.

The sealing ring 1 has a rearward axial cylindrical spigot 12 so that the back of the ring presents a shoulder 13 into the angle of which the smaller diameter free end 14 of the sleeve 2 seals fluid-tight and fits fast so that the ring 1 is held against rotation by the

sleeve 2. As an optional feature, shown only in Fig. 1, projections 15 may be moulded on the inner surface of the sleeve 2 to engage in keyways 16 in the spigot 12 and positively oppose relative rotation of the sealing ring 1 in the sleeve 2. Alternatively, projections could be provided on the sealing ring to engage in keyway recesses in the sleeve 2.

As can be seen by comparison of Figs. 1 and 2, the end 14 of the sleeve 2 must be stretched to pass on to the spigot 12 and consequently constantly tends to contract and thus promote a static seal in the angle of the shoulder at the back of the ring 1.

Engagement of the end 14 of the sleeve in the angle of the shoulder at the back of the ring 1 may also be utilised to promote maintenance of the frusto-conical form of the forward part 17 of the sleeve 2 and an alternative construction for this purpose is illustrated by Fig. 3. As shown, the back of the ring 1 is undercut in the angle of the shoulder to form a recess 18 around the spigot 12, to receive fully the end 14 of the sleeve and support the forward part 17 of the sleeve 2 in its frusto-conical shape.

The frusto-conical shape of the part 17 of the sleeve 2 can be seen in Fig. 2 from which it can also be seen that a rearward part 19 of the sleeve is also basically of frusto-conical shape although this is to some extent masked by thickening of the rearward end 20 of the sleeve, for moulding-in of the inner rim of the mounting cup 3, and thickening of a central band 21 of the sleeve to give a designed degree of axial stiffness.

The flexible junction, corresponding to a toggle joint,

between the frusto-conical parts 17 and 19 of the sleeve 2 is defined by circumferential groove 22 and this optionally seats a garter spring 23 which tends to constrict the central portion of the sleeve and augment its resilient axial load.

As shown in Fig. 1, the seal is installed so that the sleeve 2 is held under some axial compression between the counterface 8 of the impeller 9 and the mounting cup 3 held in the pump body bore 4.

The seal assembly of the cup 3, sleeve 2 and ring 1 forms in effect a fluid-tight diaphragm dividing the bore 4 of the pump body into a pressure space P, at the impeller side through which the cooling water is circulated, and an atmospheric space A through which the shaft 10 passes to its bearing 11 and external driving means (not shown).

The pressure of water in the space P is not constant, varying with impeller speed and water temperature, and the variation of pressure must be counteracted in its effect on the sealing ring 1 and sleeve 2 so as to avoid such a variation of bearing load of the sealing land 7 on the counterface 8 as could spoil their fluid sealing tightness.

To achieve the necessary counteraction; the sleeve 2 provides a toggle system which balances the effect of fluid pressure on the axial loading of the ring 1, as explained below.

The basic principle is illustrated diagrammatically by Fig. 4 in which the two frusto-conical parts 17 and 19 of the sleeve 2 are represented by the two legs 17 and 19 of a toggle joint interpivoted at 22.

If a uniform pressure P is applied to the two legs,

which in this case are of equal length, there is no axial reaction force when the angle θ is 45° , $R_A = 0$. For angles of θ less than 45° , R_A is positive as indicated by the arrows in Fig. 4, and vice versa.

R_A thus represents the reaction on the axial loading of the sealing ring 1 resulting from fluid pressure on the sleeve 2.

For practical reasons, it is convenient to make the rearward end of the sleeve 2 of larger diameter and this is equivalent to tilting the toggle joint by an angle ϕ to the seal axis X - X as shown diagrammatically by Fig. 5.

With equal leg lengths, there is a range of values for the angles θ and ϕ for which $R_{A1} = 0$ and this criterion is reached when $2\theta + \phi = 90^\circ$. If θ is less than the value calculated from this equation, then R_{A1} is positive and vice versa. It should be noted that R_{A2} is not always equal to R_{A1} .

The system can be made to have a zero reaction at one end even if the lengths of the legs are unequal. This is illustrated by Fig. 6 in which the reaction is zero when the following equation is satisfied:

$$\frac{l_2}{l_1} \cos (\theta + \phi) = \cos [\pi - (\theta + \angle) - (\theta + \phi)]$$

For values of $(\theta + \angle)$ less than those calculated from this equation the reaction force R_{A1} is positive, and vice versa.

It can be shown that different proportions of pressure balancing can be achieved by appropriate

selection of the toggle angles and leg lengths.

Fig. 7 illustrates the equivalence of a seal sleeve, in accordance with the present invention, to a toggle system. For simplicity, equal leg lengths of the toggle system are shown.

It will of course be appreciated that allowance must be made for the circular cross-sectional shape of the sleeve 2 so that, even though the leg lengths are equal, the total area of each leg of the sleeve is different because their mean radii are different. This results in the balance condition being slightly different from the simple two-dimensional case but in practice the simple analysis is adequate.

In addition to the effect of fluid pressure on the sleeve 2, allowance must be made for the effect on the axially-directed faces of the sealing ring 1, respectively the margin of the front face 6 around the land 7 and the face of the shoulder 13 around the end 14 of the sleeve. The differential area of these faces, the inherent resilience of the sleeve under installed axial compression and the contractile load of the spring 23 are all factors in the total balance of the seal.



CLAIMS

1. A face seal comprising a rigid sealing ring carried by a free end of a coaxial resiliently deformable sleeve having means at its other end for mounting the sleeve fluid-tight on one member so as to present the sealing ring to bear axially against a counterface on another, relatively rotatable, member, the resiliently deformable sleeve being a moulded elastomeric sleeve which is geometrically equivalent to an axially opposed pair of frusto-conical parts joined pivotally together at their larger diameter portions, the larger diameter portions of the frusto-conical parts of the sleeve forming a circumferential flexible junction with a circumferential groove in which is seated a garter spring, the smaller diameter rims forming respectively the free end of the sleeve to carry the sealing ring and the other end of the sleeve having the mounting means, and the sleeve forming a toggle system which, in use, is exposed to the pressure of the fluid to be sealed and exerts on the sealing ring an axial bearing load having a value dependent on the angles of conicity and the ratio of the diameters of the free end and mounting end of the sleeve.

2. A face seal according to claim 1, characterised thereby that the free end of the sleeve is stretched to pass on to, grip fast and seal around a shouldered back of the sealing ring.

3. A face seal according to claim 2, characterised thereby that the sleeve and sealing ring have inter-engaged projections and keyways positively to oppose relative rotation of the sealing ring in the sleeve.



4. A face seal according to claim 2 or 3, characterised thereby that a recess is provided in the angle of a shoulder at the back of the sealing ring and receives fully the free end of the sleeve to support the adjacent part of the sleeve in frusto-conical shape.

5. A face seal according to any foregoing claim, characterised thereby that the mounting means comprises an annular mounting cup on to the inner peripheral rim of which the respective end of the sleeve is moulded.

6. A face seal according to any foregoing claim, characterised thereby that a forward face of the sealing ring has an annular land to bear against a plane counter-face.

7. A face seal substantially as shown by Figs. 1 and 2 or 3 of the accompanying drawings and described with reference thereto.

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