ANNALS of Faculty Engineering Hunedoara – International Journal of Engineering
ISSN: 1584 - 2673

MODALITIES OF REDUCING THE LEAKAGE FLOW IN MECHANICAL SEALING

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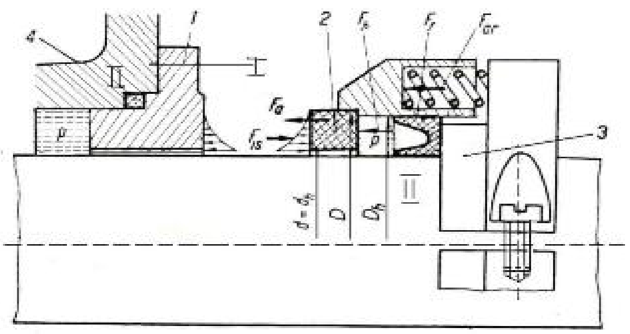
Abstract
The paper presents the connection between the contact pressure on the sliding ring, the size of the interstice and the pressure of the sealed fluid determined experimentally as well as the modalities of reducing the flow discharge.
Keywords
Leakage, unsealing, flow discharge

1. GENERAL CONSIDERATIONS

In the case of the mechanical seals, the sealing is obtained by a small interstice between two rings with front contact surfaces, which are in relative motion (figure 1).



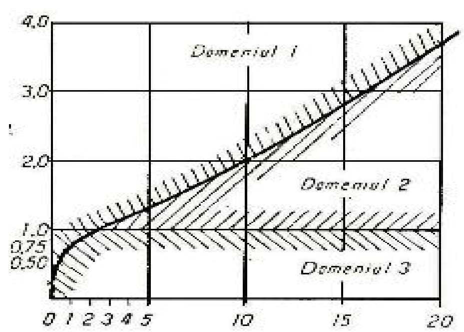


Figure 1

Figure 2

Experimentally it has been observed that there is a connection between the contact pressure on the sliding ring p_a, size of the interstice k and the pressure of the sealed fluid p (figure 2).

In the field noted 1 there is no pressure forming in the interstice $p_{is}\approx 0$ and $p^2_a=p_{ar}+k_p$. The interstice contains fluid that is leaking through the contact surface irregularities. There is a limit lubrication discharging rapidly to a dry friction that can lead to rapid wear.

Fluid losses marked Q are given with the help of the empirical equation:

$$Q=\pi d(p-p_e\pm p_z)60Sh^2/p^2_a \quad (1)$$

where:

- d - Entrance diameter of the fluid in the interstice
- p – The pressure of the sealed fluid
- p_e – external pressure
- p_z - pressure due to centrifugal force
- S – Interstice specific coefficient
- h – Interstice size
- p_a - axial contact pressing

It can be noted that the fluid loss through leakages is largely influenced by the size of the interstice and by the contact pressure.

Seals in this area are characterized by a stable operation, low pressure in the interstice and loss of fluid through minimal leakage. In the field noted 2 there is a pressure p_{is} in the interstice that can grow to the amount of fluid pressure p. The interstice is a friction joint with a low coefficient of friction. Loss of fluid can be calculated quite precisely with the equation noted 1. In the field noted 3, the seal has the most favorable conditions for friction in the interstice, but at the same time also the greatest loss through leakage. In the interstice it is established a laminar leakage; the losses by leakage of fluid can be calculated by the relationship:

$$Q = \pi(p-p_e \pm p_z)d_m * h^3/12\eta b \quad (2)$$

where: d_m - average diameter of the ring; η – dynamic viscosity of the fluid

2. LOSS OF FLUID THROUGH UNSEALING

2.1 Parameters that determine the loss of fluid

Mechanical sealing behavior is influenced by:

- relationship between the acting surface of the fluid and the frontal contact surface $k = A_h/A$;
- relative speed of sliding between the contact surfaces and the sealed fluid pressure
- the couple of materials of the two sliding rings in contact;
- the sealed medium, its lubrication and cooling properties, its chemical behavior, the content of impurities;
- the shape of the interstitial of the surfaces in contact, influenced by the nature of mechanical and thermal strains that appear during operation;
- roughness of the surfaces in contact their deviation from the geometrical shape;
- friction, vibrations, pressure shocks, continuous working or with stops, the ability of heat dissipation, lubrication direction in relation with the direction of the centrifugal forces;
- Temperature of the sealed medium and contact surfaces and their evolution in time.

2.2 Ways of reducing the flow discharge

The ratio of surfaces $h = A_h/A$ may range from positive, over unitary or sub unitary, or even negative.

The “loaded” seals situate in fields of operation 1 and 2 with minimum loss through the interstice.

In the unloaded constructions the pressing on contact surfaces is made by the spring force.

Experimental research [2] showed that pressure in the interstice is dependent on the ratio k and viscosity (figure 3). For joint studies with low viscosity (propane or butane), the seal must be designed with a value k = 0.7 in order not to lose contact between sealing surfaces r_e, while for water a value k=0.58÷0.6 is enough. For high viscosity mediums (oils) k = 0.3÷0.4. Normally, mechanical sealing show radial plane surfaces, with the great manufacturing advantage of simplicity.

p/p_1,A

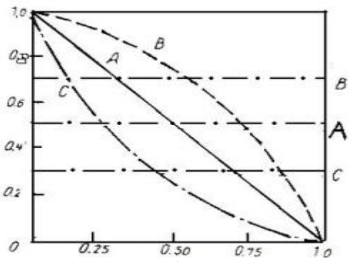


Figure 3

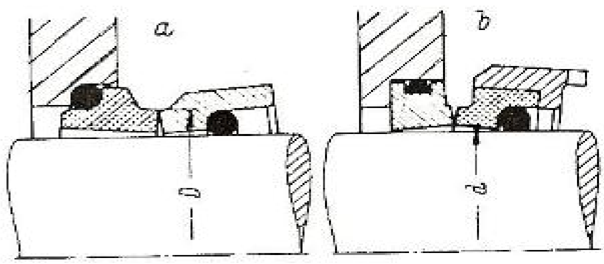
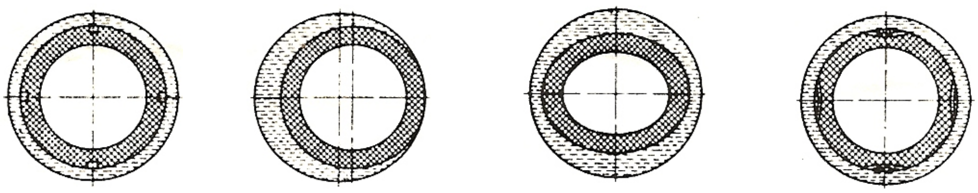


Figure 4

The configuration of the area may suffer modifications due to heat or wear, applied torsion moment, radial or axial forces; the rings deform and the interstice becomes convex, concave or tilted with peripheral contact, internal or external (figure 5). If the operating conditions remain constant, by choosing a suitable couple of materials in contact, wear can gradually restore the parallelism to the ring surfaces, if time and contact pressure is convenient. Besides geometry, the roughness of the rings surfaces in contact has a considerable influence on losses. If the roughness rises losses do to unsealing rise also. As in the friction-wear process appear strong heating in the area of contact thus leading to deformations of the interface, results that in heavy operating conditions in particular (pressures, high speeds) in order to reduce the flow out of sealing constructive measures are necessary to diminish wear.



a b c d

Figure 5

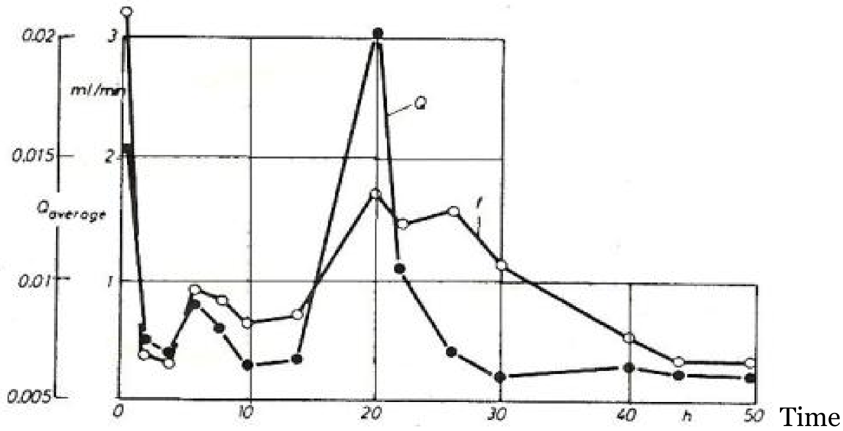


Figure 6

Figure 6 presents the construction of sealing surfaces in contact with frontal circular channels eccentric friction surfaces, elliptical rings, circular ring channels, with effect on the hydrodynamic lubricating film between sliding surfaces.

Figure 7 presents the interdependence between the flow loss Q and the coefficient of friction for a high pressure seal with frontal sealing surfaces with radial channel.

3. CONCLUSIONS

The geometry of a mechanical sealing interstice, its roughness, can be changed depending on working conditions. In turn they influence the force pressing the two rings, the pressure of the interstice, losses through leakage of the fluid and even the friction conditions.

Leak flow rate may thus rise even when constant operating conditions are present. In mechanical sealing the condition that the lubricant has no pressure in the interstice (see fig.2 in area X) is very important to ensure the stability of operation and minimum loses due to fluid leakage.

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