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HYDRODYNAMIC EFFECTS RESULTED FROM SOME GEOMETRIC FEATURES OF THE INTERFACE SURFACE OF FRONT SEALING.

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ABSTRACT : In the real case of using a frontal sealing the friction state is mixed, wet and dry and just in some particular cases is wet, when is more important to avoid friction than to avoid leakage. Mechanical and thermal overload are the factors that conduct to the increase of sliding forces of a frontal sealing. In order to ensure a better lubrication, is necessary that in the interface of the sealing, a lubricant film to born which will conduct to the maintain of hydrodynamic, hydrostatic and mixed lubrication.

1. INTRODUCTION

By processing of some channels on the sliding surface the required flow is obtained to create some hydrodynamic regions of high pressure and good lubrication. In figure 1 there are presented some of these solutions.

The radial ring solution (fig. 1), have high performances by decreasing of friction and wear. The hydrodynamic effect is also stimulated by some thermal deformations which are born due to the non uniform cooling, the waviness also helping the appearance of fluid edges. The channels are processed in the ring with higher hardness and the behavior of of the sealing is depending on the rate of c/b. If this ratio is too small, than the lubrication is insufficient and if the ratio is too high the leakage are growing. A ratio of:

$$C = 0{,}4\ kb \qquad (1)$$

is recommended in order to have a good lubrication.

Another objectives is that the impurities not to penetrate in the interface and for that is recommended that the processing to be made:

- on the fixed ring for p1 interior;
- on the rotating ring for p1 exterior.

The thermo-hydrodynamic rings, with channels with circular arc form (fig. 1, a, h – for p1 exterior, j – for p1 interior). These has a good efficiency due to:

- a good cooling;

- repeal of impurities;
- independence of rotation direction.

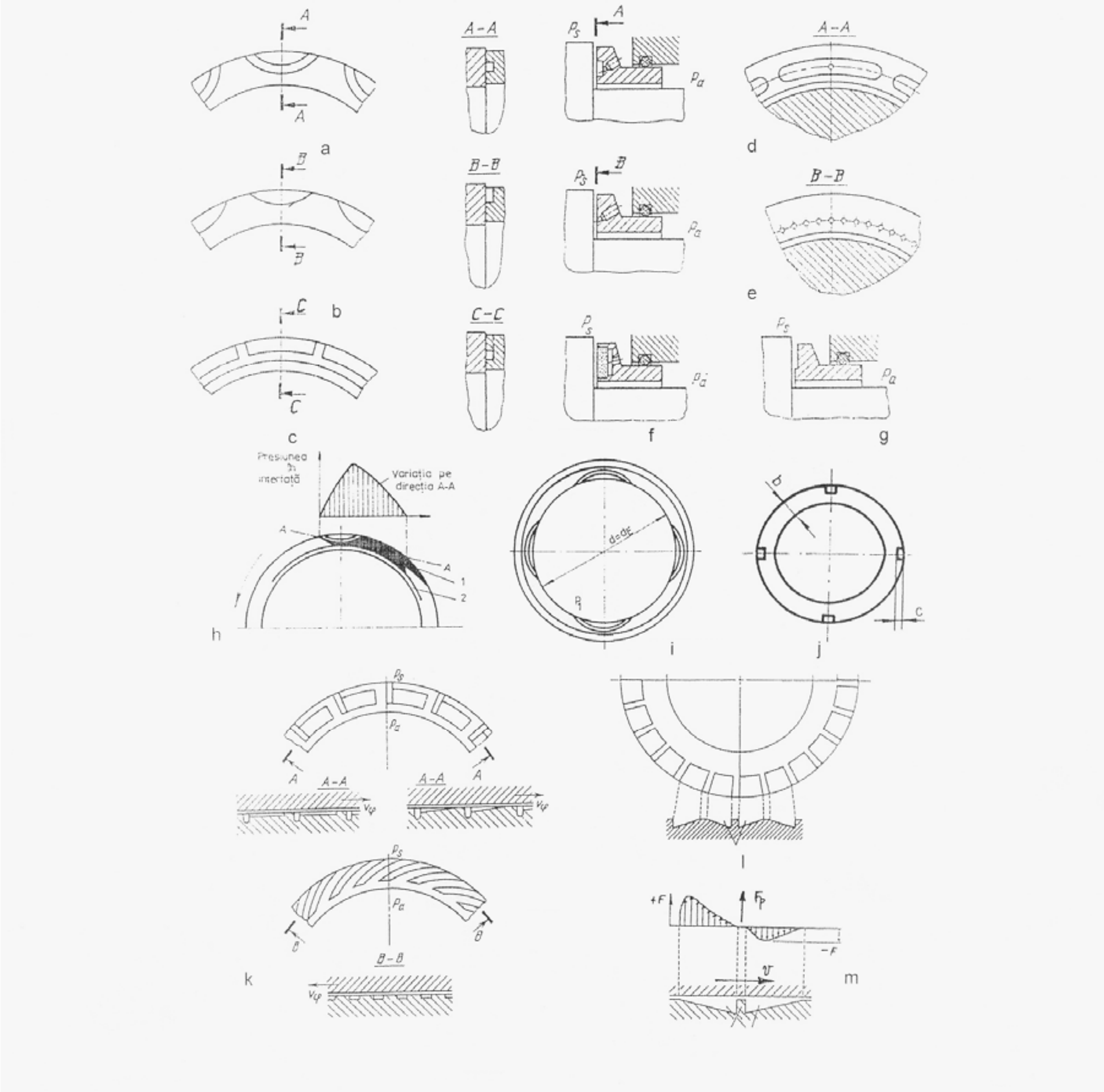

Fig. 1 – Hydrodynamic effects by surface geometry modifications.

These sealing are working in a thermo-hydrostatical regime due to the temperature differences: the region of channels has a better cooling than the other regions. The differences in dilatation modifies the initially plane surface realizing good lubrication. In which a horn of hydrodynamic pressure in the interface region presents a variation like in figure 1, h (1- support zone, 2 – sealing zone).

The dimensioning according to relation (1) the number and the step of the channels having importance.

This solution had allowed reaching of pressures p_1 = 250 barr and p_1v = 5000 barr m/s.

In figure 1 is presented the variation of some characteristic parameters (f – friction coefficient, q – leakage flow, U – wear) as a function of pressure for this type of sealing.

Spiral channel ring (fig. 1 k/B) are used at gases sealing. The interface of the rotating ring has a support zone on which spiral (logarithmic) channels are processed and an interior zone of the sealing stop. The spirals are moving the gas and by compressing pushes it through the stop obtaining a lubricant gas film. The gas leakage helps the interface cooling. The sealing is working dry, and there is no need for liquids to lubricate or to cool. Another solutions are: figure 1, c, circular channel with radial guides, figure 1,d,e, the technological fluid enters the interface holes realizing an HD and HS respectively a GD+GS effect. A similar effect by processing steps on the interface (figure 1, g), at figure 1, f, in interface is put a porous material in which enters the lubricating liquid. Figure 1,k/A, presents a solution of sliding face manufactured in steps o the circumference and figure 1, l, with double slope steps.

2. COMPUTING GEOMETRIC PARAMETERS OF THE CHANNELS.

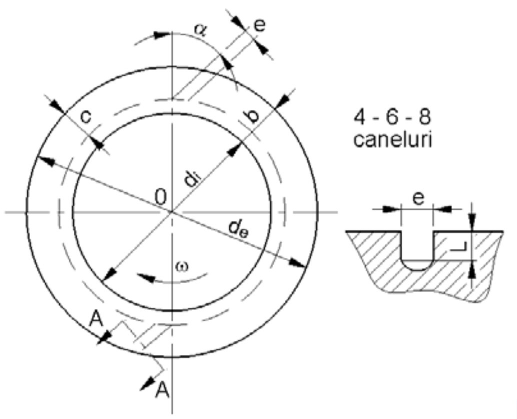

Fig. 2. Geometry of the channel, upper view.

The study of hydrodynamic and hydrostatic phenomena in their majority can be made using an adequate coordinate system.

In order to compute geometric parameters of the channels (figure 2) a rectangular coordinate system is considered with the origin on the symmetry axis of the shaft (figure 2.1. and 2.2.). The point A_1 will be denoted O_1, the axis O_1X_1 is considered collinear with the segment AB, and the axis O_1Y_1 collinear with the segment *AD*. Axis O_1Z_1 will be parallel with axis *OZ* so the coordinate system will be rectangular if the angle δ formed by the segments *AB* and *AD* will be 90.

In order to establish the geometric parameters of the studied channels we can consider the followings:

- the working fluid is Newtonian and continuous;
- the cross section of the channel is rectangular;
- the fluid properties are constant;
- the interface surfaces are maintaining their distance;
- the flow is linear.

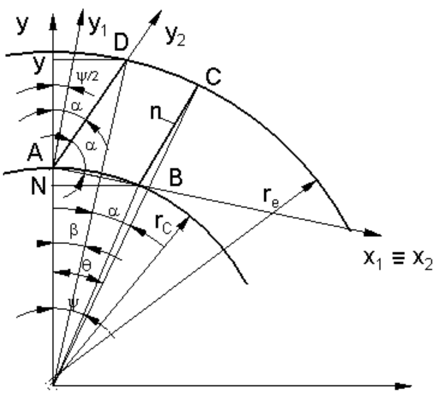

Fig. 2.1

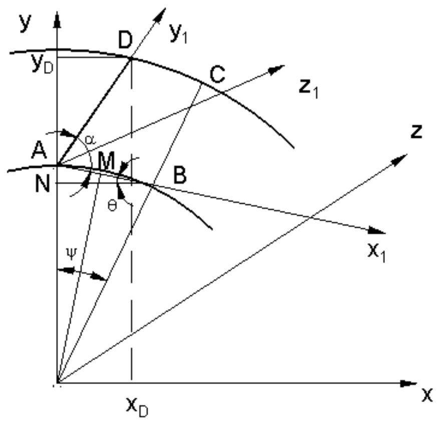

Fig. 2.2

The surface of the channel in which the fluid will flow is defined by the rectangle ABCD.

The *AB* = *e* [mm] dimension is known, also the angle *α* [˚] of the channelin accordance to *Oy*, axis, the exterior radius r_e [mm], interior radius r_i [mm] and the radius of the channel r_c [mm] are also known.

In the *OAB* triangle, applying the cosine theorem we obtain:

$$\cos\Psi = \frac{2r_c^2 - e^2}{2r_c^2} = 1 - \frac{e^2}{2r_c^2} \tag{2}$$

from which:

$$\Psi = \arccos\left(1 - \frac{e^2}{2r_c^2}\right) \tag{3}$$

$$\sin\Psi = \sqrt{1-\cos^2\psi} = \frac{e}{r_c}\cdot\frac{1}{2} \tag{4}$$

In the *AOD* triangle also by the cosine theorem we obtain:

$$\cos(180-\alpha)=\frac{AO^2+AD^2-OD^2}{2\cdot AO\cdot AD}=\frac{r_c^2+m^2-r_e^2}{2\cdot r_c\cdot m} \tag{5}$$

and similar :

$$m^2-2r_c\cdot m\cdot\cos(180-\alpha)+r_c^2-r_e^2=0 \tag{6}$$

where :

$$m=|BC|$$

Equation (6) is a second order equation and will have two roots. Because the parameter *M*, represents a length this can have only positive value and so :

$$\Delta=4r_c^2\cdot\cos^2(180-\alpha)-4r_c^2+4r_e^2 \tag{7}$$

$$\cos(180-\alpha)=-\cos(\alpha) \tag{8}$$

and the solution of this equation will be :

$$m=\frac{-2r_c\cos\alpha+2\sqrt{r_c^2\cos^2\alpha-r_c^2+r_e^2}}{2} \tag{9}$$

simplifying :

$$m=-r_c\cos\alpha+\sqrt{r_e^2-r_c^2\sin^2\alpha} \tag{10}$$

In figure 2.2, because:

$$\left.\begin{array}{l} AB\perp OM \\ BN\perp AO \end{array}\right\}\Rightarrow\varphi=\frac{\psi}{2} \tag{11}$$

The depth of the channel can be determined from the equation of the circle with the diameter A_1A_2 (fig. 3):

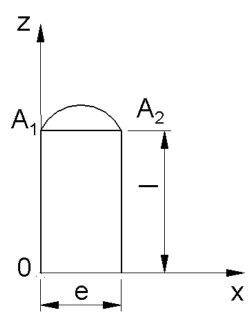

Fig. 3. Geometry of the channel, cross section.

The equation of the circle of diameter A_1A_2 will be:

$$(x-x_{A_1})(x-x_{A_2})+(z-z_{A_1})(z-z_{A_2})=0 \tag{12}$$

$$x_{A_1} = 0 \qquad z_{A_1} = l$$
$$x_{A_2} = e \qquad z_{A_2} = l \tag{13}$$

so we will have:

$$(x-0)(x-e)+(z-l)(z-l)=0 \tag{14}$$

from where:

$$z^2 - 2zl + \left(x^2 - e^2 - ex\right) = 0 \tag{15}$$

$$\Delta' = l^2 - x^2 - l^2 + ex = x(e-x) \tag{16}$$

$$z_{1,2} = l \pm \sqrt{x(e-x)} \tag{17}$$

But because we need the positive dimension :

$$z = l + \sqrt{x(e-x)} \tag{18}$$

3. CONCLUSIONS

The lubrication made by this type of interface of the front sealing is due to the channels with different forms and dimensions, which allow the fluid to enter the interstice between the to rings of the sealing. From technological point of view the channels can be manufactured using different procedures, corresponding to the complexity of the channels shape. If the complexity is high so will be the cost of manufacturing.

The presented channel shape is simple and can be obtained by milling process which is much lower than electro-erosion which is needed at complex shapes.

REFERENCES

1. Mayer. E., Leakage and Friction of Mechanical Seals Witch Special Consideration of Hydrodinamic M.S.Int. Conf. of Sealing England
2. Netzel. J., Hight Performance Gas Compressor Seals. 11-th Internat. Conf. of Fl. Sealing 1987
3. Brink V. H., Handbook of Fluid MacGrow-Hill, Inc., Newyorc 1993
4. Buido; T., Echipamente şi Tehnologii pentru Prelucrări Neconvenţionale. Ed. Universitatea din Oradea 2006
5. Balekics M., Tribologie. Universitatea Tehnică Timişoara 1998