JOURNAL OF ENGINEERING
annals OF
FACULTY OF ENGINEERING HUNEDOARA

ESTIMATION OF GAP LEAKAGES OF VALVE PLATES IN ROTARY PISTON HYDROMACHINERY

Krasimir TUJAROV

University of Ruse, BULGARIA

ABSTRACT:
Basic problems of the hydrostatic machinery are estimation of leakages trough seals or bearings clearances. The authors submit method and results for determination the value of leakages through valve plate of multistroke hydrostatic motor.
KEYWORDS:
Leakage, valve plate

1. INTRODUCTION

The sufficient volume of working fluid is a necessary prerequisite for the overall machinery efficiency [3, 4] and hydrostatic equilibrium of moving parts and of liquid layer carrying capacity of friction pairs. The volumetric efficiency - characterizing the specific value of liquid leakages through friction pairs - is an important design parameter of pumps and hydro machinery. Estimation of leakages in context is certainly of keen interest and could be carried out for two-dimensional flow for given pressure field calculated by the Reynolds equation (the Laplace equation in particular).

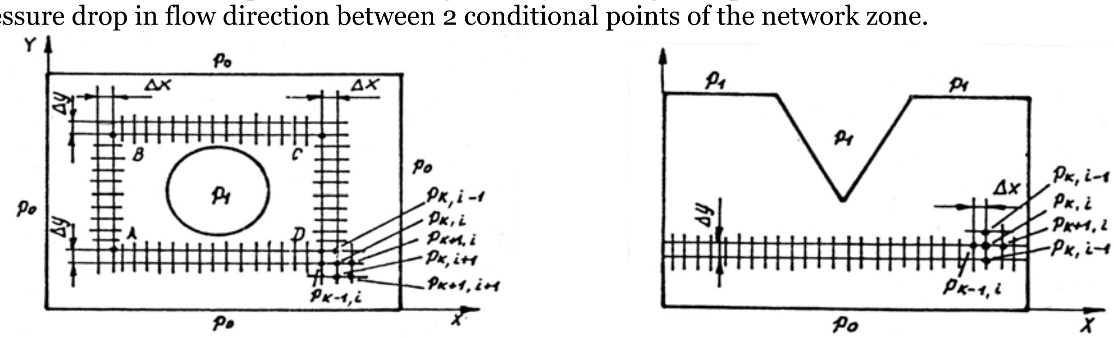
2. METHOD FOR ESTIMATION OF LEAKAGES THROUGH FRONT AND RADIAL GAPS [2].

A part of the calculated surface exited by a liquid (a zone of high pressure) is separated from the inlet surface (a zone of low pressure) by means of a conditional perimeter. For such a perimeter a closed regtangle or polygon may be used provided the outflow from zone with pressure p_1 into zone with pressure p_0 takes place in various directions (Fig. 1a). In case of outflow in specific direction (Fig 1b) a direct or dotted lines may be used. The leakage perimeter consists of "m" or "n" elementary rectangular sites of area ΔxΔy. The gap flow of most volumetric hydraulic machines is of laminar nature (Re < 100); hence the Poiseuile formula calculates the leakage through each elementary rectangle.

The most common case represents the calculation procedure of leakages through a wedge-shaped gap for varying liquid viscosity. The input data file takes the values of h_{jk} and μ_{ik} and these are calculated or assigned in advance. The leakage flow rate has the form:

$$Q = \frac{L}{12l}\sum_{i=1}^{m}\frac{h_i^{3}\Delta p_i}{\mu_i m} \tag{1}$$

where l is the value of perimeter (in Fig. 1, l=Δy); L-length of perimeter (L=AB+BC+CD+AD); Δp_i-pressure drop in flow direction between 2 conditional points of the network zone.



a b

FIGURE 1.

The described method is used for calculation of leakages through the pressure window of a valve plate of axial piston pumps and hydraulic motors with wedge-shaped gaps.

The leakage through the whole perimeter (Fig. 1) for constant values of gap h and viscosity \i is calculated according to the formula:

$$Q = \frac{L}{12l}\sum_{i=1}^{m}\frac{\Delta p_i}{m} \tag{2}$$

3. EXPOSITION

The presented article considers the case of a valve plate (Fig. 2) for 6-run (m=6) 8-cylinder (z=8) hydraulic machine functioning at constant pressure p = 10, 20, and 30 MPa, p = 0 MPa, p = 0 Mpa, sliding velocity V = 3 m/s at n = 60 RPM, constant thickness of oil layer h= 5,10, 20, 30, 40 and 50 mm, oil temperature t = 10, 20, 30, 40, 50, 60 and 70 °C. The theoretical flow rate of the hydraulic machine is 60 dm^3/min. Fig. 3 presents the sector 1 of the value plate from Fig. 2 with the isobaric and liquid flow lines for one of the 16-th positions of the counter-disk in relation to the distribution disk; the position has been determined through a TERMO program PC calculation. Such a pressure field in numerical form is a starting point for leakage determination [1]. The leakage perimeter in the shape of two concentric polygons has been singled out in a way for the high pressure (p_i) window of the calculated surface to be situated in the interior of the zone. The PC calculation according to formula (2) gives results for the values of the pressure window leakages for sector 1 of valve plate for h = 5 μm, t = 40 °C as a function of the counter-disk rotation angle in relation to the angle plate.

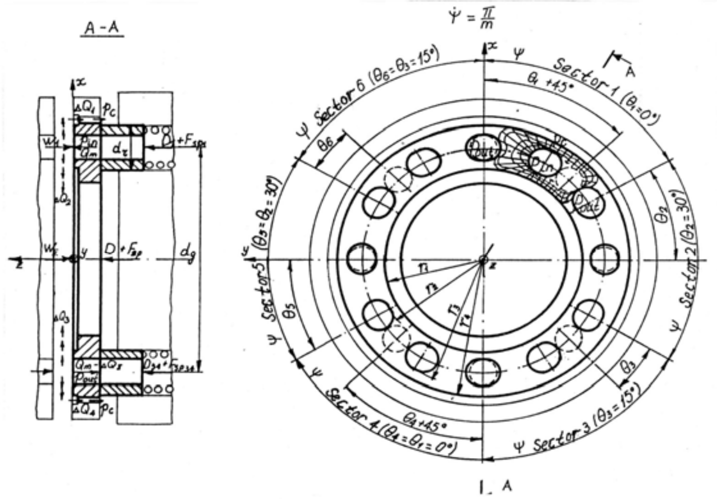


FIGURE 2.

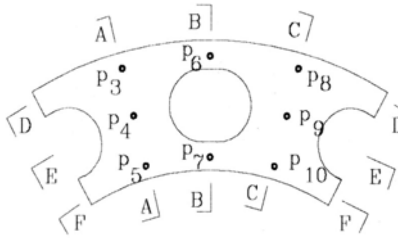


FIGURE 3.

The calculation results are graphically represented in Fig. 4. The symmetry of the directional control valve brings the conclusion for equivalence, respectively, between: flow of sector 4 and flow in sector 1, flow of sector 2 and flow in sector 5, and flow of sector 3 and flow in sector 6. Taking into account the phase angle of specific placement of the counter-disk openings in relation to the distribution disk in Fig. 2 for the various sectors being, respectively, $\theta_1=\theta_4=0°$, $\theta_2=\theta_5=30°$, $\theta_3=\theta_6=15°$ the formula for the total leakage through the gap between the disks can be worked out:

$$Q = 2\left[Q_1(\Theta)+Q_1(\Theta+30)+Q_1(\Theta+15)\right],\ \text{mm}^3/\text{s} \tag{3}$$

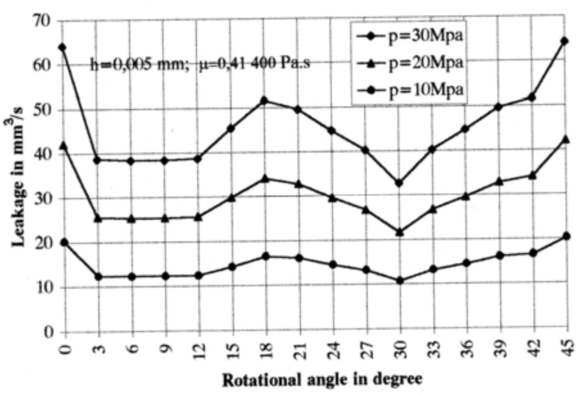


FIGURE 4. Leakage trough a sector in dependent of rotational angle

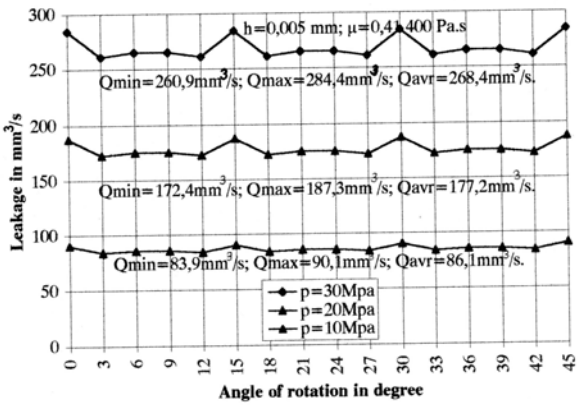


FIGURE 5. Leakage trough valve plate

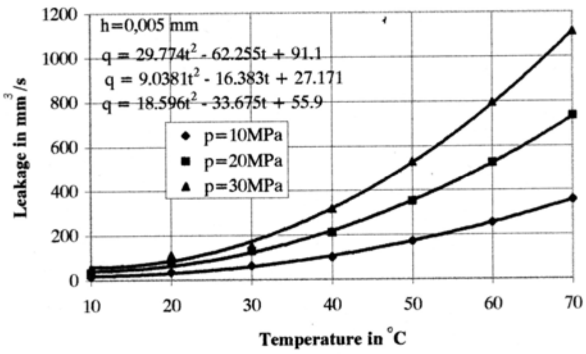


FIGURE 6. Dependence of the valve's plate leakage on the gap

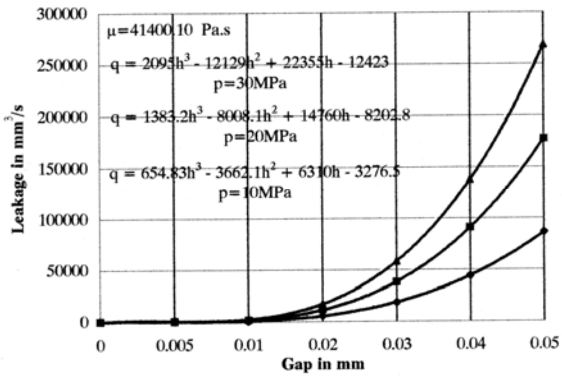


FIGURE 7. Dependence of the valve's plate leakage on the oil temperature

The calculation results are graphically presented in Fig. 5. It is clear that the leakage through the valve plate gap takes values at an interval θ = 15°. The maximum value is Q_{max} = 284,4 mm³/s, the amplitude is ΔQ=23,5 mm³/s , the mean value Q_{avr}=268,4 mm³/s at p - 30 Mpa; Q_{max} =187,3 mm³/s, the amplitude is ΔQ=14,9 mm³/s , the mean value Q_{avr}= 177,2 mm³/s at p = 20 Mpa; Q_{max} = 90,1 mm³/s, the amplitude is ΔQ=6.2 mm³/s , the mean value Q_{avr}==86,l mm³/s at p = 10 Mpa. It is to be seen that for all pressures the amplitude ΔQ is ten times smaller than the mean value Q_{avr}. Hence, the leakage can be taken to be constant. The influence of leakage through distributor on the volumetric efficiency can be determined by means of the graph taking into account the value of the theoretical flow rate.

4. CONCLUSION

When calculating the leakage the thickness and shape of liquid layer (film) should be taken a starting data, both depending on working fluid nature and interaction specificity of sliding pairs. Thus, the influence of the gap on the leakage value should be estimated taking into account the viscosity (respectively, oil temperature) and similarly, the way the gap affects the temperature. These relations are built by means of equation (2) and data from Fig. 5; the results are graphically and analytically represented in Fig. 6 and Fig. 7, respectively. Fig. 7 shows that gaps < 0,01 mm affect the leakage value insignificantly, but bigger gaps have a sharp rise of influence. A comparison between Fig. 7 and Fig. 6 shows that the influence of viscosity on leakages in wide range of temperatures is quite insignificant and is kept in the range of influence of gap up to 0,01 mm.

BIBLIOGRAPHY

[1] G. Gujgulov, A. Jotova, Tujarov K. Determination of separation on force of valve plate for multystroke hydraulic motor. Proceeding from the international scientific conference, Nitra, 1994.
[2] R. M. Pasinkov. Computing of pressure distribution and leakages trough seal gaps. Moskow, "Newspaper machinbuilding", 5, 1970.
[3] Beloev Hr., N. Stancheva, N. Nikolov, D. Stanchev. Some results of experimental investigation of computer system for energy effectiveness of mobile machines. INMATEH 2008-III, Internationale symposium "Engineering and management of sustainable development in agriculture, transport and food industry", p. 51-55, Bucharest, 2008.
[4] Beloev Hr. Computer system analysis for enegy efficiecy control of agricultural and mobile transport machines. Acta technologica agriculturae-The scientific journal for agricultural engineering, volume 11, number 2, ISSN 1335-2555, Nitra, Slovakia, 2009.