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FUNCTION OF THE SERVICEABILITY OF CONTACTING SEAL OF HYDROPNEUMATIC CYLINDER

Summary. For the evaluation of serviceability of reciprocating motion contacting seal, that operates by friction of boundary lubrication, the calculating model on the basis of the empirical data about the hydraulic leakage in form of the function of equivalent number of loading cycles is proposed.

Keywords: hydraulic leakage, serviceability, motion

For estimation of the remaining resource and probability of no-failure operation of sealing elements (Fig. 1) it is necessary and enough to conduct the analysis of the empirical curve of wear and its mathematical approximation, thus define the temporary features of the full curve wear, as factor of limiting values of the fixed resource.

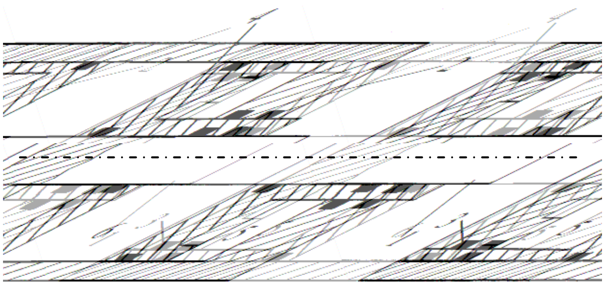

Fig. 1. Scheme hydraulic – pneumatic cylinder: 1 – rods with the piston, 2 – cylinder, 3 – sealing elements, 4 – booster, 5 – volume of the booster with liquid, 6 – volumes of the cylinder filled by gas

The defining factor of the sealing element wear (without measurement of geometries), under indirect evaluation of their condition, take the consumption of liquid in the

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booster $G(N)$ from value of the pressure, warm-up factors, change of thermal physics parameters of liquids and the other arguments [3]. By means of results measurement of the consumption of liquids the curve (Fig. 2), was created of the integral valuing the influence of all argument on sought function $G(N)$. The approximation is possible to conduct with the method of chosen points.

To get the deterministic curve of wear it is possible to divide into three stages: run-in (the stage 1), formed wear (2) and disastrous wear (3) (fig. 2), each of which approximate its equation:

– for the first stage:

$$G(N) = h_1\left(1 - e^{-\mu_1 N^{\alpha_1}}\right) \text{ under } 0 < \alpha_1 \le 1; \tag{1}$$

– for the second stage:

$$G(N) = \alpha_2 N + B \text{ under } \alpha_2 = \text{const}, B = h_1; \tag{2}$$

– for third stage:

$$G(N) = h_3\left(1 - e^{-\mu_3 N^{\alpha_3}}\right) \text{ under } \alpha_3 > 1, \tag{3}$$

where:

$G(N)$ – function of the consumption of liquid from the cycles number N of loading;
α_1, α_2, α_3, μ_1, μ_3 – variable parameters of functions of the consumption of liquid;
h_1, h_3 – coordinates of the completion of the corresponding stages.

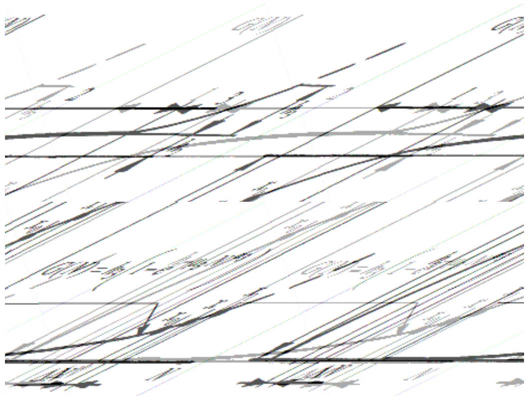

Fig. 2. Functions of the consumption of liquid in stages: run-in (1); the normal usage (2) and disastrous wear (3)

Thus as $h_1+h_3 \gg h_2$ for the whole curve the equation can be presented in the form

$$G(N) = h_1\left[1 - \exp\left(-\mu_1 N^{\alpha_1}\right)\right] + h_3\left[1 - \exp\left(-\mu_3 N^{\alpha_3}\right)\right] \tag{4}$$

From equation (1) the value μ_1 is found

$$\mu_1 = -\frac{\ln\left(1 - \frac{G(N)}{h_1}\right)}{N^{\alpha_1}} \tag{5}$$

As a result of differentiation the equation (1) with respect to N and having substituted in it μ_1 is determined parameter α_1 is determined in the form

$$\alpha_1 = -\frac{\frac{dG(N)}{dN}}{\left(h_1 - G(N)\right)\cdot \ln\left(1 - \frac{G(N)}{h_1}\right)} \tag{6}$$

For reception h_1 the equation (1) is transformed and is definitively received

$$h_1 = G(N) + \frac{\left(\frac{dG(N)}{dN}\right)^2}{\frac{d^2G(N)}{dN^2} + \frac{\frac{dG(N)}{dN}}{N}} \tag{7}$$

Similarly from equation (3) the values h_3, μ_3, α_3 are found

$$h_3 = G(N) - h_1 - \frac{\left(\frac{dG(N)}{dN}\right)^2}{\frac{d^2G(N)}{dN^2} + \frac{\frac{dG(N)}{dN}}{N}}; \tag{8}$$

$$\alpha_3 = -\frac{\dfrac{dG(N)}{dN}}{\left(h_1 + h_3 - G(N)\right)\cdot \ln\left(1 - \dfrac{G(N) - h_1}{h_3}\right)}; \tag{9}$$

$$\mu_3 = -\ln\left(1 - \frac{G(N) - h_1}{h_3}\right) / N^{\alpha_3} \tag{10}$$

For analysis of the function of the consumption of liquid $G(N)$, it is accepted that the most weighty argument is cycles number N [3]. Herewith, the first and the second derived $\dfrac{dG(N)}{dN}$, $\dfrac{d^2G(N)}{dN^2}$ are indirect factors of the consumption of liquid on chosen three points x_0, x, x_1 with the same value ΔN on the curve for stage 1 and 3 (see Fig. 2).

Thereby, algorithm is designed for analysis of the remaining resource and serviceability of sealing elements on indirect experimental measurements of the consumption of liquid of the boosters. Particularly important is the checking of the cycles number, change of the temperature, thermo–physical parameters of liquid and material of the seal appears the possibility of the direct influence on function reliability of hydropneumatic cylinders. The value of the consumption of liquid is an integral factor, which is realistic if in the process of exploitation the measurements of the characteristic are executed

$$g(N) = \int_0^{N_\Sigma} \left(\frac{dG(N)}{dN}\right) dN / N_\Sigma \tag{11}$$

where:

$g(N)$ – specific consumption of liquid for period of the N_Σ cycles.

On the basis of cyclic characteristic it is possible to define the coordinates of the stage of the completion of the run-in, terminations of the stage of normal usage and starts of the disastrous wear.

The variability of loading mode of hydropneumatic cylinder, long breaks in exploitation and others it is possible to take into account the way of the determination of the equivalent cycles number of the load

$$N_E = k_{EN} \cdot N_\Sigma, \tag{12}$$

where:

k_{EN} – factor of equivalence of the cycles, equal initial moment the k order of the spectrum of the relative loads of the standard mode of exploitation [4].

Scientifically motivated and reliable decisions of the considered questions in the process of the usages of the concrete product allow:

- integrally to value the beginning or termination of the certain stage of seal wear;
- validly install nominal or lightened (for a period of run-in) mode to usages and choice corresponding antifriction additives;
- forecast the remaining resource of the sealings and periods of the undertaking the planned technical maintenance, including refilling by liquid, gas and change sealing elements.

REFERENCES

1. **Syforov A. I.,** 2001: Issledovanye processov vliyayushchikh na nadyodjnost' i rabotospos bnost' hydropnyevmocylyndra. Viestnik HGTU
2. **Parfyenyuk I. P.,** 1988: Eksperymentalnye issliedovanya pierietiechek gaza v porshnievykh kontaktnykh uplotnienyakh. Khimicheskye i niephtyanoye mashinostroyenie. №11.
3. **Syrycyn T.A.,** 1981: Nadiodjnost' hydro- i pnievmoprivodov. Moskva Mashinostroyenie
4. **Reshetov D. N., Ivanov A.S., Phadieyev W.W.,** 1988: Nadiedjnost' mashin. Moskva: Vyssha Shkola

Recenzent: prof. dr hab. Eugeniusz Krasowski

1. **Сифоров А.И**., 2001: Исследование процессов, влияющих на надёжность и работоспособность гидропневмоцилиндра. Вестник ХГТУ: Изд. ХГТУ.
   Syforov A. I., 2001: Issledovanye processov vliyayushchikh na nadyodjnost' i rabotosposobnost' hydropnyevmocylyndra. Viestnik HGTU
2. **Парфенюк И.П.,** 1988: Экспериментальные исследования перетечек газа в поршневых контактных уплотнениях. Химическое и нефтяное машиностроение. №11.
   Parfyenyuk I. P., 1988: Eksperymentalnye issliedovanya pierietiechek gaza v porshnievykh kontaktnykh uplotnienyakh. Khimicheskye i niephtyanoye mashinostroyenie. №11.
3. **Сырицин Т.А.,** 1981: Надёжность гидро- и пневмоприводов. Москва: Машиностроение.
   Syrycyn T.A., 1981: Nadiodjnost' hydro- i pnievmoprivodov. Moskva Mashinostroyenie
4. **Решетов Д.Н., Иванов А.С., Фадеев В.В.,** 1988: Надёжность машин. Москва: Высш. шк.
   Reshetov D. N., Ivanov A.S., Phadieyev W.W., 1988: Nadiedjnost' mashin. Moskva: Vyssha Shkola