4.2.34. TURBOMOLECULAR PUMP (TMP) NON-DESTRUCTIVE FAILURE PREDICTING SYSTEM

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It was found that small axial load, e.g. the weight of the TMP shaft, results in squeezing of the balls between races and in the displacement of the balls from their normal equally-spaced positions along the race. This leads to substantially increasing of the force between the balls and the spacer and to increasing of wear rate also as to the vibration of the rotating ball bearing increasing.

The system uses a method of the rotor shaft torque determination, which depends on current strength in electric drive. The another advantage is the friction work determination, which is being spend on the spacer of the balls.. If we know the electrical power being used by the TMP at any time we can to detect the friction work A:

$$A = \int_0^t (W - W_{\min})\, dt,$$

where W – electrical power used by the TMP while the spacer is squeezed; $W_{\min}$ – normal electrical power used by TMP drive while spacer isn't squeezed; t – time interval during the spacer squeezing by the balls.

The wear of the spacer is being estimated by the amplitude of the vibration variation on a specific frequency corresponding to the frequency of a ball with the spacer contacting [1]. The interaction between balls and the spacer has a stochastic nature, while the resistance torque is exponentially distributed [2]. The energy power of this interaction is supposed to be used in the diagnosing system. The calculation shows that the maximal power of TMP type 1500 004 with two ball bearings is equal to 470 W, while the mean resistance power is 50 W. The resistance torque varieties from 0.023 N.m to 0.19 N.m that results in varying of the rotation speed from 2.23×10^4 to 2.1×10^4 rpm.

So, the instant power of TMP may be used for the contacting frequency between the ball and the spacer estimation as well as for the wear degree determination. The described TMP diagnosing system allows also excluding the emergency failure of TMP. Let us consider the main advantages of the created diagnosing system:

– putting the emergency repairs of the TMP into planned ones allows to exclude time of the emergency repair ($Qa = 4 – 20$ hours), and to replace it by planned repair ($Qn = 0{,}5 – 2$ hourrs), also as to enlarge a longevity of the TMP 1-2 orders higher. The TMP longevity increases from gamma percent longevity resource ($T\gamma$) into average longevity (Ta), which can be 1–2 orders higher;

– the described method creates the possibility to mark out the power, which was spent on wear of the ball bearing (wear of the spacer) from the total electric power, which was used by electromotor of the pump.

In the result we have the possibility to watch the rapidity of the wear of the ball bearing and to estimate the factors that have a negative influence upon condition of the ball bearing wear and upon the pump condition as a whole.

References:

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