DETECTION OF ERRORS IN THE VIBRATION DIAGNOSTICS OF PUMP UNITS

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Annotation. Timely resolution of problems arising from the use of pumping units is impossible without supervisory and analytical work. A modern and perfect way of detecting pumps that are not working properly in the units is diagnosing. The article gives the results of the work done on the development of a diagnostic system for pumping units at pumping stations. The use of the proposed diagnostic system leads to a reduction in costs when using pumping units and the costs of their maintenance. This article provides a mathematical model and analytical calculations to determine the amount of vibration that occurs in pump units.

Keywords: vibration diagnostics; accelerometer; equipment; signal; vibration accelerations; vibration speed; mathematical model; pump; diagnostics; reliability; device; probability of failure-free operation; spectrogram; vibrations.

НАСОС АГРЕГАТЛАРИ ВИБРОДИАГНОСТИКАСИНИНГ ХАТОЛИКЛАРИНИ АНИҚЛАШ

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Аннотация. Назорат ва таҳлил ишларини олиб бормасдан туриб насос агрегатларидан фойдаланиш даврида келиб чиқадиган ҳар хил муоммоларни ечиб бўлмайди. Насос агрегатларида содир бўладиган асосий бузилишларни аниқлашнинг замонавий ва мукаммал усули бу, уларни диагностика қилиш ҳисобланади. Мақола насос станцияларидаги насос агрегатларини диагностика қилиш тизимини ишлаб чиқишга қаратилган. Таклиф этилаётган диагностика қилиш тизимидан фойдаланиш натижасида насос агрегатларидан фойдаланиш кўрсаткичларининг ошишга ва таъмирлашга сарф қилинган ҳаражатларни камайтиришга эришилади.

Калит сўзлар: вибродиагностика; акселерометр; қурилма; сигнал; вибротезланиш; титраш тезлиги; математик модел; насос; диагностика; ишончлилик; ускуна; ишламай қолишлик эҳтимоли; спектрограмма; титраш.

ВЫЯВЛЕНИЕ ПОГРЕШНОСТИ ВИБРОДИАГНОСТИКИ НАСОСНЫХ АГРЕГАТОВ

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Аннотация. Своевременное решение проблем, возникающих при использовании насосных агрегатов невозможно без проведения надзорных и аналитических работ. Современным и совершенным способом обнаружения недосдатков в работе агрегатов насосов является диагностирование. В статье приведены результаты работ разработке диагностической системы насосных агрегатов на насосных станциях. Внедрене по предлагаемой диагностической системы приведёт к снижению затрат при эксплуатации насосных агрегатов и расходов на их техническое обслуживание. В данной статье представлена математическая модель и аналитические расчеты для определения величины вибрации, возникающей в насосных агрегатах.

Ключевые слова: вибродиагностика; акселерометр; оборудование; сигнал; виброускорения; скорость вибрации; математическая модель; насос; диагностика; надежность; устройство; вероятность безотказной работы; спектрограмма; вибрации.

Introduction. Currently, in our country, using water lifting machines, more than 50% of arable land is irrigated. The system of water supply to the water users depends on the technical condition of the pump units used, various technical and technological measures are applied to ensure their reliable operation. Theoretical research and analysis, taking into account the specificity of pump units, carrying out research work on the development and use of modern diagnostic equipment, is one of the most pressing issues of our day [1].

Delivery of energy carriers to domestic and foreign consumers is directly related to the reliability of main pipelines, pumping and compressor equipment. An important role in the complex of measures that ensure the stable and reliable operation of this equipment is played by work related to monitoring its technical condition but various operational parameters. Currently, to solve the problem of assessing the technical condition of rotary equipment and, in particular, centrifugal pumping units, vibration of its bearing assemblies is considered as the main parameter.

Methods. Analysis of the use of hydro mechanical equipment in the lifting machine system has shown that one of the main causes of their failure is vibration, it is important to identify and analyze it. Determination of vibrations in pump units, which are part of hydro-mechanical equipment, measurements have been made to study their current state, it can be achieved in the future. As a result of the introduction of pumping system diagnostics, along with the reasons for the disruptions in the operation. They will be identified without technical damage, and a database on how long they can be used without interruption will be generated [2].

The pump unit is a complex system, in the process of changing their status over time, such indicators should be selected, be able to assess the actual state of the system as a result of determining these parameters. This task is performed during the pump unit operation and during the first phase of use, its indicators are maintained or changed insignificantly. This is achieved during this period as parts of the pump unit provide consistent performance. Investigating changes between interconnected elements in the system and the correct formulation of the diagnostic matter is required to determine the extent to which they can play a key role [3].

As a result of the analysis of the pump unit operation, it was found that the interconnection between its parts can be divided into a three-tier system. The first stage is a pump unit that contains energy and mechanical components, it consists of a pump unit and an electric motor. In turn, the pump unit and the electric motor are the second step, its elements consist of details and parts and interconnections between them. The links between these parts are of the type of mechanical bonding and are part of the kinematic pair. Since their movement has one or more degrees of freedom, it is regarded as a system consisting of separate parts, which may be included in the movement of common mechanical systems.

This means that each element that forms them has a different dimension than the stationary coordinate system. These indicators are qualitative characteristics of mechanical bonding, the structure of the structure (distance between the axis and axis, bending, etc.). The third stage of the system consists of separate details that are part of the second phase, characterized by their molecular composition. Changes in their content lead to changes in the design of materials. Such cases include cracks, cracks, corrosion andcausing damage due to erosion effects [4].

Usually, accelerometer vibrations are recorded at certain points on the machine, and vibrations are recorded. This signal is converted into vibrations or vibrations by integrating on a device or computer called a vibrator. These three types of signals are considered to be cyclic polygenic processes in vibration diagnostics.

When performing vibration diagnostics with accelerometer mounted at specific points of the machine, the signal is usually recorded in the form of vibrations. This signal is transformed into vibrations or vibrations by integrating on a device or computer called a vibration collector. All these three types of gestures are considered to be cyclic polygenic processes in vibration diagnostics.

Mathematical modeling is usually aimed at solving equations given the operation of pump units in different operating modes. A special program has been developed to accurately assess the impact of changes in operating modes on pump units. Using the software, it is possible to determine the optimal operation of pump units [5].

Results. The values obtained as a result of sudden measurements during measurement can be uncertain. Therefore, it is necessary to determine the threshold values for each parameter measurement. These values are determined taking into account the errors made during the diagnosis.

The probability of making a mistake is determined by the following expression:

$$\Omega = \Omega_1 + \Omega_2;$$

where: Ω_1 – the probability of displaying a malfunction when the system is in operation;

Ω_2 – the condition of perceiving the system as defective in case of any defects. $M+1(j=0,1,2...M)$ position, $N\ (i=1,2...N)$ high for each case of diagnostic parameters Y_{ji} and the bottom P_{ji} the state of their vectors using boundary values> $[P_{ji}$ and $Y_{ji}]$when measured at intervals.

$$P_{ji} \succ Y_{ji}; \qquad (1)$$

That is, the defined value P_{ji} and Y_{ji} between two boundaries N – if located between dimensional parallelepiped j the case. The lower bound was not used in this case.

If the obtained data is not linked to the above data, Ω_1 of j the condition that occurs for the chi state is determined by the following expression.

$$\Omega_{1j} = \Omega(\gamma_o)\prod_{i=1}^{N}\int_{P_{ji}}^{Y_{ji}} f\left(\frac{\chi_i}{\gamma_o}\right) d\cdot\chi_i; \qquad \mathbf{(2)}$$

J the probability of chi is determined by the following expression.

$$\Omega_{2j} = \Omega(\gamma_j)\prod_{i=1}^{N}\int_{P_{oi}}^{Y_{oi}} f\left(\frac{\vec{\chi}_i}{\gamma_j}\right) d\cdot \vec{\chi}_i; \qquad (3)$$

where: γ_o - density of the required standard position,
γ_j - the likelihood of an unusual situation.
M the probability of a standard deviation being false is:

$$\Omega_1 = \Omega(\gamma_o)\sum_{j=1}^{M}\prod_{j=1}^{N}\int_{P_{oi}}^{Y_{oi}} f\left(\frac{\vec{\chi}_i}{\gamma_j}\right) d\cdot \vec{\chi}_i \qquad (4)$$

M probability of detecting an event

$$\Omega_2 = \sum_{j=1}^{M}\Omega(\gamma_j)\prod_{i=1}^{N}\int_{P_{oi}}^{Y_{oi}} f\left(\frac{\vec{\chi}_i}{\gamma_j}\right) d\cdot \vec{\chi}_i; \qquad (5)$$

where: $\Omega(\gamma_j) - j$ the probability of a ire our state.

In general, these parameters are not interrelated (3) - (5) orthogonal is changes are additionally accepted to detect errors in expression use. This type of substitution includes K with the covariance matrix type in its vectors.

$$Y' = K - Y;$$

(3) - (5) the new orthogonal is in expression is based entirely on the acquisition of Y, which is a spatial characteristic.

The characteristic parameters are determined taking into account the regularity of the system and the signs of the defects. The resulting information is used for diagnostics. These parameters include harmonic parameters that exceed the value.

When diagnosing the condition of the pump blades, the number of hormonal foams is determined by multiplying the number of holes on the surface by the number of rotations of the work blade. To determine its value, the extrinsic values in the range studied are subtracted and numbered. When defects occur more than three times during detection or irregularly, their occurrence values are calculated using the following expression:

$$N_1 = \frac{1^Z}{n^{i=Z}}\sum_{f_o-\frac{a}{2}}^{f_o+\frac{a}{2}} A(f_i); \qquad (6)$$

where: n – the number of points in the interval;
$A(f_i)$ - f_i the amplitude of the spectra at the frequency.

One of the most common parameters during vibration measurement is vibration. Because vibration measurement and processing are determined by vibrations, you have to extract vibrational values from the spectrum.

To do this, we use the following expression to determine vibrations in the range of 10-1000 Hz values

$$V = \frac{1}{2\pi}\sum_{i=10}^{1000}\frac{A(f_i)}{f_i}; \qquad (7)$$

Another parameter calculated using spectral amplitude is the depth of the modulation. It is calculated using the following expression:

$$\gamma(f) = \frac{A(f)}{\xi}\cdot 100\%; \qquad (8)$$

where: $A(f) - f$ frequency signals;
ξ- the amount of signal that occurs.

Signal amount is a constant component of the detected signal. Its value is determined by the zero channel of the spectrum. So it is expression will look as follows:

$$\gamma(f) = \frac{A(f)}{A(0)}\cdot 100\%; \qquad (9)$$

Diagnostic parameters to determine the state of the aggregate are determined by this method [6].

By setting the maximum value of the pump head, established on the basis of technical and economic calculations, and using the random variable conversion theorem or the results of statistical modeling, determine the pump resource by the parameter (head) and the values of the resource distribution density (Fig. 1).

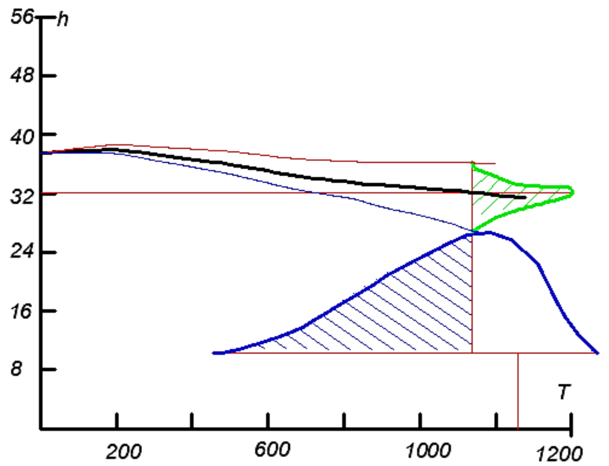

Fig. 1. Dynamics of pump head and its life.

To test the reliability of the developed dynamic model in SANIIRI, we carried out bench tests of the centrifugal pump DA-86 (Q_o=0.13 m^3/s, H_0=36 m, n=1687 min^{-1}). close to its characteristics for general-purpose pumps of the type K 290/30 (Figure 2). The theoretical curve of the change in the pump head from the test time is calculated from the results of the micrometer of the parts.

A good coincidence of the theoretical and experimental curves was noted. The relative error is 2-9%, which allows to draw a conclusion about the effectiveness of the developed model. It can be used in controlling the reliability of pumps, determining the optimal sequence of increasing the longevity of their elements, developing methods for assessing the quality of repairs using methods and means of accelerated testing [7].

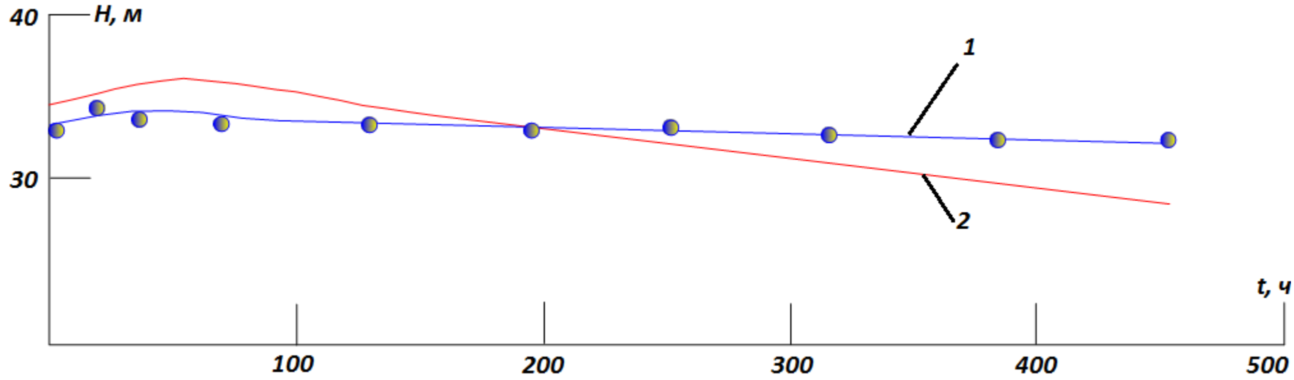

Fig. 2. Dependence of pump head on test time: 1- the experimental curve; 2-theoretical.

Conclusion. On the basis of the obtained data, the mathematical model, which represents the threshold values of parameters caused by irrigation pump units, allows calculating and predicting the probability of defects in pump units. The noise and vibration induced by hydrodynamic and mechanical oscillations are subject to similarity patterns. They can be calculated by calculating the rotation speed and size of the pumping wheel. This combination of characters allows you to determine the probability and amount of the defect.

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