Diagnostics of pumping units of pumping station of machine water lifting

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Abstract. The purpose of diagnostics is to determine the operability of the pumping units of the pumping station of the machine water lifting at a given time and to identify defects in their components. For this reason, the article presents diagnostic issues for pumping stations No. 1 - No. 6 of the Karshi main canal, designed and commissioned in 1965-1976, where 6 pumping units of the OPV11-260EG type with electric motors of the VDS-375/130-24 type are installed, vertical pumping units, shaft power – 8010 kW, rated power electric motor – 12500 kW, voltage – 10.0 kV, stator current – 825.0 A, maximum permissible temperature of the stator winding – 120 ^{O}C, bearing temperature – no more than 70 ^{O}C. Diagnostics of the main equipment involves the prompt detection of malfunctions as a result of processing sensor readings of the standard monitoring system, sensor readings are entered manually once a day, and data from monthly and special tests. Technological algorithms of vibration and thermal diagnostics are similar to those developed for vertical pumps installed at thermal power plants, the processes being diagnosed in which are similar to the processes occurring in pumping units of a pumping station. Taking into account the above tasks, algorithms have been developed for diagnosing the main components whose condition affects the performance of the pumping unit: the upper bearing, the upper crosspiece, the stator winding and core, the upper and lower guide bearings, and the electric motor bearing. Possible malfunctions of pumping unit components and ways to eliminate them are given.

1 Introduction

The efficiency of operation of pumping stations (NS) of machine water lifting is primarily determined by the reliability and safety of pumping units (NA), taking into account the rational use of water resources to ensure an uninterrupted water supply to the consumer. A necessary condition for an unambiguous assessment and development of reasonable measures to maintain reliability and safety is identifying the condition in which the operated equipment is located. The main methods of obtaining reliability and safety data (NS) clearly include processing information about equipment failures, i.e., assessment of reliability and safety based on operational data. Diagnostics should also be attributed to

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information about reliability and safety. Diagnostics aims to determine the equipment's operability at a given time and identify defects in their individual nodes.

2 Methods

On most NS, monitoring of the normal functioning of the NA to assess their technical condition during operation is carried out by operational personnel in the traditional way as a result of visual observation of the indicators: pressure at characteristic points of the flow path, temperature of active elements and cooling agents, as well as by the general change in the condition of the equipment: - increased vibration, etc.

However, with this approach, it is impossible to identify specific causes of equipment malfunction and prevent emergency shutdowns on time. The consequence of this is also not always justified preventive, ongoing, and major repairs.

Intensive development of control and measuring equipment and computer equipment widespread introduction of microprocessor devices for converting and analyzing information on computers create favorable prerequisites for expanding the possibility of monitoring and evaluating the technical condition of the equipment, for combining disparate diagnostic methods and tools into a single system for more reasonable management of the operation of the equipment, planning their maintenance and repairs.

On most NS, the following technological parameters are monitored by the available standard means water levels in the lower and upper reaches; oil in oil baths; the temperature of bearings, active steel, windings, and cooling air of electric motors; the pressure of water, oil, and air in pipelines; the presence of water flow (movement) in the technical water supply; electrical parameters (current and the voltage of the rotor and stator of the electric motor, the amount of electricity consumed, the power factor), etc.

The levels of the beef are recorded by float level meters, which form electrical impulses for the secondary device. Two converters are used for temperature control – thermal resistance and thermal signaling devices. The signals from the thermal converters are output to a logometer, the sequential switching of which allows you to determine the temperature state of one of the elements ON. For signaling or emergency shutdown of the unit, thermal alarms are installed. Recording switch devices for fixing electrical parameters are located on the NS's central control panel boards.

However, the amount of information received using regular control is clearly insufficient to diagnose emerging defects. To detect a defect and locate it, it is necessary to expand the scope of temperature control. Most importantly, the introduction of vibration monitoring and measurement of shaft run-out is also required. Vibrations are one of the main criteria for the quality and reliability of the unit's operation and should be measured simultaneously with the registration of the shaft run-out with a certain frequency at the main units of the unit that determine its technical condition.

To determine during operation the position of the rotor in the stator bore, and the presence of short-circuited turns in the electric motor's rotor winding, it is also necessary to control the asymmetry of the rotor magnetic field.

Thus, the development of a system for diagnosing the technical condition of the NA presupposes the availability of technical means for measuring and monitoring the current state of the unit and the availability of computer equipment (SVT) and should be implemented on a specific operating NS.

As the experience of the operation of the NS of the Karshi trunk Canal (KMK) shows, it is not always possible to obtain complete information. To develop and implement methods of technical diagnostics of NS equipment, a thorough preliminary analysis of the available technical means of recording and monitoring the main indicators at the station is required. Specific conclusions are drawn for each type of equipment individually based on its results.

Diagnostics of the condition of pumping units is determined by such basic units, the condition of which affects the operability of the unit, such as upper and lower guide bearings (VPD and NAP) and the electric motor bearing.

A fragment of the algorithm for diagnosing the main components of the pumping unit is shown in Figure 1.

2.1 Upper bearing of the pumping unit

An algorithm for assessing the state of radial low-frequency vibration and shaft run-out. Input information: radial low-frequency vibration of the GNP in operating mode; radial low-frequency vibration of the pipeline; radial low-frequency vibration of the GNP with a drained ante-chamber; shaft fight in the area of the GNP in operating mode; shaft fight in the area of the GNP with a drained ante-chamber, at 5% of the nominal revolutions.

The functioning of the diagnostic algorithm for radial low–frequency (1 - 8 Hz) vibration on the GNP begins with the input of the initial data: radial low-frequency vibration of the GNP; the battle of the shaft in the area of the GNP.

The fact of occurrence of malfunctions is the excess of the boundary values of the shaft battle in the area of the GNP and the radial low-frequency vibration of the GNP. Otherwise, the subroutine is terminated, and control is transferred to the next subroutine. Possible malfunctions: increased GNP clearances, - adjusting the clearances; loosening the GNP fastening, - tightening the GNP bolts; hydraulic unbalance of the impeller (RC) - auditing the RC and its chamber; mechanical unbalance of the RC, - balancing the RC, increased GNP clearances, - expose the gaps; shaft line fracture, - expose the shaft line.

2.2 The upper crosspiece of the electric motor

An algorithm for assessing the state of high-frequency vertical vibration.

Input information: vertical high–frequency vibration of the VC in operating mode; vertical high-frequency vibration with a changed angle of rotation of the blades by 1^{o} - 2^{o}; vertical high-frequency vibration with a drained water intake; the water level in the water intake.

The algorithm's functioning for diagnosing vertical high-frequency vibration of the upper crosspiece begins with the input of initial data: vertical vibration of the VC, and the water level in the water intake. Measurements for other parameters are made only at the request of the algorithm. The fact of the occurrence of malfunctions is the excess of the boundary values of the vertical high-frequency vibration of the VC. Otherwise, the subroutine is terminated, and control is transferred to the next subroutine.

3. The upper crosspiece of the electric motor.

An algorithm for assessing the state of vertical low-frequency vibration.

Input information: vibration with a frequency of 1 – 25 Hz; vibration with a frequency of 4 – 5 Hz; vibration with a frequency of 18 – 20 Hz.

The functioning of the vertical low–frequency vibration algorithm begins with the input of the initial data: vertical low-frequency vibration VC (1 - 25). Measurements for other parameters are made only at the request of the algorithm. The fact of the occurrence of malfunctions is the excess of the boundary values of the vertical low-frequency vibration of the VC. Otherwise, the work of the subroutine is terminated, and control is transferred to the next subroutine.

The increased level of vibration can be caused by the malfunctions listed below: the non-perpendicular of the mirror disk to the shaft axis - eliminate the defect; the shock input of the flow to the blades of the RC - inspect the working path for the presence of foreign objects; the coincidence of the natural frequency of the VC with disturbing hydraulic forces in the flow path - change the hydraulic mode of the pump (the angle of rotation of the blades, switching to a different speed).

4. The upper crosspiece of the electric motor.

An algorithm for assessing the state of radial low-frequency vibration.

Input information: radial low-frequency (reverse) vibration of the upper crosspiece (VC) in operating mode; radial low-frequency vibration of the stator housing; radial low-frequency vibration (NC); radial low-frequency vibration of the electric motor foundation; radial low-frequency vibration of the VC on the run-out at 95% rpm; shaft fight in the area of the upper motor bearing.

The functioning of the diagnostic algorithm for radial low-frequency (reverse) vibration begins with the input of the initial data: the battle of the shaft in the area of the VPD and the radial low-frequency vibration of the VC. The remaining measurements, according to the parameters listed in the list, are made only at the request of the algorithm. The fact of the occurrence of malfunctions is the excess of the boundary values of the radial low-frequency vibration of the VC; otherwise, the work of the subroutine is completed, and control is transferred to the next subroutine.

The following malfunctions can cause the increased vibration level: listed below: increased gaps of the VPD and NAP - adjust the gaps; loosening of the VK attachment to the stator housing - fix the VK to the stator housing; loosening of the stator housing attachment to the NC – fix the stator housing to the NC; loosening of the NC attachment to the foundation –fix the NC to the foundation insufficient rigidity of the foundation - to strengthen the foundation; electromagnetic imbalance - to set uniform air gaps between the rotor and the stator; mechanical unbalance of the rotor of the electric motor - check the attachment of the rotor to the shaft, balance the rotor.

5. Winding and stator core of the electric motor.

An algorithm for assessing the state by temperature. Input information: stator winding temperature, temperature after the air cooler, vibration (vertical or radial) of the stator core.

The algorithm's functioning for diagnosing the winding and the stator core temperature begins with the input of the initial data: the stator winding temperature. Measurements for other parameters are made only at the request of the algorithm. The occurrence of malfunctions is an excess of the temperature of the stator winding of the electric motor; otherwise, the work of the subprogram is completed, and control is transferred to the next subprogram.

The following malfunctions can cause an increase in the temperature of the stator winding: poor-quality operation of the air cooler and cooling system - to audit the air cooler and cooling system; contamination of the frontal parts of the stator winding and ventilation ducts of the stator core - to clean the frontal parts and ventilation ducts; weakening of the pressing of the active steel of the stator core, self-unscrewing or breakage of tie pins or release bolts - to audit of the stator core, if necessary, replace the tie pins and release bolts.

6. Upper and lower guide bearings of the electric motor.

An algorithm for assessing the state by temperature. Input information: temperature of the upper and lower bearings of the electric motor -Tvp, Tnp; oil level in the oil tank - Nm; cooling water temperature – Tov.

The algorithm's functioning for diagnosing the temperature of the upper and lower bearings of the electric motor begins with the input of initial data. The occurrence of malfunctions is an excess of the temperature of the electric motor bearings; otherwise, the work of the subprogram is completed, and control is transferred to the next subprogram.

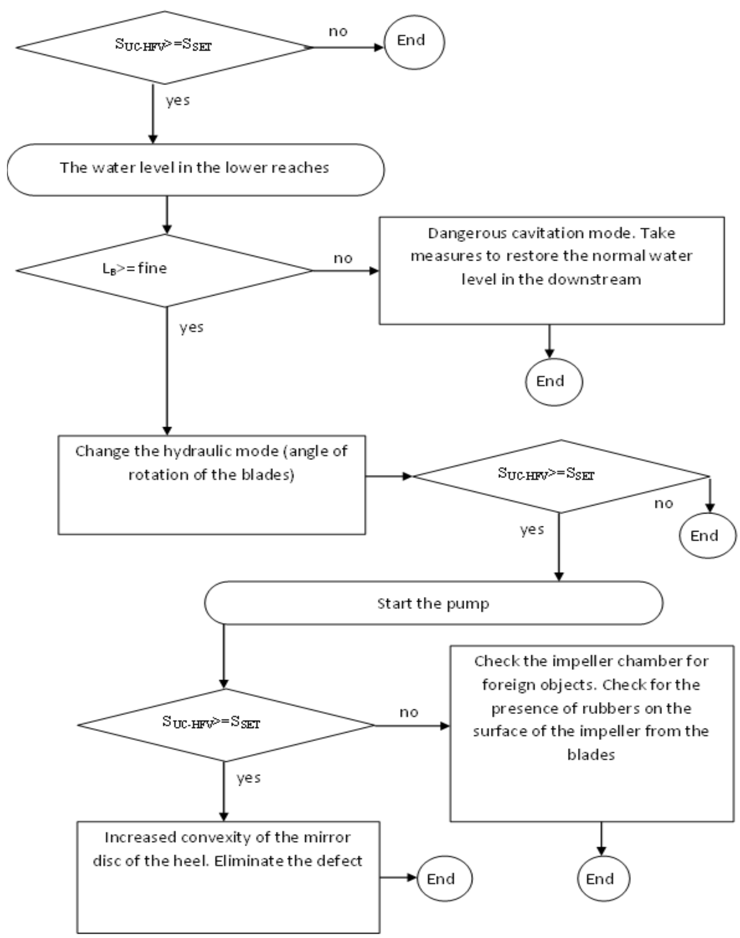
An increase in the temperature of the electric motor bearings can be caused by the following malfunctions: low oil level in the maslovanna - raise the oil level, eliminate the cause of leakage; increased oil level in the maslovanna - water leakage from the cooling system - conduct an oil analysis, eliminate water leakage; increased cooling water temperature; the non-concentric arrangement of the rotor in the stator - align the rotor about the stator.

7. Electric motor support.

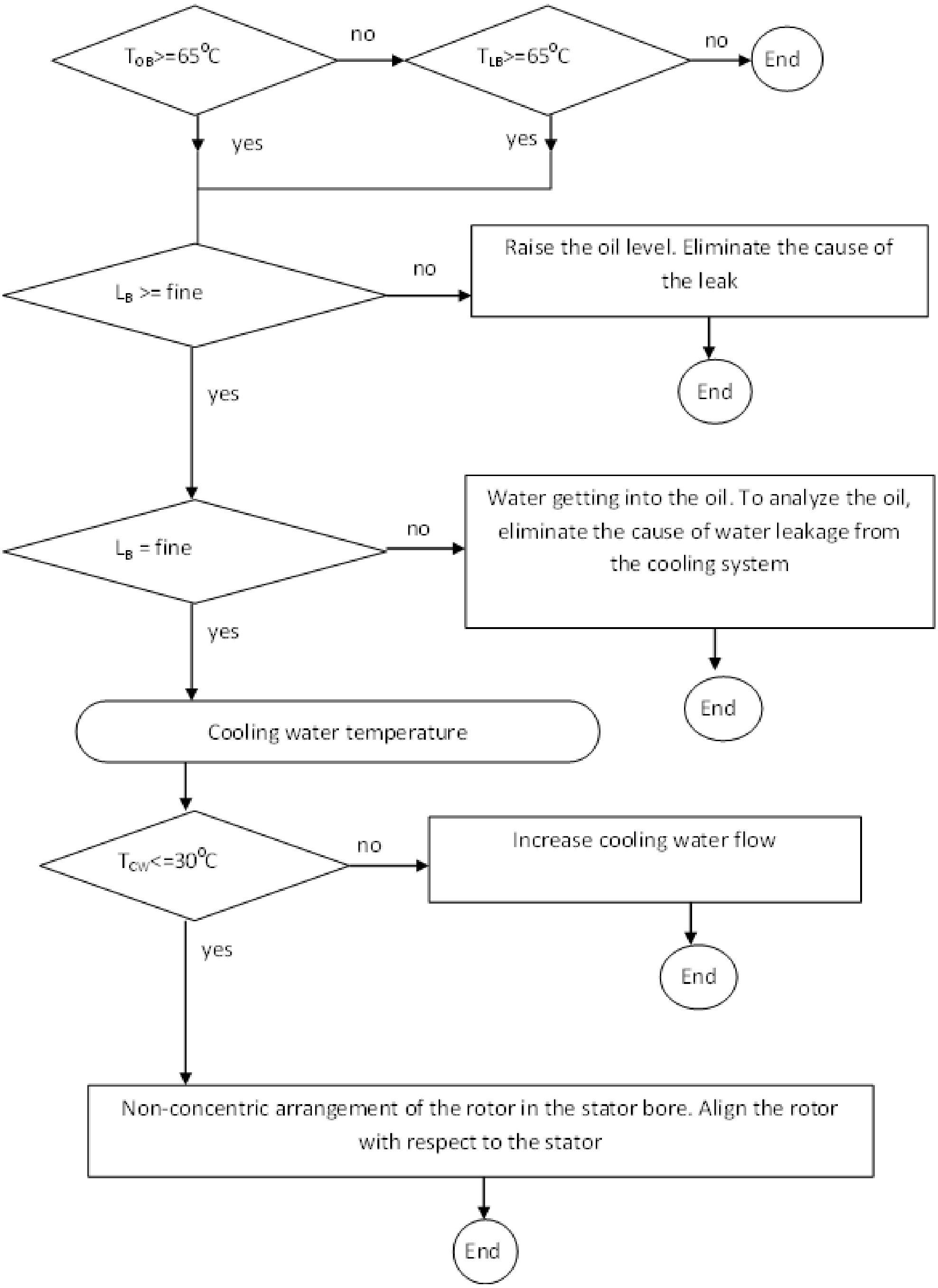
An algorithm for assessing the state by temperature. Input information: the temperature of the two inserts of the podpyatnik - T_{1p}, T_{2p}; the oil level in the oil tank; the temperature of the cooling water.

The functioning of the algorithm begins with the input of the initial data. The occurrence of malfunctions is an excess of the temperature of the thrust bearing liner. Otherwise, the subroutine is terminated, and control is transferred to the next subroutine.

An increase in the temperature of the podpyatnik liner can be caused by the following malfunctions: a low oil level in the oil pan - raise the oil level, eliminate the cause of leakage; an increased oil level in the oil pan by water leakage from the cooling system - conduct an oil analysis, eliminate water leakage; increased cooling water temperature; deterioration of the mirror surface of the podpyatnik disk, increased macroerosion of the mirror disk of the podpyatnik - carry out an audit of the mirror disk, eliminate the defect; by crumpling the heads and threads of the support bolts, - to carry out an audit of the support nodes of the podpyatnik, to eliminate the defect.



a)



b)

Fig. 1. Fragment of algorithms for diagnosing the main components of the pumping unit

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3 Conclusions

1. Using the proposed operational control algorithm, we can diagnose the technical condition of the PS, calculate the risk, determine the severity of each violation and assess the safety of each element of the PS, addressing each of them, displaying their states on the computer screen and effectively identify emergency factors, take the necessary emergency corrective measures aimed at improving the safety of the power substation, which allows preventing an emergency in the power substation.

2. The risk formula of the power supply substation is derived, which allows for assessing the safety of the power supply substation.

3. It is proposed to use a neural network to conduct a probabilistic analysis of the safety of PS, with the help of which it becomes possible to determine the severity of each violation and the treatment of each of them allows you to display the state of PS on the computer screen and effectively identify emergency factors and take the necessary emergency development of corrective measures aimed at improving the safety of PS, as well as other industries [17-29].

References

1. Arkadov G.V., Pavelko V.I., Finkel B.M. VVER diagnostic systems. Monograph. p.391 (2010)
2. Birger I.A. Technical diagnostics. Mechanical engineering, (1978), p.240.
3. Glazunov L.P., Smirnov A.N. Design of technical means of diagnostics.Moscow: (1982) p.168.
4. Alexandrovskaya L.N., Aronov I.Z., Elizarov A.I. Statistical methods of security analysis of complex technical systems: Logos, (2001), p.233.
5. E. J. Henley, H. Kumamoto. Reliability of technical systems and risk assessment. Mechanical Engineering, (1984), p. 528.
6. Savina N.V. Reliability of electric power systems. Amur State University, (2011), p.268.
7. Anisimov D.N. Reliability of automation systems. Publishing House of MEI, (2003) p.96.
8. Billinton R., Allan R. Assessment of reliability of electric power systems. Moscow (1988), p. 288.
9. Kalyavin V.P., Rybakov L.M. Reliability and diagnostics of electrical installations.– Yoshkar-Ola: Publishing House of the Mord. State University (2000) p. 348.
10. Kitushin V.G. Reliability of energy systems. – Novosibirsk: Publishing house of NSTU, (2003), p. 256.
11. Mikhailov V.V. Reliability of power supply of industrial enterprises. Moscow (1982) p.150.
12. Shubin R.A. Reliability of technical systems and technogenic risk. Tambov: Publishing House "TSTU", (2012), p.79.
13. Rudenko Yu. N., Ushakov I. A. Reliability of power systems. Moscow (1989) p.328.
14. Fokin Yu.A., Tufanov V.A. Assessment of reliability of power supply systems, Moscow (1981) p.224.

15. Tolyagan Kamalov, Solixjon Halikov. Assessment of reliabilite and safety of work large pumps of machine irrigation systems. In E3S Web of Conferences **139**, 01014 (2019)
16. T. Kamalov, S. Halikov. About the national safety management of the pumping installations of the pumping station of the machine irrigation system. In E3S Web of Conferences **216**, 01157(2020)
17. Kh. Sapaev, Sh. Umarov, I. Abdullabekov. Critical frequency of autonomous current inverter when operating on active-inductive load. In E3S Web of Conferences **216**, 01153 (2020)
18. M. Tulyaganov. Optimization of natural gas combustion in furnace of steam boilers. E3S Web of Conferences **216**, 01155 (2020)
19. Voron O.A., Tuluaganov M.M., Petrushin A.D. Improvent of the power supply system for isothermal rolling stock. Journal: Proceedings of the Rostov State Transport University. **4** (53), pp.28-32 (2020)
20. Petrushin A.D., Smachney V.Y., Tuluaganov M.M. Elecric drive for transport systems. Journal: Proceedings of the Rostov State Transport University **4** (53), pp. 91-95 (2019)