Monitoring the technical condition of the electric centrifugal pump during the repair process

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Abstract. The article discusses the process of monitoring the technical condition of an electric centrifugal pump during repair work at a service company. The procedure for repair work, the identification of defective parts and components of the pump section, and electric motor, visual and instrumental control of the technical condition are described. The results of the rejection of parts and assembly units are analyzed. Recommendations have been developed to reduce the rejection of parts and units of the installation.

1. Introduction
Reliable and uninterrupted operation of electric centrifugal pump installations has a direct impact on the efficiency and safety of the oil production process. The creation of the required level of reliability of pumping units is ensured by the competent organization of the maintenance and repair system, the quality of which depends on technical and technological processes [1].

Increasing the reliability of pumping units becomes not only a technical but also an economic issue, since the effect of increasing the reliability indicators is achieved only with the minimum total resources spent on the creation of pumping units and its subsequent operation. Therefore, the optimization of resource support for the process of maintenance and repair of pumping units is an urgent task [2].

The Vankor field is annually repaired 550 installations of electric centrifugal pumps. A set of works on maintenance and repair of electric centrifugal oil pump installations is carried out by a specialized contractor Baker Hughes JSC, which in its actions is guided by a documented quality management system for the operation of downhole pumping equipment [3].

The strategy to improve the quality of repair work in the organization of Baker Hughes JSC is aimed at identifying and eliminating the weak elements of pumping units identified during their operation, at improving the technical level of repair work using modern technological solutions [4].

2. Materials and methods
The technological process of repairing an electric centrifugal pump installation consists of the following:
- external cleaning of the surface of the pump, electric motor, and hydraulic protection;
- disassembly of the pump, electric motor, and hydraulic protection, washing of parts;
- fault detection of parts;
- replacement of parts that are out of order and recognized as unsuitable for subsequent operation by new parts;
- assembly of the pump, electric motor, and hydraulic protection;
- acceptance tests and bench tests of units and the pump unit itself.

Repair sites are completed with the necessary technical documentation: process cards, assembly drawings, and other design documents. Technical documentation is recorded and stored in organized places. Changes in the design group of the electric centrifugal pump installation are agreed by the service company that provides maintenance and rental of such plants.

Assembled pumps that are sent for repairs are cleaned of dirt, oil, and sand. The representative of the repair organization checks and draws up the acceptance certificate, which indicates the general technical condition of the pumps, the detected defects, and the conformity of their completeness with the complete list.

Repair of installation units for electric centrifugal pumps is carried out at specialized workplaces and production sites under technological processes.

The tasks set are to ensure high-quality repair, as well as eliminating the likelihood of repeated use in the assembly of inappropriate parts and assemblies. In the presence of maximum allowable wear, in addition to the control of the performers after the faulty components and installation components, incoming inspection of spare parts, testing of pump sections, independent technical control is carried out in the repair organization [5, 6].

The materials and components used in the repair of components undergo incoming inspection, have documentary evidence of their compliance with state and industry standards, technical specifications. Parts and assemblies that were in operation and are used repeatedly without restoration, as well as newly manufactured and restored, must comply with the documentation for the repair of manufacturers. It is allowed using parts and components that were in operation and have, after restoration, structural changes while maintaining the maximum deviations of the geometric dimensions of the landing, mating surfaces, and other surfaces, per the requirements of the cards of technical requirements for fault detection [7, 8].

The following data are given in the technical requirements cards for fault detection: probable defects, means and methods of technical control, permissible sizes, and recommended recovery methods.

The dimensions of the main parts and assemblies are controlled in sections and planes. As a result of the defect, the parts should be sorted into the following groups:
- parts suitable and not requiring restoration;
- parts with defects and subject to restoration;
- parts with at least one irreparable defect not subject to subsequent use.

Shafts of sections before the assembly procedure are edited and tested on the dial indicator. The condition of the keys is checked by visual inspection and a micrometer. On the surface of the dowel, cracks of any nature and location, seizures, breaks, grooves, and dents are not allowed.

3. Results and discussion

The MTBF of the installation of an electric centrifugal pump has been operated on for oil companies for no more than 10 years. The failure time, in contrast to the overhaul period, shows the operating efficiency not so much of the well itself as the equipment to ensure its operation, namely, the average operability of the installation of an electric centrifugal pump from the start of an operation to fail.

For installing an electric centrifugal pump, a failure is any malfunction, which requires the replacement of underground equipment or its part with a workable set of equipment or its part.

Data on the rejection of parts of electric centrifugal pump installations during the current repair for the period from 2010 to 2013 are presented in Figure 1.

Data on the rejection of submersible electric motor parts for the period from 2010 to 2013 are presented in Figure 2.
Figure 1. Disassembling parts of electric centrifugal pumps

Figure 2. Rejection of submersible motor parts

In the event of damage to the protective external anti-corrosion coating to the base of the metal and in the absence of the possibility of restoration by the service company that service and rent electric
centrifugal pump installations, cover the body parts, pump sections are transferred from a corrosion-resistant version to an identical group of non-corrosion-resistant version [9].

The assembly process and the subsequent assembly of the installation units are carried out following the job order for the unit. The following information is reflected in the task assignment: manufacturer, the standard size of the installation unit, node number, execution group, date of assembly, list of drawings, number of new and repair parts, Surname, Name, Patronymic of the picker. This document is stored in a service company that maintains and rents electric centrifugal pump installations, covers body parts during the warranty period of equipment operation [10].

Increasing the time between failures of equipment of electric centrifugal pump installations is carried out by replacing a worn-out unit during the repair process with a new unit. Sometimes a replacement is made with a more reliable design made by the manufacturing plants. And after that, the installation is tested on a computer stand with the removal of the operating characteristic. Management of the test process and processing of measurement results is carried out using computer technology with the issuance of a quality certificate. Information about the tests is stored in the database [11].

The ratio of installation of new and repair underground equipment of electric centrifugal pump installations is shown in Figure 3. The failure ratio of new and repair underground equipment of electric centrifugal pump installations are shown in Figure 4.

The increase in rejection of underground equipment nodes of electric centrifugal pump units for the period from 2010 to 2013 is due to the following:

1) an increase in the mechanized well stock;
2) an increase in factors complicating the operation of underground ESP equipment: an increase in EHF (the number of suspended particles), an increase in the gas factor, an increase in water cut; an increase in the average operating frequency of the ESP;
3) an increase in the use of repair underground ESP equipment at a mechanized well stock.

![Figure 3](image)

**Figure 3.** Relationship between the installation of new and repair underground equipment of electric centrifugal pump installations.
Figure 4. Failure ratio of new and repair underground equipment of electric centrifugal pump plants.

4. Conclusion

As a result of the analysis and work performed, the following measures were developed to reduce the rejection of nodes of underground equipment of the ESP:

1. Carrying out a project of production work in wells with a significant operating time;
2. An increase in criteria for the quality of assembly of repair equipment of the ESP;
3. Reducing factors complicating the operation of underground equipment of ESP:
   - apply a filter at the ESP unit and modules, namely, sand separators in wells, where the removal of mechanical impurities complicates the operation. After stopping the wells, startup at the lowest possible frequency, followed by a smooth output to the frequency approved by the technological regime;
   - use the conical assembly of the ESP pump together with the gas separator and the MVP module in wells, where a massive gas factor complicates an operation;
   - to test the hydrophobic compositions in the areas of formation water breakthrough in horizontal wells with high water cut.

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