Improvement of pin flexible coupling construction

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Abstract. The purpose of the study is to increase the service life of coupling joints of centrifugal pumping units by designing a modernized coupling joint. During the operation of centrifugal units, there is a problem associated with a short service life of the couplings due to the imbalance of the half couplings, improper balancing of the rotor, etc. The authors conducted an objective and comprehensive analysis of the flexible coupling operation. Based on the results of the study of the existing construction, the coupling joint was modernized using the example of the pin flexible coupling for a centrifugal pump 200D90. The flexible coupling construction, which has no analogues in Russia, has been created. Due to the proposed upgraded construction, the coupling provides increased service life and more reliable operability in service.

1. Introduction
During the operation of centrifugal pumping units for transporting well products and process water, a problem arises due to the short service life of the couplings, which are used to transfer torque from the electric motor shaft to the shaft of the electric centrifugal pump.

In general, the coupling is the most worn-out part of a centrifugal pumping unit. Currently, the following couplings are used to connect centrifugal pumps with electric motors: PFC CP 60/198 State Standard 21424-75, PFC 200D/90, PFC CP 1000/180 State Standard 21424-93 [1,5]. The presented coupling joints have a number of disadvantages: it takes a long time to install couplings; installing and removing couplings, it is possible to deform the joint parts, violate the integrity of the coupling joint structure; get more vibrations during operation and, as a result, reduce the mean-time-between-failures; increased risk during hot works in the pumping block at process installations; outdated construction of used coupling joints.

Also, the main reason for reducing the service life and premature failure of the couplings is the pumping unit vibration [2]. List parameters affecting the level of pumping unit vibration:
- misalignment of the drive and pump;
- rotor imbalance;
- incorrect landing of the rotor on the shaft;
- incorrect connection of pipelines;
- impact of couplings;
- violation of bearing elements geometry;
- defects of bearing assembly;
- cavitation of the pumped medium;
- loosening of parts attachments;
- thermal expansion of pump construction elements;
• damage to foundations and supports;
• insufficient or poor quality lubricants, etc.

The purpose of the study is to increase the service life of coupling joints of centrifugal pumping units by designing a modernized coupling joint. Research objectives: reduction of non-production time during work on replacing the electric motor of pumping units; reducing the risk level of installation and dismantling of coupling joints; elimination of possible coupling joint destruction; reducing costs related to the use of welding engineering; simplification of coupling joints replacement procedure; possibility of restoration due to the modularity of the proposed product construction; simplification of repair work for routine repair and maintenance, as well as bearing assembly replacement operations; reducing the cost of repair and maintenance work.

2. Materials and methods
The vibration level was measured in accordance with the international standard ISO 10816-3:1998 "Evaluation of machine vibration by measurements on non-rotating parts" [8]. Also, the operation of centrifugal pumps was monitored based on the condition of bearings, couplings, shafts in accordance with the standards for flexible couplings [3].

Factors affecting pumping unit vibration level. As a result of field test of the centrifugal pumping unit, the following factors were identified, that reduce the operational reliability of the equipment.

✓ Incorrect alignment with the pump;
✓ Half couplings imbalance (worn-out pins, misalignment of pins holes or misalignment of half coupling);
✓ Clearances of bearing assemblies (bearing defects);
✓ Balancing the pump and electric motor rotors [4];
✓ Frame base abutment and attachments.

3. Results and discussion
In case of deviation of one or several factors of pump operation, the bearings fail, both in the pump and in the electric motor.

Measures for extension of coupling service life. The authors proposed measures to improve the efficiency and safe operation of pumping units. The vibration state of pumping units was monitored by determining the zones and boundaries of the vibration state, measuring the vibration velocity, vibration acceleration, and constructing their spectral graphs. The operation of pumping units in non-nominal operating modes was also studied. The installation of elements of a vibration isolating compensating system was carried out and bearing capacity of pumping blocks foundations was increased. The study initially considered the existing construction of the used coupling joint shown in Figure 1.

Figure 1. Standard factory-made couplings

The following disadvantages were identified:
1. Non-production time spending on the installation and dismantling of coupling joints [6,7];
2. The use of pullers during disassembly leads to the formation of scorings along the inner diameter of the half coupling, on the pump shaft and the electric motor rotor;
3. Coupling joints are supplied unbalanced which increases the vibration coefficient, and as a result, reduces the time to failure;
4. The service life is reduced, and the imbalance of the coupling joints increases due to coupling installation and dismantling operations;
5. Increased risk during hot works in the pumping unit at process installations;
6. Short service life from 3 to 5 years.

**Modernized version of the flexible coupling.** As part of the ongoing construction work, a modernized coupling joint was created, shown in figure 2, 3. Construction work was carried out using the professional application program Kompas 3D V18 [9]. Dowel pins have been added to the existing construction, which are installed in special milled holes. They allow performing routine repair operations, quick installation, dismantling and replacement of coupling joints.

Modernized version of coupling:

![Figure 2. Modernized coupling assembly](image)

![Figure 3. Modernized pin flexible coupling](image)
Modernized coupling construction. Figure 3 shows a disassembled modernized half coupling of an electric motor PFC State Standard 21424-93. The considered construction of the coupling joint makes it possible to exclude incorrect alignment of the pump and the electric motor, and as a result, reliable operation of bearing assemblies will be ensured, and bending of shafts is excluded. Thus, we simplify the methods of installation and dismantling of this type of PFC (Pin Flexible Coupling State Standard-21424-93 for a centrifugal pump 200D90).

![Figure 3. Modernized coupling joint](image)

Figure 4 shows the modernized pin flexible coupling. The advantages of the proposed model are: simplicity of construction, it is also possible to offset the shafts relative to the horizontal axis from 1 to 5 mm, the radial offset of the shafts is from 0.1 to 0.4 mm. This is achieved by using compensators made of rubber that make it possible to compensate for the above offsets. The most significant advantage is the possibility of installing the coupling without pressing operation, which greatly simplifies the installation and dismantling of the coupling joint. Construction disadvantage is balancing on false shafts during coupling installation.

![Figure 4. Modernized pin flexible coupling](image)

4. Conclusions
Tests have shown that the use of a modernized pin flexible coupling increases its service life, operability operating safety of centrifugal pumping units. The results of the prototypes confirm the increase of vibration speed level to the level of "good", an increase in the bearing capacity of pile footings, foundations of pumping blocks.

The following advantages of the modernized construction should be noted:
1. Reducing the time spent on the installation and dismantling of coupling joints due to the use of a detachable construction with locating pins;
2. Reducing the dismantling time of the modernized coupling due to the use of the modernized construction;
3. Reduction of non-production time and cost for routine repairs and overhaul of pumping units due to reduced time for disassembly and assembly of the modernized pin flexible coupling;
4. Ease of installation and dismantling of the half coupling during maintenance and repair operations of centrifugal units due to the removal of the half coupling’s upper part;
5. Reducing the vibration level of pumping units due to the balancing of the coupling joint, and as a result, increasing the interrepair time;
6. Reducing the risk due to the refusal of hot works in the pumping block at process installations;
The construction of a pin flexible coupling, proposed in the work, allows improving the technological maintenance of pumping units, simplifying the routine repair overhaul. As a result, the reliability of pumping units increases, which is very relevant for oil complex facilities pumping large volumes of liquid.

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