THE PROBLEM OF THE APPEARANCE OF CRACKS IN THE ROTOR STRUCTURE OF THE HYDROGENERATOR

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Introduction. Hydrogenerators (HG) are synchronous salient-pole electric machines in the vast majority of vertical execution, however, there are also horizontal ones, which are called capsule HG (Fig. 1).

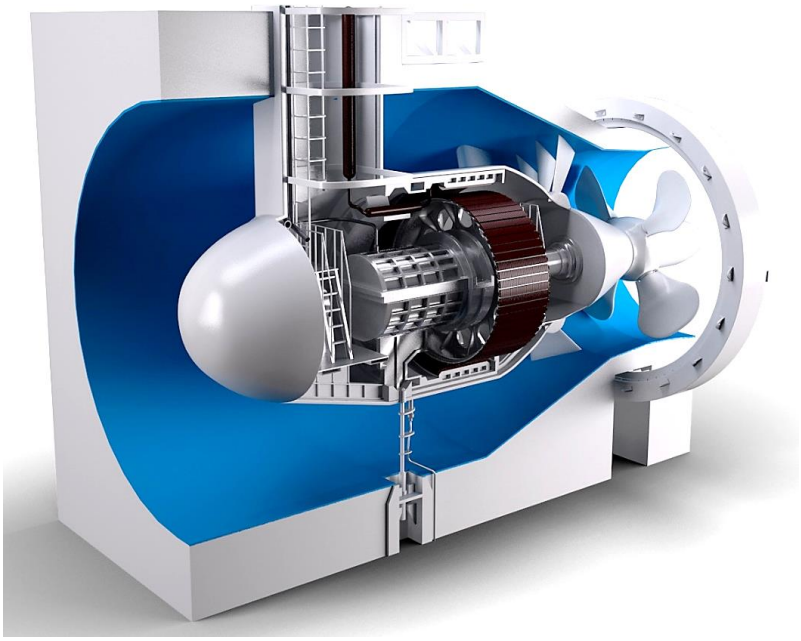

Figure 1 – Capsule HG [5]

HG of the vertical suspended type are used in high-speed hydraulic units. They are the optimal solution for fast-moving HG. Their main advantages are greater mechanical stability of hydraulic power units [1].

When creating low-pressure channel and tidal power stations, there is a need for HG of the capsule type. The horizontal hydroturbine, structurally related to such a HG, forms a sealed hydrounit of a streamlined shape, which works directly in the water flow. This type of HG makes it possible to speed up the process of construction of hydraulic structures, reduces the amount of concrete work, and shortens the distance between the axes of the units.

The main advantage of the capsule type is optimal reliability. The average working life of HG is at least 7 years, and the service life reaches 40 years or more. On average, their operating mode reaches as much as 27,000 hours [1].

In Ukraine, this type of HG has been used at the Kyiv and Kaniv HPPs since 1964. Abroad, such equipment is installed at the Klosterfoss HPP in Norway, the Purnari-2 HPP in Greece, the Mukerian HPP in India, and others.

One of the dangerous types of damage for the functioning of the entire HG is the appearance of cracks in the elements of the rotor, which can lead to its destruction. Most often, cracks occur due to overloading of the rotor shaft or due to the low quality

of the materials of its elements. It is extremely important to detect this type of damage at an early stage of its occurrence.

The goal of the work. Determine the conditions for the occurrence of cracks in the structure of the rotor of the HG.

Materials and research results. Fatigue is an area of mechanical engineering that has been well studied recently. This phenomenon is the cause of a considerable number of mechanical malfunctions in machine elements. Because of this, the fatigue analysis of a complex product was invented to determine its durability, which becomes very difficult if performed by analytical calculations without the use of modern software.

With the help of analytical calculations or with the use of software, engineers have long sought to investigate the issue of material fatigue of various complex mechanisms, in particular, HG rotors. The method of finite elements, which is used in modern software of this direction, is an effective way of implementing field calculations, thanks to which it is possible to check possible failures of machine components due to fatigue of materials. Since the manifestation of such effect in HG rotors is not widespread, it requires a detailed study. The results obtained from the research using ANSYS software showed that cracks in the HG rotor can often occur due to material fatigue. In article [2] it was demonstrated that the applied method is very accurate if it is used correctly and that it gives results that correspond to reality.

Characteristic types of damage of the blades of HG impellers, which usually work in corrosive-active environments at a high level of static and cyclic loads, are: corrosive and erosive wear, cracks and possible bends.

During the operation of HG, cracks may form in the blades of the impellers in some cases: in radial-axial turbines – on the outlet, and sometimes on the inlet edges of the blades in the places of connection with the rim; in rotary vane turbines – at the leading edges of the blades, at the junction of the leading and peripheral edges, as well as in the flange-to-blade flanges.

To repair a crack on the blades of the impeller at the leading or trailing edges, a hole is drilled at the end of the crack to prevent its further development. At the place of the crack, a sample of material (preferably X- or K-shaped) is processed mechanically to deposit metal on both sides of it. The sample is welded, starting from the end of the crack to the edge. The surface of the samples should not have sharp corners, the edges should be smooth, the shape and dimensions should ensure the availability of welding.

When welding low-carbon steels with electrodes of the E-42A type, in order to reduce the stresses and prevent possible deformations, welding is performed with hammering of the deposited metal with pneumatic hammers (chisels with a rounded cutting edge with a radius of 2 mm). The first and last rolls or layers are not hammered, so as not to cover cracks that may have formed. Recently, to prevent the development of a longitudinal crack at some distance from its ends, grooves are cut or polished, which are then welded with a viscous electrode. After controlling the surface, it is cleaned to a metallic luster by removing the etched layer [3].

On (Figure 22) are shown the types of pole attachment to the rotor: a – by bolt (screw); b – with the help of shanks; c – comb-shaped [4]. As for the HG rotor itself,

when fixing the pole with a dovetail, cracks can appear on the rim of the rotor on the side of the loaded groove, as well as on the pole in the thinnest place of the dovetail or T-shaped shank. When using a comb fastener, ring cracks may occur in the places where the bolts are located, as well as on the pole in the places where the pole meets the rotor shaft.

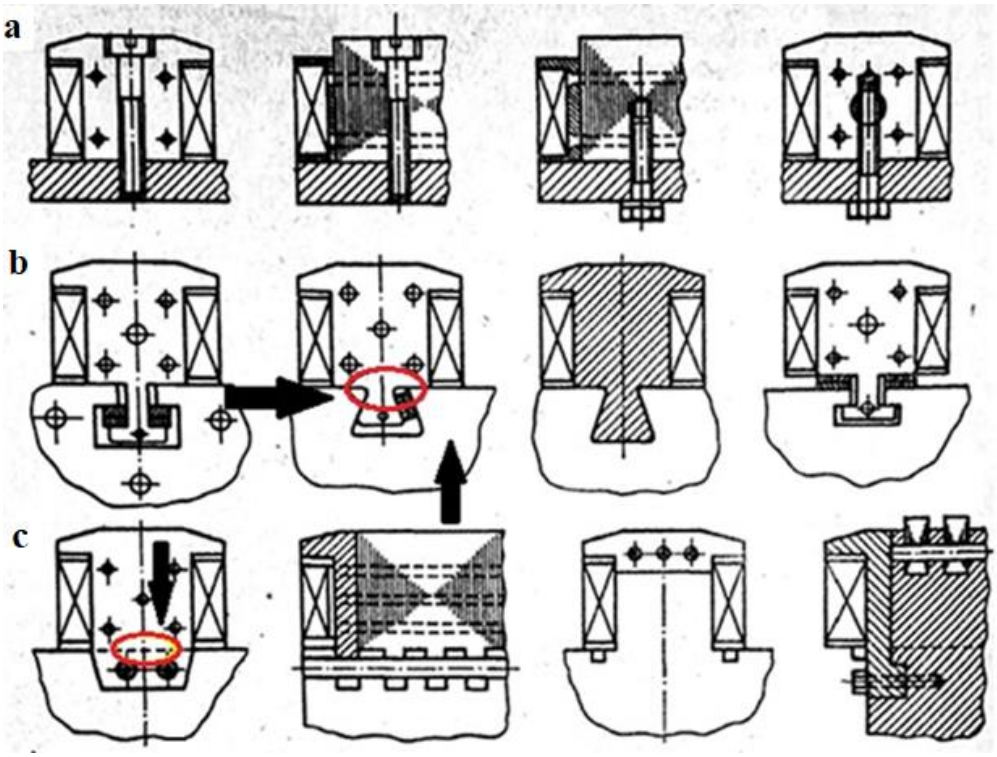

Figure 2 – Types of fixing poles to the rotor: a – by bolt (screw); b – with the help of shanks; c – comb-shaped [4].

Conclusion. Hydrogenerators are a very popular type of electric machine used to provide electricity to modern cities. HGs work in difficult conditions and are quite complex in their design. One of the reasons for the appearance of cracks in the HG rotor elements is material fatigue and local excess mechanical forces in the pole cores.

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