EXPERIENCE IN OPERATING HYDRAULIC STRUCTURES AND EQUIPMENT OF HYDROELECTRIC STATIONS
CORROSION OF EMBEDDED PARTS OF INTAKE WORKS OF THE MINGECHAUR HYDROELECTRIC STATION

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Earlier investigations of the corrosion of hydraulic structures were concentrated on an evaluation of the reliability and behavior of various elements of the mechanical and hydro-power equipment of hydroelectric stations and their protection from corrosion with the use of various methods. The least vulnerable, easily protected part of structural elements was examined in a general analysis of the state of corrosion of the structures, i.e., these investigations were carried out for objects which by their nature can be dismantled without particular technical difficulties during operation of the stations, repaired by the usual methods (by repair welding of defects), or protected (painting, etc.) without dismantling.

During the investigations the main problem was the selection of the most economical and reliable method of protecting gates and trash racks, which can be dismantled for repairs. Elements of hydraulic turbines, including runners, gate apparatus, and pit linings, are amenable to repair. Protection of the inside surfaces of pressure conduits surge towers, and other objects against corrosion after their draining is also possible.

Only those elements which are constantly under water, including at great depths, and cannot be dismantled cannot be inspected and protected from corrosion by the usual method. The embedded parts of structural elements are such elements subjected to especially harsh external effects.

However, necessary attention has still not been devoted to problems of their corrosion behavior and methods of their protection. At the same time, in many respects the normal operation of the entire complex of hydraulic structures depends on their reliability and condition. Disturbance of the working condition of the embedded parts can cause difficulty in operating the gates and racks. To eliminate such defects it is necessary to conduct complex diving operations. Failure of individual embedded parts can lead to the occurrence of emergency situations and the need to conduct complex repair works to eliminate defects and even to disruption of the normal functioning of equipment.

Embedded parts of hydraulic structures are subjected to all corrosive effects characterizing the working conditions of all metal elements of hydraulic structures (i.e., corrosion, mechanical, ice, and biological effects). There are also additional factors making the working conditions of these structural elements still worse. The formation of crevice corrosion in the gaps between the slides of the gates and the embedded parts is possible on embedded elements. When manufacturing individual sliding elements of gates from high-alloy steel, the formation of macrocells between the high-alloy steel of the gate and low-alloy steel of the embedded parts is possible. Simultaneously with this, the effect of aeration macrocells occurring between parts of the structural element located at different depths and of the macrocells occurring on metal at the contacts washed by water and parts of the structural elements contacting the concrete occur. We will give the results of investigating the state of corrosion of embedded parts for the example of the hydraulic structures of the Mingechaur hydroelectric station.

The potentials of these hydraulic structures were investigated, which made it possible to analyze the character of processes causing corrosion of embedded parts and to propose methods of preventing them. One of the main factors causing corrosion of large structural elements is the formation of macrocells on their surfaces, the cause of which is heterogeneity of electrode processes at the boundary of the metal with the environment. This heterogeneity can have the most diverse origin — physicochemical under the effect of aeration cells, mechanical, thermal, or biological — but it always leads to the same factors determining corrosion, viz., the occurrence of a potential heterogeneity at the boundary of the metal with the environment. This situation is common for all metal structures, including for those of hydro-stations and, in particular, for their embedded parts.

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Therefore, it was first of all necessary to study the effect of heterogeneity, which could be done only on the real metal structural elements of embedded parts of hydraulic structures under the actual conditions of a hydrostation subjected to a large number of factors acting on them. The majority of these factors act not only on the embedded parts but also on all metal structural elements of a hydrostation contacting water. However, for the embedded parts there are special conditions which intensify all other corrosive effects — interaction between the reinforcement of reinforced concrete and the steel of the embedded parts. The results of investigating such cells under laboratory conditions are given in Table 1. The reinforcement of the reinforced concrete contacts the embedded parts of hydraulic structures by means of strong arc-welded joints and forms with them a common single electrical circuit. At the same time, the reinforcement is in contact with the external environment through the layer of concrete, hydration of which provides a high-alkaline medium at the boundary of the reinforcement with the water electrolyte, under the effect of which the electrode potential of the reinforcement shifts to the positive region compared with the potential of the embedded parts. As a result of this, a macrocell occurs, the cathode of which is the reinforcement of the reinforced concrete. Anodic polarization caused by the effect of such a macrocell intensifies all other corrosive effects.

As is seen from the data in Table 1, the primary potential difference between the metal and reinforcement, reaching very large values, can lead to the occurrence of large current densities. However, they rapidly decrease with time. This process of decay occurs as a consequence of rapid "denobling" of the cathode — the reinforcement in the concrete.

Figure 1 shows a decrease of the current density in couples with a ratio of 1:1 and 3:1 between the surface of the reinforcement in the concrete and the steel contacting water. As is seen from Fig. 1, the greater this ratio, the greater the anode current density occurring on the surface of the bare steel electrically connected with the concrete reinforcement. As is seen from Fig. 2, not only that part of the reinforcement which is located in underwater structural elements and whose potential can relatively rapidly be "denobled" but also the reinforcement located in water-saturated concrete above the water level, where moisture penetrates under the effect of osmotic pressure, can participate in the formation of such couples. In this zone, where the hydrolysis products are washed out considerably more slowly than in the underwater zone, areas of considerable passivation can occur.

A comparison of the polarization characteristics (Fig. 3) of steel 1 and reinforcement 2 shows that the occurrence of corrosion in reinforcement and mechanical equipment electrically connected to concrete structural elements can be caused by the occurrence of different types of corrosion couples. They include: between the reinforcement in the above-water and underwater zones contacting concrete with a different degree of hydrolysis; between the reinforcement of concrete structural elements and bare metal directly contacting water; between exposures of the reinforcement in defects of the concrete and reinforcement in the concrete; between reinforcement of reinforced concrete and embedded parts of structural elements.