WORK OF THE LENINGRAD METAL FACTORY INDUSTRIAL ASSOCIATION TOWARD MODERNIZING HYDRAULIC TURBINES AT EXISTING HYDROELECTRIC PLANTS

V. M. Malyshev

Long observations on the state of hydraulic turbine equipment made by the Leningrad Metal Factory Industrial Association and analysis of experience with its operations in different power systems make it possible to determine the operating characteristics of different hydraulic turbine assemblies and to evaluate their reliability. Systematization of the results of such analysis has led to the need for performing designs and technical studies as well as to the carrying out of experimental investigations. Also, general trends which determine the basic work directions have been found. In particular, it has been established that at several hydroelectric plants there has been substantial wear of the bearing sleeves of the guide vanes as well as of the sealing devices and that significant cavitation damage has occurred in the internal passage elements. In various machines cracks have developed in the runner blades, wear of the shaft casings in the turbine bearings has occurred, and normal operation of the bearings themselves has been disturbed. On the other hand, in connection with the general progress in the power field, the requirements on the level of equipment effectiveness and increase in the intermaintenance period have been made more stringent.

Continual search for possibilities for improving the design of hydraulic turbines and increasing their reliability undoubtedly lead to results which are the basis for feasible modernization. Systematic work of the Association with a view to improving the fabrication quality of hydraulic turbine equipment is also an essential factor in the problems of development of more reliable assemblies. In the last few years the Leningrad Metal Factory (LMZ), jointly with workers at the hydroelectric plants and in the power systems, has made a considerable effort to introduce and perfect more reliable types of assemblies, as well as to implement measures which substantially improve the operating effectiveness and increase the intermaintenance period. Especially significant work has been carried out in the Niva, Tuloma, and Chirchik hydroelectric plant systems, as well as at the Bratsk, Bukhtarma, Krasnoyarsk, Farkhad, and other hydroelectric plants.

In this article, the writer describes some results of work conducted by the LMZ to modernize hydraulic turbine equipment, which can be used for solving modernization problems at other hydroelectric plants. It has been necessary to devote considerable attention to the friction assemblies in guide vanes. Long operation has inevitably led to gradual wear of the bearing sleeves of the guide vane pivots. According to the statistics, in the Soviet hydroelectric plants there is equipment with a total capacity of 6 million kW which has been operated for more than 20 years. This undoubtedly has built modernization of guide vane supports into a large-scale problem. The main direction of this work is the development of synthetic materials, capable of maintaining their initial dimensions under operation in water and possessing good antifriction properties. Different alternatives for bearing sleeves have been worked out, whose operating stability has long been verified under laboratory conditions and directly at the hydroelectric plants. It has been found that use can efficiently be made of bearing sleeves based on an epoxy-glass composition which ensures low coefficients of friction (to 0.1) and low wear under unit pressures of up to 400 kg/cm². For the base, as reinforced part, use is made of glass fiber impregnated with ED-20 epoxy resin containing a polyfluoroethylene hardener [1]. The fabricated sleeves are placed in the metal rims, using a special glue, and the rims are installed in sockets or directly in the turbine cover. The labor involved in fabrication of such sleeves is low and the cost of the materials is about 2 rubles per kg. In combination with the covering of the supporting pivots of the guide vanes
by corrosion-resistant jackets, the use of the above-mentioned synthetic sleeves makes it possible to substantially increase the reliability and durability of the assembly.

Such modernization measures were implemented at one of the Niva hydroelectric plants, where the bronze sleeves of the guide vane pivots had undergone considerable wear, reaching 3 mm along the diameter. In August 1976 the guide vanes of unit No. 1 of the Niva-2 plant were equipped with pressed sleeves made from a polymer antifriction material and the friction assemblies were fully reconstructed by covering the pivots with stainless steel and installing rubber cups. At the Niva-3 hydroelectric plant the friction assemblies of the guide vanes of unit No. 1 were replaced. In accordance with the factory recommendations, sleeves with antifriction polymer layers were installed, the pivots were covered with stainless steel, and cups were installed. In the future it is planned to install polymer sleeves in all the units of this hydroelectric plant system. At the present time the LMZ is in charge of technical direction for establishment of a section for fabrication of sleeves with polymer layers at these hydroelectric plants.

Similar work has been performed in the Chirchik hydroelectric plant system. In 1974, at a specialized maintenance enterprise of the system and under the technical direction of LMZ workers, a section was established for fabrication of sleeves with antifriction polymer layers. At the present time, four units of the F. G. Loginov hydroelectric plant and one unit of the Tavak hydroelectric plant have sleeves with polymer layers. The wear characteristics of the bronze sleeves and the reconstruction work for the friction assemblies are similar to those of the Niva hydroelectric plant system. In the Chirchik system use of the new antifriction material in the pivot supports of the guide vanes significantly simplified the design and made it possible to eliminate the system of centralized supply of thick lubricating oil, which not only resulted in a saving in bronze and oil, but also considerably increased the operating reliability of all units. Inspection of the sleeves on one of the Chirchik plant units after one and a half years of operation showed that these sleeves had experienced practically no wear.

The successful experience with operation of synthetic sleeves in guide vanes has made it possible to extend their introduction also into runners of Kaplan turbines. In the turbines of the Upper Tuloma hydroelectric plant there was significant wear of the runner bronze sleeves, which reached 1.5 mm along the diameter. The wear was attended by considerable oil leakage from the runner. During the major maintenance period (December 1976 to May 1977), in the runner of unit No. 3 the bronze sleeves in all the friction assemblies of the runner were replaced by experimental sleeves with antifriction polymer layers. Subsequently, major maintenance was performed by replacing the sleeves also in unit No. 4.

One of the most widespread phenomena requiring periodic repairs is cavitation erosion of elements of the internal passages of hydraulic turbines. At several hydroelectric plants the periodicity of major maintenance is determined by the need for opportune repair of cavitation damage. An essential circumstance in this regard is the operating condition of the hydraulic turbine during the initial period. The widespread trend toward placing units in operation with partially-filled reservoirs and using the design runners has generally led to significant cavitation damage and to a corresponding need to apply a large volume of reconstruction coatings. In this connection, the techniques recommended by the factories have not always been adhered to. All this has resulted in inevitable distortion of the design geometry of the runner blades, which has additionally intensified the erosion. At the LMZ, systematic investigations have been performed both in laboratories and at existing hydroelectric plants, simultaneously in several directions, namely: a) study of cavitation resistance of different materials and electrode coatings; b) study of the nature and basic laws governing cavitation destruction; c) development of measures for reducing the intensity of cavitation erosion; d) reconstruction of spots subjected to cavitation destruction. These investigations have made it possible to determine the basic laws inherent to cavitation erosion and to work out effective recommendations for reducing the destruction, which could be carried out by local forces under the direction of specialists from the factory [2, 3].

These recommendations consist in the following: a) the reconstruction coatings should be applied with special electrodes, taking into account the blade dimensions and materials; b) after application of the reconstruction coatings it is necessary to carefully polish the surfaces and to exert due control on the agreement between the reconstructed surfaces and the