WAYS TO INCREASE THE RELIABILITY AND OPERATING LIFE OF HYDRAULIC TURBINE EQUIPMENT WHEN RECONSTRUCTING HYDROELECTRIC STATIONS

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In accordance with established practice and the standards, the service life of hydraulic turbine equipment at hydroelectric stations is 30 years. At present half of the hydrostations in countries of the Commonwealth of Independent States have been operating 30 and more years. By 2000 the majority of hydrostations constructed in the years of Soviet power will reach 30 years of operation. In connection with this arises the serious problem of reconstruction and reequipping hydrostations with replacement of the main and auxiliary hydropower equipment by new, improved equipment which would meet current requirements [1, 2].

A survey of the state of equipment at hydrostations that have operated 30 and more years indicates that it is worn out and obsolete. The equipment requires more frequent repairs with increased expenditures on conducting repair and restoration works. As a result of wear, the technical and technical—economic indices of the turbines have decreased substantially. This led to a decrease of the efficiency of using the equipment and flow, which inflicts economic loss. Worsening of the efficiency of using hydrostations that have exhausted their life will continue during further operation.

To maintain a sufficient level of operating efficiency of hydrostations, a radical renovation of the main and auxiliary equipment is needed. Selective partial reconstruction forced due to financial difficulties and renovation of equipment, just as measures on prolonging its operating life, do not solve the problem. This to some extent can reduce its acuteness for a certain time, but the needed efficiency and reliability of operation of the units will not be achieved. To provide a high technical level of reconstructed units it is not enough to simply replace the equipment with restoration of its former parameters and characteristics.

Considerable scientific and technical progress has been made in the area of hydropower engineering and hydraulic turbine manufacture during the past 30-40 years. Thus, for example, the level of efficiency of turbines has increased 3-5%, the cavitation characteristics of all types of hydraulic turbines have improved substantially, the specific speed has increased, new designs have been found, etc. It is completely obvious that all scientific and technical achievements presently available should be incorporated in the equipment being renovated at hydrostations.

However, the achievement of modern characteristics and parameters of the units at hydrostations being reconstructed is a difficult scientific and technical problem. This is explained first of all by the fact that the waterways and reinforced-concrete blocks of the units made 30 years ago differ from modern ones in their parameters and configurations. It is not possible to change them substantially at operating hydrostations. The installation of new runners with different blade systems in the old waterways cannot completely meet the requirements imposed on the new equipment. In connection with this, the approaches to the creation of equipment for hydrostations being newly constructed and reconstructed should be different. On the basis of the individual characteristics of various hydrostations, the extent and character of their reconstruction can be different. At the same time there exist paramount tasks concerning all hydrostations to be reconstructed and reequipped. Such tasks include:

- provision of a new, at least 30 year, service life during which the equipment should operate efficiently and reliably;
- increase of the single capacity of the units in the same unit block;
- more complete automation of technological processes and outfitting hydropower stations with diagnostic systems.
- Environmental protection measures should be carried out when reconstructing the hydrostations, etc.

The technical level of the equipment being renovated and the efficiency of the further use of the flow at the hydrostations being reconstructed will depend completely on the degree of accomplishing these tasks. The maximum effectiveness
from reconstruction can be achieved with the most complete replacement of the worn equipment and partial change in the parameters and configuration of the waterways of the unit blocks. Technically, this is a feasible task, although it requires additional expenditures. But if there are such possibilities, then it is expedient to take all measures which provide a modern level and operating efficiency of the units during the entire service life. Unconditionally, these additional expenditures will be paid back in a short time. At the same time, any additional expenditures related to a change in the waterways and replacement of equipment should be scientifically founded, since each particular hydrostation has individual characteristics and the same changes in the waterways will be effective differently. Therefore, appropriate investigations, from which it could be seen that particular results will produce various changes, should be carried out in the projects.

One of the important tasks which should be accomplished when reconstructing hydrostations is an increase of the power and cavitation characteristics of the turbines. This technical task can be accomplished almost always, although it requires a certain amount of calculation and experimental works at the turbine manufacturing plants. This is explained by the fact that in recent years new, improved methods of hydrodynamic calculations of blade systems of hydraulic turbines with the use of modern computing machinery have been created which make it possible to create highly efficient blade systems of hydraulic machines with smaller expenditures of time on conducting calculation and experimental works. Furthermore, at present, many turbine runner blade systems with high power and cavitation indices at all ranges of heads have already been created. The installation of these runners even in old or partially altered waterways will improve the power and cavitation characteristics of turbines. Of course, they will be somewhat inferior in their level to the turbines created for newly constructed hydrostations, nevertheless, their level will be sufficiently high. Partial alteration of the waterway of the unit block will also promote improvement of the power and cavitation characteristics of reconstructed turbines.

Another important task which is set when reconstructing hydrostations is an increase of the single capacity of the units. This is explained by the fact that the parameters of the hydrostation and turbine equipment were selected with consideration of the particular conditions and requirements which occurred in that historical period in which a particular hydrostation was constructed. During 30 and more years of development of hydropower engineering these conditions and requirements changed, which is reflected in the hydrostation reconstruction projects. However, at operating hydrostations the possibilities of increasing the single capacity of the units are limited. An increase of capacity can be achieved due to the following main factors: the use of faster turbines with high cavitation characteristics, the use of the safety margins with respect to cavitation and opening of the gate apparatus, increase of the design head, etc. The expediency of increasing the single capacity of the units is determined as a result of appropriate technical—economic calculations and design studies for each particular hydrostation.

However, one of the most important factors which can become decisive when solving the problem of increasing the capacity of the units being replaced is often not taken into account here to a sufficient degree. This concerns provision of a new (at least 30 years) service life and high reliability of operation of the renovated equipment. The simple replacement of old units by new ones with higher power and cavitation characteristics still does not mean that they will operate more reliably and efficiently. Moreover, an increase of the single capacity by increasing the specific speed and boosting the regimes, as a rule, is related to the occurrence of more developed unsteady processes in the waterway of the hydropower station. This, in turn, leads to the occurrence of more considerable dynamic loads acting on the blade system and support assemblies of the units. Increased dynamic loads on the runner lead to fatigue failure of the blades, increased vibrations, and decrease of the operating reliability of the hydropower equipment. Practice confirms that replacement of equipment without due evaluation of the dynamic processes caused serious difficulties in assuring reliable operation of the units. In connection with this it should be acknowledged that to solve the problem of increasing the single capacity of the reconstructed units it is insufficient to limit oneself to power, cavitation, and pulsation tests of model turbines. For this it is necessary to conduct special investigations of dynamic processes and to take appropriate measures to provide operating reliability of turbine equipment. Without this an increase of the single capacity of the units cannot be considered justified.

The problem of providing operating reliability of turbine equipment during the entire newly established service life is presently acquiring great urgency, since the efficiency of using hydrostations depends substantially on it. At the same time, long experience in operating units at many hydrostations indicates that reliability, and especially dynamic reliability, is not always provided even under the design operating conditions of the units. This problem is complicated at hydrostations being reconstructed, since runners with new blade systems are installed in old waterways. Therefore, in recent years turbine equipment customers have been imposing ever greater demands on providing dynamic reliability with giving them the appropriate scientific substantiations.

An increase of the operating reliability of turbine equipment is a complex scientific and technical problem dependent on the effect of many factors. It cannot be solved just by increasing the quality of manufacture, although this is important. A