READERS’ LETTERS AND COMMENTS

CONCERNING OPERATION OF THE POWER EQUIPMENT AT THE ZAGORSK PUMPED-STORAGE STATION*

A. A. Zakharov and M. M. Cherepanov

The series of articles in Gidrotekhnicheskoe Stroitel’svo, No. 4, 1996, devoted to the experience of operating the power equipment of the Zagorsk pumped-storage station (PSS) is quite interesting and useful. The systematized and generalized materials will undoubtedly be useful for the development and formation of water storage in domestic hydropower engineering, being, moreover, the grounds for a useful and fruitful discussion. Precisely in this respect we would like to express some comments concerning individual points which are ambiguous or not touched upon in the given materials or simply supplementing them.

Concerning Direct Asynchronous Starting. In the articles "Characteristics of the Design, Assembly, and Experience in Operating the Generator-Motors of the Zagorsk Pumped-Storage Station" and "Methods of Starting the Reversible Units of the Zagorsk Pumped-Storage Station in a Motor (Pump) Regime" a conclusion was made about the need and advisability of rejecting this starting method, including due to a decrease of the operating reliability of the unit. Such a conclusion was first substantiated in [1], which the authors cite, as long ago as 1985; unfortunately, 1995 is erroneously indicated in the citation to the article. Of recent works it is necessary to mention [2], where various methods of starting in a pump mode are described in detail and a decrease of the reliability of the equipment as a result of direct asynchronous starts is mentioned. Using the experience gained in operating the Zagorsk PSS, the authors convincingly confirm the technical and economic inexpediency of direct asynchronous starts of high-power generator-motors.

At the same time, the viewpoint is rather widespread that the generator-motor designed for direct asynchronous starts is more reliable than the usual one owing to the massive poles on the rotor, special high-power damper system, and strengthened fastening of the stator winding, and these considerations are also completely valid. To clarify this contradiction it is necessary to clearly separate the pluses and minuses of the matter. Concerning the minuses: the shortcomings of a generator-motor with a direct asynchronous start are caused by this requirement of a direct start. Precisely it compels introducing an additional reactance into the design of the machine for reducing the starting current, i.e., actually, that current-limiting reactor which is used in an asynchronous reactor start with a low voltage. Precisely for this reason deep stator slots with magnetic shunts were made and the number of turns of the stator winding was increased, which led to a decrease of reliability of the stator [1]. The starting current-limiting reactor is used, however, only during starting and then is taken out of operation. The designs increasing the reactance of the generator and useful only when starting in a pump mode are harmful during the entire time of operation of the unit with a load. Concerning the pluses: actually, the use of massive poles, high-power damper system, and strengthened fastening of the stator winding in high-power generator-motors increases their reliability. During operation of the Zagorsk PSS a case occurred when the unit in a pump mode lost excitation but remained connected to the supply line. The rotor was turned by water in the generator direction of rotation and rotated for a certain time until the unit was disconnected manually. Only the massive poles and high-power damper connectors enabled the unit to remain in commission, the usual generator-motor would have been damaged. Thus, the design of massive rotor poles with high-power connectors is "superreliable," but it should not be uniquely tied to direct asynchronous starting. It has the right to an independent existence, although it is more expensive to carry out. A generator-motor without direct starting but with massive poles and high-power damper connectors will be maximally reliable but more expensive. The expediency of its use should be determined by a technical and economic analysis.

*Response to a group of related articles published in the journal Gidrotekhnicheskoe Stroitel’svo, No. 4, 1996.

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Shaft Seal. In the article "Hydropower Equipment of the Zagorsk Pumped-Storage Station: Design Features and Operating Experience," efforts to improve the factory design of the turbine shaft seal not having sufficient reliability during operation, which did not lead for now to positive results, are described. In this connection we want to mention [3], which gives an analytical solution of the performance conditions of such a seal, from which are seen the causes and way to overcome the existing difficulties. This material did not find any operators' evaluation although is can be completely useful.

Preturbine Gate. In the articles "Analysis of the Principal Scheme and Layout of the Main Hydropower Equipment at the Zagorsk Pumped-Storage Station" and "Hydropower Equipment of the Zagorsk-Pumped-Storage Station: Design Features and Operating Experience," the question is raised about the advisability of installing a preturbine gate on the upstream side at newly planned PSSs. The grounds for this are the increased water leaks through the closed gate apparatus (CGA) at the Zagorsk PSS, which led to water losses from the upper reservoir, large active power consumption in the synchronous capacitor (SC) regime, and increased vibrations of assemblies in the synchronous capacitor regime with a pump direction of rotation (SCP).

The posing of this question itself is logical. However, first of all the question arises about the magnitude of the leaks. Such data are absent in the article. The unsatisfactory estimates of the leaks through the CGA at the Zagorsk PSS are valid, but are qualitative and are based on indirect indices. The known methods of measuring leaks through the CGA are rather labor-intensive and are quite rare in operating practice. The author developed a very simple method of determining leaks through the CGA taking quite little time and not requiring high skills of the doers. The method, owing to its simplicity and minimum expenditure of time, can serve as a means of quick diagnosis of the technical state of the gate apparatus, since it makes it possible:

- without draining the unit, to quickly evaluate the working order of the gate apparatus in the event of the occurrence of any defects;
- to plan beforehand repairs of the gate apparatus, following the change in leaks with time;
- to evaluate the quality of the works performed when putting new turbines into operation or after overhauling the gate apparatus.

Measurements of leaks through the CGA taken by this method on three units of the Zagorsk PSS gave results of 0.36-0.69-0.75 m³/sec for a norm of 0.5 m³/sec. These figures indicate available unused possibilities of bringing the leaks to the norm because if one of the units has leaks below the norm, it is possible to bring the others to the same state. The article "Reconstruction of the Design Technology of the Synchronous Capacitor Regime of the Units at the Zagorsk Pumped-Storage Station" mentions increased air losses from the runner pit in a SC regime. The large water leaks through the CGA are also the main cause of this, bringing them to the norm will make it possible to solve also the problem of air losses from the runner pit.

Thus, a quantitative analysis of water leaks through the CGA should be the first stage of examining the expediency of installing preturbine gates, and the method of measuring leaks deserves wide testing and use in operating practice.

Economy of Storing Water. In the published materials undeservedly little attention was devoted to the economy of the technological schemes of PSSs, primarily the all-out reduction of technological discharges from the upper reservoir. The water of the upper reservoir is lifted in the pump regime and therefore is very expensive. It seems that here there are considerable reserves which should be used. We can name the following:

- provision of the heat- and water-supply system (HWS) with water from the upper reservoir in the presence of two (primary and backup) pumps of the HWS from the lower reservoir is not advisable. It is hardly worth providing for such a wasteful backup;
- provision of the oil coolers of the main transformers with water from the upper reservoir can be replaced by water from the lower reservoir. The existing difference of water levels in the lower pool and the levels of installing the oil coolers provide this completely;
- the discharge of water of the upper reservoir for the water—air ejector of the SC regime is hardly justified. There are other sources for covering the air losses;
- bring the water leaks through the CGA to the norm.

Table 1 gives the quantity of peak electricity which can be produced on the water saved during the year. It seems that in PSS projects the technological discharge of water from the upper reservoir should be permitted only for economically substantiated purposes.