ANALYSIS OF THE CONDITION OF EQUIPMENT AT RUSSIAN HYDROELECTRIC STATIONS AND MEASURES TO MAINTAIN ITS PERFORMANCE

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The Russian hydropower industry under conditions of the transformations occurring is one of the most reliably functioning links of not only electric power but also of the country’s entire fuel and energy complex. With a general decline in electric power consumption in recent years, the production of electricity at hydrostations remains stable, depending only on the natural conditions of particular years. In many regions of the country precisely reliable operation of hydrostations is one of the main stabilizing economic factors. Even in dry years (1996 and 1997) the proportion of power production at hydrostations was about 20%, and the proportion with respect to installed capacity relative to the total installed capacity of the country’s power stations was 21.5%.

The fuel effect from power production at hydrostations is presently estimated by the saving of fuel in an average amount of 62 million tons of standard fuel. A considerable part of this saving is provided in energy-deficient regions, which is especially important under present-day conditions. The high efficiency of producing electricity at hydrostations is due to a number of factors, including the constant natural renewability of resources, absence of a fuel component, high labor productivity during operation, comparatively small wage disbursements, high level of the production process, and comparatively slow wear and tear of the fixed assets.

The low cost of power production at hydrostations has a significant effect on the level of electric power rates. In 1997 the average rate for electricity of a hydrostation joint-stock company being delivered to the FOREM system was 25.83 rubles/kWh (in nonominated prices), which is lower than the rate of delivering electricity of a state regional power station joint-stock company – 210.74 rubles/kWh, of a nuclear power station – 149.66 rubles/kWh, and district power joint-stock company – 125.30 rubles/kWh, by respectively 8, 6, and 5 times. In the absence of hydrostation power the rate for electricity in the FOREM system would be 30% higher. Hydrostations play a considerable role in providing the necessary quality of the power supply, participating in covering the nonuniform part of the daily electric load curves and regulating the frequency and voltage; they promote a uniform operating regime of thermal and nuclear power stations, increasing the reliability and economy of operating the latter; they are used for covering unforeseen changes in the electric load, performing the role of a brief prompt emergency power reserve.

Thermal large-capacity (300 MW and more) power-generating units and large nuclear power station units are the main equipment of Russia’s power system, especially its European part. Their regulating possibilities are limited, especially for the nuclear power station units, and therefore failure of a hydrostation, including because of failure of equipment, will lead to displacement of large units of thermal power stations to the variable load zone, which in a number of power systems is simply impermissible and, in any event, will promote increased wear of the thermal power equipment. Long operation of the majority of hydropower facilities, the insufficient volume of financing works on modernization and repair of equipment, and tightening of its operating conditions led to its substantial wear, and therefore to preserve the existing stock of turbine-generator units it is necessary to develop a long-range program for maintaining hydrostation equipment in an operable state.

The existing stock of hydropower equipment of Russian hydrostations has exhausted its life to a considerable extent. The unsatisfactory state of the equipment due to its physical wear and tear does not permit hydrostations to fully use the general system regime and regulating functions, worsens the operating and economic indices of the hydrostations, lead to a decrease of power production, and creates the danger of unpredictable complete or partial failure of individual hydrostations.

About 400 turbine-generator units of various types and capacity are operating at Russian hydrostations with a total capacity of 43.8 million kW. Most units were put into operation in the 1950-60s, at the same time units put into operation as long ago as the 1930-40s remain in operation. The equipment of these hydrostations has exhausted the standard service life and is at the brink of physical deterioration, which is confirmed by the increasing number of
failures of the equipment and increase of downtime of the units under repair. Only the high quality and durability of the domestic hydropower equipment produced earlier make it possible for now to keep in service the equipment that has used up its standard life.

Long operation of worn equipment at hydrostations under conditions of its tightening operating regimes leads to the following negative consequences:

1. More than half of the incidents and failures of hydrostation equipment is caused by wear of the components and parts. Damages to turbine runners, runner pits, and turbine bearings became more frequent, i.e., the main components of a unit whose restoration requires its complete dismantling with taking it out of operation for a long time.

2. In recent years the actual downtimes of units under repair have exceeded the standard time by 3-3.5 times and more, the time between servicing at some hydrostations has been shortened to 2-2.5 years instead of the 5-7 years standardized by the technical operating regulations. Here, owing to the difficult financial situation of hydrostations and of the industry as a whole, the number of units being repaired is decreasing. Due to repair downtimes the proportion of hydrostations in covering the required power in power systems is decreasing, the underutilization of the capacity of hydrostations on passing through the annual maximum is reaching 12-14% of the installed capacity of hydrostations.

3. Equipment maintenance costs are increasing sharply, their proportion in the cost of producing electricity at hydrostations that have been in operation for a long time is reaching 20-25% and are trending toward a further increase.

4. The weighted average efficiency of the equipment is decreasing, underproduction of electricity during the flood is occurring due to long repair and reequipping downtimes, and the environmental characteristics of the equipment are becoming worse.

Planned modernization of the equipment was carried out in the 1970-80s. In the mid-1980s a large-scale reconstruction program was developed, which could be accomplished only provided centralized financing, and industry began its realization. But even at that time this program was not completely fulfilled because of the lack of funds. Complete replacement of hydropower equipment was done only at the Lower Tuloma and Iova hydrostations and on a number of units of the Kuban sequence of hydrostations. Only generator and turbine equipment was modernized at other hydrostations. Under today's conditions the fulfillment of such a program is becoming simply unrealistic.

At present the financial possibilities of hydrostations permit fulfilling only partial volumes of works on equipment modernization. With consideration that the complete replacement of equipment at multiple-unit hydrostations will actually occur over the course of a long time, the optimal method of keeping the units in an operable condition for a rather long time (10-15 years) is to carry out expanded overhauls with replacement of individual turbine and generator components and parts. Such a combined scheme of performing the works is being used today at the Volgograd, Saratov, Volga, and a number of other hydrostations.

It should be noted that the works carried out in recent years on complete replacement of turbines (Rybinsk, Volgograd, and Volga hydrostations), the cost of which, as is known, is always equal to or even greater than the cost of foreign analogues, showed the low quality of the equipment being supplied by the Leningrad Metals Plant (LMZ). Under conditions of a financial deficit, the operating service is forced to spend considerable funds to eliminate purely plant defects.

In conclusion it is necessary to note the following:

1. The situation that has developed with the replacement of equipment of the Rybinsk, Volgograd, and Volga hydrostations once again poses the question of the need to inspect equipment at the manufacturing plant before operation.

2. The standard guidelines for delivery of new equipment (TT, TU, TZ) should undergo an independent expert evaluation. Equipment delivery contracts must provide for fines when the manufacturer does not meet obligations with respect to the quality of the equipment delivered based on labor input to eliminate the defects revealed during installation.

3. When carrying out expanded overhauls with replacement of individual components and parts, it is necessary to conduct mechanical check tests before and after overhaul, using the recommendations and methods of the State Trust for the Organization and Improved Efficiency of District Electric Power Stations and Networks (ORGRÉS).

4. The need for equipping the units with modern monitoring and measuring instruments is obvious. But the operating service needs, and today this is possible, to determine the optimal number of measurement points and appropriate instruments. Specialists of ORGRÉS, which in the past 3-4 years have been analyzing the market of apparatus being offered by various companies, can help in this matter. Furthermore, on the basis of this analysis recommendations were worked out on promising types of apparatus, which after modification can be used both for monitoring vibrations and for diagnostic systems of the hydrostation units.