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COMPARATIVE ANALYSIS OF POWER TESTING METHODS OF HYDROELECTRIC POWER PLANT UNITS

Abstract. The paper considers a comparative analysis of existing methods of energy testing of HPP units, such as relative and absolute method. Energy tests are carried out in order to obtain operational and capacity characteristics of the turbine and units of the hydropower plant, which further allows the personnel of the hydropower plant to operate the turbine in optimal modes. Technical indicators recorded in the process of power testing are analyzed. Positive and negative sides of the methods are considered, appropriate recommendations for their use are given.

Keywords: energy tests, HPP units, absolute method, relative method, HPP turbine operational characteristics, guiding apparatus.

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Introduction. As it is known energy tests of units at hydroelectric power plants are carried out in parallel by two methods: relative method and absolute method. Energy tests are carried out in order to obtain operational and power characteristics of the turbine and units of the hydropower plant, which further allows the personnel of HPP to operate the turbine in optimal modes. This is highly relevant, as it provides the efficiency of the unit turbine, guaranteed by the manufacturers in all ranges of power heads [1].

Materials and methods. As a rule, energy tests are carried out in two stages – preparatory work and energy tests themselves. Two units are selected for testing at the HPP: one is a shoreline unit with an engaged piezometric system, and the other is a channel unit with a good piezometric system too. The choice of these two units is due to the fact that the characteristics of the channel units may differ slightly from those of the onshore units [2,3]. This is due to the influence of backwater and flow distortion at the outlet of the suction pipes by the bank located at an angle to the front of the HPP building. Initially, all energy tests at HPPs until 1959 were carried out only by the relative method and only then the absolute method was introduced with measurement of turbine flow rate by hydrometric turntables. According to the approved general program of power tests of units, all tests are carried out with the determination of turbine absolute efficiency factor, and the modes of tests of units

by the absolute method are selected on the basis of the preceding tests carried out by the relative method. All ranges of load changes and opening of the guide apparatus for different angles of turbine impeller blades turning correspond to certain heads, which ensure the removal of operating characteristics of hydraulic units by the relative method. Propeller characteristics are taken for all the specified angles and heads and the corresponding envelopes are carried out. These data further serve as a basis for selection of optimal modes for all angles, in which velocity measurements are carried out by the propellers.

During the energy tests, the following values are recorded [4]:

1) the mark of the upstream level by four laths installed in the grooves of the emergency gate of the spillway, and the mark of the upstream water level is taken as the arithmetic mean of the readings of all laths;

2) downstream water level mark by two floats with scales fixed on cables, and the floats are installed one by one in each conduit, and the downstream water level mark is taken as the average reading of two floats;

3) opening of the guiding apparatus - according to the scale installed on the servomotor rod of the guiding apparatus;

4) the angle of rotation of the impeller blades - on the scale on the oil receiver;

5) pressure drop in the measuring section of the spiral chamber - by water differential manometer;

6) power of the unit;

7) unit revolutions;

8) load of neighbouring units - by panel wattmeters;

9) head at the turbine as the difference between the levels of the upstream and downstream.

In the process of energy tests by the relative method, at least 3 measurements of the upstream and downstream horizon, power of the unit, pressure drop in the measuring section of the spiral chamber and other parameters were made at each operating mode of the unit. During energy tests by the absolute method, from 2 to 10 measurements of the above-mentioned values are made in the process of flow measurement at each mode [5].

Research results and discussion. Energy tests carried out by the relative method aim at obtaining combined dependences of the above-mentioned quantities without determining the absolute value of the turbine flow rate and efficiency. Instead of the turbine flow rate, the value of the differential drop at two specially selected points in the turbine flow path, proportional to the flow rate, is determined. Instead of the turbine efficiency, a value proportional to it is determined. This method allows to determine the nature of the combined dependence in a short period of time, and hence the combined links, i.e. to determine the most economical modes of operation of the turbine by efficiency. However, this method does not provide an opportunity to determine the absolute value of the turbine efficiency and the guarantee of the manufacturer, to determine the refined operational characteristics of the unit and to clarify the methodology of conversion of the data of model tests on full-scale turbines [6].

The purpose of energy tests carried out by the absolute method is to determine the absolute values of flow rates and efficiency, as well as the dependence of flow rate on head. Measurement of turbine flow rates according to this method is carried out by determining the average velocities using a horizontal turntable row equipped with hydrometric turntables. In order to reveal the actual conditions of the flow approach to the gauging station and to determine the absolute values of flow angles, additional laboratory studies are carried out on a flat model of the water intake using

the EGDA method, and a hydrodynamic flow grid is constructed in a plane close to the longitudinal axis of the unit. Subsequent stages of energy tests of aggregates with flow measurement are carried out at the horizontal position of the axes of vertices [7].

When testing the aggregates by the absolute method, simultaneously with the measurement of velocities along the cross-sections of water conduits and other parameters, the pressure drop in the measuring section of the spiral chamber between the piezometric sensors was measured. Thus, for the same regime points absolute and relative efficiency of the turbine are determined and the corresponding characteristics are plotted. Comparison of the combined coupling curves constructed from the unit test data, both by absolute and relative methods, indicates their complete coincidence. Turbine performance characteristics plotted by absolute and relative efficiency for the same heads have a complete coincidence over the entire power range.

Conclusion. Comparison of the corresponding operating characteristics and combined coupling curves constructed by absolute and relative test results leads to similar conclusions. Thus, the results of the comparison testify to the mutual coincidence of the main energy characteristics obtained from the test data of HPP units by absolute and relative methods.

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СУ ЭЛЕКТР СТАНЦИЯ АГРЕГАТТАРЫНЫҢ ҚУАТЫН СЫНАУ ӘДІСТЕРІНІҢ САЛЫСТЫРМАЛЫ ТАЛДАУЫ

Аңдатпа. Мақалада СЭС агрегаттарының энергетикалық тестілеуінің қолданыстағы әдістеріне, соның ішінде салыстырмалы және абсолютті әдістеріне талдау жасалады. Энергетикалық сынақтар турбиналар мен су электр станция агрегаттарының пайдалану және қуаттық сипаттамаларын анықтау үшін жүргізіледі. Бұл СЭС персоналына турбиналарды оңтайлы режимдерде басқаруға мүмкіндік береді. Мақалада қуатты сынау барысында тіркелген техникалық көрсеткіштер талданады. Әдістердің оң және теріс жақтары қарастырылып, оларды қолдану бойынша ұсыныстар беріледі.

Тірек сөздер: энергетикалық сынақтар, СЭС агрегаттары, абсолютті әдіс, салыстырмалы әдіс, СЭС турбиналарының пайдалану сипаттамалары, бағыттаушы аппарат.

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СРАВНИТЕЛЬНЫЙ АНАЛИЗ МЕТОДОВ ИСПЫТАНИЯ МОЩНОСТИ АГРЕГАТОВ ГИДРОЭЛЕКТРОСТАНЦИЙ

Аннотация. В статье рассматривается сравнительный анализ существующих методов энергетического тестирования агрегатов ГЭС, таких как относительный и абсолютный методы. Энергетические испытания проводятся с целью определения эксплуатационных и мощностных характеристик турбин и агрегатов гидроэлектростанции, что в дальнейшем позволяет персоналу станции управлять турбинами в оптимальных режимах. В статье анализируются технические показатели, зафиксированные в процессе испытаний мощности. Рассматриваются положительные и отрицательные стороны методов, а также даются соответствующие рекомендации по их использованию.

Ключевые слова: энергетические испытания, агрегаты ГЭС, абсолютный метод, относительный метод, эксплуатационные характеристики турбин ГЭС, направляющий аппарат.