EXAMINATION OF TECHNICAL SOLUTIONS ADOPTED FOR THE REPAIR AND RECONSTRUCTION OF EQUIPMENT AT HYDROELECTRIC AND PUMPED-STORAGE POWER PLANTS

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The question as to whether independent examination of technical solutions is needed for the selection of equipment for hydroelectric and pumped-storage power plants has, for some time now, become rhetorical for economically developed countries, but remains significant as usual for Russia, which is converting to civilized relations.

The arguments made by opponents of the examination are normally reduced to the following. There is the relation between the two parties - the Client, who knows clearly his own demands and potential, and the Contractor, who knows to what degree these demands can be met in conformity with the Client's potential. The drawing of independent experts into these relationships represents unjustified additional expenditures, since the qualification and experience of the contractor are usually sufficient for the independent solution of all problems that arise. Here, both parties - Contractor and Client - are interested in highly efficient production.

World practice has demonstrated, however, that the development of hydraulic-turbine building will take another path. A network of independent national laboratories exists, where all newly developed water-power equipment is subjected to mandatory independent examination, and only a certificate obtained from such a laboratory may serve as confirmation of equipment qualities declared by the manufacturer. The practice of bringing in independent specialists (frequently from third countries) to examine the quality of delivered equipment has come into widespread use. When equipment manufactured by the Nongovernmental Organization Turboat (Khar'kov) was delivered for the Pedra del Agil hydroelectric plant (Mexico), the quality of the equipment was examined by specialists from a company in the United States, who were hired specifically for this purpose by the Mexicans.

Mandatory examination of all stages of design work (feasibility study, conceptual design, and detail and contractor designs), which is performed by qualified specialists of leading organizations, had also been specified in the practice of domestic hydraulic-turbine building (within the framework of the USSR).

In all cases, this has contributed to the adoption of more effective solutions that have made it possible to improve the technical and economic level of development. For the Sayano-Shushenskoe hydroelectric power plant, for example, the governmental organization Leningrad Metal-Working Plant proposed a hydraulic turbine with a unit capacity $N_i = 500$ MW under a design head $H_d = 194$ m. In discussing expert conclusions, the AOOT NPO TsKTI advanced an alternative scheme for the solution, which provided for an increased unit turbine capacity $N_i = 650$ MW at $H_d = 194$ m with the same clearance dimensions of the setting, and made it possible to reduce the number of hydraulic generating sets at the hydroelectric plant. Focusing attention on the conclusion drawn by the examination, the plant conducted a set of additional investigations, as a result of which the unit turbine capacity was increased to $650$ MW, and attains $735$ MW under heads above $200$ m in the final alternate scheme.

The history of the development of a new impeller for the reconstructed Volga hydroelectric plants may serve as another example of the importance of the timely examination of technical solutions. Using 40 years of design data on the operating conditions of these hydroelectric plants, the governmental organization Leningrad Metal-Working Plant developed a design for a five-blade impeller. This solution had to be rejected, however, since the combinations of heads and suction heads actually encountered at the hydroelectric plants did not support the nominal turbine capacity (due to cavitation restrictions).

There is currently no obligation for independent examination. Conversion to a two-party Client/Contractor relationship frequently leads to negative consequences for the Client.

Thus, replacement of the standard PL-5A impeller at the No. 1 Vilyuisk hydroelectric plant by a new PL 70/3184 impeller (developed by the nongovernmental organization Turboat, Khar'kov) resulted in a loss instead of an increase in the operating efficiency of the equipment. In graphic form, this is apparent from comparison of the
turbine-performance curves \( (N_t) \) with the standard (PL-5A and new (PL-70/3164) impellers at the most frequently encountered head (Fig. 1). Under the basic operating loads \( (N_a = 25-65 \text{ MW}) \), the turbine now operates at a lower efficiency than that prior to the impeller’s replacement. These curves were calculated from results of model investigations of corresponding impellers, disregarding the scale effect due to the difference between the diameters of the models and full-scale impellers. Other drawbacks of the new bladed system were exposed:

- the maximum efficiency of the full-scale turbine (89%) was 4% lower than that guaranteed by the plant (according to data derived from full-scale tests by the Lengidroproekt);
- the plant’s cavitation guarantees are not fulfilled (the influence exerted by cavitation on efficiency begins to make itself felt under loads lower than those guaranteed by the plant);
- the forces developed by the impeller’s servomotor were insufficient for blade adjustment (it was required to perform additional work at the hydroelectric plant); and,
- due to the high level of axial vibrations under small loads, it was required to introduce regime limitations.

The example in question is not unique. A similar situation was also encountered after replacing the bladed system on the turbines at the Pavlovo hydroelectric plant. The turbine with the new impeller (PL 50/1075) has a reduced efficiency level as compared with the old impeller over the entire range of loads when operating at the basic head \( H = 32 \text{ m} \) (Fig. 2). The new impeller does not support the rated capacity of the set at the design head, while operation of the equipment is accompanied by elevated vibration and failure of impeller chambers (operating information from the hydroelectric plant).

Noncorrespondence between the interests of the Client and Contractor is the objective cause of the situations encountered at these hydroelectric plants. For the equipment Contractor, the delivery of equipment that is already available and does require modification of a component at maximum cost is the most effective solution. It is unreal for the client to resist this tendency independently by virtue of the limitation of his own experience, the impossibility that a course on all achievements in hydraulic-turbine building in Russia and abroad exists, and the inaccessibility of information on the performance of water-power equipment at the hydroelectric plants in Russia and countries of the Commonwealth of National Governments, and on problems that have arisen there.

Moreover, it is necessary to form a clear understanding of trends in the development of power engineering, which will determine the operating conditions of the equipment, and, of course, also the future effectiveness of the equipment selected.

Summarizing what has been stated above, it is possible to conclude: independent examination is required, since it prevents the Client from making decisions that would for him be erroneous, and makes it possible to enhance the effectiveness of the resources invested in equipment.

The answer to the question concerning the stage of development in which it becomes effective to introduce an independent expert can be sought in existing practice.