

Abstract

To solve the problems of optimal design of cyclically symmetric structures under static loading, an approach is proposed and tested on critical structural elements of hydraulic turbines. One of the basic problems in the design of hydraulic turbines is considered, namely, ensuring their strength and reliability under continuous operation under the influence of a static loading. The problem of optimal design of the original and modified covers of the rotary-blade hydraulic turbine operating in the normal mode is solved. A Kaplan turbine cover is a complex spatial structure consisting of thin-walled elements. Therefore, the finite element method is used for the calculation, which allows to take into account the design features and the range of external influences acting in the process of operation. The covers with the original and modified hole in the rib are chosen as the initial design. Therefore, the finite element method is used for the calculation to most fully take into account the design features and the spectrum of external influences acting during operation. As the initial design, covers with an initial and modified hole in the rib were selected. The geometric parameters of the cover are modified to minimize the cover weight. The thicknesses of structural elements are taken as design variables. The minimum and maximum thicknesses, as well as maximum stress intensity values are limited. The objective function is the cover weight. The hybrid search optimization method is used to solve the optimization problem. The distribution of axial displacements and stress intensity in the original and modified cover design during normal operation was obtained. It is established that the weight of the cover structure is reduced by 30%, and the range of rolled thicknesses is reduced by five positions, which is essential in the manufacture of a new structure. At the same time, the stress values in the optimal design at modification of the hole in the nervures did not exceed the permissible values. The proposed approach will be further applied to the analysis of structures in the power engineering industry.

Keywords: optimal design, rotary-blade hydraulic turbine, finite element method, hybrid search optimization method, original and modified cover design