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Harmonization of hydropower plant with the environment

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Abstract

The influence of a hydropower plant on the environment is analyzed. The frequent starting and stopping of hydropower plant turbines are considered to cause the erosion of river-bed and damage to river flora, fauna and the environment generally. The harm may be reduced by passing the entire runoff of the river through turbines without changing the flow of runoff and the accumulation of water in a reservoir [Klimpt J-E, Riveiro C, Puranen H, Koch F. Recommendations for sustainable hydroelectric development. Energy Policy 2002; 30(14): 1305–1312]. This idea cannot be realized in a traditional hydropower plant. The range of runoff changes of Lithuanian rivers is much broader than the capacity of one or more turbines of the same power.

The characteristics of several turbine types are analyzed. The carrying capacity of a cross flow turbine is regarded to have the widest range. In addition, the width of the range may be expanded with special auxiliary equipment. This type of turbine is equivalent to two or even three turbines of varying capacities, and it can handle the discharges from any season.

The possibilities for expanding the range of turbine capacity by means of working with varying speeds of rotation are discussed. Special mechatronic systems for controlling mechanical and electrical equipment of a hydropower plant, working with varying speed of turbines revolution, are presented. The investigation of mathematical models of the systems under both autonomous and systematic regimes shows their efficient operation and sufficient quality of electrical power.

Keywords: River runoff; Turbine; Capacity; Efficiency; Mechatronic system

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1. Introduction

As environmental protection requirements with regard to energy production technologies become evermore strict, inevitably therefore cleaner renewable energy sources attract more attention. Based on the experience of many centuries, hydropower is one of the most popular of these sources. The energy of the river water flow is easily concentrated, but its development induces the flooding of significant areas, changes the landscape, the river hydraulic regime and the living conditions of water fauna and flora in the long reach of the river. Some of these changes are harmful, and others are useful. The reduction of harmful factors caused by hydropower development is the aim of our work [1].

After the construction of a valley-type hydropower plant (HPP) and filling of the reservoir, water depth increases upstream of the plant, and its velocity decreases. Fish communities [2,3] as well as the sorts of plants change. Due to the elevation of the open and ground water level, the microclimate [4], flora and fauna alter within the area surrounding the reservoir. The flow regime downstream becomes different from that of the natural river flow and is influenced by the HPP work regime. Each change of turbine work regime causes sudden fluctuations of water level. Due to these phenomena long-lasting scour goes on in a river bed [5]. The living conditions are intolerable for fish communities, and for this reason their populations are reduced or they vanish completely [6]. The determination of the influence of a HPP on the river flow regime in the downstream reach and the measures, which can be taken to reduce its strength are the aim of our work.

2. Alternation of Lithuanian river runoff

The alternation of the flow parameters velocity, depth and discharge along the river over time is here called the flow regime. In order to define the influence of a HPP on the river flow regime, we have analyzed it in comparison with the regime under natural conditions. Lithuanian river runoff varies in time within a great range whose width depends on many factors. It is commonly known that river regime parameters reach maximum magnitudes in Spring flood time and minimum in Summer drought and also in Winter cold periods (see Fig. 1). The amplitudes of parameter alternation depend first of all on the presence of lakes, reservoirs, forests, and swamps in the river basin, accumulating and restraining the water precipitation.