

Article

Laboratory Modeling of an Axial Flow Micro Hydraulic Turbine

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Featured Application: The identified features of the flow for different cases are necessary for predicting the parameters of micro hydraulic turbines and developing recommendations for expanding the range of regulation of turbine operating cases while maintaining high operating efficiency.

Abstract: This article is devoted to detailed experimental studies of the flow behind the impeller of an air model of a propeller-type microhydropower turbine in a wide range of operating parameters. The measurements of two-component distributions of averaged velocities and pulsations for conditions from part load to strong overload are conducted. It is shown that the flow at the impeller outlet becomes swirled when the hydraulic turbine operating mode shifts from the optimum one. The character of the behavior of the integral swirl number, which determines the state of the swirled flow, is revealed. Information about the flow peculiarities can be used when adjusting the hydraulic unit mode to optimal conditions and developing recommendations to expand the hydraulic turbine operation control range with preservation of high efficiency. This stage will significantly save time at the stage of equipment design for specific field conditions of water resource.

Keywords: axial micro hydraulic turbine; swirl number; hydraulic turbine efficiency; laser-Doppler anemometer (LDA)



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1. Introduction

Hydropower, being the oldest area of renewable energy, currently provides a significant contribution to world electric energy generation [1]. The basis of this production is large-scale hydropower plants (HPP), which are built on large rivers and require heavy capital expenditures on the creation of dams. Further broadening of hydropower is limited on the one hand because suitable water resources for the creation of large-scale hydropower systems are already fully exploited in many countries [2]. On the other hand, the construction of new big HPP in places where such resources exist is hampered by economic reasons or safety concerns [3]. At that time, it is recommended the attention to utilization of the hydropower potential of natural water sources in the form of small rivers and streams [4], as well as technical systems of irrigation and water supply [5]. According to the classification of hydro turbines used in the literature, the class of microhydropower turbines (MHT) include devices less than 100 kW, which are considered often as an off-grid technology for the electricity generation [6,7]. Development of MHT systems addresses the current global concerns on climate change demanding decarbonization of the energy generation sector and increasing use of renewable energy sources [8–12]. Microhydropower has been considered as a reliable electricity generation technology for remote communities [11,13], living where extension of centralized power distribution networks is very expensive.

Different hydro turbine types are employed nowadays depending on parameter range of available water resources in terms of head and flowrate [1,11]. As moving towards

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