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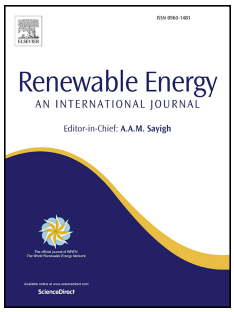

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Numerical Analysis of Non-axisymmetric Flow Characteristic for a Pump-turbine Impeller at Pump Off-design Condition

Zhao Xiaoran[1], Xiao Yexiang[1], Wang Zhengwei[1], Luo Hongying[2*], Ahn Soo-Hwang[1], Yao Yangyang[1], Fan Honggang[1]

1. State Key Laboratory of Hydroscience and Engineering & Department of Thermal Engineering, Tsinghua University, Beijing, 100084
2. Water Conservancy and Civil Engineering College, Tibet Agriculture and Animal Husbandry College, Lingzhi 860000 ,China

Abstract:

The present paper analyzed the inner flow characteristic of a reversible pump-turbine at pump mode with the optimal guide vane opening. An unusual asymmetrical feature of both pressure fluctuation and flow pattern inside the rotating impeller was detected under a pump off-design condition, in which the flow rate is smaller than that of hump district. The steady and unsteady simulations were performed in ANSYS 16.0 with the SAS SST-CC turbulence model. The simulation results of pressure fluctuations show that there exists a noteworthy difference of pressure amplitudes in each rotating flow passage, which is not obvious under other conditions. Flow pattern analysis indicates that the impeller flow fields are asymmetrical in different passages under this pump off-design condition, with significant flow separation and vortexes. When exploring the possible causes for this particular flow pattern, it is revealed that the specific elbow structure has an impact on the flow distribution in the draft tube. Flow separation and reverse flow are discovered in the conical and elbow part of the draft tube, which leads to the uneven flow pattern at the impeller inlet. It is demonstrated that there is a close relationship between unsteady flow structures and asymmetrical pressure fluctuation characteristic.

Key words: Pump-turbine, Rotating impeller, Asymmetrical flow, Pressure fluctuation, Vortex flow

1. Introduction

During the past decades, the energy demand has increased dramatically, followed by some important energy issues. One of them is the stability of the grids, which is influenced by the supply and demand fluctuation. Pumped-storage power is a good complement to the other renewable energy resources for electrical balance[1]. Pumped storage power stations undertake the tasks of grid peak shaving, frequency modulation, phase modulation and valley filling in electric power system. Pump-turbines operated in pumped storage power stations are characterized by high hydraulic heads and bidirectional operations at various working conditions.

The present requirements demand the pump-turbines to be used at off-design conditions. Thus, it is important to expand the operating range and to ensure working stability of pump-turbines. In a transient

*Corresponding author: Hongying Luo, associate professor in Tibet Agriculture and Animal Husbandry College
E-mail: lhy_xz@sina.com.