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#### ACCEPTED MANUSCRIPT

# Symmetrical and unsymmetrical tip clearances on cavitation performance and radial force of a mixed flow pump as turbine at pump mode

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Abstract: Transient cavitating flows of a mixed-flow PAT (pump as turbine) at pump mode 11 12 are investigated experimentally and numerically. Radial force on principal axis is recorded 13 and compared between PAT with unsymmetrical and symmetrical tip clearance. Numerical simulation with improved cavitation model by modifying the vapour pressure is conducted, 14 and the simulation results agree well with the experiments. Tip clearance has great influence 15 16 on PAT cavitation performance. The pump energy performance will deteriorate with tip clearance increasing. In addition, in comparison with the symmetrical tip clearance, the 17 unsymmetrical tip clearance makes the PAT cavitation performance worse. As the cavitation 18 19 develops, the unsymmetrical tip clearance simultaneously influences the magnitude and 20 direction of radial force, while the symmetrical tip clearance only influences the magnitude 21 of radial force. The dominant frequencies of radial force of symmetrical and unsymmetrical 22 tip clearances are related to the blade number and guide vane number, respectively. The 23 maximum amplitude of force fluctuation for unsymmetrical tip clearance is 7 times that for 24 symmetrical tip clearance.

- Keywords: pump as turbine; symmetrical and unsymmetrical; tip clearance; radial force;
   cavitation
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### 28 **1. Introduction**

Clean and cheap renewable energy sources are playing more and more important role nowadays. Hydropower is the most promising and high efficiency among all the renewable energy sources [1]. PAT (pump as turbine) is widely used as storage power plant [2-4], water distribution networks [5-6] and pressure reducing valves (PRVs) sites with small power output capacities [7] owing to their cost effectiveness, high efficiency, effective storage capability and high flexibility. Recently, the transient characteristic and operation stability of PAT have been heated topics. Li et al. [8-10] studied the hysteresis characteristic of turbine by Entropy production analysis, and he also investigated the transient Download English Version:

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