Added mass effects of attached cavitation on the blades of a Francis runner

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Long Abstract

Abstract

Hydropower, a clean and renewable energy resource, has been developed worldwide for the economic development and improvement of people's living standards. It has also been used to improve the stability of the smart power grid.

Depending on the water head of hydropower plants, various types of hydraulic turbines such as Francis, Kaplan and Pelton have been designed to maximize efficiency. Francis turbines, which combine radial and axial flow, are the most common type in use nowadays since they can operate in a quite wide water head range. Due to the extreme hydrodynamic conditions found by the flow inside the runner channels at off-design operation, attached blade cavitation may occur with different dimensions and locations.

In order to avoid damages provoked by structural resonances and material fatigues, the structural behavior of the Francis runner has to be carefully investigated during design phase. Many research works have been carried out to predict the dynamic behavior of Francis runners in air and in still water based on both measurement and simulation [1-12]. However, the presence of attached cavitation on the runner blades has not been considered yet with enough detail. Only limited work has been performed on a hydrofoil to investigate the added mass effects under cavitation demonstrating their significance[13,14]. However, the hydrofoil is only a very simple structure compared with the complex Francis runner. Therefore, it is necessary to investigate the added mass effects of blade attached cavitation on the structural response of Francis runners.

Consequently, a Francis runner with 13 blades has been selected to carry out the structural behavior analysis by numerical simulation of the fluid structure interaction phenomenon. In particular, the added mass effects of different types of attached cavitation on the dynamic responses of both just one blade and of the entire runner have been investigated in detail and the results are presented in this paper.

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