On the pump mode shutdown sequence for a model contra-rotating pump-turbine

J Fahlbeck, H Nilsson and S Salehi

Department of Mechanics and Maritime Sciences, Chalmers University of Technology, SE-412 96 Gothenburg, Sweden

E-mail: fahlbeck@chalmers.se

Abstract. Contra-rotating pump-turbines are currently being studied in the ALPHEUS EU H2020 project as an alternative for low-head pumped hydro storage (PHS). To have an efficient PHS facility, it is important to know how to operate the pump-turbine unit under transient conditions to be able to adapt to demand variations rapidly. Therefore, this study focuses on the transient pump mode shutdown sequence of a contra-rotating pump-turbine. Two different sequences are evaluated using computational fluid dynamics simulations. The sequences are denoted as 'preliminary' and 'new' since the preliminary sequence is similar to a sequence in one of our earlier studies. It is shown that the preliminary sequence produces reverse flow and large load gradients on the runners. The new sequence manages to avoid reverse flow and reduces the load gradients. The main reason the new sequence is advantageous is because a valve is closed before speeding down the runners. However, the new sequence produces larger load fluctuations, and a wider frequency spectrum of pressure fluctuations, compared to the preliminary sequence.

1. Introduction

Low-head pumped hydro storage (PHS) is one solution to aid the growing need for energy storage because of the increasing share of intermittent renewable energy sources [1]. Low-head PHS is generally relevant in countries that lack high mountain regions where it is not possible to construct typical high-head PHS. New runner designs with contra-rotating pump-turbines (CRPT) have been suggested as an alternative configuration for low-head PHS [2]. The ALPHEUS (Augmenting Grid Stability Through Low Head Pumped Hydro Energy Utilization and Storage) EU H2020 [3] project has the aim to study CRPTs for low-head PHS.

Preliminary studies of the CPRT pump mode startup and shutdown sequences [4] have shown that the runners may be subjected to large and rapid load variations. Large load variations can potentially damage the machine after enough cycles. It is for that reason important to study transient sequences to understand how the potentially detrimental load variations can be limited. The pump mode startup sequence of the CRPT has recently been comprehensively analysed and optimised by Fahlbeck et al. [5, 6]. However, the CRPT pump mode shutdown sequence has until the present day not gained much attention. The current study is for that reason investigating two alternative shutdown sequences with the help of computational fluid dynamics (CFD) simulations. One of the evaluated sequences is based on our earlier work [4] and is denoted 'preliminary', and the other sequence is denoted 'new' since it has not been examined previously.