CHALMERS
UNIVERSITY OF TECHNOLOGY

A Low-Head Counter-Rotating Pump-Turbine at Unsteady Conditions

Downloaded from: https://research.chalmers.se, 2026-04-04 22:11 UTC

Citation for the original published paper (version of record):
Fahlbeck, J., Nilsson, H., Salehi, S. (2022). A Low-Head Counter-Rotating Pump-Turbine at Unsteady Conditions. OpenFOAM Workshop (OFW17) Book of abstracts

N.B. When citing this work, cite the original published paper.

research.chalmers.se offers the possibility of retrieving research publications produced at Chalmers University of Technology. It covers all kind of research output: articles, dissertations, conference papers, reports etc. since 2004. research.chalmers.se is administrated and maintained by Chalmers Library

(article starts on next page)

A LOW-HEAD COUNTER-ROTATING PUMP-TURBINE AT UNSTEADY CONDITIONS

JONATHAN FAHLBECK*, HÅKAN NILSSON AND SAEED SALEHI,
Department of Mechanics and Maritime Sciences, Chalmers University of Technology,
*SE-412 96 Gothenburg, Sweden, *fahlbeck@chalmers.se*

Keywords: *Pump-turbine, low-head, energy storage, counter-rotating, head losses*

With the increased amount of energy produced from variable renewable energy sources, such as wind and solar power, the need to store energy increases. The reason is that it is necessary to cope with the variation in energy being produced by the renewables to stabilise the electrical grids [1, 2]. The most widely used technology for energy storage on a large scale is today pumped hydro storage (PHS) [3]. For PHS to be economically feasible, a high head is typically required, which puts topographical constraints on where it can be built. However, the EU project ALPHEUS aims to develop PHS for low-head applications, hence allowing PHS at yet unexplored sites. In the project, new reversible counter-rotating pump-turbine (CRPT) concepts are explored as an alternative runner design for low-head situations. The CRPT consists of two runners rotating in opposite direction from one another and it is suggested that it can reach higher efficiencies and be more compact compared to a single runner arrangement [4].

In the present work a model counter-rotating pump-turbine for the ALPHEUS project is numerically analysed with computational fluid dynamics (CFD) simulations. The simulations are carried out using unsteady CFD in OpenFOAM-v2012. In the simulations, the two runners rotate individually via prescribing a solid body rotation to the runner domains. The individually rotating runners causes a intricate rotor-rotor interaction which is resolved by the numerical model. An example of this is shown in Figure 1, where a complex vortical structure is developing by the runners and support-structures. Furthermore, the CRPT is in reality part of large hydraulic system which effects the performance of the machine. The system includes bends, valves, long pipes, and two large water reservoirs. To restrict the size of the computational domain, the novel `headLossPressure` boundary condition, developed by Fahlbeck et al. [5], is used to include the main effects of the hydraulic system. To summarise, this study will show the potentials with a CPRT in a PHS application through CFD simulations, explain the used numerical framework, and demonstrate a use case for the new `headLossPressure` boundary condition.

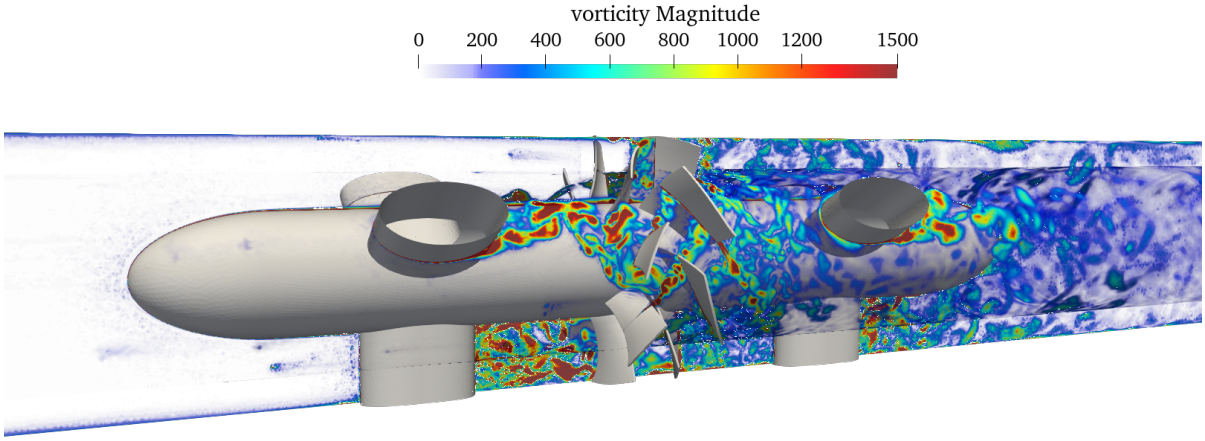

Figure 1: Vorticity magnitude of a CRPT at the design point

Acknowledgments

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 883553. The computations were enabled by resources provided by the Swedish National Infrastructure for Computing (SNIC) at NSC and C3SE, partially funded by the Swedish Research Council through grant agreement No. 2018-05973.

References

[1] S. Rehman, L. M. Al-Hadhrami, and M. M. Alam, "Pumped hydro energy storage system: A technological review," *Renewable and Sustainable Energy Reviews*, vol. 44, pp. 586–598, 2015.

[2] E. Barbour, I. A. G. Wilson, J. Radcliffe, Y. Ding, and Y. Li, "A review of pumped hydro energy storage development in significant international electricity markets," *Renewable and Sustainable Energy Reviews*, vol. 61, pp. 421–432, 2016.

[3] IHA, *2020 Hydropower Status*. International Hydropower Association (IHA) Central Office, London, 2020.

[4] A. Furukawa, T. Shigemitsu, and S. Watanabe, "Performance test and flow measurement of contra-rotating axial flow pump," *Journal of Thermal Science*, vol. 16, no. 1, pp. 7–13, 2007.

[5] J. Fahlbeck, H. Nilsson, and S. Salehi, "A HEAD LOSS PRESSURE BOUNDARY CONDITION FOR HYDRAULIC SYSTEMS," *OpenFOAM® Journal*, vol. 2, pp. 1–12, 2022.