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

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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.

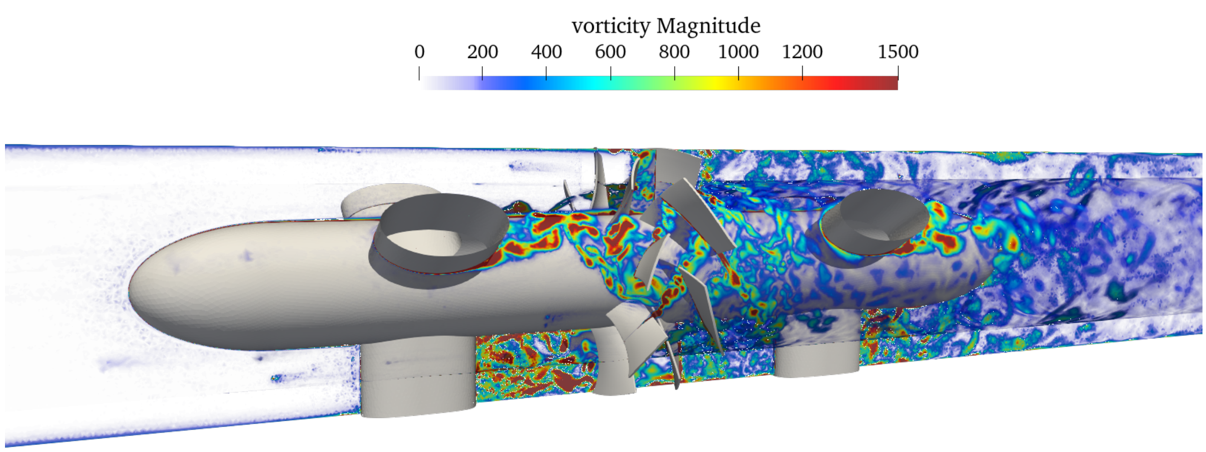

Figure 1: Vorticity magnitude of a CRPT at the design point

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