Innovative ecological hydropower concepts using the TUM Multi-Shaft Power Plant

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Introduction
Given the growth in population, the rise of energy consumption, and the need to reduce greenhouse gas emissions, hydropower continues being an attractive source of electricity generation all over the world. While hydropower offers indeed many advantages, it also faces complex challenges. Modifying the river ecosystem and flooding significant areas of land, are difficulties that must be considered and managed during the execution of any new hydropower project.

Researchers at the Chair of Hydraulic and Water Resources Engineering developed the TUM Hydro Shaft Power Plant (TUM-HSPP) as an eco-friendly alternative for hydroelectric power generation. The TUM-HSPP features a fully submerged power plant, placed in a shaft, in front a weir that allows the downstream migration of aquatic specimens and the natural flow of sediment. This new approach offers a cost-effective and nature-compatible use of a small run-of-river power plant [Sepp and Rutschmann, 2014] that does not alter the course of a river. For the implementation in rivers with larger flow rates, the TUM Multi-Shaft Power Plant (TUM-MSPP) was envisioned. The concept is based on the principle of the single shaft, where TUM-HSPP modules are aligned next to each other. The special characteristic of the system lies in the integration of nature-like channel in between the shafts that enables the passage of aquatic species.

Finding the optimal geometrical configuration for the TUM-MSPP, and including and optimizing the necessary elements to guarantee a controlled and functional energy conversion, is still a matter of investigation and the bulk of this doctoral research project. An additional emphasis will be placed on ensuring the connectivity for aquatic species and optimizing the operation to ensure the bed load transport processes through the structure.
Objectives and methodology
In this research, hydrodynamic simulations are the key pillar to optimize the hydraulic performance of the TUM-HSPP and create basic guidelines for the dimensioning of the structures. The Computational Fluid Dynamic software used for the simulations is the commercial package FLOW-3D®.

The first task of the research was to create a robust numerical model that can simulate accurately the hydraulic behaviour of the TUM-HSPP. For this purpose, the first model was based on the geometry and hydraulic features of the existing pilot plant of the Obernach Research Institute.

Based on the established numerical model for the TUM-HSPP, the transition to modelling with multiple shafts was made. There are several areas of interest, for instance: the configuration of the inlet area, establishing the influence for the guiding walls with the special condition of having horizontal inlet structures, and the configuration of the eco-migration channel. Another point of evaluation and optimization of the Multi-shaft concept is the ecological aspect, in particular, the fish entrainment risk.

The third module of the research aims to analyse the sediment transport and create operational guidelines in order to comply with the environmental constraints downstream of the TUM-MSPP location. For this last stage of research, the simulations will be extended to larger river sections and conducted as 2-dimensional with the open source software TELEMAC. The idea is to use the results from the previous stages as internal boundary conditions for the hydropower section in the extended new 2D model.

With the results and experiences gathered during the different research stadiums, a scheme for the ecological evaluation of this new concept will be generated and proof of the ecological sustainability of the TUM Multi-Shaft concept will be available for the research community and governmental authorities.

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References