PUMPS AS TURBINES FOR ENERGY RECOVERY IN WATER SUPPLY SYSTEMS: TURBINE MODE CHARACTERIZATION AND OPERATIONAL CONTROL OPTIMIZATION

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ABSTRACT

Water supply systems are infrastructures with potential for energy production as they supply water by means of pressurized pipes, many times with excessive energy. The integration of micro-hydropower plants in WSS remains a challenge as they are characterized by a demand-driven daily variation of discharge, and the need to properly assure the water supply, restricting the power plants' operational conditions.

Pumps operating as turbines are pointed as a cost-effective solution, but still facing major challenges. The main difficulty lies in the performance prediction of turbine mode, as pump manufacturers lack this information and existing methodologies are not fully reliable. Additionally, the efficiency is highly affected by discharge variations, as pumps do not have inlet flow control. Several strategies have been pointed to overcome this limitation (e.g., operation in parallel or variable speed operation), but, the comparison of effectiveness between each approach is not reported.

The current research aims at the characterization of variable speed operation of pumps operating as turbines based on an extensive experimental data collection program, and on the development of an optimization strategy for the maximization of energy recovered. The experimental program aims at the collection of data for discharge, head, shaft rotating speed and torque, water temperature, generator tension and current, for three pumps with different unit specific speeds. Obtained results will be used for predicting the Turbine Hillchart Model, for a certain unit specific speed, based on the polynomials chaos expansion theory. The obtained Hillchart will be used for optimizing operational controls of the pump aiming at the maximization of the energy produced.

The development of this work points towards filling the gap of knowledge in design and operation of micro-hydropower plants using pumps running as turbines. The use of excessive energy enables the increase of the water supply systems' efficiency, contributing for the improvement of the sustainability of the infrastructures of tomorrow.

Keywords: pump as turbine, energy recovery, water supply systems, experimental programme, numerical model.