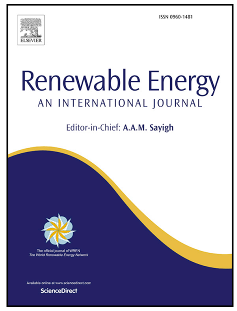
Accepted Manuscript



Pumps as turbines for efficient energy recovery in water supply networks

M. Kramer, K. Terheiden, S. Wieprecht

PII: S0960-1481(18)30053-3

DOI: 10.1016/j.renene.2018.01.053

Reference: RENE 9658

To appear in: *Renewable Energy*

Received Date: 30 January 2017

Revised Date: 11 October 2017

Accepted Date: 15 January 2018

Pumps as turbines for efficient energy recovery in water supply networks

M. Kramer[a,*], K. Terheiden[a], S. Wieprecht[a]

[a]*Institute for Modelling Hydraulic and Environmental Systems, University of Stuttgart, Germany*

[*]Corresponding author

Email address: matthias˙kramer@hotmail.com (M. Kramer)

URL: www.iws.uni-stuttgart.de (M. Kramer)

Abstract

The present work aims to enhance the energy efficiency of water supply networks by investigating technical and economical feasibility of energy recovery plants at low installed capacities. A cost effective stainless steel machine is investigated in pump and turbine operation and established conversion methods are used for predicting the best efficiency point of the turbine. The obtained results show a reasonable agreement of the BEP, but experimental investigations are still indispensable for a determination of complete Q-H-characteristics.

The hydraulic machine is implemented in field at the transfer shaft of a high-level tank and valuable data concerning investment costs and water hammer have been collected. A proposed cost classification scheme will facilitate the acquisition of investment costs for further applications. The economic profitability of the hydropower plant is evaluated by the net present value method and the obtained results give incentives to exploit unused energy recovery potential within water supply systems.

Keywords: Energy recovery, Water supply system, Pump as turbine, Micro-hydro, Economic efficiency

1. Introduction

Energy recovery, in terms of drinking water supply systems, is defined as a process where the energy of the residual supply pressure is recovered. For a long time now, there has been energy recovery systems implemented in drinking water supply networks. However, there is still an unused potential especially in the application range of hydraulic machines with low installed capacities e.g. located at transfer shafts or tank-inlets. So far, commonly implemented turbine types for energy recovery purposes are Francis-turbines [21], micro-hydro impulse turbines [15], Axent turbines [17] or pumps in reverse operation mode, also known as PAT's (pumps as turbines). In comparison to the other hydraulic machinery used in the same field of application, PAT's are less expensive and can be used in a wide application range. Up to now, mainly larger potentials of approximately $P \geq 50\ kW$ are used for energy recovery in German water supply systems. This is due to the fact, that characteristics of cost efficient stainless steel pumps are regularly not available in turbine mode.

This study aims to make use of cost efficient reverse running pumps at low capacity sites within drinking water systems. Therefore, the implementation of stainless steel pumps in turbine operation mode is investigated regarding the technical and economical feasibility. Measurements are conducted on a PAT in laboratory and field tests. Within these investigations, typical Q-H-relations (Q: discharge, H: head), efficiency curves, power curves and runaway characteristics are recorded. Furthermore, the best efficiency point (BEP) is determined in order to convert pump characteristics into turbine characteristics. In practical tests, the hydraulic machine is implemented in a drinking water supply system. These site investigations are essential to evaluate the possible occurrence of water hammer in case of a load drop. To prove economical feasibility of the designed energy recovery plant, the net present value is evaluated. Data, such as investment costs, maintenance costs and feed-in tariffs are evaluated in order to be able to draw more general conclusions regarding the economic profitability of energy recovery units at low installed capacities. Moreover, the obtained results might give an indication of investment costs for other potential sites.