World Academy of Science, Engineering and Technology
International Journal of Environmental and Ecological Engineering
Vol:9, No:03, 2015

Pump-as-Turbine: Testing and Characterization as an Energy Recovery Device, for Use within the Water Distribution Network

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Abstract : Energy consumption in the water distribution network (WDN) is a well established problem equating to the industry contributing heavily to carbon emissions, with 0.9 kg CO2 emitted per m3 of water supplied. It is indicated that 85% of energy wasted in the WDN can be recovered by installing turbines. Existing potential in networks is present at small capacity sites (5-10 kW), numerous and dispersed across networks. However, traditional turbine technology cannot be scaled down to this size in an economically viable fashion, thus alternative approaches are needed. This research aims to enable energy recovery potential within the WDN by exploring the potential of pumps-as-turbines (PATs), to realise this potential. PATs are estimated to be ten times cheaper than traditional micro-hydro turbines, presenting potential to contribute to an economically viable solution. However, a number of technical constraints currently prohibit their widespread use, including the inability of a PAT to control pressure, difficulty in the selection of PATs due to lack of performance data and a lack of understanding on how PATs can cater for fluctuations as extreme as +/- 50% of the average daily flow, characteristic of the WDN. A PAT prototype is undergoing testing in order to identify the capabilities of the technology. Results of preliminary testing, which involved testing the efficiency and power potential of the PAT for varying flow and pressure conditions, in order to develop characteristic and efficiency curves for the PAT and a baseline understanding of the technologies capabilities, are presented here: •The limitations of existing selection methods which convert BEP from pump operation to BEP in turbine operation was highlighted by the failure of such methods to reflect the conditions of maximum efficiency of the PAT. A generalised selection method for the WDN may need to be informed by an understanding of impact of flow variations and pressure control on system power potential capital cost, maintenance costs, payback period. •A clear relationship between flow and efficiency rate of the PAT has been established. The rate of efficiency reductions for flows +/- 50% BEP is significant and more extreme for deviations in flow above the BEP than below, but not dissimilar to the reaction of efficiency of other turbines. •PAT alone is not sufficient to regulate pressure, yet the relationship of pressure across the PAT is foundational in exploring ways which PAT energy recovery systems can maintain required pressure level within the WDN. Efficiencies of systems of PAT energy recovery systems operating conditions of pressure regulation, which have been conceptualise in current literature, need to be established. Initial results guide the focus of forthcoming testing and exploration of PAT technology towards how PATs can form part of an efficiency energy recovery system.

Keywords : energy recovery, pump-as-turbine, water distribution network, water distribution network
Conference Title : ICWEEM 2015 : International Conference on Water, Energy and Environmental Management
Conference Location : Madrid, Spain
Conference Dates : March 26-27, 2015