Particle Swarm Optimization applied to optimal management of pumps and pressure control valves for real-time control in water supply systems

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ABSTRACT

Much of the control of water supply systems (WSSs) is under the decision of operators, which manage pumps and valves with the empirical expertise obtained during their working career. If, on the one hand, the command based on the experience leads to better results for regular conditions of operation, on the other hand, emergency situations or accidents can affect the decision of the operator, leading to worse maneuvers (Sandeep and Rakesh, 2011). Water network models coupled with optimization algorithms can be a powerful tool to suitably manage WSSs. These hybrid models are used both to reduce the operational cost of pump operation, determining the better speed for the speed drive (Abkenar et al. 2014), and to reduce the water losses in the pipelines determining the number and the location of pressure control valves (Dai and Li, 2014) and (Savic and Walters, 1997).

Most recently, a fully integrated vision of urban systems has propitiated the inclusion of the operation of the water system in the so-called concept of smart city. Accordingly, the new models try to gather the reduction of losses, the energy saving, and in some cases, the energy production. Bringing together these points is hard and can require a robust model to obtain satisfactory and applicable results for real time control purposes.

This work shows an integrated system to determine the speed of pumps and the set point of valves looking for the reduction of cost and the losses of water. Therefore, we have developed a coupled model with the EPANET Toolkit – a water network simulator –, and with Particle Swarm Optimization (PSO) – a bio-inspired optimization algorithm. The PSO implemented in this work uses the capabilities of ASO (agent swarm optimization) (Montalvo et al. 2014), endowed with specific modifications that enhance search ability and self-adapt the parameters of the method to accelerate convergence. The advantage of a fast model to determine operational rules is the possibility of application to real-time control.

The main results after applying the proposed methodology boil down to the determination of the set of precise online maneuvers both for regulating valves and pumps (in term of both their state and rotational speed) that minimize the network energy cost, while simultaneously, manage to reduce the network leakage level as a result of suitably adjusting the network pressure according to the changing functional needs of the network.