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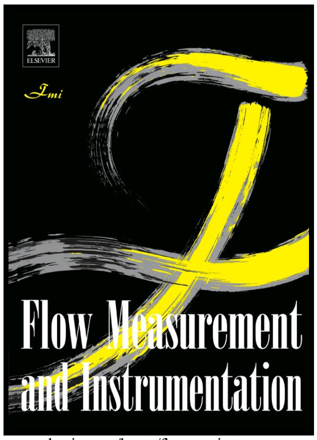

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Hydraulic Modelling of Control Devices in Loop Equations of Water Distribution Networks

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Abstract

The simulation of hydraulic behaviour of water distribution networks (WDN) needs to develop and implement a mathematical model that is able to consider a wide range of control devices of complex systems. A literature overview is primarily provided for the solution procedures of steady state simulation of nonlinear pipe network hydraulics. Typical elements of pressure regulating valves are conceptually described and differentiated into their functional characteristics to incorporate their hydraulics in the simulation model. They are explored by considering their possible topological positions and operating states. A novel efficient methodology using an *unknown head-loss function* is initially presented for the hydraulic simulation of network flow problems containing static and/or dynamic closed pipes. Closed pipes can be mainly obtained in the distribution networks either by turning off the isolation valves at a pipe segment or as a result of the operating state of unidirectional control devices depending on the pressure distribution in the pipe network. Thereupon, this approach is extended to integrate the control elements of pipe networks such as check valves, pressure reducing (PRV) and safety valves as well as booster/pumping stations. An iterative numerical algorithm is applied to solve the loop equations using the Newton-Raphson method for the linearized energy equation, where Hardy-Cross technique is locally used to correct flow rates of loops containing closed pipes in the iteration procedure. The developed hybrid approach demonstrated robust and very fast converging behaviour for real-world pipe network applications. Moreover, it can consider a variety of combinations of control devices in different network configurations. Several empirical head loss formulas can be additionally used in combination with the commonly known equations such as Hazen-Williams and Colebrook-White head loss formulas. The application of the algorithm will be briefly demonstrated by discussing some simulation results from example and real world large scale WDN.

Keywords: Water Supply, Pipe Network Hydraulics, Mathematical Modelling, Closed Pipes, Check Valves, Pressure Reducing Valves, Safety Valves, Pump/Booster Stations