Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 186 (2017) 135 – 142

Procedia Engineering

www.elsevier.com/locate/procedia

XVIII International Conference on Water Distribution Systems Analysis, WDSA2016

A new non-iterative method for pressure-driven snapshot simulations with EPANET

E. Pacchin[a,*], S. Alvisi[a], M. Franchini[a]

[a]KWR, Groningenhaven 7, 3433 PE Nieuwegein, The Netherlands

Abstract

This study compares different recently proposed methods for Pressure-Driven snapshot simulations of water distribution networks using the EPANET software interface and proposes a new one. The proposed method is based on the insertion of a sequence of devices consisting of a General Purpose Valve (GPV), a fictitious junction, a reach with a check valve and a reservoir at each water demand node. The proposed method differs from other methods previously proposed in the literature – and similarly based on the insertion of sequences of devices consisting of a valve and a reservoir or emitter – in that it uses a GPV. In fact the GPV allows the user to define the relationship between the flow (i.e. supplied demand) and available pressure, making the proposed sequence of devices capable of representing different relationships among these variables, unlike the other non-iterative methods already proposed in the scientific literature, in which the relationship is implicitly fixed by the structure of the sequence of devices used. Applications to two case studies and comparison with the results of the non-iterative methods already proposed in the scientific literature highlight the accuracy and flexibility of the proposed method and show, by contrast, the unreliability and limits, in terms of precision, of some of the methods previously proposed in the literature.

Peer-review under responsibility of the organizing committee of the XVIII International Conference on Water Distribution Systems

Keywords: pressure-driven analysis; Epanet; valve; water distribution system

* Corresponding author. Tel: +39-0532-974932
E-mail address: elena.pacchin@unife.it

Peer-review under responsibility of the organizing committee of the XVIII International Conference on Water Distribution Systems
doi:10.1016/j.proeng.2017.03.219

1. Introduction

Software programs for simulating the hydraulic behavior of pipe networks are of great importance for the design and management of water supply and distribution systems. Most of these programs are based on the global gradient algorithm – GGA ([1], [2]), which is also the solver code of EPANET [3], a software package that is widely used in a variety of settings, from the professional to the academic. In particular, in hydraulic simulation software based on the GGA proposed by Todini and Pilati [1], including EPANET, it is assumed that the *delivered flow* Q at each node with an unknown head is fixed and equal to the *required flow,* or water demand, Q^{req} at the node itself, whilst the flow in the pipes and the head at the nodes with an unknown head is assumed to be unknown. According to this assumption, therefore, the flow delivered at the *i*-th node is assigned and independent of the available head at the same node; this type of approach is generally referred to in the scientific literature as Demand-Driven (DD).

In reality, however, the flow delivered at the nodes of a network is tied to the available pressure head. This type of operation is referred to in the scientific literature as Pressure-Driven (PD) and the $Q-H$ link characterizing it can be expressed by the following relationship:

$$Q = \begin{cases} 0 & \text{if } H \le H^{min} \\ \alpha Q^{req} & \text{if } H^{min} < H < H^{des} \\ Q^{req} & \text{if } H \ge H^{des} \end{cases} \tag{0}$$

where α is the coefficient enabling the flow rate to be modulated when $H^{min} < H < H^{des}$. Various formulations for characterizing α as a function of H, H^{min} and H^{des} have been proposed in the literature, including, for example, the ones proposed by Wagner et al. [4], Tucciarelli et al. [5] and Fujiwara and Ganesharajah [6], given respectively by:

$$Q = Q^{req} \cdot \left(\frac{H - H^{min}}{H^{des} - H^{min}} \right)^{0.5} \tag{0}$$

$$Q = Q^{req} \cdot \sin^2 \left(\frac{H - H^{min}}{H^{des} - H^{min}} \right) \tag{0}$$

$$Q = Q^{req} \cdot \frac{(H - H^{min})^2 \cdot (3H^{des} - 2H - H^{min})}{(H^{des} - H^{min})^3} \tag{0}$$

It is important to observe that in situations where a pressure deficit can occur – for example when assessing the reliability of a system after a pipe or a pumping station is shut off or taken out of service – it is advisable to use a PD simulator, which will make it possible to identify the nodes where the water demand is not completely (or not at all) met. In light of this, over the past decade a variety of approaches have been proposed which focus on the development of simulation models enabling a PD analysis of pipe networks. These approaches can be divided into two main types: the solver algorithm of the simulation model can be modified so as to take directly into account the relationship between delivered flow and available head at the node, or else a simulation of the PD type can be run using a DD simulation model, such as EPANET, after suitable adaptations have been made.

In the former case, algorithms have been developed which, by modifying the GGA method originally proposed in [1], enable the flow delivered at the nodes to be modified according to the available pressure (e. g. [7], [8]). Clearly, by their very nature, these approaches entail the implementation of new hydraulic simulation software.

In the latter case, by contrast, use is made of an already existing hydraulic simulation software program that operates in the DD mode. With specific reference to EPANET, which, as previously noted, is a DD software program whose use is well established, a number of techniques have recently been presented. Such techniques make it possible to carry out simulations with this type of software while achieving results that are equivalent to those provided by a PD