Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 52(5) (2020) 297-300
DOI: 10.22060/ceej.2018.15272.5867

Identifying the Location and Amount of Two Simultaneous Leaks in Water Supply Networks by a Two-step Algorithm

R. Moasheri, M. R. Jalili Ghazizadeh*
Faculty of Civil, Water, Environmental Engineering, Shahid Beheshti University, Tehran, Iran

ABSTRACT: Leakage in the water distribution systems is a crucial issue because of some problems such as water loss, water pollution, and land subsidence. The current leakage detection methods are usually costly and time-consuming; therefore, some new methods have been developed based on the water networks simulation. In this paper, a new method for identifying the location and amount of leakage in water distribution systems based on a two-step algorithm is introduced. The first (Stepped Algorithm) and second (Firefly Algorithm) steps to determine the leak location and amount of leakage are respectively used which is applicable for up to two simultaneous leaks. The proposed method is based on the comparison of the network hydraulic simulation results and some field network data (pressure or flow or their combination). "Also, this method has no sensitivity on the location of leaks and can identify low amounts of leakage (below 0.3% of the network inflow") The obtained results for six examples in a looped-water network are presented. The results show that the proposed algorithm can locate both one leak and two simultaneous leaks and their leakage values with less than 8% error. The proposed developed method can be utilized by operators of water supply networks for finding unreported leakage..

Review History:

Received: 2018-11-10
Revised: 2018-11-29
Accepted: 2018-12-05
Available Online: 2018-12-17

Keywords:

Calibration
Firefly algorithm
Leak detection
Two-step algorithm
Water supply networks

1. INTRODUCTION

Due to the limited water resources in the global, it is important to control losses and water leakage of distribution networks. One of the indicators for assessing the performance of water distribution networks is non-revenue water amount. Non-revenue water is divided into three main segments of real losses, apparent losses, and permissible non-revenue consumption. The real loss includes losses from water storage tanks and leakage from water transmission networks, water distribution systems, and service connections. The amount of water leaked in water distribution systems varies widely between different countries, regions, and systems, from as low as 3–7% of distribution input in the well-maintained systems in The Netherlands to 50 percent in some undeveloped countries [1]. Sometimes leaks reported more than 70% of the total water losses [2]. In the present paper, a new method has been developed to determine the location and amount of leakage. The proposed method can allocate for up to 2 leaks in water distribution systems. In this method, in the first step, the developed algorithm determines the location of the leak (stepped algorithm) and in the second step, the firefly algorithm [3] is used to determine the amount of the leaks.

2. METHODOLOGY

In this paper, a two-step method has been developed in Matlab software to find the location and amount of leakage. The first step algorithm, called the stepped algorithm, is used to determine the location of leaks. In the following, using the second step algorithm (firefly algorithm), the amount of leakage is determined. For this purpose, it is necessary to obtain a field observation data from the project site including pressure and flow). The method of this algorithm is to compare the amount of the field pressure or flow meter installed in different parts of the network with the results of the computer model produced for the different leakage scenarios. That scenario with the minimum error value with the field observation data, indicates the location of the leak.

*Corresponding author's email: m_Jalili@sbu.ac.ir

2.1. STEPPED ALGORITHM

The purpose of the step algorithm is to determine the location of the leaks. First, the leakage amount is distributed between the two arbitrary nodes. Therefore, the total number of generated scenarios is equal to: $\frac{N!}{2(N-2)!}\left[\frac{Q_L}{\Delta Q}-1\right]+N$ .Where N is the number of network nodes, Q_L is total leakage and ΔQ is the amount of the chosen increment for leakage.

Each production scenario calculated in the Epanet software and the pressure values and flow rates of the pipes are calculated for this scenario. For this purpose, a computerized communication program is prepared between the proposed algorithm and Epanet software using MATLAB software. That way, for each scenario, node loading information, including leakage and node consumption, is transferred to the Epanet software, and for each scenario, a hydraulic analysis is performed. The obtained results are then returned to the original algorithm. At this stage, the target function (The sum

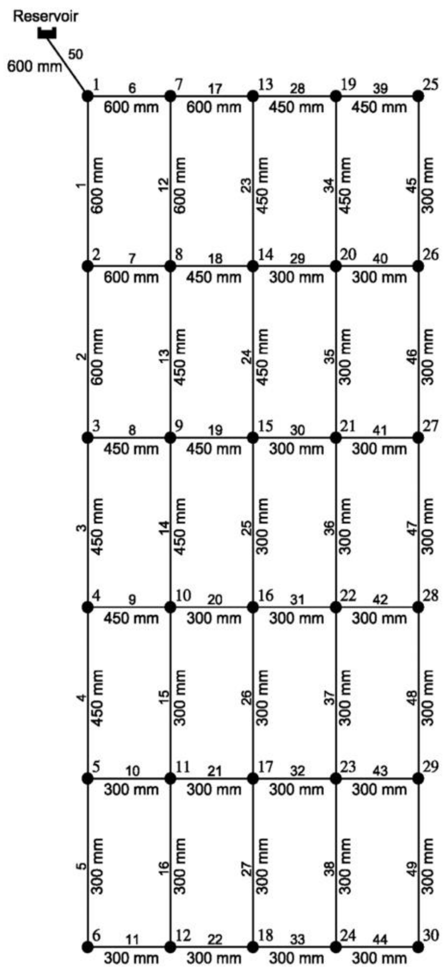

Fig. 1. Network of the case study [4]

of the difference between measured and simulated pressure and / or flow) is calculated. At the end of this step, the scenario with the minimum amount of object function is determined as the scenario of the site leak.

2.2. Firefly Algorithm

In the second step of the two-step algorithm, the leakage amount in the selected scenario obtained from the previous step is determined using the firefly algorithm. In this study, each population of fireflies, indicating the leakage value in each node, has different values for each leaked node. For each Firefly (amount leakage node) the value of the objective function is calculated, and the minimum function value is selected as the best population. Based on the firefly algorithm, the other populations tend to the best firefly.

2.3. Case study

The modified Polakis network [4] (Figure 1) has been selected as case study work. In this network, each junction node has a demand 30 l/s. Based on the proposed method in the stepped algorithm, ΔQ is 0.25 Lit/s. The parameters of the firefly algorithm in this study are defined as follows:

$$\beta_0 = 2 ,\alpha_\infty = 0 ,\alpha_0 = 0.2 ,\gamma = 1, m = 0.1 ,\text{max } iteration = 100$$

Proposed algorithm for the studied network is used for six examples which their results are given below. For this case study with a trial and error process, it was determined that the best form of the field observation is the combination of flow and pressure meters (Nodes pressure 11, 15, 28, 30 and flow pipe-46).

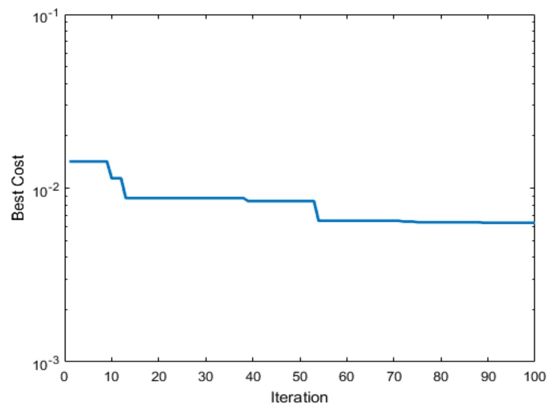

Fig. 2. Objective function changing of the firefly optimal population against the iteration number (example 2)

3. RESULTS AND DISCUSSION

In the first example, the aim was to find a leak of 2.5 lit/s in node 21. After running the two-step algorithm, the software reported the location of leaks at node 21 and its value of 2.5 lit/s. In the second example, the purpose was finding the position and determining the amount of two simultaneous leaks at node 15 (1.33 lit/s), and node 23 (3.67 lit/s). After running an algorithm, the software reported the location of leaks at node 15 (1.43 lit/s) and node 23 (3.64lit/s). In Figure 2, has been shown Changes in the objective function of the optimal population of firefly against the number of iteration. In the third case study, the purpose was finding the position and determining the amount of two simultaneous leaks at node 11 (1.03 lite/s), and node 27 (2.47 lit/s) which again successfully found by the proposed algorithm as node 11 (0.98 lit/s) and node 27 (2.49lit/s).

In the same way, this two-step algorithm is used for the other three scenarios as follows:

- Example 4: real leakage assumed at node 10 (1.23 lit/s) and 24 (1.77 lit/s). Obtained results were at node 10 (1.22 lit/s) and node 24 (1.76 lit/s).
- Example 5: real leakage assumed at node 29 (1.33 lit/s) and 30 (1.84 lit/s). Obtained results were at node 29 (1.30 lit/s) and node 30 (1.87 lit/s).
- Example 6: real leakage assumed at node 19 (1.33 lit/s) and 25 (1.84 lit/s). Obtained results were at node 19 (1.23lit/s) and node 25 (1.98 lit/s).

As the results show, the proposed algorithm accurately determined the location and amount of leaks with high accuracy.

4. CONCLUSIONS

In this paper, a new method for determining the location and amount of one or two simultaneous leaks in water distribution networks is developed. One of the advantages of the proposed method is the high accuracy in determining the location and the amount of leakage. This algorithm can use both pressure and and flow or their combining data. Another benefit of the proposed algorithm is that very low leakage rates are detectable and the number of fields needed observations is clear from the beginning. The overall results indicate that the developed method can be used for finding the location and amount of up to 2 simultaneous unreported leaks in water distribution networks.

REFERENCES

[1] Puust, R., Kapelan, Z., Savic, D.A., and Koppel, T., 2010. "A review of methods for leakage management in pipe networks". *Urban Water,* 7(1), pp. 25-45.

[2] Samir, N., Kansoh, R., Elbarki, W., and Fleifle, A., 2017. "Pressure control for minimizing leakage in water distribution systems". *Alexandria Engineering*, 56(4), pp.601-612.

[3] Xin-She, Y., 2010. "Engineering Optimization : an introduction with metaheuristic applications". *John Wiley & Sons*.

[4] Poulakis, Z., Valougeorgis, D., and Papadimitriou, C., 2003. "Leakage detection in water pipe networks using a bayesian probabilistic framework". *Probabilistic Engineering Mechanics*, 18(4), pp. 315-327.

HOW TO CITE THIS ARTICLE

R. Moasheri, M.R. Jalili-Ghazizadeh, Identifying Position and Amount of Two Simultaneous Leaks in Water Supply Networks by a Two-step Algorithm, Amirkabir J. Civil Eng., 52(5) (2020) 297-300.

DOI: 10.22060/ceej.2018.15272.5867