Multi-Objective Optimization of Pumping Station Operation in Water Distribution Network Using ACO

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Abstract

Ant Colony Optimization (ACO) is one of the recent evolutionary algorithms with high speed and efficient search comparing to other optimization methods. This research has two main objectives to optimize the operation of pumping station in water distribution network (WDN) by means of ACO. The first object is to minimize the cost of pumping energy consumption through the scheduling of pumping station and the second one is to maximize the reliability of pumping station. Due to the fact that in most of the multi-objective optimization problems in WDNs the objects are in conflict with each other, which means that improving one of the promises leads to the weakness of at least one of the other objectives, therefore, there is not only one specific solution. These solutions are presented by the pareto front. To find the best solutions in this algorithm, by means of crowding distance, it is tried to produce a set of solutions with uniform distribution and to converge the solutions to the true pareto front.

By using multi-colony ant algorithm for multi-objective optimization that is modeled in Visual C++, the ability of this model is assessed to show the convergence and efficiency of this algorithm. Moreover, with the linkage of the proposed model to the EPANET2.0 simulator software, maximization of the reliability of pumping stations and minimization of the cost of pumping energy consumption are considered as a multi-objective optimization through a case study.

Keywords: Cost, Multi-objective optimization, Pareto front, Pumping station, Reliability.

1. Introduction

Pumping stations not only are encountered as costly elements of water distribution network, but also they play a crucial role in providing water with sufficient pressure and discharge to consumers. Therefore, careful analysis of pumping stations is important. Number of pumps in pumping stations should be calculated through an adequate economic analysis. Generally, in pumping stations, several pumps are used to increase the reliability, efficiency, and flexibility of the network. Mehzad et al. (2011), investigated reliability of the water distribution system by defining the reliability of network through different failure scenarios after a single-objective optimization based on cost. Most researches which have been conducted on optimization of water distribution networks only have looked at single-objective-optimization of WDN and they have not considered the joint operation of the system including the cost and reliability of the system together. In this research, multi-objective ant-colony optimization is conducted.

For designing water distribution network, multi-colony ant algorithm which is based on Ant-Q optimization algorithm was proposed by Mariano & Morales (1998). In this operation, each colony constructs the answer for its own purpose which will be provided to the next colony thereafter. In this method, non-dominated answers, which are calculated after passing the second colony, are used to update the pheromone for next iterations.

Romero & Manzanares (1999) proposed MOAQ algorithm to solve the multi-objective optimization of WDN based on ant colony algorithm. Cardoso et al. (2003) defined multi-objective optimization of MONACO to optimize water distribution systems. Afshar et al. (2009) conducted a study to optimize the performance of reservoir through multi-colony ant algorithm optimization and non-dominated answers of external archive with new operation of transferring data. They considered some functions to minimize lack of hydroelectro-power and to minimize lack of demand for downstream of the network. They calculated the best