Application of Genetic Algorithm in Optimal Design of Surge Tank in Pipeline System

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Abstract

In this paper, Genetic Algorithm is used for optimal design of surge tank in pipeline systems under transient conditions. The Implicit Method of Characteristics is used for simulation of pipeline system. The objective of using GA is to optimize the cost of surge tank in system by minimizing its volume such that an existing pipeline can resist pressure surges induced by transient operation of the system. The method is applied to two example problems of transient flow caused by valve closure. The results clearly emphasize on applicability of optimization model for the optimal design of surge tanks in pipeline systems.

Keywords: Genetic algorithm, Water hammer, Transient flow, Surge tank, Implicit method of characteristic.

1. INTRODUCTION

Optimal design of pipeline system can reduce the cost and effect of transient flow in the systems. This involves determining the commercial diameter of pipes while satisfying the water demand and allowable pressure head at each node. Moreover, water hammer, which is produced by a rapid change of the flow velocity in the pipelines, usually results in violent change of the pressure head, which is then propagated in the pipeline in a form of a fast pressure wave leading to sever damages. The transient effects should, therefore, be taken into account when designing new pipelines and operation of existing pipelines. Optimization techniques can prove very useful in this regard.

Keedwell and Khu [1] proposed new cellular automata (CA)-inspired approach for the optimal design of water distribution networks. They show that their proposed method required a limited number of model evaluation. They applied their algorithm to a test network and two real water distribution systems with the objective of determination of pipes diameter while minimizing the cost of pipes. They compared the results of CA algorithm with genetic algorithm and showed that CA solutions were obtained in much less computational time than GA. Varma et al. [2] applied Nonlinear Programming (NLP) methods for optimal design of water distribution systems. Pipe flows, pressure drops and diameters of pipes were used for the formulation of the optimal design problem. A reduced optimization problem, obtained by the elimination of hydraulic constraints, was proposed and a successive quadratic programming was used for its solution. Farmani et al. [3] proposed a self-adaptive fitness formulation for solving constrained optimization of water distribution networks. Their method does not require any parameter tuning and initial feasible solution. The method is applied to two networks and the results show that the proposed method found optimum solution with less computational effort in comparison with other constraint handling algorithms. Afshar et al. [4] proposed a method for simultaneous optimization of layout and component-size of pipe networks. Their method is based on the reliability concept, which is evaluated as the number of independent paths from source nodes to each consumption node. The start point of their method is considering the maximum layout, including all possible connection. Then, by applying an iterative design-float procedure, move from the current to cheaper layout to satisfy the predetermined reliability. The performance of the method is tested with a benchmark example and the results show the superiority of their proposed method to the existing methods. Halhal et al. [5] used a structured messy GA (SMGA) for multi-objective optimization of the network rehabilitation. They showed that SMGA performed much better than a standard GA in large networks. Recently, Afshar and Rohani [6] proposed an Implicit Method of Characteristics (IMOC) to remove the shortcomings of the conventional method of characteristics. In the IMOC, all the devices in a pipeline system were defined in an element-wise manner and their governing equations were assembled to form the final system of equations to be solved for the unknown nodal heads and flows. This method was