Dynamic penalty function as a strategy in solving water resources combinatorial optimization problems with honey-bee mating optimization (HBMO) algorithm

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ABSTRACT

Because of the complexity of some optimization problems, evolutionary and meta-heuristic algorithms are sometimes more applicable than the traditional optimization methods. Some difficulties in solving design-operation problems in the field of engineering are due to the multi-modality of the solution region of these problems. Since the design variables usually are specified as discrete variables and other continuous decision variables have to be set according to the range of the discrete ones, the possibility of trapping the final solution into some local optimum increases. In such cases, the capability of both traditional and evolutionary algorithms decreases. Thus, the development of a strategy to overcome this problem is the subject of this paper. For water utilities, one of the greatest potential areas for energy cost-savings is the effective scheduling of daily pump operations. Optimum design operation of pumping stations is a potential problem in this area that performs a wide background of solutions to this problem with different methods. Computation in all methods is driven by an objective function that includes operating and capital costs subject to various performances and hydraulic constraints. This paper achieves the optimal control and operation of an irrigation pumping station system by one of the latest tools used in optimization problems, which is the honey-bees mating optimization (HBMO) algorithm and is tested with a practical design. The HBMO algorithm with dynamic penalty function is presented and compared with two other well-known optimization tools which are the Lagrange multipliers (LM) method and genetic algorithms (GA) as well as with the previous results of the HBMO algorithm with constant penalty function for the same problem. The LM, GA and HBMO approaches simultaneously determine the least total annual cost of the pumping station and its operation. The solution includes the selection of pump type, capacity and the number of units, as well as scheduling the operation of irrigation pumps that results in minimum design and operating cost for a set of water demand curves. In this paper, the HBMO algorithm is applied and the dynamic penalty function is tested to demonstrate the efficiency of this combination simultaneously. The results are very promising and prove the ability of combining the dynamic penalty function with the HBMO algorithm for solving combinatorial design–operation optimization problems. Application of all these models to a real-world project shows not only considerable savings in cost and energy but also highlights the efficiency and capability of the dynamic penalty function in the HBMO algorithm for solving complex problems of this type.

Key words | combinatorial optimization problems, dynamic penalty function, honey-bee mating optimization, optimal design, optimum operation, pumping stations

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