Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 186 (2017) 530 – 536

Procedia Engineering

www.elsevier.com/locate/procedia

XVIII International Conference on Water Distribution Systems Analysis, WDSA2016

Hybrid optimization proposal for the design of collective on-rotation operating irrigation networks

C. Mireya Lapo[a]*, Rafael Pérez-García[b], Joaquín Izquierdo[b], David Ayala-Cabrera[b]

[a]*Universidad Técnica Particular de Loja, San Cayetano Alto, Loja 11-01-608, Ecuador*
[b]*FluIng-IMM, Universitat Politècnica de València, Cno de Vera s/n Edif. 5C, Valencia, 46022, Spain*

Abstract

Hybrid models have been used in many engineering applications in order to find better solutions and to reduce project costs. In this paper a methodology for the optimal design of collective working shift irrigation systems is proposed. The proposal is based on a hybrid model of optimization, which includes Linear Programming (LP) and Genetic Algorithms (GA). The method is applied to an irrigation network to check its effectiveness to minimize the total investment costs for pipelines. The results are compared to another hybrid model for optimization, which is based on Nonlinear Programming (NLP) and GA. The advantage of the developed method is a more cost effective design using discrete pipeline diameters.

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

Keywords: Collective irrigation networks, irrigation on-rotation, optimal network design, optimization, genetic algorithms

1. Introduction

Irrigation systems are instrumental solutions for the growing food demand worldwide. Design, management and operation of these systems are fundamental for a rational use of water, for economic development in agriculture and for environmental sustainability [1]. Advanced technical irrigation systems facilitate the operation and make the service more efficient. However, one important decision parameters for these systems is the economic aspects. The

* Corresponding author. Tel.: +593-07-370-1444; fax: +593-07-258-5974.
E-mail address: cmlapo@uptl.edu.ec

Peer-review under responsibility of the organizing committee of the XVIII International Conference on Water Distribution Systems
doi:10.1016/j.proeng.2017.03.266

design of Pressurized Collective Irrigation Networks (PCINs) is of special interest in the agricultural sector, because they are suitable for high crop production concurrently with reductions in investment and operating costs, as well as to mitigate environmental and social impacts [2]. The implementation of working shift on-rotation irrigation systems in PCINs has been strengthened due to its simplicity in operation and economy, especially in small farms with high dispersion of hydrants, irregular plots and topography [3]. However, this practice includes an additional variable compared to irrigation demand system, which must be considered in the design of the network, namely the allocation of working shifts for each hydrant. The model input data are the costs of the pipelines (locally available), the network topology and the hydraulic requirements. The output data are the lengths of the pipes at each branch of the network, the operating pressure at the head of the network, the total investment costs and the working shifts assigned to each hydrant. For a feasible model run the speed range of the flow inside the pipes has to be established to prevent sedimentation and scour, as well as the pressure range set for each hydrant. The objective of the proposed methodology is to reduce the total investment costs for pipelines of working shift on-rotation irrigation systems.

The paper is structured as follows: In section 2 a brief introduction of hybrid models implemented in hydraulic engineering and their importance is given. Section 3 presents general applications of hybrid models in working shift on-rotation irrigation systems. Section 4 describes the components of the proposed hybrid model and its architecture. In section 5 the implementation of the hybrid model is explained and in section 6 the model is applied to a case study. The paper ends with general conclusions.

Nomenclature

C_T	total investment costs of the network [$]
i	pipe number
C_i	pipe unit price [$/m]
$L_{i,j}$	length of the path sections and diameter corresponding to section j [m]
j	section number
$S_{0,n,k}$	set of lines belonging to the path between nodes 0 and n (in the turn k)
$hf_{i,k}$	head losses in the set of lines belonging to the path (in the turn k)
$\Delta H_{0,n,k}$	maximum allowable head loss between node 0 and node n [m]
ND	number of sections in line i

2. Hybrid models

Applying hybrid models have solved many problems in hydraulic engineering and water management. One type of hybrid model combines artificial neural networks with the continuity equation. Thus, the prediction of the discharge downstream a river system is possible [4]. Other hybrid models are used to predict the outflow of pressurized hydrocarbon pipes by coupling numerical solution techniques with hydraulic flow models [5]. In the area of irrigation networks hybrid models are implemented to minimize power consumption of the working shift hydrants by combining Dynamic Programming (DP) and Genetic Algorithms (GA) [6]. Another application in this area is the allocation of the working shifts to different hydrants, looking for the most cost effective option by means of GA [7]. Finally, hybrid models are used to minimize the total investment costs of working shift PCINs using Nonlinear Programming (NLP) and GA [8].

3. Working shift on-rotation irrigation system

The development of algorithms for working shift on-rotation irrigation networks is important, due to the improvement of the flow circulation in the pipelines. It offers a reduction of total investment costs for irrigation networks [9], because all designed flow at each section are taken into account for the total downstream discharge. The