Contents lists available at SciVerse ScienceDirect

Chemical Engineering Research and Design

journal homepage: www.elsevier.com/locate/cherd

Integrated framework for the design of pipeline systems using stochastic optimisation and GIS tools

Eftychia C. Marcoulaki[a,*], *Ioannis A. Papazoglou*[a], *Nathalie Pixopoulou*[b]

[a] *System Reliability and Industrial Safety Laboratory (SRISL), National Centre for Scientific Research "Demokritos", PO Box 60228, Athens 15310, Greece*

[b] *Penspen Limited, 405 Messogeion Avenue, Athens 15343, Greece*

A B S T R A C T

This work presents an optimisation framework for the routing and equipment design of main pipelines to be used for fluid transmission. There are many considerations in these design problems, involving various constraints, decisions and the associated costs for the construction, operation, maintenance, etc., of the system. In practice, engineers rely on experience, try out various design alternatives, and use simulators for engineering calculations, cost models, geographical information systems and equipment databases to identify promising options. The present approach proposes a systematic search for optimal and near-optimal solutions. The search is based on stochastic optimisation, and assumes that the same information and simulation tools as in the case of design by trial and error are available. An application example is used to demonstrate the approach and test the robustness of the optimal search using Simulated Annealing.

© 2012 The Institution of Chemical Engineers. Published by Elsevier B.V. All rights reserved.

Keywords: Pipeline routing; GIS; Optimisation; Simulated Annealing; Process design; Safety

1. Introduction

During the last couple of years and despite the economic downturn, the number of oil and gas pipelines being planned and built is increasing, to meet the growing energy demands. Planned projects on December 2011 accounted for 119,938 miles of international pipelines, compared to 24,260 and 17,941 at the end of 2010 and 2009, respectively. Projects in various stages of construction had a 25% increase compared to their 2010 and 2009 figures, and accounted for 36,304 miles in 2011 (Tubb, 2011, 2010).

Many researchers have acknowledged the need for systematic methodologies to design optimal pipeline systems. Recent work on pipeline optimisation focused mainly on optimal layout development and minimisation of compressor fuel consumption. Wu et al. (2007) introduced a model to minimise the main pipeline length for compressor stations placed in series or forming a network. Ruan et al. (2009) presented a model that minimised the total pipeline and compressors investment cost. Middleton and Bielicki (2009) presented a model that estimated costs and solved for optimal spatial deployment for an efficient pipeline network. Rios-Mercado et al. (2006) formulated a minimisation problem for the fuel consumption of compressor stations in the natural gas pipeline transmission system. Baumrucker and Biegler (2010) considered the minimisation of operating fuel consumption in pipeline networks. Kabirian and Hemmati (2007) proposed a cost model combining installation and operating costs, to develop optimal network structures by selecting the type and location of pipeline and compressor stations. Grigoriev and Grigorieva (2009) also considered the location of control devices. Marseguerra et al. (2004) considered the optimal layout problem for a pipeline of given length in the presence of uncertainties in the failure rates of its constituent parts (i.e. pipes and joints). Wolfgang (2008) highlighted the need for combining investment and operating costs with system safety and maintainability.

Abbreviations: ASME, American Society of Mechanical Engineers; GIS, geographical information system; PCD, pressure control device; SA, Simulated Annealing; SRISL, System Reliability and Industrial Safety Laboratory; USD, United States Dollar.

* *Corresponding author*. Tel.: +30 210 6503743; fax: +30 210 6545496.
E-mail addresses: emarcoulaki@ipta.demokritos.gr, emarcoulaki@gmail.com (E.C. Marcoulaki).

Received 21 March 2012; Received in revised form 14 May 2012; Accepted 17 May 2012
0263-8762/$ – see front matter © 2012 The Institution of Chemical Engineers. Published by Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.cherd.2012.05.012