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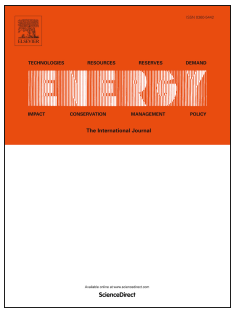

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Prediction and Verification of Risk Loss Cost for Improved Natural Gas Network Layout Optimization

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Abstract Natural gas pipelines play a key role in the transmission and distribution of natural gas, and reliable optimization of the pipeline network can lead to safe and guaranteed gas transmission to individuals with minimum risk loss and effective cost. Therefore, we developed an improved layout optimization procedure and applied a new prediction method, the fuzzy comprehensive evaluation method, which is based on entropy weight and backpropagation (BP) neural network (NN). We used it to comprehensively calculate risk loss cost to achieve improved layout during the planning stage and used it to determine the initial risk loss cost. We verified the procedure using a genetic algorithm (GA) for two different layouts, one of which is the improved optimum layout and the other the conventional optimal layout. Finally, the optimized results of four different layouts were determined and the total cost of the new layout is 9.79% and 8.49% less than that of the two conventional layouts. This shows that the new prediction method of risk loss cost provides an efficient and effective means of synchronizing risk loss cost and total cost during the layout planning stage for natural gas transmission network.

Keywords Layout optimization; Comprehensive risk evaluation; Risk loss cost; Neural network (NN); Genetic algorithm (GA).

1 Introduction

The objective of a natural gas network is to transport gas to the consumer at the lowest possible overall cost. Natural gas pipelines play an important role in the transmission and distribution of natural gas because of their convenience, economy, and reliability (Zaman et al., 2012). In China, a large number of complex piping systems located have been constructed in highly populated zones to transport and distribute gas due to the increasing consumption of natural gas in recent years. China built more than 85,000 km of trunk gas pipelines by the year 2012 (Tubb, 2012). However, accidents caused by gas leakage may pose great threats to urban public safety and cause substantial economic losses (Jonkman et al., 2003; Montiel et al., 1996; Montiel et al., 1998). Safety and reliability of pipeline networks at the operation stage have been studied extensively because of their important roles in the risk loss of natural gas transportation (Rios-Mercado and Borraz-Sanchez, 2015). To this end, the total cost should include routine costs (such as fixed construction cost and operational cost) and risk loss costs from all types of accidents during operation. Therefore, it is imperative to synchronize the minimum risk loss with the total cost during the planning stage of natural gas transmission and distribution networks.

A conventional optimal layout can usually be produced either by synchronous optimization layout method or shortest layout method. To date, there have only been a few studies of the former layout. The layout optimization presented by Sanaye is committed to synchronizing the minimum total costs (containing investment and operating costs) and layout but does not consider the risk loss (Sanaye and Mahmoudimehr, 2013). There are plenty of studies regarding the latter layout.