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MULTI-OBJECTIVE OPTIMIZATION FOR THE PLACEMENT OF GAS DETECTORS IN NATURAL GAS STATION CONSIDERING MULTIPLE FACTORS

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Abstract

When gas leakage incidents occur at natural gas stations, the potential consequences, such as fires or other accidents, can be severe. This emphasizes the critical importance of implementing high-efficiency gas detection systems at these stations. Key considerations in designing such systems include detection time and the cost-benefit ratio (CBR). This research proposed a novel multi-objective optimization framework aimed at strategically situating detectors to achieve a balance between enhancing detection efficacy and optimizing investment outlays. To address the variability inherent in potential gas leakage incidents, a complete set of accident scenarios (CASS) is formulated, integrating diverse leak sources and wind field dynamics. To manage the computational cost associated with simulating the consequences of these leakage scenarios, the K-means clustering analysis technique is leveraged to screen representative scenarios from CASS. Subsequently, the dispersion consequences are modeled using computational fluid dynamics (CFD) methods. The proposed multi-objective optimization paradigm concurrently prioritizes the minimization of cumulative detection time (MCDT) while ensuring the preservation of a judicious cost-benefit ratio. This optimization framework is solved through the utilization of an enhanced non-dominated sorting genetic algorithm (NSGA). Finally, a case study is also conducted to illustrate its application and the gas detector network optimization results in a natural gas transmission station.

Key words: computational fluid dynamics, cost-benefit ratio, gas detectors, multi-objective, optimization

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