A Strategy for Optimal Sensor Allocation to Detect Hazardous Gas Releases

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ABSTRACT

All chemical plants using hazardous gas have the potential to produce fatalities when part of the gas is accidentally released. In this work, it is assumed that the gas is released according to the worst-case scenario. A set of potential points, $PP$, to allocate sensors are defined based on practical issues. CFD simulation, where all obstacles are included, is carried out to estimate steady-state concentrations on each $PP$. This procedure is repeated to configure a Monte Carlo simulation where different meteorological conditions are used to cover the whole range of wind speed and wind direction. To solve the allocation, the procedure is as follows: The $s$ points having the maximum concentration in each Monte Carlo run are first selected. More points could be selected when the level of concentration equals the worst $s$-point concentration. Each $PP$ contains an associated set $S_{PP}$ of the Monte Carlo run where the point was considered successful, i.e. the run where the point had the highest concentration. The storage demand is thus substantially reduced. When all runs have been performed, the selection of the best allocation consists on finding the point with the highest number of successful runs. When a selection is obtained, the runs contained in the selected $S_{PP}$ are removed from the others $S_{PP}$ in $PP$. For allocating a given number of $s$ sensors, the procedure is repeated $s$-times unless all Monte Carlo runs have been detected. In this way, the procedure prevents redundancy in the allocation. When the given $s$ sensors have been allocated, the efficiency can be estimated by dividing the number of undetected Monte Carlo runs by the total number of run simulations. When the percent of detection is given, the procedure stops when this efficiency is achieved. It would result in the best allocation for the minimum number of sensors. The case study considers a pilot plant where an explosive gas is assumed to be released from a pipe feeding a tubular and catalytic reactor.

Keywords: Sensor allocation; Gas Dispersion; Hazardous release; Stochastic Optimization; CFD simulation.