

Fuzzy logic for process safety analysis

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ABSTRACT

Fuzzy logic deals with uncertainty and imprecision, and is an efficient tool for solving problems where knowledge uncertainty may occur. Such situations frequently arise in a quantitative fault and event tree analysis in safety and risk assessment of different processes. The lack of detailed data on failure rates, uncertainties in available data, imprecision and vagueness may lead to uncertainty in results, thus producing an underestimated or overestimated process risk level.

This paper explores the application of fuzzy sets theory for basic tools used in process safety analysis such as fault and event tree methods which can be further used in the “bow-tie” approach for accident scenario risk assessment. In the traditional fault and event tree analyses, the input variables are treated as exact values and the exact outcome data are received by an appropriate mathematical approach. In the fuzzy method, all variables are replaced by fuzzy numbers in the process of fuzzification and subsequently using fuzzy arithmetic, fuzzy probability of the top event for fault tree, and fuzzy outcome probabilities for event tree are calculated. A single value for each of the outcome event result is obtained with the use of one of the defuzzification methods. A typical case study comprising a fault tree for rupture of the isobutane storage tank and the event tree for its consequences is performed and a comparison between the traditional approach and fuzzy method is made.

Keywords: Process safety analysis; Fuzzy logic; Risk assessment; Uncertainty; Bow-tie model; Fault tree analysis; Event tree analysis