Special issue
Risk-based approaches to design and operation of process systems

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Traditional rule-based approaches to the design of engineered systems tend to consist of three main phases: Conceptual design, preliminary design, and detailed design.

Traditional approaches have long been employed as powerful tools for specification and utilization of general knowledge in design. When it comes to the operation of engineered systems, operators are likely to follow the technical guidelines that offer prescriptive requirements based on currently available knowledge and experience. In this context, safety rules are usually treated as design and operational constraints, preventing innovation for system performance improvement. This, in turn, may result in over-conservative design and operational problems.

Risk assessment is not new to many industries. Still, the results are usually used merely to identify risk management strategies rather than make modifications to the design and operation of systems to increase safety in a cost-effective way. The underlying rationale of risk-based approaches to design and operation seems to be more in line with the philosophy adopted by the industries to apply the goal/performance-based approach.

This special issue presents some risk-based approaches and methodologies to improving the design, operation, and management of chemical and process facilities onshore and offshore.

Li et al. (2020) have proposed a methodology by integrating an index-based risk evaluation system and fuzzy TOPSIS model for risk management of aging urban oil and gas pipelines. The authors demonstrated that the methodology could effectively prioritize the safety hazards of aging pipelines, thus helping identify strategies to reduce the operational risk.

Lu et al. (2020) developed a methodology based on Bayesian network to identify the critical aspects in offshore oil spillage and subsequently enable effective oil spill recovery strategies. Accounting for uncertain parameters such as sea ice conditions, ship-ship collisions and consequent oil outflow, oil dispersion and spreading in the ice conditions, etc. A Bayesian Network model for the mechanical oil spill recovery system was developed.

With regard to risk assessment of rare accidents, Arif et al. (2020) applied the outlier-based extreme value theory to estimate the probability of iceberg collisions. Considering iceberg collision as a heavy tail event, they used the maximum likelihood criterion to estimate the distribution parameters.

Bhaskaran et al. (2020) developed fault identification and prediction methods based on K-means clustering and time-series forecasting incorporated with linear regression algorithm to predict and assess the risk of crack and blockages due to abnormal pressure fluctuations.

Yang et al. (2020) investigated the mitigation performance of the process protection systems. Modeling several chain accidents of H_2S-containing natural gas leakage and explosion by varying the response time of the process protection system, they proposed that the process protection systems are more effective than evacuation procedures and can mitigate the adverse impacts of fire and explosions regardless of whether the emergency evacuation is conducted or not.

Considering natural-technological events (Na-Techs), Qin et al. (2020) developed a methodology for assessing and reducing the vulnerability of storage tanks to hurricanes. Considering the multi-hazard nature of hurricanes, they used Bayesian network to combine the failure modes while considering their conditional dependencies. Extending the developed BN to an influence diagram, the cost-benefit filling of storage tanks with water prior to the advent of hurricanes was shown as a viable measure for reducing the damage probability.

Yang et al. (2021) assessed the operational reliability of wellbore casing using data statistics and numerical simulation. Identifying the model variables such as including rock mechanics, cement ring, and casing string strength factors, the authors employed statistical analyses to determine the distribution parameters of the model variables. Monte Carlo simulation was then conducted to obtain the residual strength distribution and the reliability of the wellbore casing.

Qi et al. (2021) introduced the so-called bi-directional connectivity diagram (BDCD) to visualize the interactions between multiple process units during accidents. They showed that safety barriers interrupt the connection between the units and thus minimize the influence of one BDCD node on another. The authors argued that the BDCD approach is more effective than traditional methods for analyzing the multi-unit accident propagation in chemical plants and for achieving intrinsic safety.

Miao et al. (2021) developed a dynamic risk classification control algorithm for coal chemical enterprises by combining the optimized neural network with a control chart. By analyzing the control chart, the optimized neural network was used to predict and early warn the risk development trend of enterprises, and optimize coal chemical enterprises' process flow. Based on dynamic risks hierarchical management and control, an application tool "dynamic risks hierarchical management and control system" was developed.

Namvar and Bamdad (2021) employed data envelopment analysis (DEA) to evaluate the relative efficiency and resiliency of process industries based on their internal structure and considering normal states, process upsets, and catastrophic events. The authors demonstrated that the developed methodology could be effectively used for monitoring and assessing risks during avoidance, survival, and recovery phases of the system.

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