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Optimizing Polymeric Fed-Batch Processes Using Reinforcement Learning

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Reinforcement Learning (RL) has emerged as a pivotal tool in the chemical industry, providing innovative solutions to complex challenges. RL is primarily utilized to enhance chemical processes, improve production outcomes, and minimize waste. By enabling the automation and real-time optimization of control systems, RL aims to achieve optimal efficiency in chemical plant operations, thereby significantly reducing operational costs and enhancing process reliability.

In the polymeric fed-batch process, which consists of the feeding phase and the digestion phase, optimization is particularly challenging due to differing constraints and control variables across the phases. This complex process necessitates a careful design of the Markov Decision Process (MDP) and the formulation of reward/cost functions that accurately reflect the operational goals and safety requirements. The irreversible and exothermic nature of these reactions further imposes stringent safety constraints, necessitating robust control mechanisms to prevent hazardous conditions.

In this study, we employ an in-house developed hybrid model to meticulously design an MDP and utilize the Soft Actor-Critic (SAC) algorithm to train an RL agent. Our primary objective is to maximize the yield of the final product while strictly adhering to safety constraints. Detailed performance comparisons between SAC-trained RL agents and human expert golden-batch execution demonstrate that the SAC-trained agent can complete the process approximately 20% faster than the golden-batch, while maintaining safe temperature boundaries and achieving comparable product yield. These promising results underscore the potential of RL to significantly enhance both the efficiency and safety of complex chemical processes, making it a valuable asset in industrial applications.

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Talk

Classification

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