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Computer Modeling and Plant-Wide Dynamic Simulation for Industrial Flare Minimization

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Abstract : Flaring emissions during abnormal operating conditions such as plant start-ups, shut-downs, and upsets in chemical process industries (CPI) are usually significant. Flare minimization can help to save raw material and energy for CPI plants, and to improve local environmental sustainability. In this paper, a systematic methodology based on plant-wide dynamic simulation is presented for CPI plant flare minimizations under abnormal operating conditions. Since off-specification emission sources are inevitable during abnormal operating conditions, to significantly reduce flaring emission in a CPI plant, they must be either recycled to the upstream process for online reuse, or stored somewhere temporarily for future reprocessing, when the CPI plant manufacturing returns to stable operation. Thus, the off-spec products could be reused instead of being flared. This can be achieved through the identification of viable design and operational strategies during normal and abnormal operations through plant-wide dynamic scheduling, simulation, and optimization. The proposed study includes three stages of simulation works: (i) developing and validating a steady-state model of a CPI plant; (ii) transiting the obtained steady-state plant model to the dynamic modeling environment; and refining and validating the plant dynamic model; and (iii) developing flare minimization strategies for abnormal operating conditions of a CPI plant via a validated plant-wide dynamic model. This cost-effective methodology has two main merits: (i) employing large-scale dynamic modeling and simulations for industrial flare minimization, which involves various unit models for modeling hundreds of CPI plant facilities; (ii) dealing with critical abnormal operating conditions of CPI plants such as plant start-up and shut-down. Two virtual case studies on flare minimizations for start-up operation (over 50% of emission savings) and shut-down operation (over 70% of emission savings) of an ethylene plant have been employed to demonstrate the efficacy of the proposed study.

Keywords : flare minimization, large-scale modeling and simulation, plant shut-down, plant start-up
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