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Soft Sensing Alkanolamine Concentration for Intelligent Circulation Optimization

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The processing of natural gas plays a vital role in producing valuable petrochemicals, such as sales gas, and NGL, which cater to various industrial needs. Nonetheless, crude natural gas often carries undesired acidic compounds, notably hydrogen sulfide (H2S), carbon dioxide (CO2), and carbonyl sulfide (COS), posing significant obstacles to effective hydrocarbon recovery and purification. To tackle this challenge, gas sweetening technologies utilize alkanolamine solutions within a self-contained recirculating system, aiming to selectively eliminate acid gases while preserving desirable hydrocarbons. By modulating the circulation rate in accordance with the incoming feed gas' acidity level, operators strive to strike a balance between preventing acid gas contamination and minimizing losses of processed products. In conventional setups, the circulation rate of lean alkanolamine is regulated solely by monitoring the bottom-tray temperature of the contactor column. Unfortunately, this simplistic approach proves unreliable under real-world operating conditions. Temperature profiles are influenced by numerous variables beyond just acid gas concentrations, including inlet temperatures of both gas feeds and amine streams, plus environmental fluctuations. As a result, operators struggle to optimize circulation rates efficiently, leading to subpar performance and increased risk of acid gas breakthrough.

A novel approach is presented, utilizing soft-sensor analytics to predict alkanolamine concentrations and optimize circulation rates accordingly. Machine learning algorithms, specifically artificial neural networks (ANNs), are employed to estimate alkanolamine levels based on carefully selected inputs derived from fundamental principles governing mass transfer operations. Predictions obtained from the ANN model serve as critical decision-making tools for adjusting circulation flows to comply with stringent process specifications and account for thermal management constraints. Ensuring adherence to predetermined ratios between acid gas mole fractions and corresponding amounts of available amine molecules ensures compliance with process specifications. Accounting for limited cooling capacities imposes adjustments to minimize excessive heat loads during regeneration phases. Empirical validation confirms notable enhancements over legacy methods. Implementation of the proposed circulation strategy yielded reductions in resource utilization across various installations. Sustained operation near optimal lean amine temperatures significantly enhanced final-product purity, characterized by appreciable diminishment of residual acid-gas contents.

The results indicate the effectiveness of proposed methodology in streamlining circulation optimization, making it an attractive option for industry-wide adoption. Notably, the proposed approach yields tangible benefits, including reduced energy consumption and prevention of acid gas breakthroughs in sweet gas products. Specifically, the method achieves a 7.5% reduction in steam consumption in regeneration reboilers. Effectively, this is equivalent to approximately 3% drop in fuel gas consumption since gas sweetening processes consume about 40% of the total steam demand to a fully integrated gas plant. Furthermore, maintaining consistently low lean amine temperatures translated to improved sweet gas quality, characterized by lower acid gas concentrations.