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Exergoeconomic assessment of the optimised vapour-recompression assisted column for palm-based fatty acid fractionation

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Abstract

In our preliminary study (Sidek and Othman, 2020), vapour recompression (VRC) proved to have a promising energy performance in the case of palm kernel oil (PKO) fatty acid fractionation. This paper extends the research by applying an exergy analysis as well as incorporating four vacuum fractionation columns to represent a real industry application. The study also included a two-step optimization approach based on response surface methodology. All configurations were evaluated for their exergetic and economic performances. Due to the high costs and low efficiency, the optimised VRC-assisted columns are not in favour of this study. The standard VRC-assisted columns, though exhibit a higher CAPEX than the conventional columns, are more thermodynamically efficient and demonstrate a substantial reduction of 84-88% in OPEX. A thorough optimisation study is needed for future works.

Keywords: vapour recompression, fatty acid fractionation, optimization, exergy.

1. Introduction

Since the pandemic, the oleochemical industry has witnessed greater product demand due to increased hygiene needs. Specific measures must be implemented to ensure a continuous supply of oleochemical products to consumers. The industry's primary separation units are distillation columns, which are used to separate oleochemical cuts. In practice, distillation columns are well-known as major energy consumers. In recent years, research on heat pump-assisted distillation has recently piqued the interest of many academics to reduce the associated energy consumption. However, no research has been devoted to heat pumping in oleochemical distillation. Besides, the majority of established oleochemical refineries in Malaysia still employ mature distillation technologies. In light of these circumstances, oleochemical distillation appears to be a prime focus for improvement. In a prior study, we discovered that vapour recompression (VRC), a popular heat pump scheme, showed promising energy performance in the case of palm kernel oil (PKO) fatty acid fractionation (Sidek and Othman, 2020). The research, although attempting to move towards a more sustainable approach, is still preliminary. The reason is that to facilitate convergence, only one fractionation column was considered to evaluate the feasibility of VRC. In an industrial operation, the PKO fatty acid fractionation involves four operational columns, which include a pre-fractionator for recovering C8-C10 products, a light-cut column for recovering C12, a middle-cut column