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Experimental campaign, modeling, and sensitivity analysis for the molecular distillation of petroleum residues 673.15 K+

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A B S T R A C T

This research activity proposes a sensitivity analysis of the molecular distillation process by focusing the attention on the response of the overall distillate flow rate under several conditions of distillation temperature and feed flow rate. Specific equations to characterize physicochemical properties of petroleum residues have been formulated by means of ASTM-based experimental campaigns combined with specific optimization techniques.

The steady state refining process simulator by Petrobras coupled with appropriate finite-difference methods is adopted for the simulation of a heated and extremely low-pressure falling film evaporator to separate a heavy residue 673.15 K+ of Gamma + Sigma crude oil. Numerical results are validated on the experimental points.

Keywords: Molecular distillation; Petroleum residue; Mathematical modeling; Simulation; Physicochemical properties

1. Introduction

Molecular distillation is a separation process based on the free transfer of molecules evaporated (unobstructed-path distillation) under high vacuum. The distance of transfer is comparable with the mean free path of the vapor molecules in the residual gas (short-path evaporation). The process operates at the lowest temperature and involves the least thermal decomposition as already discussed elsewhere (Hickman, 1943).

Between 1920 and 1940 the technique presented a revolutionary evolution, where those world's most plentiful raw materials considered "undistillable", such as the natural oils, fats, and waxes, were distillated by molecular distillation process.

In the middle 1920s C.R. Burch began experimentations in high-vacuum distillation (Hickman, 1943). He was one of the earliest workers to employ the Langmuir mercury condensation pump for producing the high vacuum in a still. Also, he examined the residue from petroleum refineries and demonstrated that a substantial proportion of this hitherto undistillable mixture could be distilled.

From vaseline he produced mobile liquid fractions of high molecular weights and exceedingly low vapor pressure. In the falling-film molecular distiller, the flowrate to be distilled is allowed to flow by gravity down a hot vertical surface on

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