Assignment 4

You are tasked with designing a MATLAB program to simulate and optimize the distillation process for a binary **ethanol-water** mixture. The simulation must account for dynamic changes in the feed composition and operating parameters of the mixture. The goal is to ensure high-purity distillate while minimizing energy consumption in the reboiler and condenser. **Use x-y equilibrium data from assignment 3**. (hint: There's a trade-off between energy spent and high-purity (xb or xd) achieved)

Requirements

1. Dynamic Feed Composition

The feed composition, x_f, flowing in at a rate of 100 mol/hr varies over time according to the equation:

$$x_f(t) = x_{f0} + A\sin(\omega t)$$

where:

- x_{f0}: Average feed composition (**Given: 0.35**).
- A: Amplitude of fluctuation (**Given: 0.07**).
- ω: Angular frequency (**Given:** $2\pi/10$ **rad/s**).

2. Variable Reflux Ratio (R)

- The reflux ratio, $R(t)$, changes **linearly** with time within the range $[R_{\min}, R_{\max}]$ (**Given:** $R_{\mathbf{min}} = 1.2$**,** $R_{\mathbf{max}} = 2.5$).
- $R(t)$ must be dynamically adjusted based on the distillate composition to maintain a purity of at least 95% (top and bottom both).

5. Energy Optimization

- Calculate the reboiler and condenser duties dynamically at each time step.
- Implement an energy optimization strategy to minimize energy consumption while achieving the required purity. (To be incl. in the presentation)

6. Process Outputs

- Plot the McCabe-Thiele diagram dynamically (utilize matlab commands like *clf, pause*, etc.), updating as the feed composition and operating conditions change.
- Plot the distillate and bottoms compositions over time.
- Plot the energy consumption (reboiler and condenser duties) over time.

7. Export Results

Export the following data to an Excel file:

- Time-step-wise values of feed composition, distillate composition, bottoms composition, reflux ratio, reboiler and condenser duties, and theoretical stages. (use commands like *table, writetable*, etc.)

Tasks

1. Simulate the distillation process dynamically for a **10-hour** operation.
2. Determine the **minimum reflux ratio** required to achieve 95% purity in the distillate.
3. Calculate the **total energy** consumed by the reboiler and condenser over the entire operation.