

BINARY DISTILLATION

OVERVIEW:

The Distillation Tower Operations program uses a bubble cap plate distillation tower with multiple horizontal plates (or trays), which promote mixing and separation of vapor and liquid flows. These plates allow for efficient separation through distillation. The column used in this system is a tall structure containing 42 plates to achieve the desired separation

Distillation Tower Structure:

- **Feed Entry:** Liquid feed enters the tower from a feed pump and flows to the "Feed Plate," located lower in the column.
 - **Rectifying Section:** The portion above the feed plate where the concentration of low boiling materials increases as vapor rises.
 - **Stripping Section:** The section below the feed plate, where high boiling materials concentrate as liquid moves downward.
- **Reboiler:** Located at the bottom of the tower, the reboiler heats the liquid to its boiling point using a steam coil, producing vapor that rises through the tower.
- **Condenser and Reflux Drum:** Vapor leaving the top of the tower passes through an overhead condenser, where it is mostly condensed into liquid. This liquid flows into the reflux drum.
 - **Reflux Pump:** Pumps a portion of the condensed liquid back into the tower as "liquid reflux," enhancing the separation of components.
 - **Products:**
 - **Bottom Product:** High boiling material exits from the tower's base.
 - **Overhead Liquid Product:** A portion of the condensed liquid from the reflux drum is removed as a product.
 - **Overhead Vapor Product:** Uncondensed vapor exits through an off-gas line.

Tower Operation

1. **Down-flow Pipes and Weirs:** Liquid flows downward through each plate via down-flow pipes, regulated by weirs that determine the liquid level on each plate.
2. **Bubble Caps:** Vapor rises through each tray, is distributed into the liquid by bubble caps, and mixes with it to facilitate separation. As vapor rises, it transfers heat to the liquid, condensing high boiling materials while vaporizing low boiling materials.
3. **Plate-by-Plate Process:**
 - Each plate acts as a mini tank, where:
 - **Liquid** from the plate above flows in, along with vapor from the plate below.
 - **Material Balance:** In a continuous operation, the material flowing into each plate equals the material leaving, creating a stable system.
4. **Heat and Material Balance:**
 - Heat from condensing vapor matches the heat required for vaporizing liquid on each plate, creating a near-equal vapor flow through each tray.
 - The bottom plate's temperature can be adjusted to control the fraction of high boiling material in the bottom product.
5. **Reboiler and Bottom Product:**
 - Liquid enters the reboiler, where it's heated to produce vapor. This vapor reenters the bottom plate and flows up the tower, enriching the bottom liquid with high boiling material.
 - Increasing the temperature here increases the high boiling fraction in the bottom product.
6. **Condenser and Reflux:**
 - Vapor from the top plate is condensed, with a portion returned as reflux to increase separation time and purity of the low boiling material.
 - **Reflux Rate:** Higher reflux rates increase the purity of the overhead product by extending the separation process.

Binary Distillation (Benzene Toluene Mixture)

