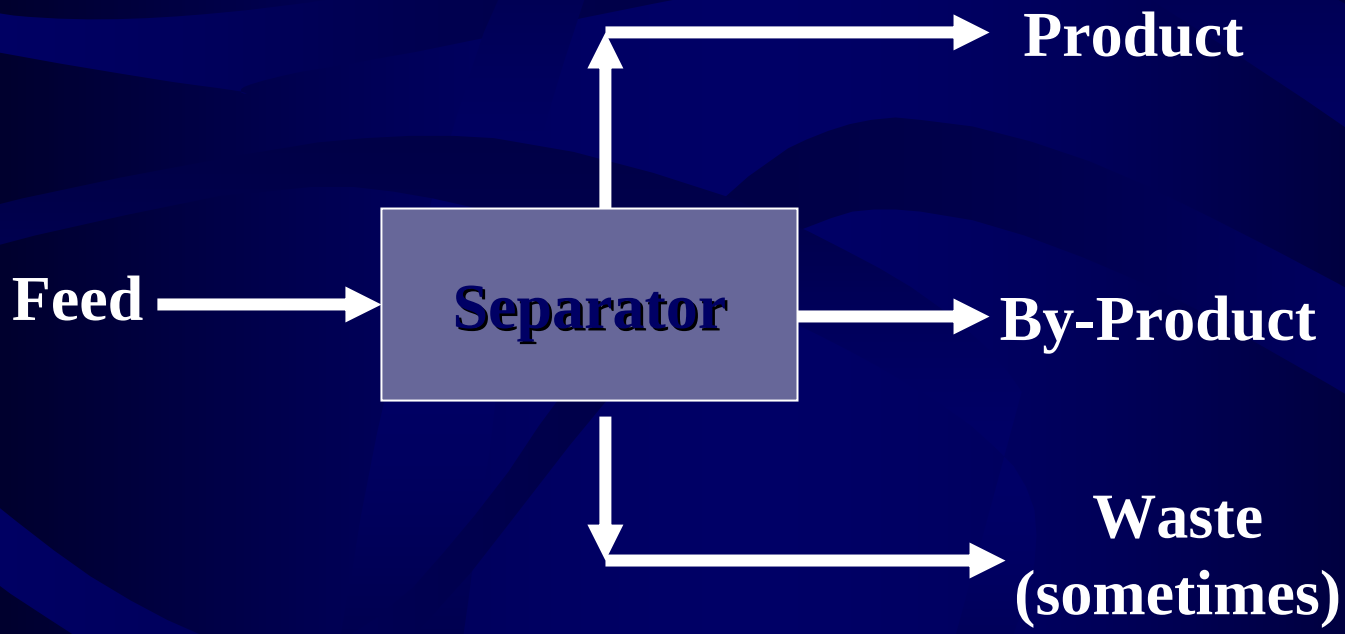
Chapter 10
Lecture # 2-2

- Separator Section

Separator Section

After the reactor section, the separator section should be studied.



Separator Section

Important Questions

❶ What type of units should be used?

❷ How should the units be sequenced?

❸ What are the product specifications for all the products?

❹ Are any of the products heat sensitive?

Separator Section

Table 10.1 Guidelines for Choosing Separation Units

- Use distillation as a first choice for separation of fluids when purity of both products is required.
- Use gas absorption to remove one trace component from a gas stream.
- Consider adsorption to remove trace impurities from gas or liquid streams.
- Consider pressure-swing adsorption to purify gas streams, especially when one of the components has a cryogenic boiling point.
- Consider membranes to separate gases of cryogenic boiling point and relatively small flowrates.
- Choose an alternative to distillation if the boiling points are very close or if the heats of vaporization are very high.

Separator Section

- Consider extraction as a choice to purify a liquid from another liquid.
- Use crystallization to separate two solids or to purify a solid from a liquid solution.
- Use evaporation to concentrate a solution of a solid in a liquid.
- Use centrifugation to concentrate a solid from a slurry.
- Use filtration to remove a solid in almost dry form from a slurry.
- Use screening to separate solids of different particle size.
- Use float/sink to separate solids of different density from a mixture of pure particles.
- Consider reverse osmosis to purify a liquid from a solution of dissolved solids.
- Use leaching to remove a solid from a solid mixture.

Separator Section

Table 10.2 Guidelines for Sequencing Separation Units

- Remove the largest product stream first. This makes all of the subsequent separation units smaller.
- For distillation, remove the product with the highest heat of vaporization first, if possible. This reduces the heating/cooling duties of subsequent units.
- Do not recombine separated streams. (This may seem obvious, but it is often disobeyed.)
- Do the easy separations first.
- Do not waste raw materials, and do not overpurify streams based on their uses.
- Remove hazardous or corrosive materials first.

Separator Section

For the separation section, other important questions to be considered include:

1. *What are the product specifications for all the products?* Product specifications are developed to satisfy customers who will use these products in their own processes. The most common specification is a minimum concentration of the main constituent, such as 99.5 wt%. Maximum impurity levels for specific contaminants may also be specified, as well as requirements for specific physical properties such as color, odor, and specific gravity. A single separation technique may not be sufficient to meet all the required product specifications.

Separator Section

Example 10.1

In the production of benzene via the HAD of toluene, it is necessary to produce a benzene product stream that contains >99.5 wt% benzene that is water white in color (i.e, absolutely clear). If the feed toluene to the process contains a small amount of color, determine a preliminary separation scheme to produce the desired benzene product

Separator Section

- As a guide, look at Fig 1.5 (HDA of toluene).
- Separation can be accomplished using distillation due to wide difference in volatility between toluene and benzene.
- Compound causing coloration is soluble in both benzene and toluene
- Laboratory test shows that benzene can be decolorized by passing it through a bed of activated carbon
- Thus, add an activated carbon adsorber as a second separation step to decolorize the benzene product.

Separator Section

2. *Are any of the products heat sensitive?* If any of the products or by-products are heat sensitive (i.e., they decompose or polymerize at elevated temperatures), the conditions used in the separations section may have to be adjusted.

Separator Section

Example 10.2

It is known that acrylic acid starts to polymerize at 90 ^{o}C. Acrylic acid must be separated from acetic acid to produce the required purity product, and the volatilities of both acids are significantly different. This points to distillation as the separation method. The normal boiling points of acrylic acid and acetic acid are 140 ^{o}C and 118 ^{o}C, respectively. How should the separation be accomplished to avoid degradation of the Acrylic acid product?

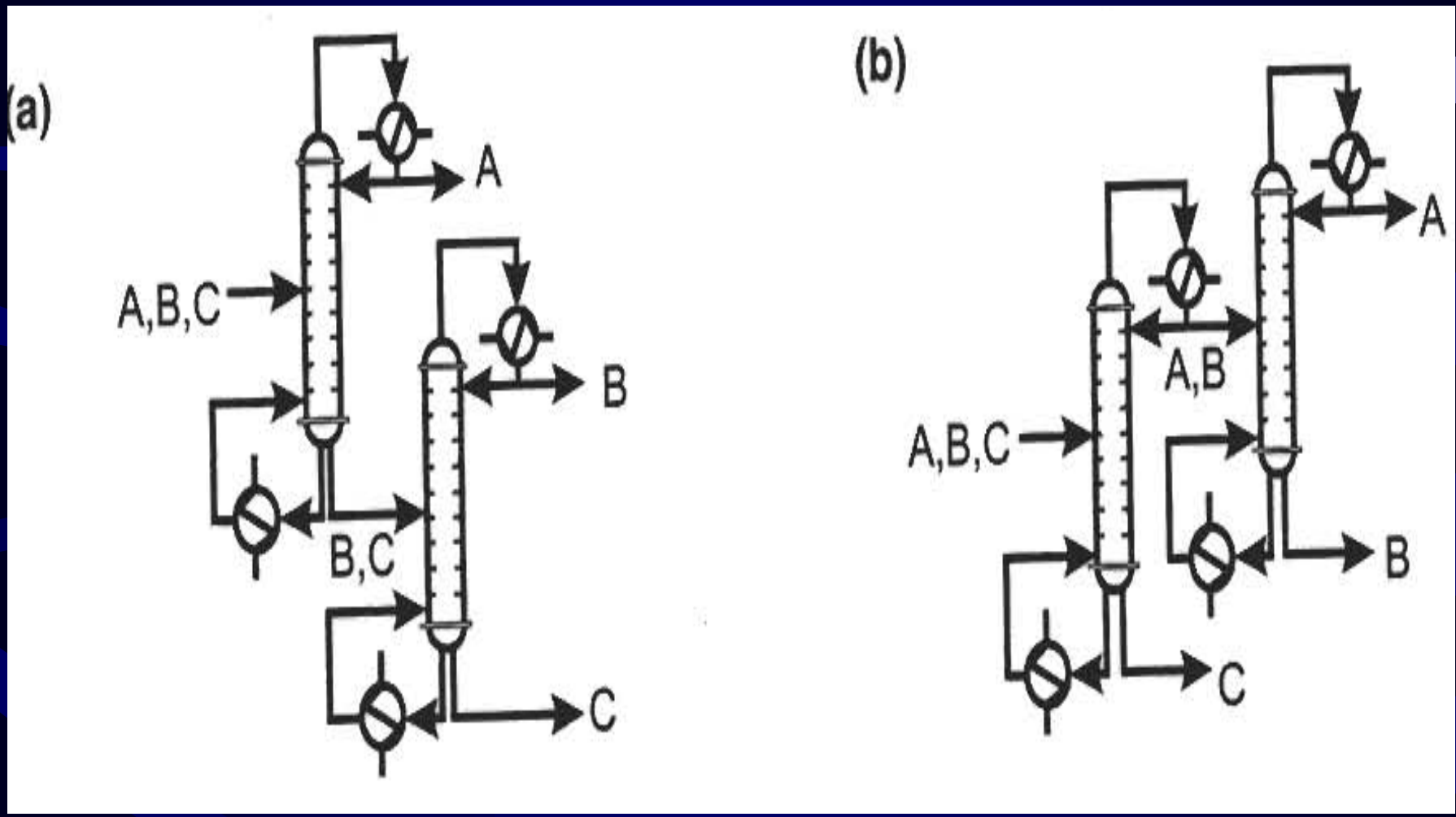
Separator Section

The distillation column must be run under vacuum to avoid the problem of acrylic acid degradation.

The pressure should be set so that the bottom temperature of the column is below 90 ^{o}C.

From Figure B.2 and Table B.4, we see that a column pressure of 0.16 bar at the bottom can accomplish the desired separation without exceeding 90 ^{o}C

Separator Section



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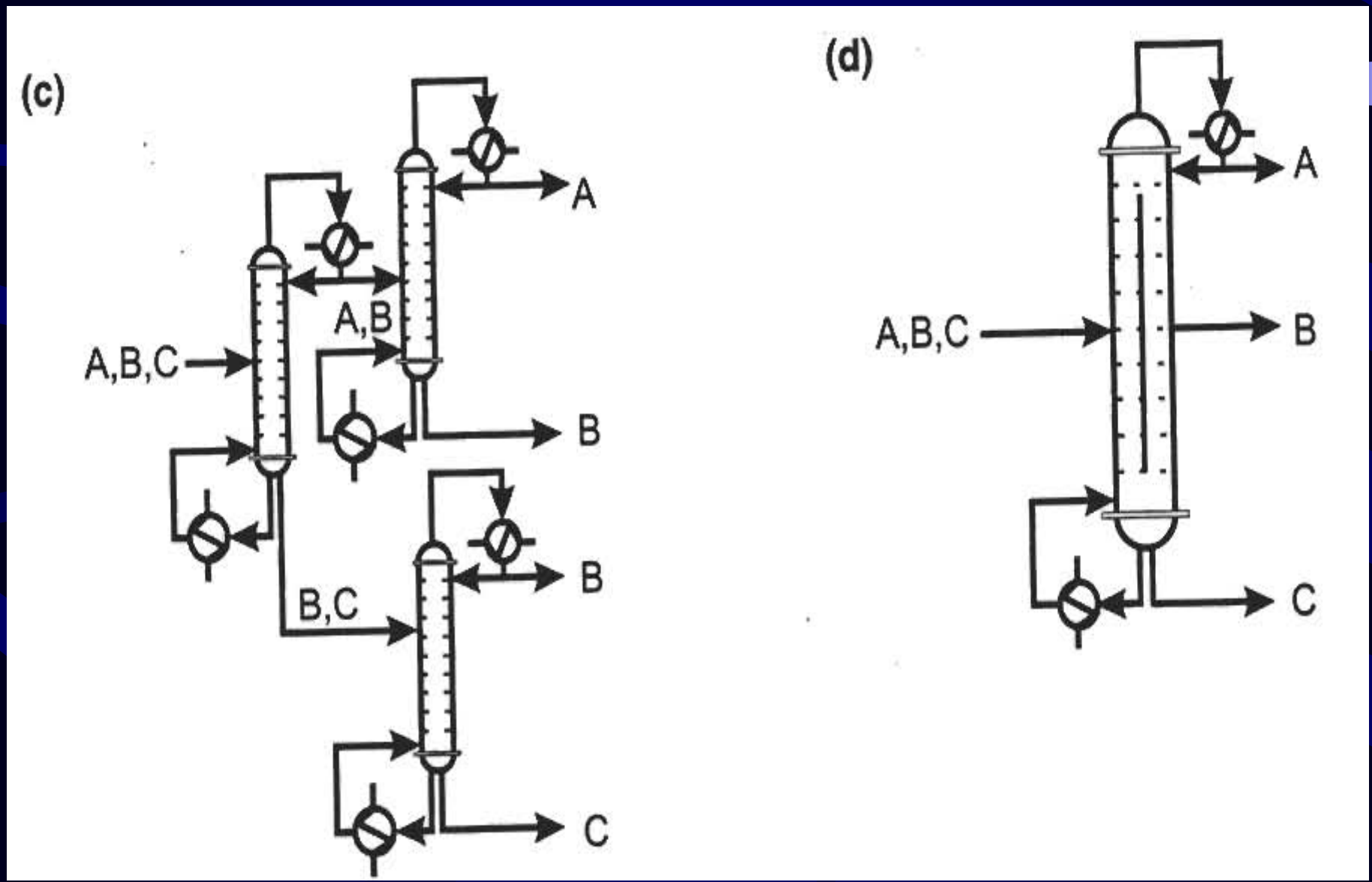

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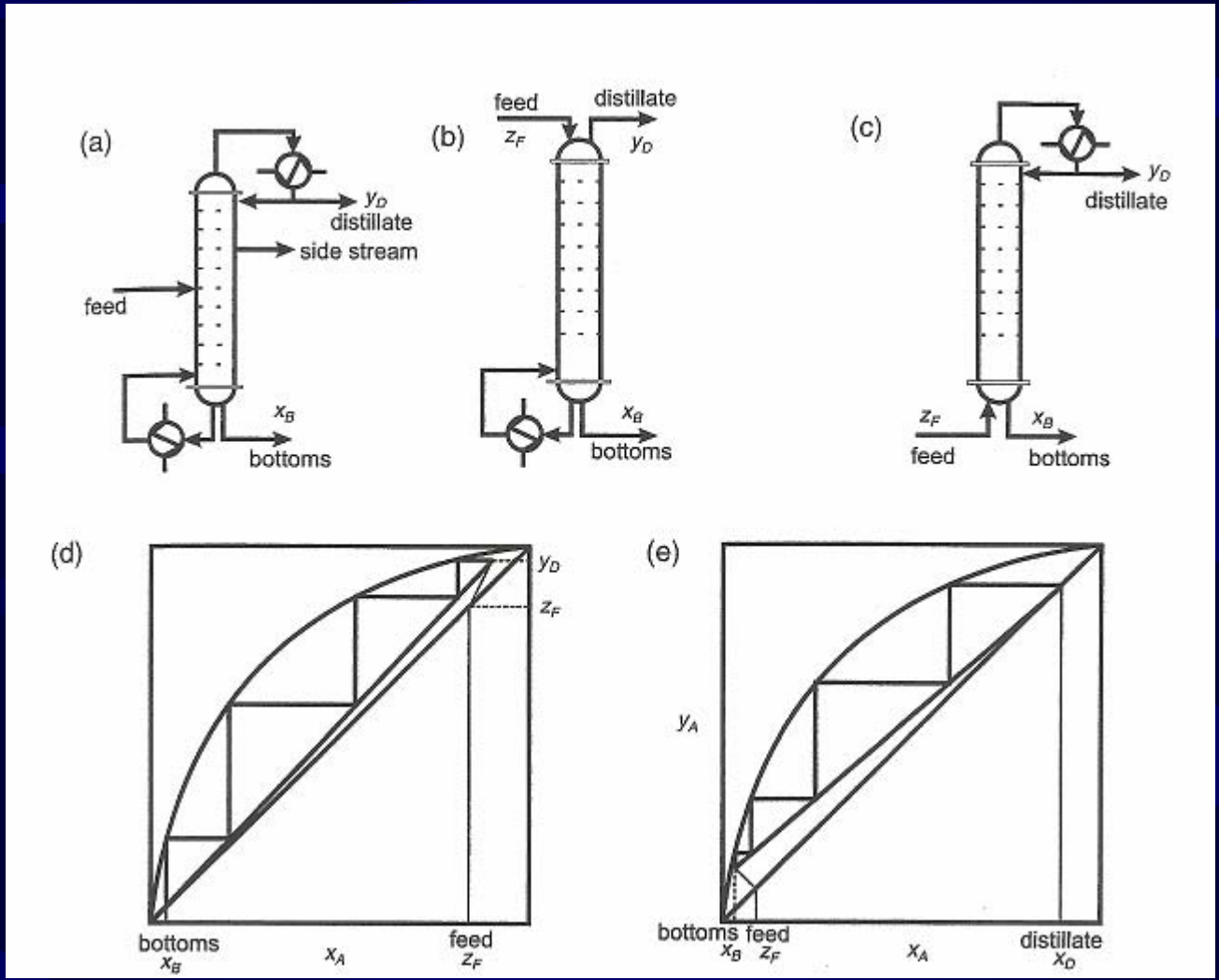
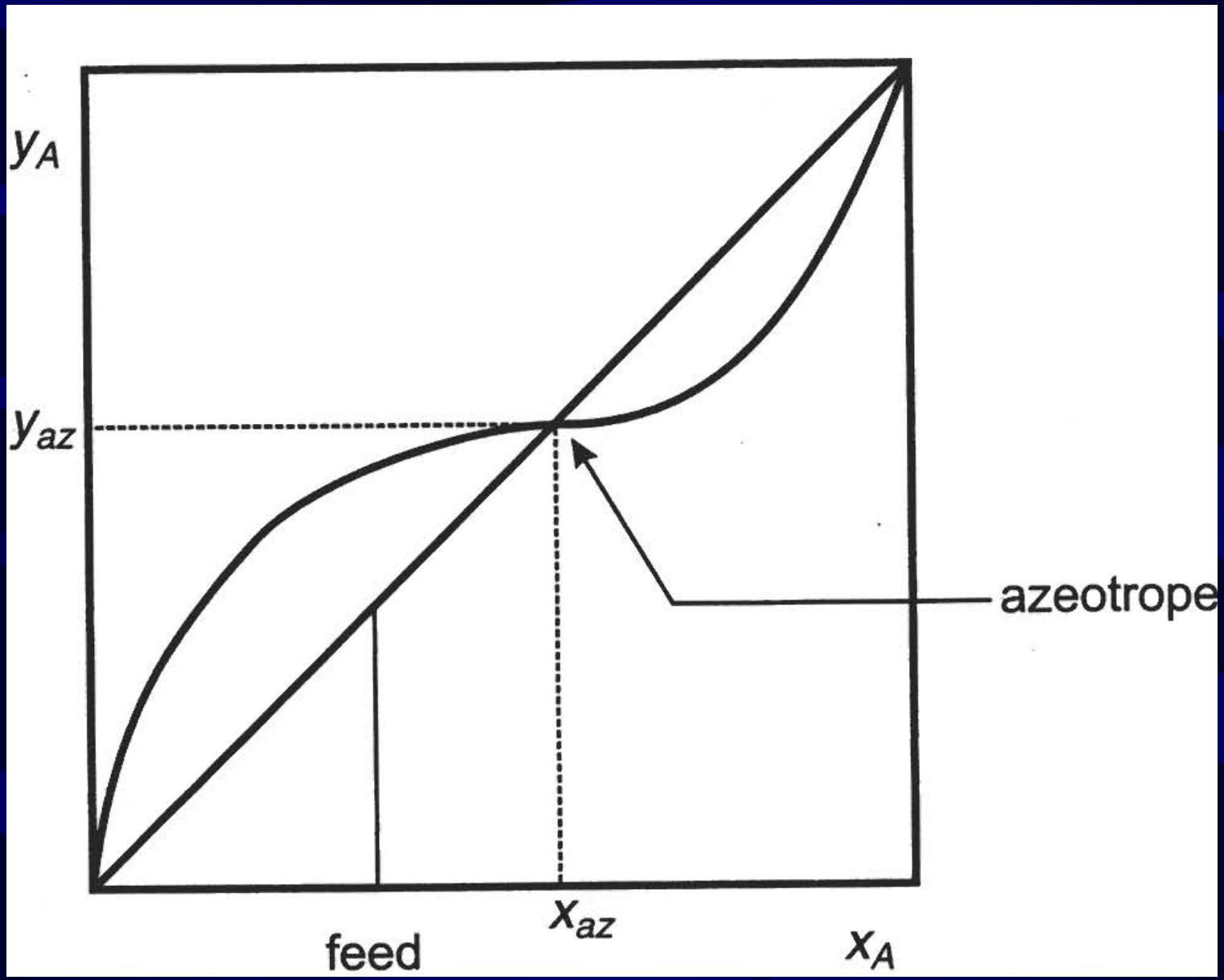


Other Distillation column arrangement

Separator Section



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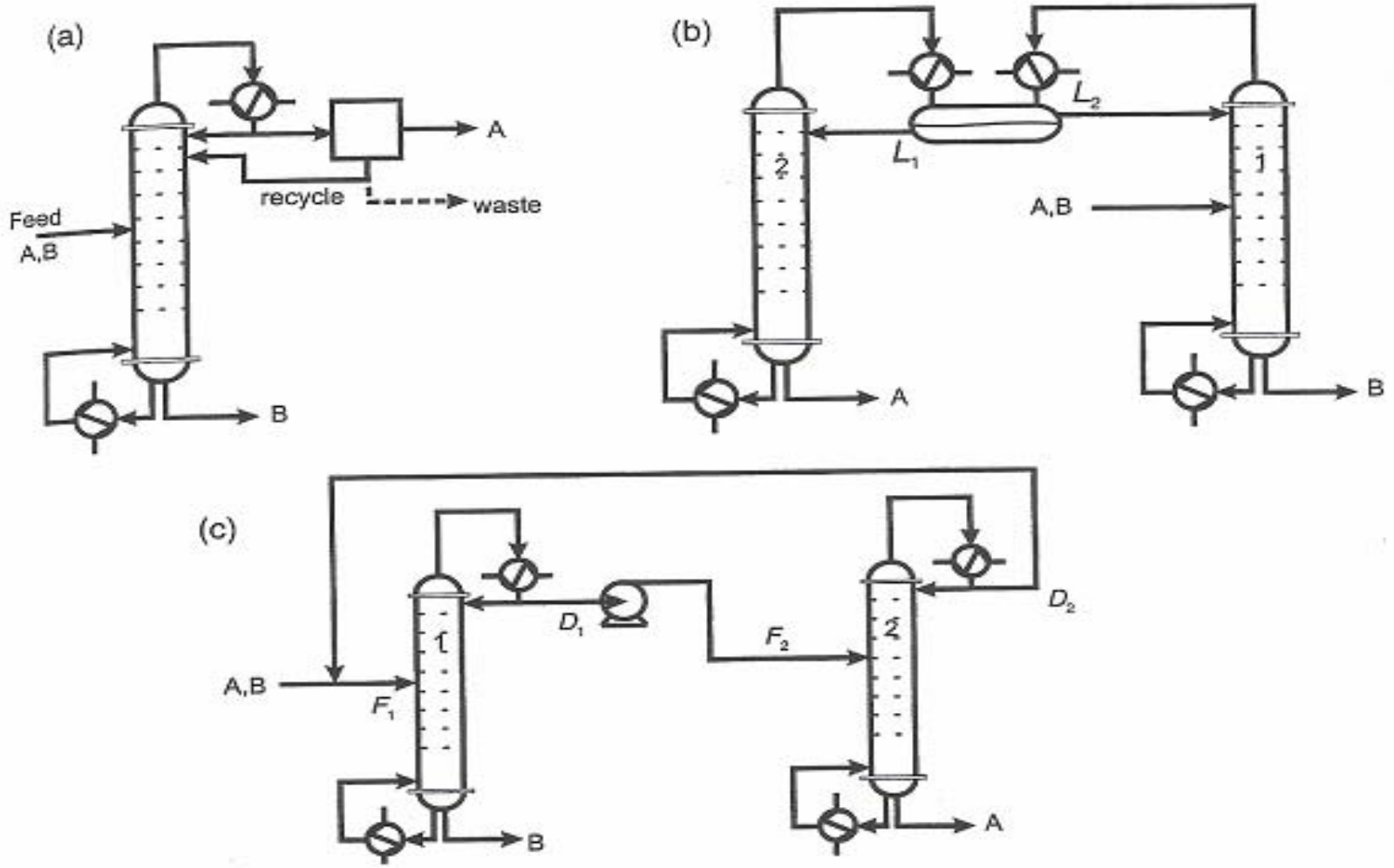

Figure 10.4 Distillation Arrangements to Separate Binary Azeotropes