LECTURE 11
TANKS, VESSELS & DRUMS - SIZING

EQUIPMENT DESIGN:
BASIC CONCEPTS

GOALS:
- Definitions and Concepts
- Types of Design
- Design Methodology
**DEFINITIONS**

- **EQUIPMENT RATING:**
  - Given the input streams, operating parameters, and size parameters, determine the equipment performance and output streams

- **EQUIPMENT SIZING:**
  - Given the input streams and the performance specifications, estimate the economically important size parameters using approximate methods

- **EQUIPMENT DESIGN:**
  - Produce a design in enough detail to guide the fabrication of the item of equipment
**EQUIPMENT DESIGN NOTES**

- For very simple situations, the design calculations are explicit. **Such as storage vessels**

- For most situations, the design calculations involve a trial-and-error search for those values of key design variables that satisfy the performance specifications and constraints.

- The details of the design methodology will differ from one equipment type to another.

- The details of the design methodology may also differ for different performance specifications for the same type of equipment.
TANKS, VESSELS & DRUMS

Vessels can be classified as follows:

(A) STORAGE VESSELS
1. Bulk Storage: Holding Time of days, weeks, or months.
2. Intermediate Storage: Holding Time of minutes, or hours.

(B) PROCESSING VESSELS
1. Mixing Vessels
2. Gas-Liquid Separator
3. Liquid-Liquid Separator
4. Solid-Liquid Separator
5. Gas-Solid Separator
6. Distillation, Absorption, Adsorption, .... Columns
7. Heat Exchangers
8. Reactors, ........

TANKS, VESSELS & DRUMS (Rules of Thumb)
1. Holding time for most intermediate storage vessels, half full, is 10 minutes.
2. Holding time for feed tank to a furnace, half full, is 30 minutes.
3. Optimum L/D ratio is 3, however a range of 2 to 5 is common.
4. Vessels of less than 4 m³ is vertical mounted on legs or brackets.
5. Vessels between 4 m³ and 40 m³ is horizontal with saddle support.
6. Vessels beyond 40 m³ is vertical tank flat bottom on concrete foundation with L/D ratio of a range 0.5 to 1.5.
VESSEL SIZING

1. Select holding time.
2. Calculate vessel volume 50% full: \( V = \frac{Q}{0.5 \cdot t} \)
3. Select vessel type and orientation.
4. Select L/D ratio.
5. Calculate vessel diameter (D) and length (L):
   \[ V = \pi D^2 \frac{L}{4} \]
   and rounding the results to nearest 0.1 meter increment.

High quality Shop fabricated vessels limits:
\[ D \leq 3.5 \text{ m} \quad L \leq 10 \text{ m} \]
Optimum Shop fabricated vessel:
\[ D = 0.74 V^{0.333} \]

EXAMPLE #1: REFLUX DRUM

**PROBLEM:** Design a reflux drum for a distillation column
- For a residence time of 15 minutes when half full,
- That has a length to diameter ratio \( L/D = 3.0 \), and
- Is horizontal.

**OPERATING CONDITIONS:**
- Flow rate out of drum is 5,000 Kg/hr
- Flow is 100% Ethanol (SG = 0.789)
**DESIGN CALCULATIONS**

- **Holdup** = \((5000 \text{ kg/hr})(0.25 \text{ hr}) = 1250 \text{ kg}\)
- **Density** = \((0.789)(1000 \text{ kg/m}^3) = 789 \text{ kg/m}^3\)
- **Volume** = \((2)(1250 \text{ kg})/(789 \text{ kg/m}^3) = 3.17 \text{ m}^3\)
  
  (To simplify the size calculations, neglect the holdup in the dished heads of the drum.)
- **Volume** = \(3.1416 \times (D^2) \times L\) (but \(L = 3.0 \times D\), so)
- \(D^3 = \left(\frac{4 \times 3.17}{3.1416}\right)\) So,
- \(D = 1.1 \text{ m and } L = 3.3 \text{ m.}\)
Requirements for Sizing & Specification

- Tanks and General Pressure Vessels
  - Type (Cone roof, floating, cylindrical PV)
  - Capacity (m³)
  - Length, height, diameter (m) [aspect ratio]
  - Operating/Design Pressure, temperature
  - Orientation (vertical, horizontal, spherical)
  - Nozzles – size (NB), type, rating and location
    - Inlets, outlets, drains
    - Instruments (LGs, P, L, T), sampling, PVRV
    - Foam entry points (storage tanks)
  - Supports (Saddle, legs, plinths, pads)
  - Materials selection