EQUIPMENT DESIGN

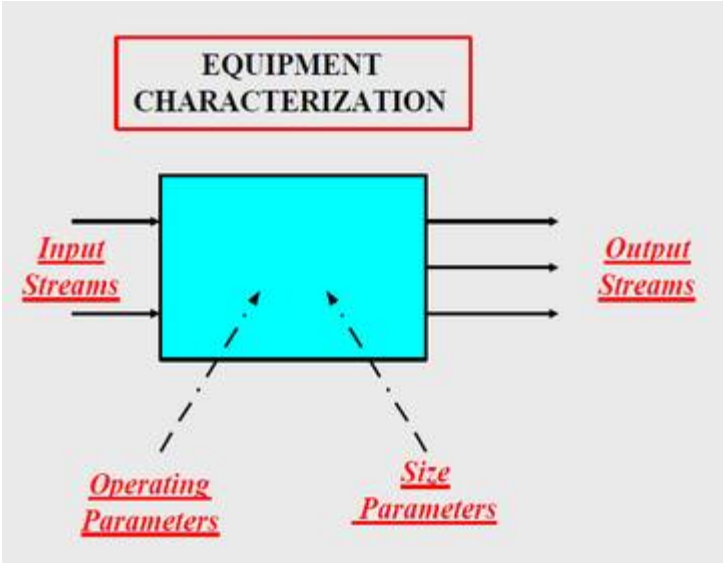
LECTURE 11
TANKS, VESSELS & DRUMS - SIZING

EQUIPMENT DESIGN: BASIC CONCEPTS

GOALS:

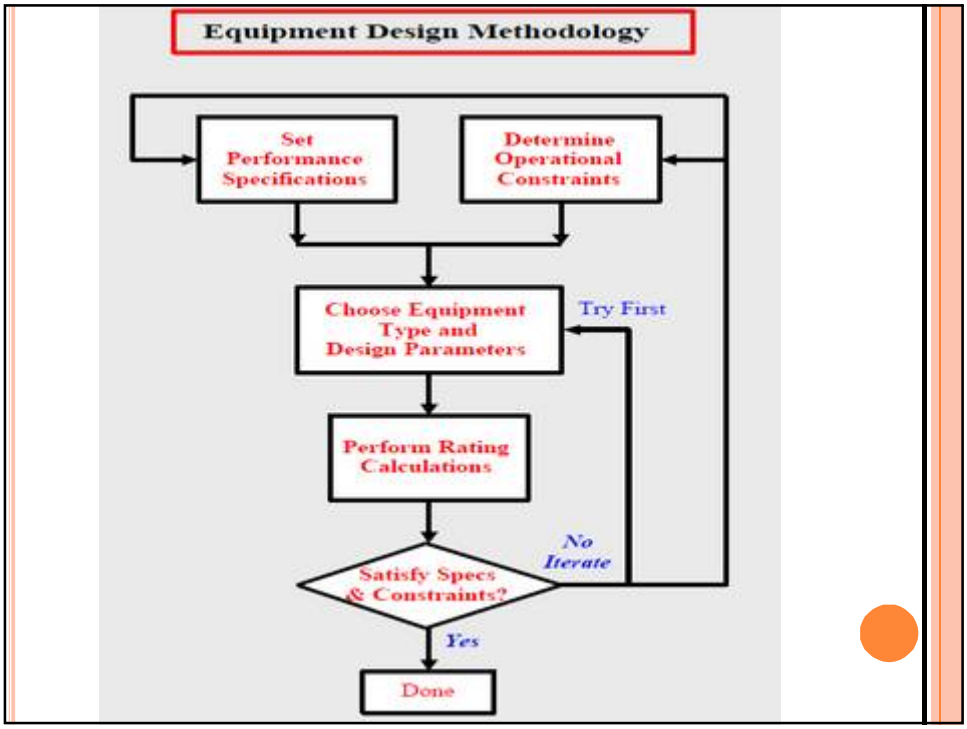
- *Definitions and Concepts*
- *Types of Design*
- *Design Methodology*

EQUIPMENT CHARACTERIZATION



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

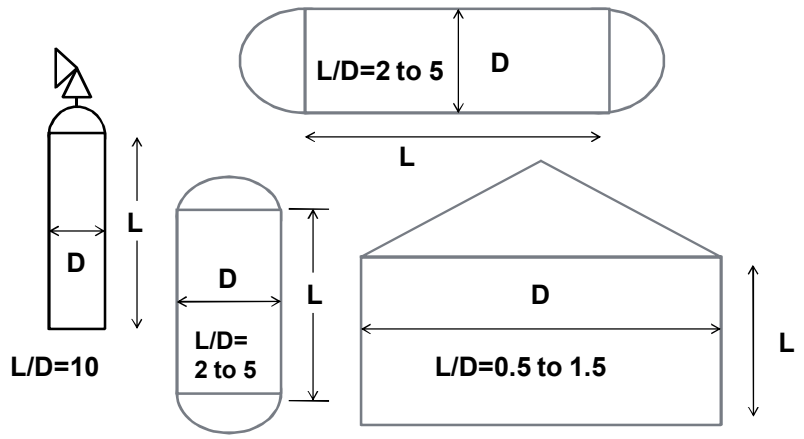
6- Distillation, Absorption, Adsorption, …. Columns

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 : $V=Q/(0.5\ t)$
3. Select vessel type and orientation.
4. Select L/D ratio.
5. Calculate vessel diameter (D) and length (L) : $V=\pi D^2L/4$ and rounding the results to nearest 0.1 meter increment.

High quality Shop fabricated vessels limits:

D <= 3.5 m L <= 10 m

Optimum Shop fabricated vessel:

$D=0.74\ V^{0.333}$

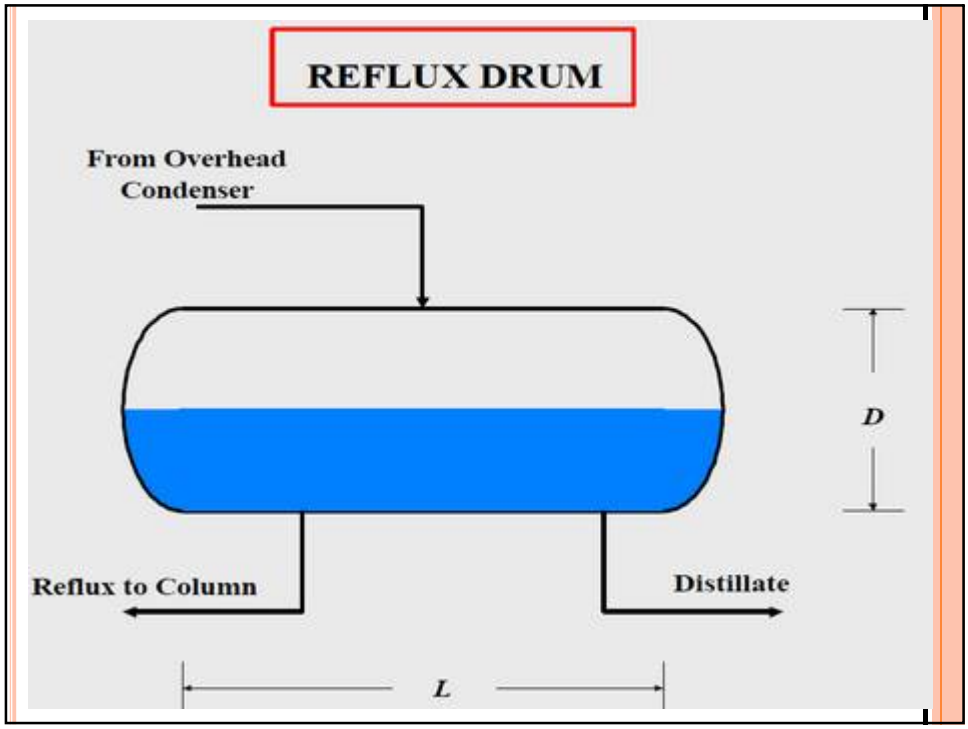
EXAMPLE #1: REFLUX DRUM

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 kg/hr)(0.25 hr) = 1250 kg*
- *Density = (0.789)(1000 kg/m³) = 789 kg/m³*
- *Volume = (2)(1250 kg)/(789 kg/m³) = 3.17 m³*

(To simplify the size calculations, neglect the holdup in the dished heads of the drum.)

- *Volume = 3.1416 (D^2) L/4 (but L = 3.0 D, so)*
- *D^3 = (4) 3.17/(3)/(3.1416) So,*
- *D = 1.1 m and L = 3.3 m.*

Requirements for Sizing & Specification

- **Tanks and General Pressure Vessels**
  - Type (Cone roof, floating, cylindrical PV)
  - Capacity (m^3)
  - 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

APPENDIX H 1001

Vessel data sheet (PROCEED)

Equipment No. (Tag)
Descript. (Func.)
Sheet No.

Operating Data

No. REQUIRED		CAPACITY		
SPECIFIC GRAVITY OF CONTENTS		COMPUTED (yes or no)		
	SHELL	JACKET FULL/HALF COIL	INTERNAL COIL	
CONTENTS				
DIAMETER				
LENGTH				
DESIGN CODE				
MAX. WORKING PRESSURE				
DESIGN PRESSURE				
MAX. WORKING TEMP				
DESIGN TEMP				
TEST PRESSURE (HYDROSTATIC)				
TEST PRESSURE (AIR)				
MATERIALS				
JOINT FACTOR				
CORROSION ALLOWANCE				
THICKNESS				
END TYPE		THICKNESS	JOINT FACTOR	
END TYPE		THICKNESS	JOINT FACTOR	
TYPE OF SUPPORT		THICKNESS	MATERIAL	
WIND LOAD DESIGN		RADIOGRAPHY %	STRESS RELIEF	
INTERNAL BOLTS MATERIAL		TYPE	NUTS	
EXTERNAL BOLTS MATERIAL		TYPE	NUTS	
INSULATION (SEP. ORDER)		INSULATION FITTING ATTACHMENT BY		
GASKET MATERIAL		INSPECTION BY		
PAINTING				
WEIGHT		EMPTY		
FULL OF LIQUID		OPERATING		
INTERNALS and EXTERNALS		DATE OF ENQUIRY	DATE OF ORDER	
ORDER No.		DRG. No.		
MANUFACTURER				

REMARKS AND NOTES: UNLESS OTHERWISE STATED ALL FLANGE BOLT HOLES TO BE OFF-CENTRE OF VESSEL CENTRE LINES N/S and E/W (NOT RADIALLY)

REF	No.	DUTY	NOM BORE mm/ins	PIPE WALL THICKNESS	TYPE	CLASS RANGE SPEC	MATERIAL	BRANCH COMPEN'N	REMARKS
A									
B									
C									
D									
E									
F									
G									
H									
H									
K									
K									
M									
N									
P									
BRANCH									

Prepared				3				6				
Checked				2				5				
Approved				1				4				
	Date	Engineering	Process	REV	By	Appr.	Date	REV	By	Appr.	Date	
Service				Company				Address				
Equipment No.												
Project No.												