

Model Examination - October 2013  
Seventh Semester - Chemical Engineering

CH 2407 – Process Equipment Design II

Time: Three hours

Maximum: 100 marks

Answer ALL Questions

Part A (5 x 2 = 10 marks)

1. TEMA code of a heat exchange is: AEM. What do these letters indicate?
2. 'Corrosive fluid is to be allocated on the tube side of the shell-and-tube heat exchanger'. Justify this statement.
3. Draw the schematics of '*forward feed*' and '*backward feed*' multiple effect evaporators?
4. What is the effect of reflux ratio on the number of stages required for a distillation operation?
5. Pressure drop estimation on the **tube side** of a shell and tube heat exchanger is found to be higher than the allowable limit. How would you change the design?

Part B (20 marks)

6. Write down the steps involved in estimating the design dimensions of the following equipment. (5)
7. Make suitable calculations to show that the given design is satisfactory in meeting the heat transfer and thickness requirements. Overall heat transfer coefficient (U) for the reboiler, for the initial estimate can be taken as 1000 W/m<sup>2</sup>.°C (15)

Part C (50 marks)

8. Draw to scale the suitable views of the equipment, mark the salient parts, and dimensions.

## Question for Part B & Part C

### Kettle-type Reboiler

It is required to design a kettle-type reboiler to vaporize 84 kg/min of n-butane at 5.84 bar. The minimum temperature of feed will be 0°C. Steam is available at 1.7 bar(g).

Physical properties of n-butane at 5.84 bar:

Boiling point = 56.1°C

Latent heat = 326 kJ/kg

Mean specific heat of liquid = 2.51 kJ/kg.°C

Surface tension of butane with its vapor =  $9.7 \times 10^{-3}$  N/m

Density of liquid butane = 550 kg/m<sup>3</sup>

Density of butane vapor = 12.6 kg/m<sup>3</sup>

Critical pressure of n-butane = 38 bar.

Saturation temperature of steam at 1.7 bar (g) = 115.2°C

Take steam side condensing coefficient as 8000 W/m<sup>2</sup>.°C, fouling coefficient 5000 W/m<sup>2</sup>.°C; Butane side fouling coefficient as 10,000 W/m<sup>2</sup>.°C.

Tube material will be plain carbon steel,  $k_w = 55$  W/m.°C

A kettle type reboiler of following specification is available:

TEMA code: AKU

Total number of U tubes: 26 (52 tube holes)

Length of one U tube: 4.8 m (average length of tubular section = 2.4 m)

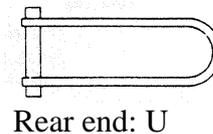
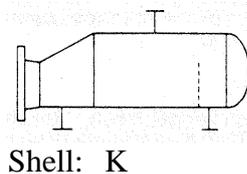
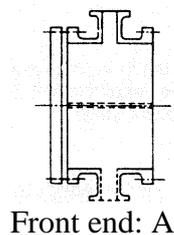
Tube OD: 30 mm; ID: 25 mm, with pitch of 1.5 times the OD of tube, square pitch

Tube bundle diameter: 420 mm

Height of weir: 500 mm

OD of outer shell: 840 mm, thickness: 12 mm

Corrosion allowance: 3 mm. Allowable stress = 98 N/mm<sup>2</sup>; joint efficiency = 85%.



TEMA code explanation