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Calculation of heat transfer area and water requirement of condensers

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Outline

- Introduction
- Heat Transfer in boiling liquids
- Heat transfer during condensation
- Factors affecting the boiling point
- Factors affecting the size of heating surface
- Factors affecting the heat transfer coefficients
- Heat and material balance of single effect evaporators



Introduction

Heat transfer in Boiling liquids

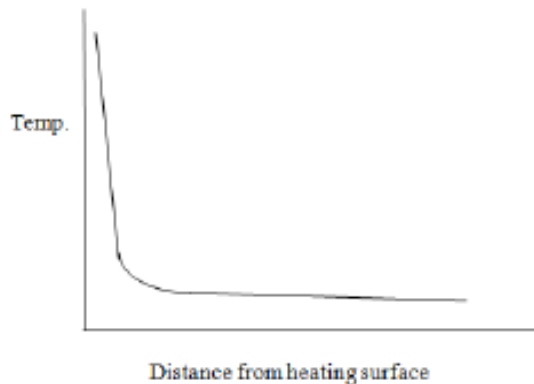


Fig-4.1: Temperature profile in heating tube

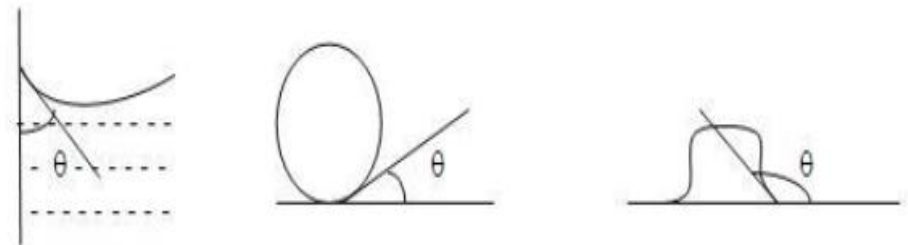


Fig-4.2: wetting capacity of the liquid based on angle θ

Boiling is classified into three types

1. Interface evaporation;
- 2) Nucleate boiling;
- 3) Film boiling



Heat transfer during condensation

- a) Factors affecting the boiling point
- b) Factors affecting the size of heating surface
- c) Factors affecting the heat transfer coefficient

Table-4.1: Normal range of values of overall heat transfer coefficients

Number of Effect	Skim milk (W/m²K)	Whole milk (W/m²K)
1st effect	2300-2600	2000-2200
2 nd effect	1900-2200	1700-1900
3 rd effect	1000-1200	900-1100

Note: 1 Watt=0.86 kcal/h, 1kcal/h =1.163 Watt



Heat and material balance of single effect evaporator

Heat Balance:

Heat Balance

$$F.h_f + S.H_s = L.h_L + V.H + Sh_c \text{ (neglecting heat losses)}$$

$$\text{Therefore, } F.h_f + S(H_s - H_c) = Lh_L + VH \text{(1)}$$

Where, F= Feed rate, kg/h

h_f = heat content of feed, kJ/kg

S=steam supply rate, kg/h

H_s = Enthalpy of steam, kJ/kg

L= output rate of concentrate, kg/h

h_L = heat content of concentrate, kJ/kg

V= rate of vapour production, kg/h

H= Heat content of vapour, kJ/kg

h_c =heat content of condensate, kJ/kg



Material Balance:

$$F = L + V \dots \dots \dots (2)$$

Based on the total solid, we have

$$F x_F = L x_L + V y \dots \dots \dots (3)$$

Where, x_F = Feed concentration, % TS

x_L = Concentration of condensed milk, % TS

y = solids in vapour (taken as zero)

Capacity:

From equation (3)

$$F x_F = L x_L \text{ as } V y = 0$$

Therefore , $F = L \cdot (x_L / x_f)$ and $L = F \cdot (x_f / x_L)$

Therefore , $(F - V) = F \cdot (x_f / x_L)$, (as $L = F - V$)

$$\text{Therefore , } V = F [1 - (x_f / x_L)] \dots \dots \dots (4)$$



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Thank you