# Evaporation and Classification

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# Outline

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Introduction

Multiple-Effect Evaporator

- Different level of vacuum in each effect of multiple effect evaporator
- Multiple effect evaporator capacity and steam economy
- Calculations for multiple effect evaporator
- Tripple effect evaporators calculations methods

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## Multiple effect evaporator

In any evaporation operation, the major process cost is the steam consumed. Therefore, methods of reducing steam consumption (or of increasing economy, defined as mass of vapour produced per unit mass of steam consumed).

## Different leel of vacuum in each effect of multiple effect evaporator

Here we assume that initially in all the calandria the level and temperature of feed is same. Now during starting of the plant steam is introduced in first calandria. So in that calandria milk initially will be heated and then raised to corresponding boiling point and vapour will be released. This vapour is going in the next calandria's heating jacket where the milk is cold and nowstart heating thereby the temperature difference between heating vapour and milk will decrease. It gives less condensation of vapour in second calandria. This gives rise of back pressure in first calandria tube and thereby the boiling point in first calandria will rise. The

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# Multiple effect evaporator capacity and steam economy

In addition to the economy increase in multiple-effect evaporation, a capacity variation would be expected. Note, however, that the temperature difference from initial steam to the final condenser which was available for a single-effect evaporator will be unchanged by inserting any additional effects between the steam supply and the condenser. For the simplest case, where each effect has area and coefficient equal to that of every other effect and where there are no boiling point rises $q_t - q_1 + q_2 + q_3 + \ldots\ldots\ldots\ldots$ where $q_t$ is the total heat-transfer rate in all effects and $q_1, q_2, q_3$ are the heat transfer rates in each of the individual effects.

$$q_t = U_1 A_1 \Delta t_1 + U_2 A_2 \Delta t_2 + U_3 A_3 \Delta t_3 + \ldots\ldots\ldots$$

Since the areas and heat transfer coefficients are equal,

$$q_t = U_1 A_1 (\Delta t_1 + \Delta t_2 + \Delta t_3 \ldots\ldots) = U_1 A_1 (\Delta t)_{total}$$

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# Calculations for Multiple effect evaporators

For a multiple – effect evaporator system calculations, the values required to be obtained are

(i) The area of the heating surface in each effect,

(ii) The kg of steam per hour to be supplied, and

(iii) the amount of vapour leaving each effect, particularly in the last one.

The given values are usually as follows

(1) Steam pressure to the first effect,

(2) Final pressure in the vapour space of the last effect,

(3) Feed conditions and flow to the first effect,

(4) Final concentration in the liquid leaving the last effect,

(5) Physical properties such as enthalpies and / or heat capacities of the liquid and vapours, and

(6) Overall heat – transfer coefficients in each effect.

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# Triple effect evaporators calculations methods

**1.** Determine the boiling point in the last effect from the known outlet concentration and pressure in the last effect,

**2.** Determine the total amount of vapor evaporated by performing an overall material balance,

**3.** Estimate the temperature drops $\Delta T_1$, $\Delta T_2$ and $\Delta T_3$ in the three effects. Then calculate the boiling point in each effect,

**4.** Calculate the amount vaporized and the flows of liquid in each effect using heat and material balance in each effect,

**5.** Calculate the value of heat transferred in each effect. Using the rate equation $q=UA\Delta T$ for each effect, calculate the areas, $A_1$, $A_2$ and $A_3$. If these areas are reasonably close to each other, the calculations are complete and a second trail is not needed. Otherwise a second trial should be performed.

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# Thank you