HEAT BALANCES

- Heat balance calculations are treated in the same manner as material balances.
- Amount of heat entering a system must be equal the amount of heat leaving the system.

  Heat in = Heat out + accumulation

- **At a steady state**, accumulation is zero (Heat in = Heat out).

Heaating of foods:

- Heat gained by food = Heat lost by water or steam

Cooling of foods:

- Heat lost by food = Heat gained by water

- **Example 4.24**: Calculate the amount of water that must be supplied to a cross-flow (çapraz akımlı) heat exchanger that cools 100 kg/h of tomato paste from 90° to 20°C. The tomato paste contains 40% solids. The increase in water temperature should not exceed 10°C while passing through the heat exchanger. There is no mixing of water and tomato paste in the heat exchanger.

Answer

m = 476 kg water required

- **Example 4.25**: Calculate the amount of steam at 121.1°C and 2 atm that must be added to 100 kg of a food product with a specific heat of 3559 J/(kg K) to heat the product from 4.44°C to 82.2°C by direct steam injection.

Answer

Heat loss by steam = Heat gain by food product

- $m \lambda = m Cp \Delta T$
- $m\ 2{,}363{,}284 = 100\ (3559)\ (82.2 - 4.44)$
- $m = 11.7$ kg steam required

- **Example 4.26**: Steam is used for peeling of potatoes in a semi-continuous operation. Steam is supplied at the rate of 4 kg per 100 kg of unpeeled potatoes. The unpeeled potatoes enter the system with a temperature of 17°C, and the peeled potatoes leave at 35°C. A waste stream from the system leaves at 60°C. The specific heats of unpeeled potatoes, waste stream, and peeled potatoes are 3.7, 4.2 and 3.5 kJ/(kg K), respectively. If the heat content (assuming 0°C reference temperature) of the steam is 2750 kJ/kg, determine the quantities of the waste stream and the peeled potatoes from the process.

Answer

P = 68.87 kg peeled potatoes

W = 35.14 kg waste

- **Example 4.27:** The milk is heated in cross-flow heat exchanger at a mass flow rate of 1000 kg/h from 42°C to 70°C. The water used for heating the milk enters the heat exchanger at 95°C and leaves the system at 80°C. If the heat is emitted from the system to its surroundings is 1 kW, then find out the mass flow rate of water used to heat the milk for 6 h of operation. The specific heat of milk is 3.9 kJ/kg °C.

Note

- System is a steady-state system.
- Specific heat of fluids do not change with temperature significantly.

Answer

- m = 1682 kg/h
- m = 1682 kg/h x (6 h) = **10 092 kg**