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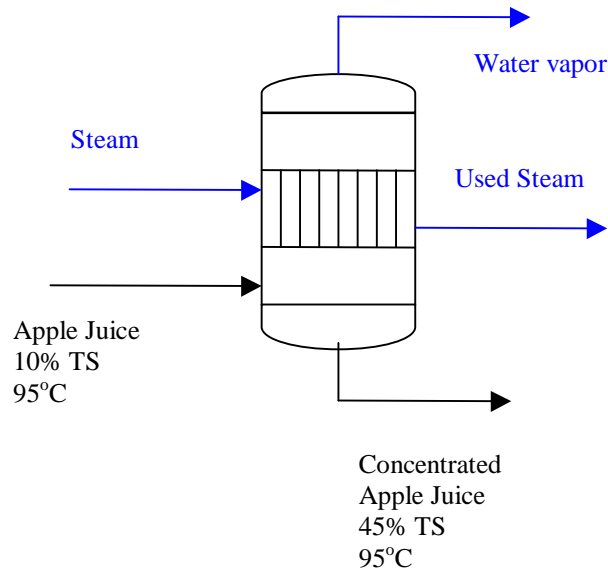
CLASS PROBLEM

An evaporator has a heat transfer surface area that allows the transfer of heat at the rate of 105,506 kJ/hr. If this evaporator is concentrating apple juice from 10 to 45 wt% solids under vacuum at 95°C, how much 10% apple juice can be processed per hour?

Given:

The 10% juice enter the evaporator at 95°C and 45% juice leaves the evaporator at 95°C. The specific heat of the 10% juice is 4 kJ/kg K and of the 45% juice is 3.2 kJ/kg K.

Solution:



Basis : 1 hour of operation

Total Energy Balance:

$$q_{\text{feed}} + q_{\text{steam}} = q_{\text{water vapor}} + q_{\text{product}} + q_{\text{condensate}}$$

$$T_{\text{reference}} = 0^{\circ}\text{C}$$

$$q_{\text{feed}} = m_{\text{feed}} C_{p \text{ feed}} (T_{\text{feed}} - T_{\text{reference}}) = m_{\text{feed}} (4) (95 - 0) = 380 m_{\text{feed}}$$

$$q_{\text{product}} = m_{\text{product}} C_{p \text{ product}} (T_{\text{product}} - T_{\text{reference}}) = m_{\text{product}} (3.2) (95 - 0) = 304 m_{\text{product}}$$

$$q_{\text{steam}} - q_{\text{condensate}} = q_{\text{product}} - q_{\text{feed}} + q_{\text{water vapor}} = 105\,506 \text{ kJ (Equation 1)}$$

$$q_{\text{water vapor}} = m_{\text{water vapor}} \Delta H_{\text{water vapor}} = m_{\text{water vapor}} (2270 \text{ kJ/kg})$$

Total Material Balance: $m_{\text{feed}} = m_{\text{water vapor}} + m_{\text{product}}$

Solids Balance: $m_{\text{feed}} (0.1) = m_{\text{product}} (0.45)$

$$m_{\text{feed}} = 4.5 m_{\text{product}}$$

$$m_{\text{water vapor}} = 3.5 m_{\text{product}}$$

Put these relationships in Equation 1:

$$304 m_{\text{product}} - 380 m_{\text{feed}} + 2270 m_{\text{water vapor}} = 105\,506 \text{ kJ}$$

$$304 m_{\text{product}} - 380 (4.5) m_{\text{product}} + 2270 (3.5) m_{\text{product}} = 105\,506$$

$$m_{\text{product}} = 16.13 \text{ kg}$$

$m_{\text{feed}} = 72.6 \text{ kg}$ 10% apple juice can be processed.