Answer on Question #72013, Physics / Molecular Physics | Thermodynamics

Question:

Water at a temperature of 15°C produces ice cubes at a temperature of −5°C. Water is taken in at the rate of 1 kg every 7 minutes and the input power to the machine is 300 W.

The specific heat capacity of water is 4187$\frac{J}{kg*K}$

The specific heat capacity of ice is 2100 $\frac{J}{kg*K}$

The specific latent heat of fusion is 335 kJ/kg

i) Calculate the heat energy extracted per kg of ice produced

ii) Calculate the thermal efficiency of the ice making machine.

Solution:

i) For producing the ice at a temperature of -5°C, first its needed to cool the water to 0°C, then freeze the water into ice, and finally cool the ice:

$Q = c_{water}m(T_{15} - T_0) + \lambda m + c_{ice}m(T_0 - T_{-5})$

$Q_m = c_{water}(T_{15} - T_0) + \lambda + c_{ice}(T_0 - T_{-5})$ – per one kilogram

$$Q_m = 4187 * 15 + 335000 + 2100 * 5 = \mathbf{408.3}\,\frac{\boldsymbol{kJ}}{\boldsymbol{kg}}$$

ii) Thermal efficiency: $\alpha = \frac{Q_{input} - Q_{process}}{Q_{input}}$

$$Q_{input} = 300 * 7 * 60 = 126\frac{kJ}{kg} < Q_m - this\ machine\ cannot\ produce\ 1\ kg\ every\ 7\ minutes$$