Physical World 2D Report

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I. Methodology

The following methodology was used to find $\lambda_{algaebottle}$:

1) Fill the bottle with 30ml of hot water at $50°C$ to $60°C$
2) asf

II. Demonstration

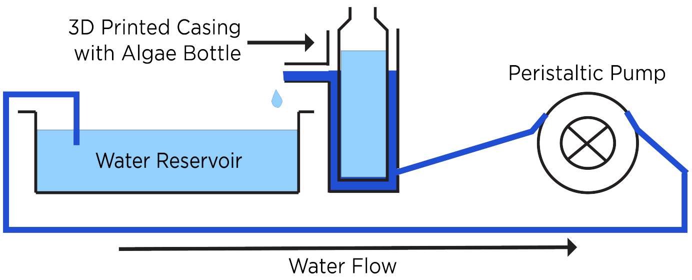

Fig. 1

III. Wcv

i. The equation of control volume in the heat exchanger

$$\frac{dE_{cv}}{dt} = \dot{Q}_{cv} - \dot{W}_{cv} + \dot{m}_i\left(h_i + \frac{V_i}{2} + gz_i\right) + \dot{m}_e\left(h_e + \frac{V_e}{2} + gz_e\right)$$

Assume steady state, so $\dot{m}_i = \dot{m}_e = \frac{dE_{cv}}{dt} = \dot{m}$ *No change in potential and kinetic energy*
Air is ideal gas.

$$\frac{dE_{cv}}{dt} = \dot{Q}_{cv} - \dot{W}_{cv} + \dot{m}\left(h_1 - h_2\right)$$

ii. The rate of heat entering control volume

$$\dot{Q}_{cv} = \dot{Q}_{exchanged}$$

$$\dot{Q}_{cv} = m_a c_a\left(\frac{dT_a}{dt}\right) - \dot{Q}_{ambient}$$

$$\dot{Q}_{cv} = m_a c_a\left(\frac{dT_a}{dt}\right) - \lambda_{algaebottle}\left(T_a - T_{amb}\right)$$

By substituting value of $\lambda_{algaebottle} = 1.76$

$$\dot{Q}_{cv} = m_a c_a\left(\frac{dT_a}{dt}\right) - 1.76\left(T_a - T_{amb}\right)$$

iii. The equation of control volume in the heat exchanger
From simplified $\frac{dE_{cv}}{dt}$ *equation in the previous part*

$$\frac{dE_{cv}}{dt} = \dot{Q}_{cv} - \dot{W}_{cv} + \dot{m}\left(h_1 - h_2\right)$$

iv. Express $\dot{W}_{cv} = f\left(T_a\right)$ assuming $\dot{W}_{cv}$ is a constant
Assume that $\frac{dE_{cv}}{dt} = 0$

$$0 = m_a c_a\left(\frac{dT_a}{dt}\right) - \lambda_{algaebottle}\left(T_a - T_{amb}\right) - \dot{W}_{cv} + \dot{m}[c_w\left(T_i - T$$

$$\lambda_{algaebottle}\left(T_a - T_{amb}\right) + \dot{W}_{cv} - \dot{m}[c_w\left(T_i - T_e\right)] = m_a c_a\left(\frac{dT_a}{dt}\right)$$

$$\int 1dt = \int \frac{m_a c_a}{\lambda_{algaebottle}\left(T_a - T_{amb}\right) + \dot{W}_{cv} - \dot{m}[c_w\left(T_i - T_e\right)]} dT$$

$$t + c = \frac{m_a c_a}{\lambda_{algaebottle}} \ln(\lambda_{algaebottle}\left(T_a - T_{amb}\right) + \dot{W}_{cv} - \dot{m}[c_w\left(T_i -\right.$$

$$\frac{\lambda_{algaebottle}\left(t + c\right)}{m_a c_a} = \ln(\lambda_{algaebottle}\left(T_a - T_{amb}\right) + \dot{W}_{cv} - \dot{m}[c_w\left(T\right.$$

$$e^{\frac{\lambda_{algaebottle}(t+c)}{m_a c_a}} = \lambda_{algaebottle}\left(T_a - T_{amb}\right) + \dot{W}_{cv} - \dot{m}[c_w\left(T_i - T_e\right.$$

$$\dot{W}_{cv} = e^{\frac{\lambda_{algaebottle}(t+c)}{m_a c_a}} - \lambda_{algaebottle}\left(T_a - T_{amb}\right) + \dot{m}[c_w\left(T_i - T_e\right.$$

IV. Derivation

$$T_i - T_{amb} = -R\rho V c\frac{dT}{dt}$$

$$\int_0^t dt = -R\rho V c\int_{T_i}^{T} \frac{1}{T - T_{amb}} dT$$

$$\frac{t}{R\rho V c} = \ln\left|\frac{T - T_{amb}}{T_i - T_{amb}}\right|$$

$$\left(T_i - T_{amb}\right) e^{-\frac{t}{R\rho V c}} = T - T_{amb}$$

$$\Delta T = \Delta T_{initial} e^{-\frac{t}{R\rho V c}}$$

References