Heat exchanger simulation - Web Labs at www.ReactorLab.net - by Richard K. Herz

This is a dynamic (transient, unsteady-state) simulation of a heat exchanger. The heat exchanger consists of an inner tube carrying the hot fluid surrounded by an annular space carrying the cold fluid.

The purpose of this simulation is to provide an interactive way to gain an understanding of heat exchangers. This simulation should not be used for design purposes.

The energy balance equations listed below are solved numerically using a finite-difference approximation.

The following specifications are made in order to reduce the number of inputs: Axial dispersion coefficients for hot and cold fluids are equal. The axial dispersion coefficient is computed from a correlation of Wen and Fan for turbulent flow (Re > 2000) of the hot fluid. The heat capacity of the exchanger body is not considered; it would slow the transient response but not affect steady state. There is negligible axial conduction. The densities of the hot and cold fluids are constant at 1000 kg/m^3. The heat transfer coefficient ratios β of the hot and cold fluids are equal. The heat transfer coefficient ratio is computed using the equations below for the hot fluid.

$$\frac{dT_h}{dt} = D_h \frac{d^2 T_h}{dz^2} - v_h \frac{dT_h}{dz} - \beta_h (T_h - T_c) \qquad v_h > 0 \quad \text{HOT FLUID}$$

$$\frac{dT_c}{dt} = D_c \frac{d^2 T_c}{dz^2} - v_c \frac{dT_c}{dz} + \beta_c (T_h - T_c) \qquad \begin{array}{l} v_c > 0 \text{ for co-current operation} \\ v_c < 0 \text{ for counter-current operation} \end{array} \qquad \text{COLD FLUID}$$

$T(\mathrm{K})$ = fluid temperature $\quad t(\mathrm{s})$ = simulation time

$z(\mathrm{m})$ = distance down exchanger in direction of hot fluid flow

$D(\mathrm{m^2/s})$ = axial dispersion coefficient for turbulent flow

$$v\,(\mathrm{m/s}) = \frac{\dot{m}(\mathrm{kg/s})}{\rho(\mathrm{kg/m^3})\, A_x(\mathrm{m^2})} \text{ = fluid linear velocity}$$

$\dot{m}(\mathrm{kg/s})$ = mass flow rate of fluid $\quad \rho(\mathrm{kg/m^3})$ = density of fluid

$A_x(\mathrm{m^2})$ = cross-sectional area for flow; A_x of tube of diameter $d_t = \pi d_t^2(\mathrm{m^2})/4$

$$\beta(1/\mathrm{s}) = \frac{U(\mathrm{kJ/s/m^2/K})\, A_w(\mathrm{m^2/m})}{\rho(\mathrm{kg/m^3})\, C_p(\mathrm{kJ/kg/K})\, A_x(\mathrm{m^2})} \text{ = heat transfer coefficient ratio}$$

$U(\mathrm{kJ/s/m^2/K})$ = overall heat transfer coefficient

$C_p(\mathrm{kJ/kg/K})$ = heat capacity of fluid

$A_w(\mathrm{m^2/m}) = \pi\, d_t(\mathrm{m})\, L(\mathrm{m}) / L(\mathrm{m})$ = heat transfer wall area per unit length of tube