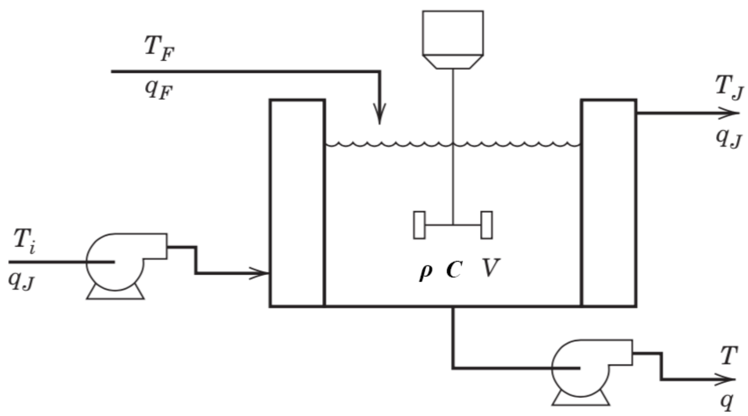
CHEM-E7190/2022: Exercise I - Modelling + simulation (Euler)

Task 1.

A jacketed vessel is used to cool a process stream. The following information is available:

1. The volume of coolant in the jacket V_J remain constant. Volumetric flow rate q_F and q_J vary with time.
2. Heat losses from the jacketed vessel are negligible.
3. Both the tank contents and the jacket contents are well mixed and have significant thermal capacitances.
4. The thermal capacitances of the tank wall and the jacket wall are negligible.
5. The overall heat transfer coefficient for transfer between the tank liquid and the coolant varies with coolant flow rate:
   $U = Kq_J^{0.8}$



Additional assumptions:

1. Density of the liquid, ρ, and density of the coolant, ρ_J are constant.
2. Specific heat of the liquid, C, and of the coolant, C_J, are constant.

Study the process diagram, then write the total mass balance equations.

Familiarise with programs `jacketedVesselNonLinmain_template.m` and `jacketedVesselNonLin_template.m`.

Experiment on how to simulate the system from different initial conditions $x(t=0) = \begin{bmatrix} x_1(0) \\ x_2(0) \\ x_3(0) \end{bmatrix}$ and varying inputs $u(t) = \begin{bmatrix} u_1(t) \\ u_2(t) \\ u_3(t) \\ u_4(t) \\ u_5(t) \end{bmatrix}$. Then implement your jacked vessel model with programs named, for example, `jacketedVesselNonLinmain.m` and `jacketedVesselNonLin.m`.

Col1	Col2
1	2
q_J	kgs^{-1}
T_F	$^{\circ}C$
T_i	$^{\circ}C$
q_F	kgs^{-1}
q	kgs^{-1}
T	$^{\circ}C$
T_J	$^{\circ}C$
V	m^3

1. Simulate the system from initial condition $T = 1$, $T_J = 1$ and $V = 1$ for a constant input $q_J = 0$, $T_F = 0$, $T_i = 0$, $q_F = 0$ and $q = 0$. Constants are $K = 1$, $\rho = 1$, $C = 1$, $A = 1$, $\rho_J = 1$, $V_j = 1$ and $C_J = 1$

2. Simulate the system from initial condition $T = 1$, $T_J = 1$ and $V = 1$ for a constant input $q_J = 1$, $T_F = 0.1$, $T_i = 0.1$, $q_F = 0.1$ and $q = 0.1$

3. Simulate the system from initial condition $T = 1$, $T_J = 1$ and $V = 1$ for an input defined as follows
   - $q_J(t) = 1$ for $t \in [0, 2.5]$, $q_J(t) = 2$ for $t \in [2.5, 5]$, $q_J(t) = 1$ for $t \in [5, 7.5]$, $q_J(t) = 3$ for $t \in [7.5, 10]$
   - $T_F(t) = 2$ for $t \in [0, 2.5]$, $T_F(t) = 0$ for $t \in [2.5, 5]$, $T_F(t) = 2$ for $t \in [5, 7.5]$, $T_F(t) = 1$ for $t \in [7.5, 10]$
   - $T_i(t) = 2$ for $t \in [0, 2.5]$, $T_i(t) = 0$ for $t \in [2.5, 5]$, $T_i(t) = 2$ for $t \in [5, 7.5]$, $T_i(t) = 1$ for $t \in [7.5, 10]$
   - $q_F(t) = 2$ for $t \in [0, 2.5]$, $q_F(t) = 0$ for $t \in [2.5, 5]$, $q_F(t) = 2$ for $t \in [5, 7.5]$, $q_F(t) = 1$ for $t \in [7.5, 10]$
   - $q(t) = 2$ for $t \in [0, 2.5]$, $q(t) = 0$ for $t \in [2.5, 5]$, $q(t) = 2$ for $t \in [5, 7.5]$, $q(t) = 1$ for $t \in [7.5, 10]$

4. What would be the realistic parameters for the constants in the real system?

You can use program `plotJacketedVessel_template.m.m` to plot your results. You can also modify it to suit your needs.