# Exothermic Continuous Stirred-Tank Reactor

File: `Ch02_E05_CSTR.m`

Nonlinear dynamics of an exothermic continuous stirred-tank reactor (CSTR). This is example 2.05 from Seborg, et al.

## Contents



## Model Equations

```
dCa
---  = q*(Cai - Ca) - V*k*Ca
dt

dT
--  = (w*Cp*(Tin - T) + U*A*(Tc - T) + (-delta_H)*V*k*Ca)/(V*rho*Cp)
dt
```

Arrhenius law:

```
k = ko * exp(-E/(R*T))
```

## Nominal Operating Conditions (Table 2.3)

```
q = 100;        % Flowrate [L/min]
cAi = 1;        % Inlet feed concentration [mol/L]
Ti  = 350;      % Inlet feed temperature [K]
V   = 100;      % Volume [L]
rho = 1000;     % Density [g/L]
C   = 0.239;    % Heat capacity [J/g/K]
dHr = -5e4;     % Heat of reaction [J/mol]

ER  = 8750;     % Ea/R [K]
k0  = 7.2e10;   % Arrhenius rate constant
UA  = 5e4;      % Heat transfer [J/min/K]
Tc  = 300;      % Coolant temperature [K]

cA0 = 0.5;      % Initial concentration [mol/L]
T0  = 350;      % Initial temperature [K]
```

## Arrhenius Rate (Equation 2-63)

```
k = @(T) k0*exp(-ER/T);
```

### Dynamic Mass and Energy Balances (Equations 2-66 and 2-68)

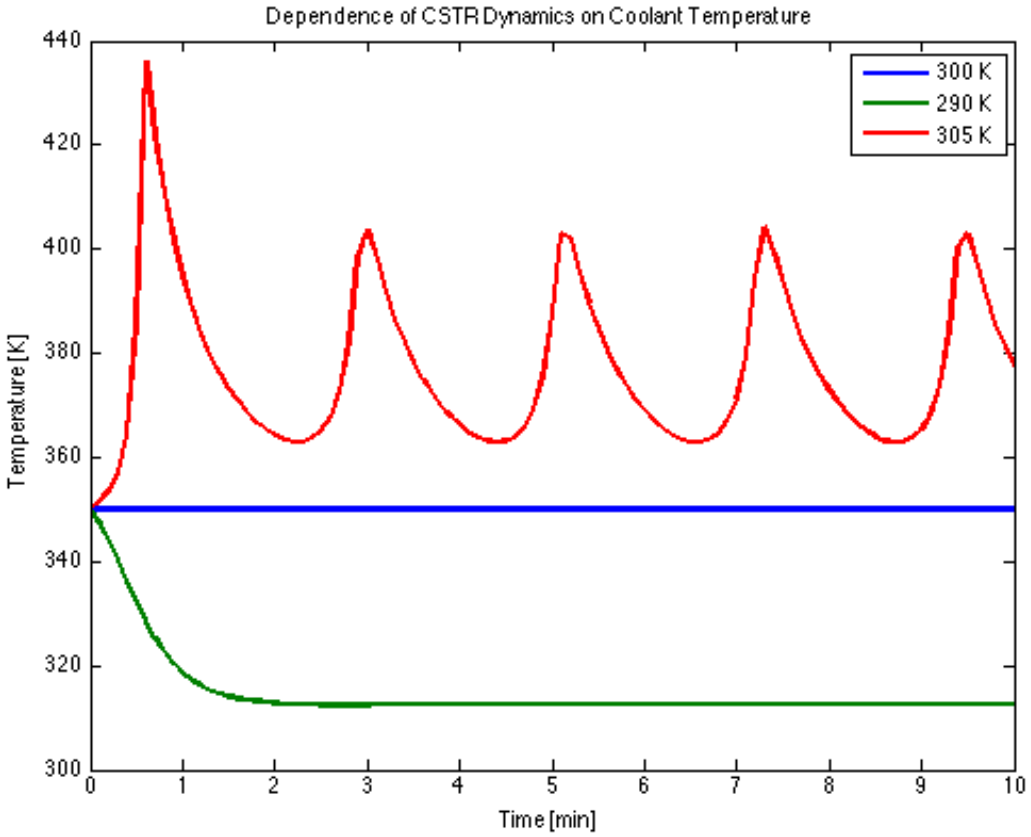
```
deriv = @(cA,T,Tc) [ ...
    (q/V)*(cAi - cA) - k(T)*cA;
    (q/V)*(Ti - T) + (-dHr/rho/C)*k(T)*cA + (UA/V/rho/C)*(Tc-T)];
```

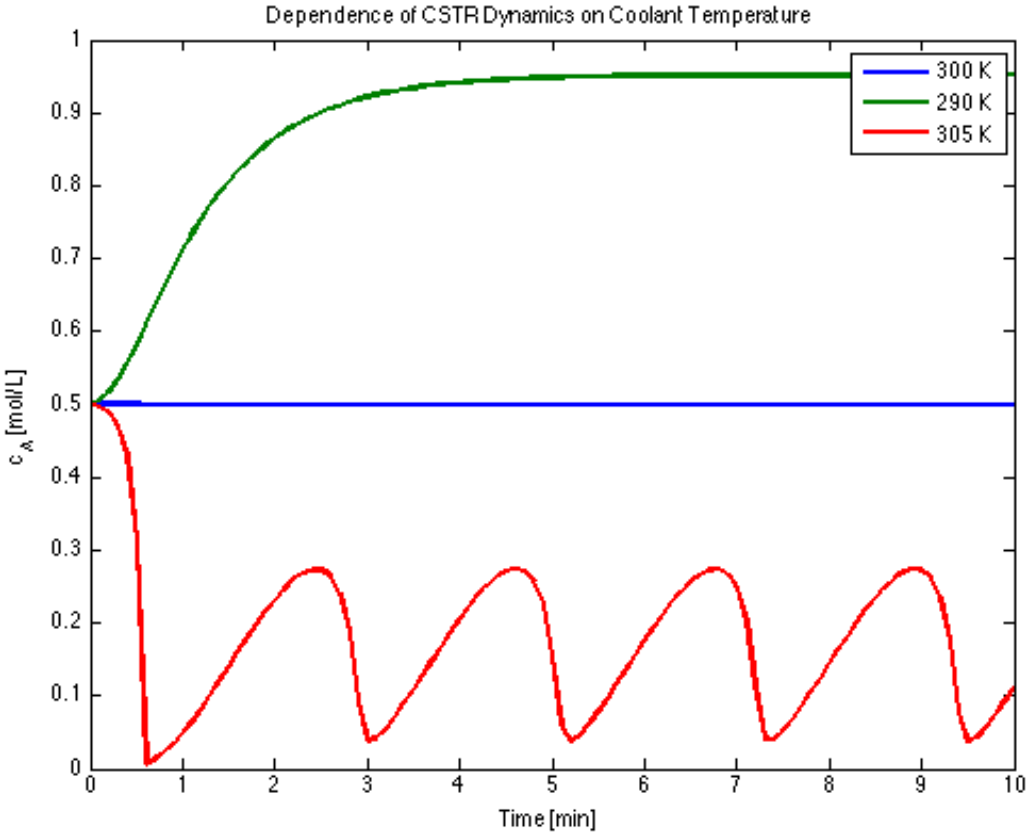
### Solution of the Differential Equations

```
% Time grid

t = 0:0.1:10;

% Solutions for three values of Tc

s300 = ode15s(@(t,x) deriv(x(1),x(2),300),t,[cA0,T0]);
s290 = ode15s(@(t,x) deriv(x(1),x(2),290),t,[cA0,T0]);
s305 = ode15s(@(t,x) deriv(x(1),x(2),305),t,[cA0,T0]);
```

### Display Solutions

```
figure(1);clf
plot(t,deval(s300,t,2),t,deval(s290,t,2),t,deval(s305,t,2),'Linewidth',2);
xlabel('Time [min]');
ylabel('Temperature [K]');
title('Dependence of CSTR Dynamics on Coolant Temperature');
legend('300 K','290 K','305 K');

figure(2);clf
plot(t,deval(s300,t,1),t,deval(s290,t,1),t,deval(s305,t,1),'Linewidth',2);
xlabel('Time [min]');
ylabel('c_A [mol/L]');
title('Dependence of CSTR Dynamics on Coolant Temperature');
legend('300 K','290 K','305 K');
```


Dependence of CSTR Dynamics on Coolant Temperature
300 K
290 K
305 K
Temperature [K]
Time [min]
440
420
400
380
360
340
320
300
0
1
2
3
4
5
6
7
8
9
10


Dependence of CSTR Dynamics on Coolant Temperature
300 K
290 K
305 K
c_A [mol/L]
Time [min]
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
6
7
8
9
10

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