Solution to Exercise

Substitution reaction in semi-batch reactor (RC1)

Cooling capacity of plant reactor

The cooling capacity can be calculated from the plant reactor data:

$$q_{ex} = UA\left(T_r - T_c\right) = 200\,Wm^{-2}K^{-1} \times 5\,m^2 \times \left(80-5\right) = 75\,kW$$

$$q'_{ex} = \frac{75000\,W}{2000\,kg} = 37,5\,W/kg$$

Since the measured maximum heat release rate is 31 W/kg, the available cooling capacity is sufficient, but practically without safety margin.

MTSR

The maximum accumulation is reached at the stoichiometric point and is: $X_{ac,max} = 0.25$.

At the stoichiometric point, the reaction mass is: $M_{r,st} = 1.4\,kg$.

MTSR is therefore : $MTSR = T_P + X_{ac} \cdot \Delta T_{ad} \frac{M_{rf}}{M_{r(t)}} = 80 + 0.25 \times 176 \times \frac{1.5}{1.4} = 128\,°C$

Criticality

The characteristic temperatures are:

T_p=80°C < T_{D24}=115°C < MTSR= 128 °C < MTT=140°C

The results are represented graphically in Figure 1.

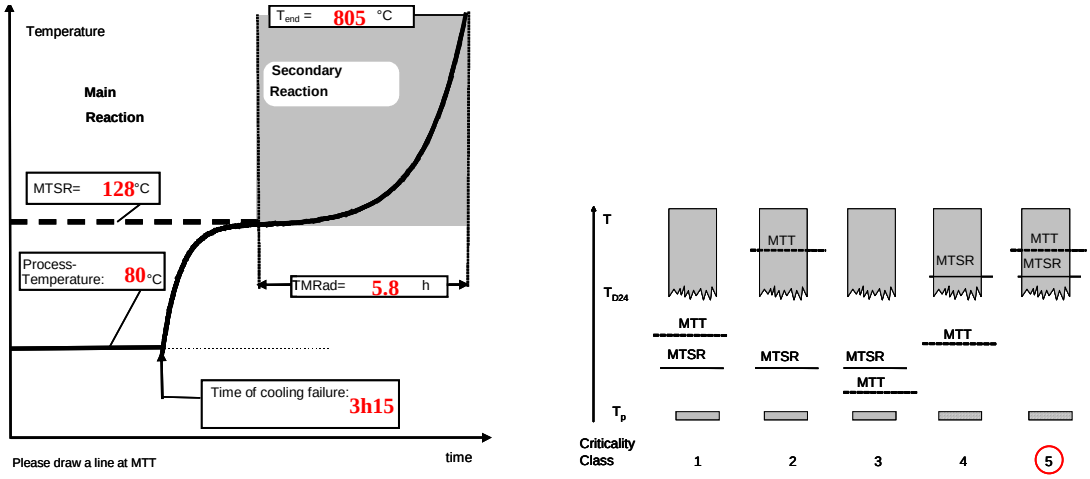

Figure 1 : Cooling Failure scenario and criticality class.