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NUCE497

HW-2 Solution

1- Given parameters:

$R_f = 0.5$ cm

$t_{clad} = 0.65$ mm

$t_{gap} = 30$ μm

$T_{cool} = 600$K

$y_{xe} = 10$ %

$h_{cool} = 2.5$ W/cm²K

$k_{zr} = 0.17$ W/cm K

Fuel Material	k_{fuel}[W/cm K][a]	Q[W/cm³][b]	$T_{melting}$[K][a]
U_{metal}	0.38	395	1405
UO_2	0.03	779	3138
UC	0.25	531	3123
UN	0.2	553	3133
U_3Si_2	0.23	463	1938

[a] Values taken from slide 18 of Lec 2.

[b] Calculated in HW-1

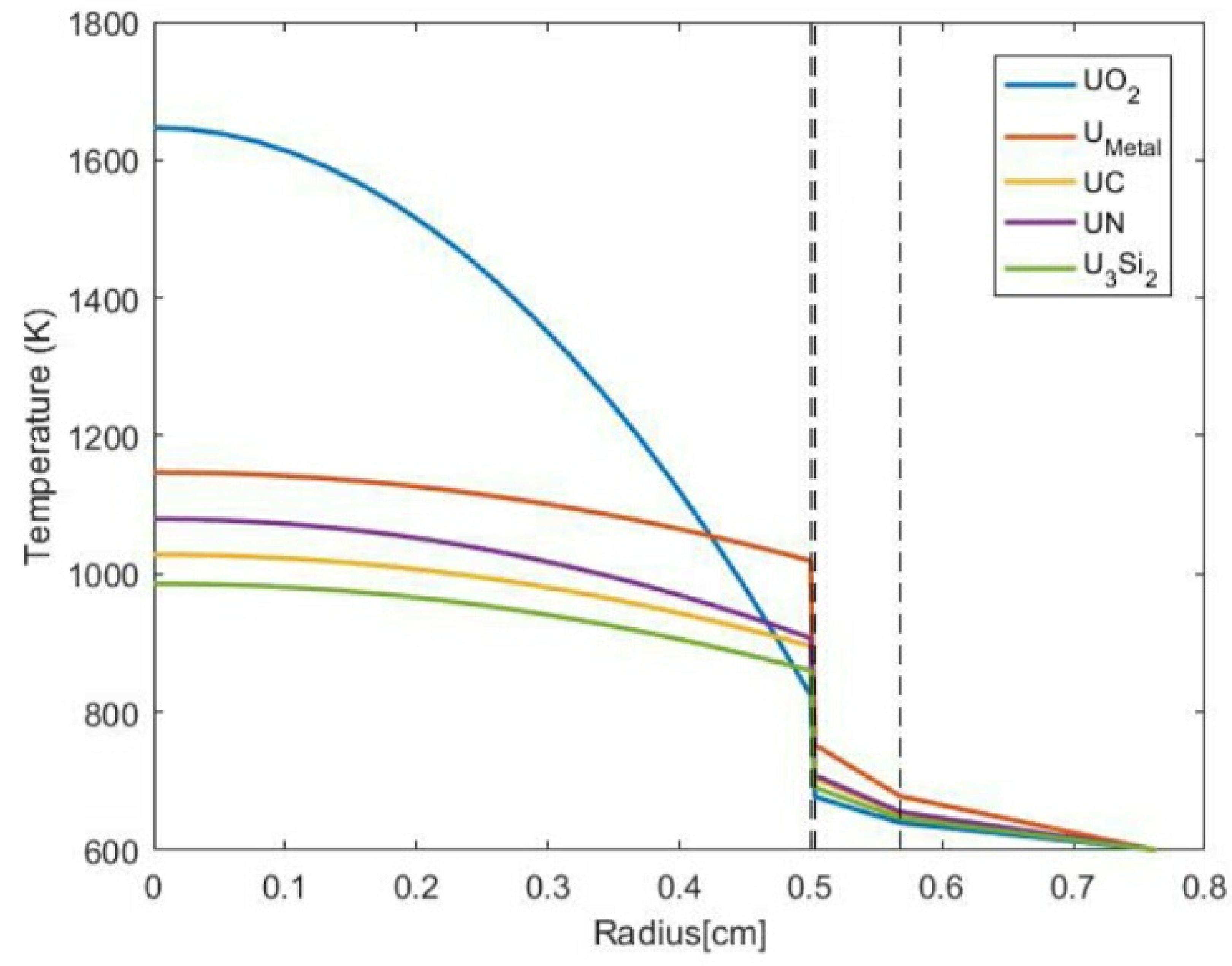
Relevant equations:

$$T_{co} - T_{cool} = \frac{Q}{2h_{cool}} R_f$$

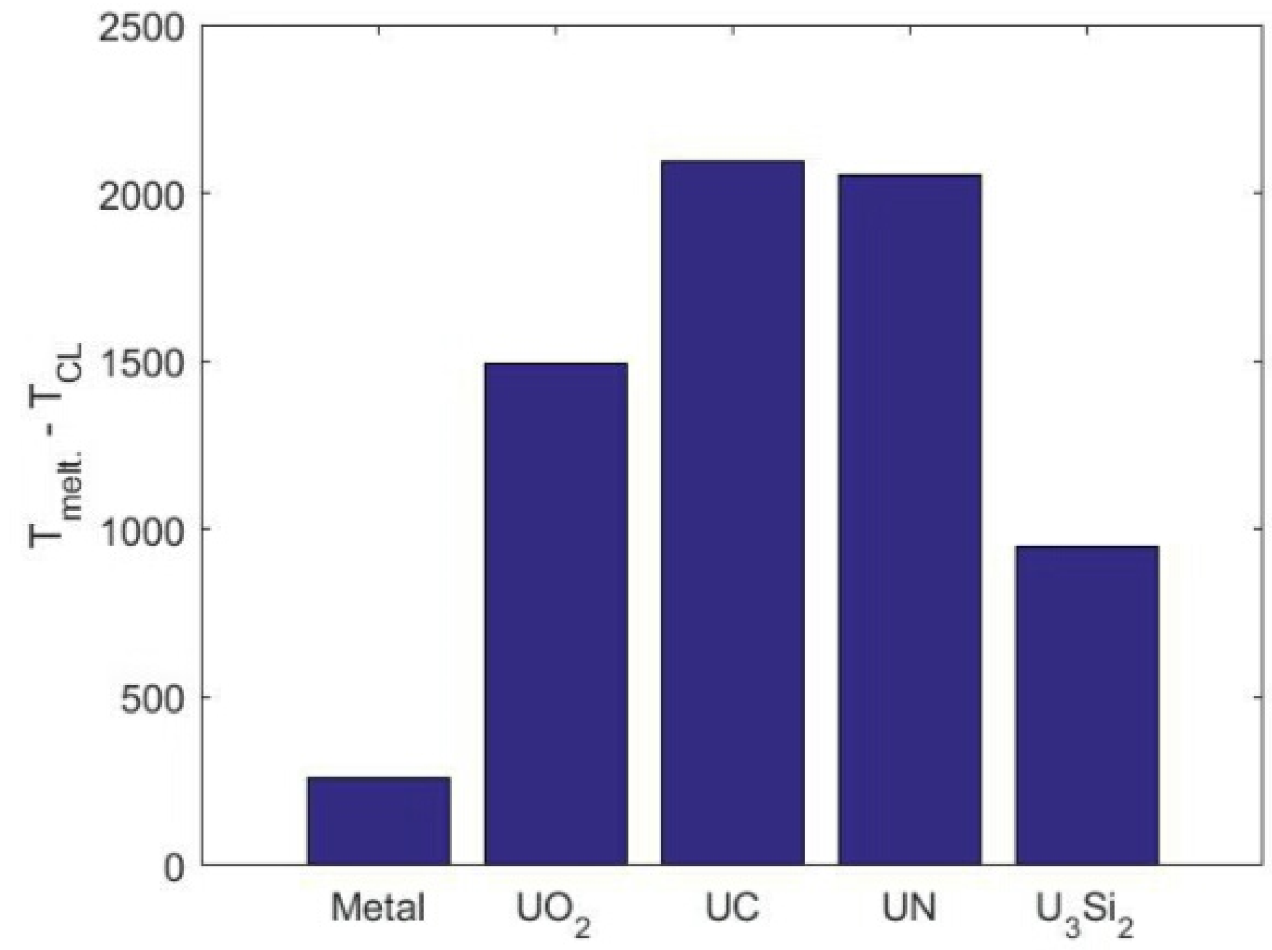
$$T_{ci} - T_{co} = \frac{Q}{2k_c} R_f t_{clad}$$

$$T_s - T_{ci} = \frac{Q}{2h_{gap}} R_f$$

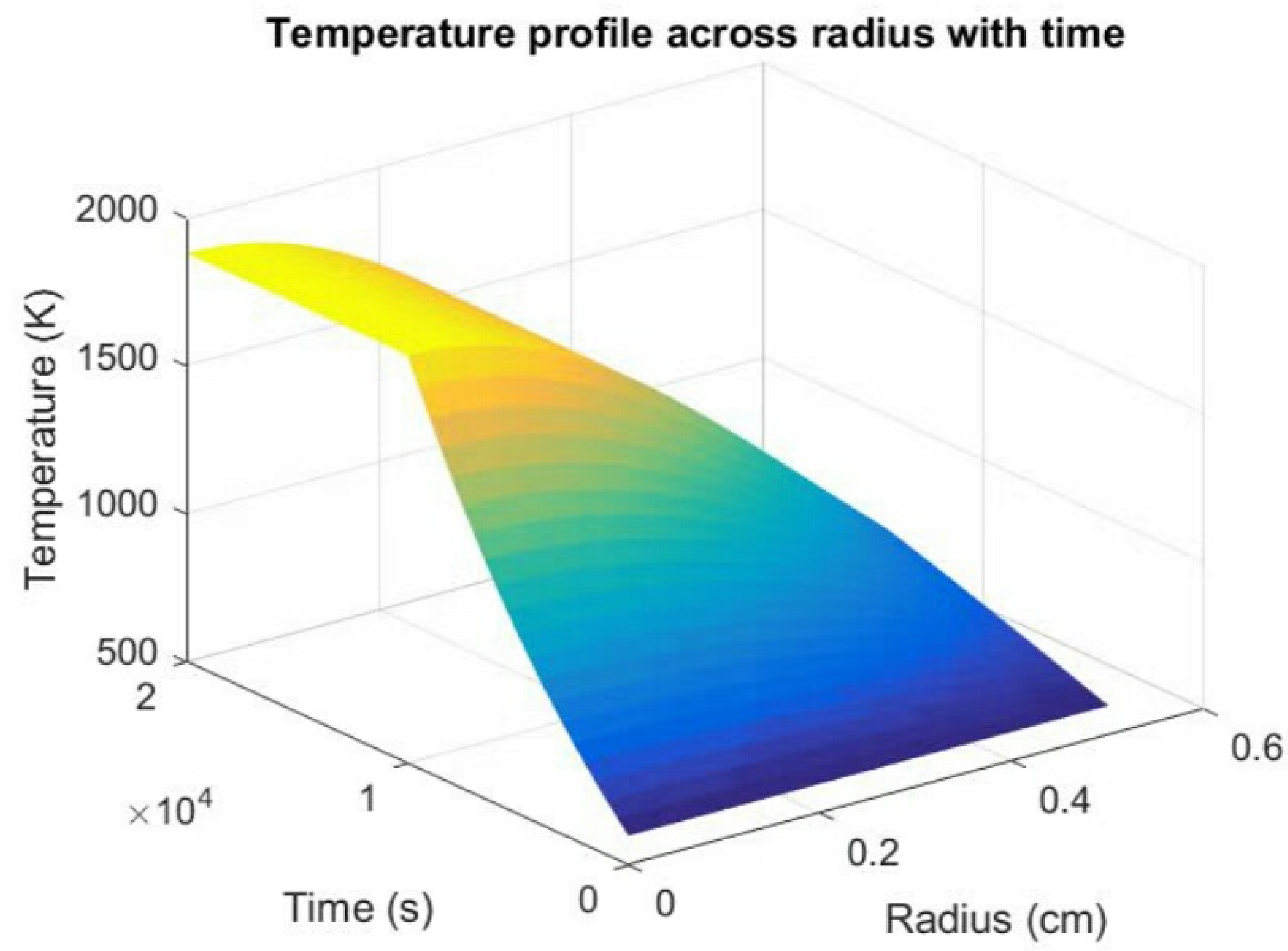
$$T_m - T_s = \frac{Q}{4k_f} R_f^2$$

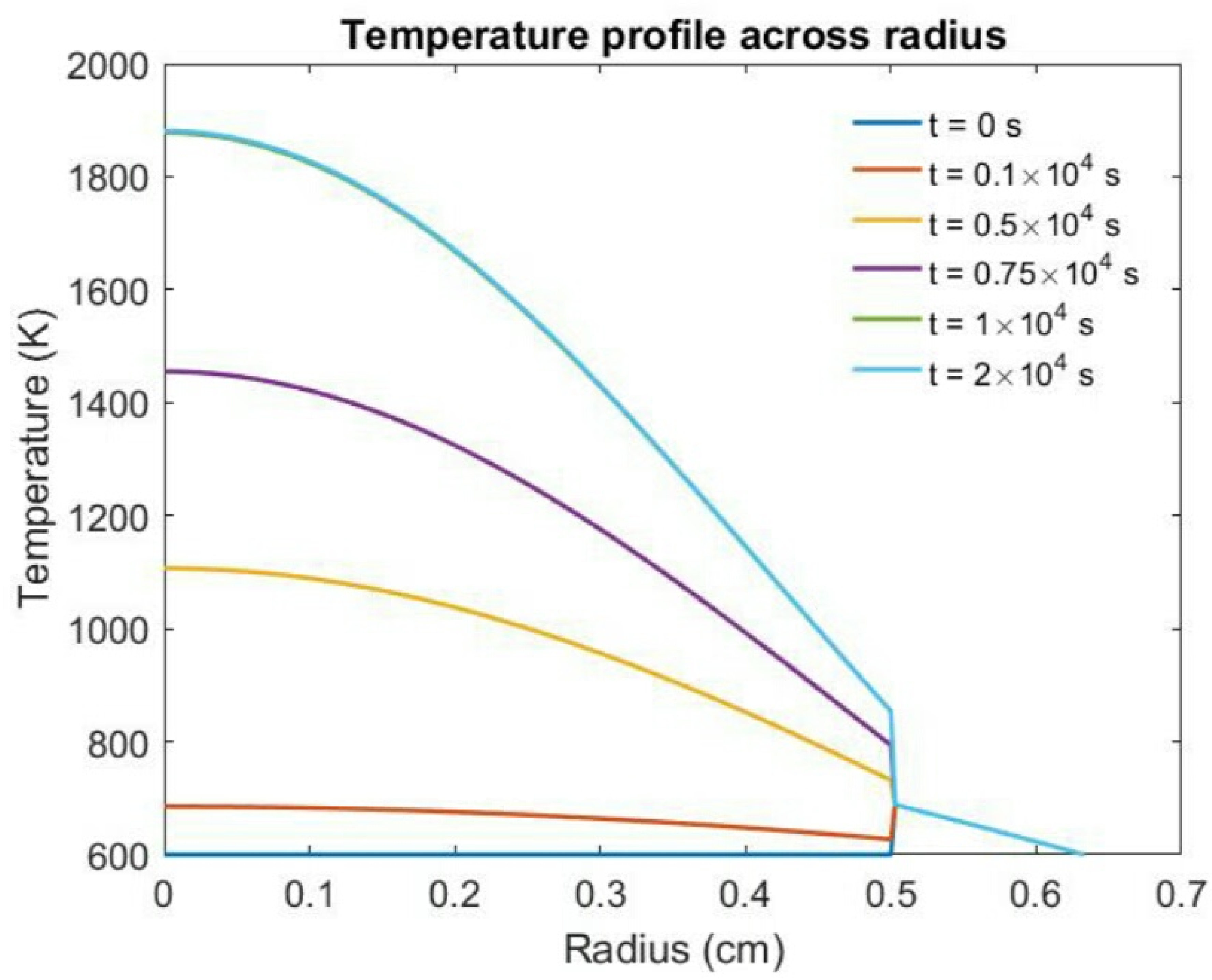


Fuel Material	$T_{melting}$[K]	$T_{centerline}$[K]
U_{metal}	1405	1147
UO_2	3138	1647
UC	3123	1028
UN	3133	1080
U_3Si_2	1938	986

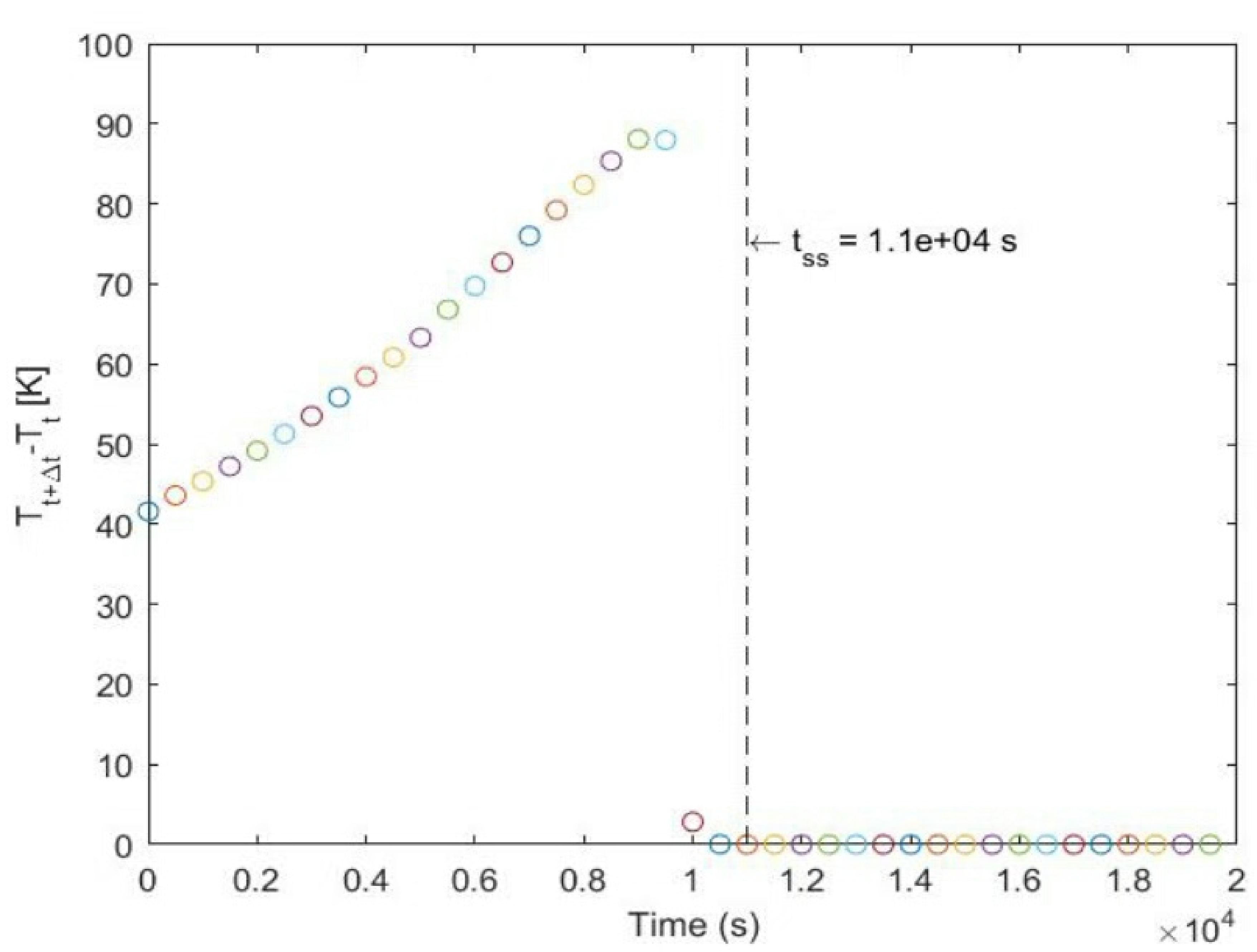


Q-2) a)

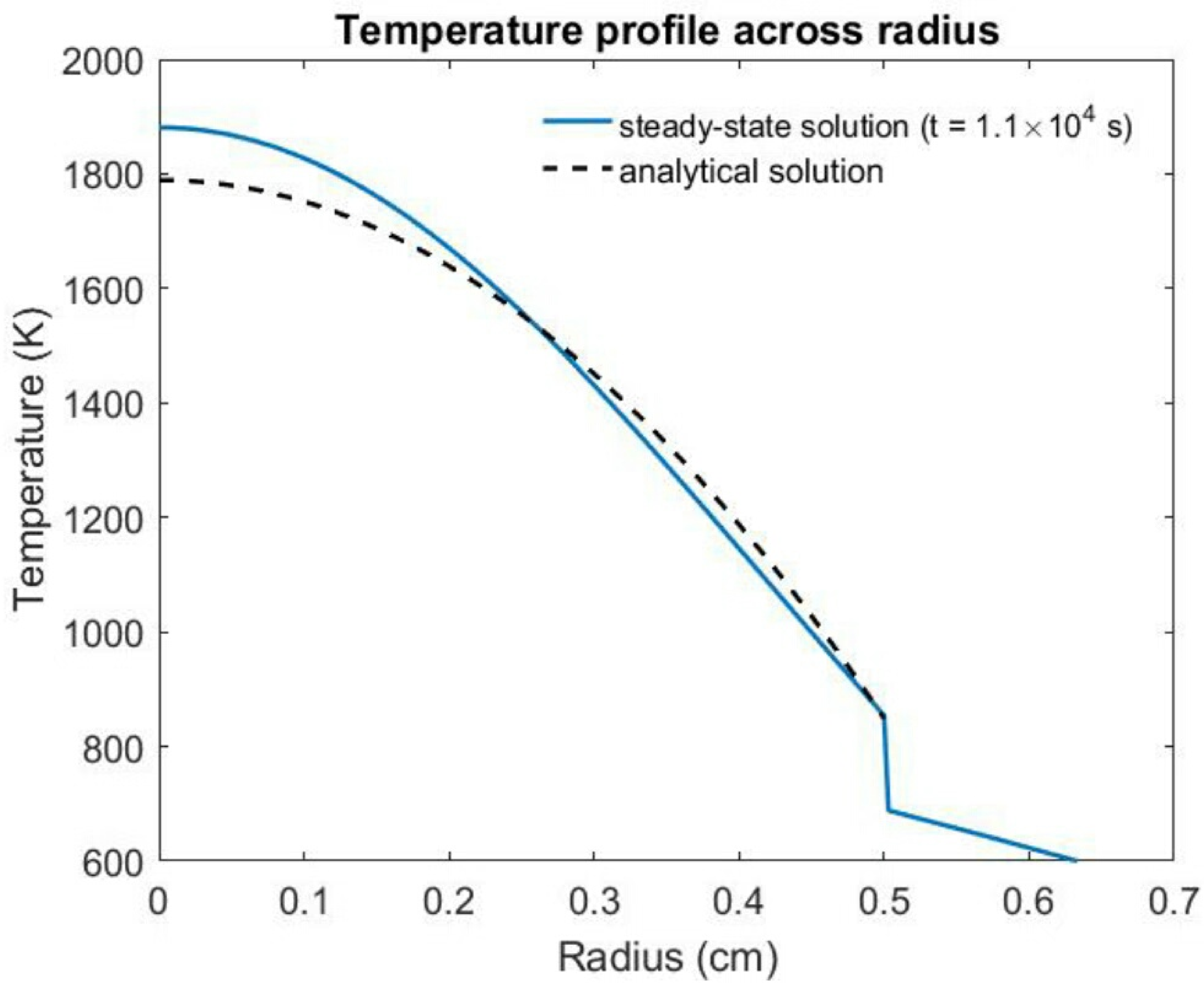




b) Max temperature difference was calculated for each time step. Steady-state solution was obtained if $\Delta T_{max} < \varepsilon = 0.001$.

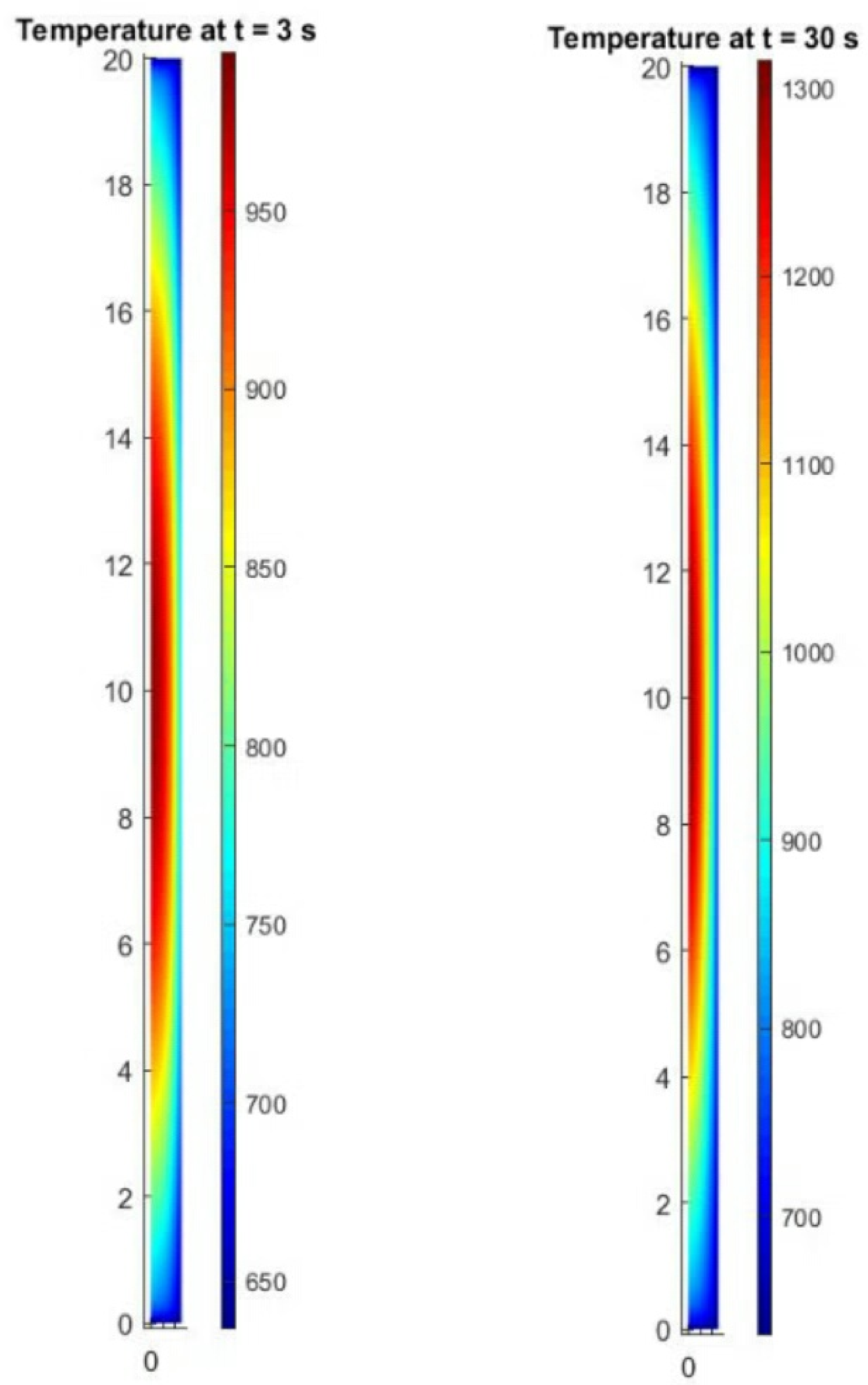


c)



Analytical solution and steady-state solution show slight variation. The main reason of this difference is the usage of constant k in analytical solution.

Q-3)



Q-4) $$\underbrace{\Delta T_{max}}_{\substack{\text{Maximum}\\ \text{possible}\\ \text{Temperature}\\ \text{Difference}}} = \underbrace{T_{limit}}_{\substack{70\%\text{ of}\\ \text{Melting}\\ \text{temperature}\\ 0.7T_{melt}}} - \Big(\underbrace{\Delta T_{fuel}}_{\substack{\text{Temperature}\\ \text{drop}\\ \text{across the}\\ \text{fuel}\\ (T_0 - T_s)}} + \underbrace{\Delta T_{gap}}_{\substack{\text{Temperature}\\ \text{drop}\\ \text{across the}\\ \text{gap}\\ (T_s - T_{ci})}} + \underbrace{\Delta T_{clad}}_{\substack{\text{Temperature}\\ \text{drop}\\ \text{across the}\\ \text{clad}\\ (T_{ci} - T_{co})}} + \underbrace{\Delta T_{cool}}_{\substack{\text{Temperature}\\ \text{drop}\\ \text{across the}\\ \text{coolant}\\ (T_{co} - T_{cool})}} + \underbrace{T_{in}}_{\substack{\text{Coolant}\\ \text{Inlet}\\ \text{Temperature}\\ T_{in}}} \Big)$$

We can rewrite this relation as follows:

$$\Delta T_{max} = T_{limit} - \left[T_0 - T_{cool} + T_{in} \right]$$

By using the results obtained in Q-1, we can calculate ΔT_{max} for each fuel material: