Exam 1 Fed. Fehr 11/02/2021

Exercise 1

$$\frac{\partial}{\partial x}\left(k\left(\frac{\partial T}{\partial x}\right)\right) + Q = 0 \quad (1)$$

$$k\frac{\partial T}{\partial x} = -Qx + C_1 \qquad T'(0) = 0$$

$$\Rightarrow C_1 = 0$$

$$k\frac{\partial T}{\partial x} = -Qx$$

$$T(x) = -Q\frac{x^2}{2k} + C_2$$

$$T(x_1) = T_1 \qquad T(X) = -\frac{QX^2}{2k} + C_2 = T_1$$

$$\Rightarrow C_2 = T_1 + \frac{QX^2}{2k}$$

$$T(x) = -\frac{Qx^2}{2k} + \frac{QX^2}{2k} + T_1$$

$$T(x) - T_1 = \frac{Q(X^2 - x^2)}{2k}$$

LHR

Target to equation (1) Four assumption were made

#1 : Study state $\nabla \cdot (K \nabla T) + Q = 0$

#2 : axisymmetric

$$\frac{\partial}{\partial x}\left(K \frac{\partial T}{\partial x}\right) + \frac{\partial}{\partial z}\left(K \frac{\partial T}{\partial z}\right) + Q(x,z) = 0$$

#3 constant in Z

$$\frac{\partial}{\partial x}\left(K \frac{\partial T}{\partial x}\right) + Q(x) = 0$$

#4 constant thermal conductivity :

equation 1

Exercice 2.

~~$T_{outercooling} - T_{cool} =$~~

$LHR = \pi R^2 Q = \pi \times (0,6)^2 \times 400 = 452,38 \, W/cm$

$t_{coating} = \frac{r_4 - r_3}{2} = 0,005 \, cm$

$t_{clad} = \frac{r_3 - r_2}{2} = 0,025 \, cm$

$t_{gap} = \frac{r_2 - r_1}{2} = 0,1 \, cm$

$$T_{coating} - T_{cool} = \frac{LHR}{2\pi R_{fuel} h_{coolant}} = \frac{452,38}{2\pi \times 0,6 \times 5,5}$$

$T_{coating} - T_{cool} = 21,81 \, K$

$T_{coating} = 21,81\,K + 800$

$T_{coating} = 821,81\,K$

$$T_{clad} - T_{coating} = \frac{LHR \times t_{coating}}{2\pi R_{fuel} K_{coating}}$$

$$= \frac{452,38 \times 0,005}{2\pi \times 0,6 \times 5/100 \ W/cm\,K}$$

$T_{clad} - T_{coating} = 12\,K$

$T_{clad} = 821,81 + 12 = 833,81\,K$

$$T_{gap} - T_{clad} = \frac{LHR\ r_{clad}}{2\pi R_f \times K_{clad}} = \frac{452,38 \times 0,025}{2\pi \times 0,6 \times 15/100}$$

$T_{gap} - T_{clad} = 20\,K$

$T_{gap} = 20 + 833,81\,K = 853,81\,K$

$$T_{fuel} - T_{gap} = \frac{LHR\ r_{gap}}{2\pi R_f\ K_{gap}} = \frac{452,38 \times 0,1}{2\pi \times 0,6 \times 25/100}$$

$T_{fuel} = 48\,K + T_{gap}$

$T_{fuel} = 901,33\,K$

$$T_o - T_{Fuel} = \frac{LHR}{4\pi K_{fuel}}$$

$$= \frac{458,38}{4\pi \times 0,5}$$

$$T_o - T_{fuel} = 72\ K$$

$$\underline{T_o = 72 + 901,33 = 973,33\ K}$$

$$\cancel{T_o}\ T_R - T_{fuel} = \frac{Q}{4k}(R_f^2 - r)$$

for $r = 0,4$

$$T_{(0,4)} = \frac{Q}{4k}(0,6^2 - 0,4^2) + 901,33$$

$$= 40 + 901,33$$

$$T_{(r=0,4)} = 941,33\ K$$

Exercice 7

$Q = E_f \times N_f \times \phi \times \sigma_f$

mlamass $U_3Si_2 = 3 \times (235 \times 0{,}195 + 238 \times 0{,}805)$

$+ 2 \times 28$

$U_3Si_2 = 237{,}415 \times 3 + 2 \times 28 = 768{,}245 \text{ g/g}$

$N_F = \frac{15{,}67}{768{,}245} \times 6{,}022 \times 10^{23} \times 0{,}195 \times 3 \frac{U}{U_3Si_2}$

$= 7{,}18 \times 10^{21} \; U^{235}/cm^3$

$Q = (200 \times 10^6 \times 1{,}6 \times 10^{-19}) \times 7{,}18 \times 10^{21} \times 2 \times 10^{12} \times 570 \times 10^{-24}$

$Q = 261{,}92 \; W/cm^3$

$f \; \frac{Q_{UO_2}}{Q}$

Exercice 4

$$LHR\left(\frac{z}{z_0}\right) = LHR^0 \cos\left(\frac{\pi}{2\gamma}\left(\frac{z}{z_0} - 1\right)\right)$$

$$LHR\left(\frac{1{,}8}{3}\right) = 150 \cos\left(\frac{\pi}{2{,}2}\left(\frac{1{,}8}{3} - 1\right)\right)$$

$$LHR\left(\frac{1{,}8}{3}\right) = 126{,}18 \ W/cm$$

$$T_{cool_{Sortie}} = T_{cool}^{in} = \frac{2{,}2}{\pi} \times \frac{180 \times 150}{0{,}28 \times 4200} \times \left(\sin\left(\frac{\pi}{2{,}2}\right) + \sin\left(\frac{\pi}{2{,}2}\, 0\right)\right)$$

$$= 10{,}85 \times (0{,}98)$$

$$= 10{,}63 \ K \text{ for Sortie}$$

Exercice 5

Forward euler

$$f(t_{n+1}) = f(t_n) + dt \frac{df}{dt_n}$$

$$y(t_1) = y(1) + 0{,}33\,(4 - 3\times 1^2)$$

$$= 6 + 0{,}33$$

$$y(1{,}33) = 6{,}33$$

$$y(t_2) = y(t_1) + 0{,}33 \times (4\times 1{,}33 - 3\times 1{,}33^2)$$

$$= 6{,}33 + 0{,}0133$$

$$y(1{,}66) = 6{,}334$$

$$y(t_3) = y(t_2) + 0{,}33 \times (4\times 1{,}66 - 3\times 1{,}66^2)$$

$$= 6{,}334 + 0{,}33 \times (-1{,}628)$$

$$y(2) = 5{,}797$$

Backward euler

$y(t_1) = y(t_0) + 0{,}33\,(4 \times 1{,}33 - 3 \times 1{,}33^2)$

$= 6 + 0{,}33 \times 0{,}0153$

$y(1{,}33) = 6{,}004$

$y(t_2) = y_{t_1} + 0{,}33 \times (4 \times 1{,}66 - 3 \times 1{,}66^2)$

$= 6{,}004 - 0{,}53$

$y(1{,}66) = 5{,}467$

$y(t_3) = y_{t_2} + 0{,}33 \times (4 \times 2 - 3 \times 2^2$

$y(1) = 4{,}142$

Exercice 6

* a Fertile material is a material that is not fissionable but can be converted into a fissile nuclide by neutron absorption

* a fissile material is capable of sustaining a nuclear fission chain reaction with neutrons

* a fissionable material is capable of undergoing fission even (with low probability) after capturing a high energy neutron

Exercice 7

- because during thermal cycling pure U metal dramatically swells

- not stable as ~~pure~~ UO_2 considering that it has three phases

Exercice 8.

Swelling density is necessary to determine the Swelling of the fuel to determine the thickness of the gap more void more smally

Exercice 9

9. we need to enrich U because only U-235 could sustain a nuclear chain reaction which exist naturally in UO_2 by 0,7% mass ~~percent~~ & we utilize UF_6 for (U-238) the enrichment.

gas centrifuge process gas is placed in a gas centrifuge cylinder rotated at a high speed

- the heavier U-238 will be pushed to the sides of the cylinder
- the enriched UF_6 will be pull out from the center

Exercice 10

Mo and Cs one is for enrichment and the other for higher (double hump distribution)

Exercise 11

- Finite difference
- Finite volume
- Finite element

~~Finit~~ Finite element is primary method for high fidelity fuel performance codes because it has continuous representation and can model any BC's and geometries