Analytical Solution for Stefan Diffusion of a wet core

1 Mole Fraction Profile

The mole fraction concentration distribution in the porous spherical shell is:

$$y_1(r) = 1 - (1 - y_{1,0}) \left[\frac{1 - y_{1,int}}{1 - y_{1,0}} \right]^{\frac{r_{core}^{-1} - r^{-1}}{r_{core}^{-1} - R_{part}^{-1}}} \tag{1}$$

2 Species Flux

$$\dot{n} = \frac{C_{tot}\, D_{eff}}{r^2 \left(\frac{1}{r_{core}} - \frac{1}{R_{part}} \right)} \ln \left(\frac{1 - y_{1,int}}{1 - y_{1,0}} \right) \tag{2}$$

3 Drying Time

The time needed for a complete drying of the wet core is:

$$t_v = \frac{\rho_E\, \varepsilon_l}{C_{tot}\, MG_E\, D_{eff} \ln \left(\frac{1 - y_{1,int}}{1 - y_{1,0}} \right)} \frac{r_{core}^2 (3R_{part} - 2r_{core})}{6R_{part}} \tag{3}$$

4 Convective velocity

From the species flux the convective velocity can easily be calculated:

$$\dot{n} = v_s\, C_{tot} \tag{4}$$

$$v_s = \frac{D_{eff}}{r^2 \left(\frac{1}{r_{core}} - \frac{1}{R_{part}} \right)} \ln \left(\frac{1 - y_{1,int}}{1 - y_{1,0}} \right) \tag{5}$$

For Nomenclature see octave documents.