function[x\_mi,k\_m,cp\_f,cp\_p,i\_s,hf,hp,re\_f,re\_p] = MEMBRANE\_PROPERTY\_1 (x\_fi,c\_d\_f,f\_w,c\_d\_p,m\_p,k\_m\_m,t\_fi,t\_pi,n\_fi,n\_pi)

% Feed inlet NaCl mole fraction

x\_mi = (x\_fi/58.44)/(x\_fi/58.44+(1-x\_fi)/18.02);

% Feed channel hydraulic diameter (m)

dh\_f = 2\*c\_d\_f\*f\_w/(c\_d\_f+f\_w);

% Permeate channel hydraulic diameter (m)

dh\_p = 2\*c\_d\_p\*f\_w/(c\_d\_p+f\_w);

% Membrane total thermal conductivity, water vapor/air thermal conductivity: 0.028 (W/m.K)

k\_m = m\_p\*0.028+(1-m\_p)\*k\_m\_m;

% Feed-specific heat capacity (J/kg.K)

cp\_f = 4217.4-3.72\*(t\_fi-273.15)+0.141\*(t\_fi-273.15)^2-2.654\*0.001\*(t\_fi-273.15)^3+2.093\*0.00001\*(t\_fi-273.15)^4+(-13.81+0.1938\*(t\_fi-273.15)-0.0025\*(t\_fi-273.15)^2)\*x\_fi\*1000\*0.607+(0.43-0.0099\*(t\_fi-273.15)+0.00013\*(t\_fi-273.15)^2)\*(x\_fi\*1000\*0.607)^1.5;

% Permeate specific heat capacity (J/kg.K)

cp\_p = 4217.4-3.72\*(t\_pi-273.15)+0.141\*(t\_pi-273.15)^2-2.654\*0.001\*(t\_pi-273.15)^3+2.093\*0.00001\*(t\_pi-273.15)^4;

% Density of feed solution (kg/m3)

rho\_f = 999.842594+6.793952\*10^(-2)\*(t\_fi-273.15)-9.09529\*10^(-3)\*(t\_fi-273.15)^2+1.001685\*10^(-4)\*(t\_fi-273.15)^3-1.120083\*10^(-6)\*(t\_fi-273.15)^4+6.536336\*10^(-9)\*(t\_fi-273.15)^5+(0.824493-4.0899\*10^(-3)\*(t\_fi-273.15)+7.6438\*10^(-5)\*(t\_fi-273.15)^2-8.2467\*10^(-7)\*(t\_fi-273.15)^3+5.3875\*10^(-9)\*(t\_fi-273.15)^4)\*(x\_fi\*1000)+(-5.72466\*10^(-3)+1.0227\*10^(-4)\*(t\_fi-273.15)-1.6546\*10^(-6)\*(t\_fi-273.15)^2)\*(x\_fi\*1000)^1.5+4.8314\*10^(-4)\*(x\_fi\*1000)^2;

% Density of permeate pure water, assuming 100% salt rejection (kg/m3)

rho\_p = 999.842594+6.793952\*10^(-2)\*(t\_pi-273.15)-9.09529\*10^(-3)\*(t\_pi-273.15)^2+1.001685\*10^(-4)\*(t\_pi-273.15)^3-1.120083\*10^(-6)\*(t\_pi-273.15)^4+6.536336\*10^(-9)\*(t\_pi-273.15)^5;

% Feed average velocity (m/s)

v\_fa = (n\_fi/rho\_f)/(c\_d\_f\*f\_w);

% Permeate average velocity (m/s)

v\_pa = (n\_pi/rho\_p)/(c\_d\_p\*f\_w);

% Ionic strength

i\_s = 19.915\*(x\_fi/1000)/(1-1.00487\*(x\_fi/1000));

**%% ------------------------------------\*\*\*\*\* The feed side** **\*\*\*\*\*-------------------------------------**

% Bulk feed viscosity (Pa.s)

miu\_f = 10^(0.0428\*i\_s+0.00123\*i\_s^2+0.000131\*i\_s^3+3\*(-0.03724\*i\_s+0.01859\*i\_s^2-0.00271\*i\_s^3)+(1-0.03724\*i\_s + 0.01859\*i\_s^2-0.00271\*i\_s^3)\*log10(2.414\*10^(-5)\*10^(247.8/(t\_fi-140))));

% Bulk feed thermal conductivity (W/m.K)

k\_f = (-0.92247+2.8395\*(t\_fi/273.15)-1.8007\*(t\_fi/273.15)^2+0.52577\*(t\_fi/273.15)^3-0.07344\*(t\_fi/273.15)^4)\*(1.0-(2.3434\*0.001-7.924\*0.000001\*(t\_fi-273.15)+3.924\*0.00000001\*(t\_fi-273.15)^2)\*100\*x\_fi+(1.06\*0.00001-2\*0.00000001\*(t\_fi-273.15)+1.2\*0.0000000001\*(t\_fi-273.15)^2)\*(100\*x\_fi)^2);

% Reynolds number of bulk feed solution

re\_f = dh\_f\*v\_fa\*rho\_f/miu\_f;

% Prandtl number of bulk feed solution

pr\_f = miu\_f\*cp\_f/k\_f;

%%

**if** re\_f < 10^4

% Nusselt number of bulk feed solution (laminar)

nu\_f = 0.664\*(pr\_f^(1/3))\*(re\_f^(1/2));

% Nusselt number of bulk feed solution (turbulent, Dittus-Boelt correlation)

**else** ,nu\_f = 0.023\*(re\_f^0.8)\*(pr\_f^0.4);

**end**

%% Feed convective heat transfer coefficient (W/m2.K)

hf = nu\_f\*k\_f/dh\_f;

**%% ---------------------------------------\*\*\*\*\* The permeate side \*\*\*\*\*--------------------------------------**

% Bulk permeate viscosity (Pa.s)

miu\_p = 2.414\*10^(-5)\*10^(247.8/(t\_pi-140));

% Bulk permeate thermal conductivity (W/m.K)

k\_p = -0.92247+2.8395\*(t\_pi/273.15)-1.8007\*(t\_pi/273.15)^2+0.52577\*(t\_pi/273.15)^3-0.07344\* (t\_pi/273.15)^4;

% Reynolds number of bulk permeate solution

re\_p = dh\_p\*v\_pa\*rho\_p/miu\_p ;

% Prandtl number of bulk permeate solution

pr\_p = miu\_p\*cp\_p/k\_p;

**if** re\_p < 10^4

% Nusselt number of bulk permeate solution (laminar)

nu\_p = 0.664\*(pr\_p^(1/3))\*(re\_p^(1/2));

% Nusselt number of bulk permeate solution (turbulent, Dittus-Boelt correlation)

**else** , nu\_p = 0.023\*(re\_p^0.8)\*(pr\_p^0.4);

**end**

%% Permeate convective heat transfer coefficient (W/m2.K)

hp = nu\_p\*k\_p/dh\_p;