ElectricFuelCellL1

This is a dynamic model of a fuel cell. The model is based on basic models in literature. It is a Level 1 model. I.e it is useful to represent a fuel cell in system. It can be parameterized to yield adequate accuracy to represent a fuel cell in a system, particularly for conceptual design. The model contains some dynamics.

References

1. Radmanesh, H., Heidari Yazdi, S. S., Gharehpetian, G. B. & Fathi, S. H. Modelling and simulation of fuel cell dynamics for electrical energy usage of Hercules airplanes. Sci. World J. 2014, (2014).
2. Thanapalan, K. K. T., Williams, J. G., Liu, G. P. & Rees, D. Modelling of a Pem Fuel Cell System. IFAC Proceedings Volumes 41, (IFAC, 2008).
3. Boccaletti, C., Duni, G., Fabbri, G. & Santini, E. Simulation models of fuel cell systems. Proc. ICEM, Electr. Mach. Chania, Greece 6 (2006). doi:10.1111/j.1743-6109.2008.01122.x.Endothelial

In[1054]:=
```
<< C:\\Hopsan\Compgen\CompgenNG.mx
```

In[1057]:=
```
path = ToFileName[{"C:", "Users", "petkr14",
    "Dropbox", "HopsanComponents", "AeroComponents", "Aero"}]
```

Out[1057]=
```
C:\Users\petkr14\Dropbox\HopsanComponents\AeroComponents\Aero\
```

In[1058]:=
```
Off[General::"spell1"]
```

In[1059]:=
```
domain = "Electric";
displayName = "FuelCellL1";
brief = "Level 1 (conceptual) Fuel cell model with some dynamics";
componentType = "ComponentQ";
author = "Petter Krus <petter.krus@liu.se>";
affiliation =
  "Division of Fluid and Mechatronic Systems, Linköping University";
SetFilenames[path, domain, displayName];
ResetComponentVariables[];
```

In[1067]:=
```
inputVariables = {
   {thetaFcRef, 1., double, "", "Power fraction reference [0,1]"}
  };
```

```
inputParameters = {
   {R, 4124.2, double, "J/Kg K", "Gas constant"},
   {cv, 10183., double, "J/Kg K", "heatcoeff"},
   {kmFC, 1000., double, "W/kg", "Fuel cell spec. power"},
   {nstack, 1, double, "", ""},
   {T, 323, double, "K", ""},
   {Tref, 298.15, double, "K", ""},
   {A, 62.5 × 10^-4, double, "m2", ""},
   {l, 25 × 10^-6, double, "m", ""},
   {Ph2, 1.476, double, "atm", "Hydrogen partial press"},
   {Po2, 0.2095, double, "atm", "Oxygen partial press"},
   {P0, 1, double, "atm", ""},
   {Faraday, 96485.3, double, "", ""},
   {dS, .85 × 10^-3  2 × 96485.3, double, "", ""},
   {dG, 228000.6, double, "", "Gibbs free energy"},
   {B, 0.15, double, "V", ""},
   {Rc, 0.0003, double, "", ""},
   {Ch2, 0.2, double, "", ""},
   {ksi1, -.948, double, "", ""},
   {ksi3, 7.22 × 10^-5, double, "", ""},
   {ksi4, -1.064 × 10^-4, double, "", ""},
   {psi, 23., double, "", ""},
   {Jmax, 672. × 10^-3  10^4, double, "A/m2", "Max current intensity"},
   {Jn, 22. × 10^-3  10^4, double, "A/m2", ""},
   {MH2, 2.016 × 10^-3, double, "kg/mol", ""},
   {cA, 10., double, "F", "Capacitance"},
   {conNum, 1000., double, "1/Ohm", ""},
   {thaucon, .1, double, "s", ""},
   {timeComp, 1., double, "", "time compression factor."},
   {e, N[E, 6], double, "", "e"}
  };
```

```
outputVariables = {
   {mFC, 1., double, "kg", "Mass of fuel cell"},
   {unernst, 1., double, "V", ""},
   {uOhmic, 1, double, "V", ""},
   {uact, 1, double, "V", ""},
   {ucon, 1, double, "V", ""},
   {ufc0, 1, double, "V", ""},
   {ufcr, 1, double, "V", ""},
   {ufc1, 1, double, "V", ""},
   {ifc0, 0., double, "A", ""},
   {etaFC, 0., double, "", "Fuel cell efficiency"},
   {Powfc, 0., double, "Power", ""},
   {rhoM, 0., double, "kg/m^3", ""},
   {WH2, 0., double, "kg/s", ""}
  };
```

In[1072]:=
```
nodeConnections = {
   ElectricQnode[fc, 0., "Port"],
   PneumaticQnode[p1, 100000., "fluid port 1"]
              };
```

In[1074]:=
$$\text{LogA1}[x\_] := -\frac{1.3\,x}{1-(0.93\,x)^4}$$

In[1075]:=
```
IfPositive =.;
```

In[1076]:=
```
J = ifc / A;
```

In[1077]:=
$$\text{localExpressions} = \Big\{$$
$$\text{cp} == R + \text{cv},$$
$$\text{Co2} == \frac{\text{Po2}}{5.08\times 10^6\, e^{\frac{-498}{T}}},$$
$$\text{ksi2} == 0.00286 + 0.0002\,\text{Log}\left[A\,10^4\right] + 4.3\times 10^{-5}\,\text{Log}[\text{Ch2}],$$
$$\text{rhoM} == \left(181.6\left(1+0.03\left(\frac{\text{ifc0}}{A\,10^4}\right)+0.062\left(\frac{T}{303}\right)^2\left(\text{lowLimit}\left[\frac{\text{ifc0}}{A\,10^4},0.\right]\right)^{2.5}\right)\right)\Big/$$
$$\left(\text{psi}-0.634-3\left(\frac{\text{ifc0}}{A\,10^4}\right)e^{4.18\left(\frac{T-303}{T}\right)}\right),$$
$$\text{unernst} == \frac{dG}{2\,\text{Faraday}} + \frac{dS}{2\,\text{Faraday}}(T-\text{Tref}) + \frac{R\,T}{2\,\text{Faraday}}\,\text{Log}\left[\frac{\text{Ph2}\sqrt{\text{Po2}}}{\text{P0}}\right],$$
$$\text{uact} == \text{lowLimit}\Big[-\big(\text{ksi1}+\text{ksi2}\,T+\text{ksi3}\,T\,\text{Log}[\text{Co2}]+$$
$$\text{ksi4}\,T\,\text{Log}\left[\text{lowLimit}\left[\text{ifc0},1.*10^{-30}\right]\right]\big),0\Big],$$
$$\text{ucon} == -B\,\text{LogA1}\left[\text{limit}\left[\frac{J}{\text{Jmax}},0.,1.075\right]\right],$$
$$\text{uOhmic} == \frac{\text{rhoM}\,l\,10^2}{A\,10^4}\,\text{ifc},$$
$$\text{ufcr} == \text{lowLimit}[\text{unernst}-\text{uact}-\text{ucon}-\text{uOhmic},0.],$$
$$\text{ufc0} == \text{lowLimit}[\text{unernst}-\text{uact}-\text{ucon}-\text{uOhmic}+\text{ifc0}/\text{conNum},0.]$$
$$\Big\};$$

In[1078]:=
```
systemEquationsDA = {
   ifc == conNum (ufc1 - ufc / nstack),
   thaucon der[ufc1] == ufc0 - ufc1,
   thaucon der[ifc0] == ifc - ifc0
  };
```

```
systemBoundaryEquations = {
   ufc == cfc + Zcfc ifc,
   pp1 == (cp1 + Zcp1 dEp1 )
  };
```

In[1080]:=
```
systemVariables = {
   ifc, ufc1, ifc0, ufc, pp1};
```

```
expressions = {
   etaFC == ufc / (nstack unernst),
   Powfc == ufc ifc,
   WH2 == MH2 nstack ifc / (2 Faraday),
   qmp1 == -MH2 nstack ifc / (2 Faraday),
   dEp1 == qmp1 cp Tp1,
   mFC == nstack unernst Jmax A / kmFC
  };
```

In[1082]:=
```
Compgen[file]
```