Google Reactor Calibration Model

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This note is to describe the parameters and formula Google IPB Reactor Calibration Model.

The proposed equivalent circuit model is described in Figure 1.

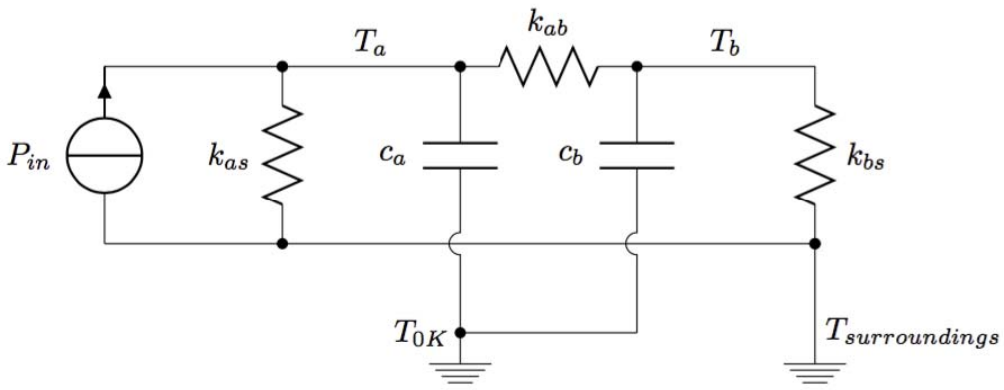

Figure 1: Circuit Model

The governing equations are:

$$\frac{dT_a(t)}{dt} = \frac{P_{in} - k_{as}(T_a - T_s) - k_{ab}(Ta - T_b)}{c_a} \tag{1}$$

$$\frac{dT_b(t)}{dt} = \frac{P_{in} - k_{ab}(T_a - T_s) - k_{bs}(Tb - T_s)}{c_b} \tag{2}$$

The parameters in the equations are:

$$k_{as} = (k_{as0} + k_{as1}T_a + k_{as2}T_a^2) \tag{3}$$

$$k_{ab} = (k_{ab0} + k_{ab1}T_a + k_{ab2}T_a^2) \tag{4}$$

$$k_{bs} = (k_{bs0} + k_{bs1}T_b + k_{bs2}T_b^2) \tag{5}$$

$$c_a = (c_{a0} + c_{a1}T_a + c_{a2}T_a^2) \tag{6}$$

$$c_b = (c_{b0} + c_{b1}T_b + c_{b2}T_b^2) \tag{7}$$

$$P_{in}(t) = (a_{10} + a_{11}T_a + a_{12}T_a^2)P_{heaterpower} + (a_{20} + a_{21}T_a + a_{22}T_a^2)P_{core-Q} \tag{8}$$

in DC P_{core-Q} is P_{DC}

T_a is the core temperature
T_b is the inner block temperature
T_s is the outer block temperature

$$P_{out}(t) = k_{as}[T_a(t) - T_s(t)] + k_{bs}[T_b(t) - T_s(t)] \tag{9}$$

$$P_{stored}(t) = c_a\frac{dT_a(t)}{dt} + c_b\frac{dT_b(t)}{dt} \tag{10}$$

The Energy COP defined as

$$COP_{energy}(t) = \frac{\int_0^t [P_{out}(t) + P_{stored}(t)]dt}{\int_0^t P_{in}(t)dt} \tag{11}$$

The Power COP defined as

$$COP_{power}(t) = \frac{P_{out}(t) + P_{stored}(t)}{P_{in}(t)} \tag{12}$$

The Google Team has done four calibration models, the table 1. lists all the parameters in the calibration models.

Table 1: Parameters in Google Model

Parms	ipb1-30-he	ipb1-30-h2	sri-ipb2-27-h2	sri-ipb2-33-he	sri-ipb2-33-h2	sri-ipb2-33-h2-2	ipb1-40-he	ipb1-40-h2
ca0	10.58	52.91	17.19	20.59	18.381	18.01	22.708	27.07
ca1	4.30E-01	2.20E-01	-6.77E-01	8.57E-02	1.52E-01	1.40E-01	1.89E-02	1.50E-01
ca2	-9.39E-04	-2.66E-04	8.59E-03	1.22E-05	-3.49E-05	-1.41E-05	1.71E-05	-1.35E-04
cb0	601.10	579.90	883.48	675.09	666.22	669.82	777.96	635.81
cb1	0.46692	0.38258	-2.75100	0.12088	0.11378	0.09365	-0.18899	0.28148
cb2	0	0	0	0	0	0	0	0
kas0	2.92E-02	2.66E-02	5.15E-05	1.72E-03	5.14E-03	3.24E-03	-8.13E-03	4.94E-02
kas1	-5.31E-05	-2.70E-05	2.35E-04	4.62E-05	3.99E-05	5.08E-05	2.49E-05	-1.96E-04
kas2	0	0	0	0	0	0	0	0
kab0	0.65350	0.61924	0.82998	0.56864	0.54634	0.48741	0.78189	0.55149
kab1	-4.87E-04	7.96E-04	-2.40E-03	8.19E-04	7.95E-04	1.01E-03	9.41E-04	5.07E-03
kab2	3.66E-06	1.00E-06	1.75E-06	-4.38E-07	-2.63E-07	-8.20E-07	-3.23E-07	-2.36E-06
kbs0	0.03301	0.03681	0.07530	0.06369	0.06328	0.06141	0.06637	0.00130
kbs1	1.57E-04	1.21E-04	-2.66E-04	5.80E-05	4.04E-05	5.72E-05	7.85E-05	3.41E-04
kbs2	6.54E-08	7.53E-08	2.74E-07	2.50E-08	7.29E-08	1.65E-08	4.11E-08	2.78E-08
a10	1	1	1	1	1	1	1	1
a11	0	0	0	0	0	0	0	0
a12	0	0	0	0	0	0	0	0
a20	0.367580	0.359820	0.425000	0.050546	0.28613	0.053757	0.049953	0.041226
a21	1.01E-03	6.65E-04	-9.20E-04	3.12E-03	1.46E-03	3.01E-03	3.92E-03	3.35E-03
a22	-9.89E-07	-9.54E-08	4.49E-06	-4.38E-06	-1.54E-06	-4.16E-06	-5.81E-06	-4.61E-06