Variables & Equations

ProMo

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Contents

1 Variables

2 root

	var	symbol	documentation	type	units	eqs
6	$F^{sink}{}_{A,I}$	F_AI_sink	incidence matrix AI sink	network		6
16	mv_I	mv_I	interface variable macro –> control	network		
27	$I_{N,A}$	I_NA	identity mapping from <N> to <A>	network		
5	$F^{source}{}_{A,I}$	F_AI_source	incidence matrix AI source	network		
22	$y_{N,t,u}$	y_Ntu	output signal in control domain	network		
8	$F^{sink}{}_{N,A}$	F_NA_sink	incidence matrix NA sink	network		
13	$S_{I,q}$	S_Aq	selection matrix arcs to outputs	network		
19	$A_{N,p,q}$	A_Npq	mapping from inputs to outputs	network		
11	$I_{t,u}$	I_tu	identity mapping from <t> to <u>	network		
9	$S_{I,p}$	S_Ip	selection matrix interface to control input	network		
7	$F^{source}{}_{N,A}$	F_NA_source	incidence matrix NA source	network		
3	$F^{source}{}_{N,I}$	F_NI_source	incidence matrix NI source	network		

	var	symbol	documentation	type	units	eqs
15	$S_{N,q,t}$	S_Nqt	selection matrix or splitter	network		
18	cz_I	cz_I	interface variable macro –> control	network		
2	$F_{N,A}$	F	incidence matrix	network		
10	$S_{I,q}$	S_Iq	selection matrix interface to control output	network		
20	$A_{N,t,u}$	A_Ntu	mapping from input elements to outputs	network		
17	cz_N	cz_N	output from control	network		
4	$F^{sink}{}_{N,I}$	F_NI_sink	incidence matrix NI sink	network		
14	$S_{N,p,q}$	S_Npu	selection matrix for stacker	network		
12	$S_{A,p}$	S_Ap	selection matrix interface species-related measures	network		
21	$u_{N,t,u}$	u_Ntu	input signal in control domain	network		
1	t	t	time	frame	s	
105	t^o	to	starting time	frame	s	4
107	Δt	t_interval	time interval	frame	s	6
106	t^e	te	end time	frame	s	5

	var	symbol	documentation	type	units	eqs
102		zero	numerical value zero	constant		1
	0					
103		one	numerical value one	constant		2
	1					
101		value	numerical value	constant		
	#					
104		oneHalf	numerical value one half	constant		3
	0.5					

3 physical

	var	symbol	documentation	type	units	eqs
23	r_{xN}	r_x	x-coordinate	frame	m	
24	r_{yN}	r_y	y-coordinate	frame	m	
25	r_{zN}	r_z	z-coordinate	frame	m	
110	V_N	V	volume	state	m^3	7
144	C_N	C	fundamental state – charge	state	$A\,s$	
109	S_N	S	fundamental state – internal entropy	state	$kg\,m^2\,K^{-1}\,s^{-2}$	
111	$n_{N,S}$	n	fundamental state – molar mass	state	mol	93
108	U_N	U	fundamental state – internal energy	state	$kg\,m^2\,s^{-2}$	
137	m_N	m	mass	state	kg	30
132	λ_S	Mm	molecular masses	constant	$kg\,mol^{-1}$	
123	R	R	gas constant	constant	$kg\,m^2\,mol^{-1}\,K^{-1}\,s^{-2}$	17
122	k^B	Boltz	Boltzmann constant	constant	$kg\,m^2\,K^{-1}\,s^{-2}$	
121	N^A	Avo	Avogadro constant	constant	mol^{-1}	

Continued on next page

5

	var	symbol	documentation	type	units	eqs
149	A_{xzN}	Axz	cross sectional are xz	secondaryState	m^2	41
143	ρ_N	rho	density	secondaryState	$kg\,m^{-3}$	36
150	A_{yzN}	Ayz	cross sectional area yz	secondaryState	m^2	42
148	A_{xyN}	Axy	cross sectional area xy	secondaryState	m^2	40

4 macroscopic

	var	symbol	documentation	type	units	eqs
160	$\hat{n}^c_{xA,S}$	`fnc_x`	molar convective flow in x-direction	transport	$mol\,s^{-1}$	52
154	$\hat{n}^d_{xA,S}$	`fnd_x`	diffusion flow in x-direction	transport	$mol\,s^{-1}$	46 89
211	$\hat{w}_A$	`fw`	a fixed work flow to start with	transport	$kg\,m^2\,s^{-3}$	106
208	$\dot{q}_{xN}$	`aq_x`	accumulation due to heat flow in x-direction	transport	$kg\,m^2\,s^{-3}$	103
204	$\dot{H}^c_{xN}$	`aHnc_x`	accumulation of enthalpy due to convective mass flow in x-direction	transport	$kg\,m^2\,s^{-3}$	99
234	$\hat{m}_{N,A}$	`fm`	convective mass flow	transport	$kg\,s^{-1}$	133
151	$\hat{q}_{xA}$	`fq_x`	heat flow in x-direction	transport	$kg\,m^2\,s^{-3}$	43
156	$\hat{n}^d_{zA,S}$	`fnd_z`	diffusion flow in z-direction	transport	$mol\,s^{-1}$	48 91
205	$\dot{H}^d_{xN}$	`aHnd_x`	accumulation of enthalpy due to diffusional mass flow in x-direction	transport	$kg\,m^2\,s^{-3}$	100
153	$\hat{q}_{zA}$	`fq_z`	heat flow in z-direction	transport	$kg\,m^2\,s^{-3}$	45
209	$\dot{q}_{yN}$	`aq_y`	accumulation due to heat flow in y-direction	transport	$kg\,m^2\,s^{-3}$	104
207	$\dot{H}^d_{zN}$	`aHnd_z`	accumulation of enthalpy due to diffusional mass flow in z-direction	transport	$kg\,m^2\,s^{-3}$	102
155	$\hat{n}^d_{yA,S}$	`fnd_y`	diffusion flow in y-direction	transport	$mol\,s^{-1}$	47 90

	var	symbol	documentation	type	units	eqs
214	$\dot{w}_N$	aw	accumulation of enthalpy due to work flow	transport	$kg\,m^2\,s^{-3}$	109
243	$y^{p+}{}_A$	y_p_positive	link variable y p positive to interface macroscopic	transport		141
206	$\dot{H}^d_{yN}$	aHnd_y	accumulation of enthalpy due to diffusional mass flow in y-direction	transport	$kg\,m^2\,s^{-3}$	101
212	$\dot{n}^d_{yN,S}$	and_y	accumulation due to diffusion in y-direction	transport	$mol\,s^{-1}$	107
210	$\dot{q}_{zN}$	aq_z	accumulation due to heat flow in z-direction	transport	$kg\,m^2\,s^{-3}$	105
194	$\dot{n}^c_{xN,S}$	anc_x	accumulation of molar mass due to convection	transport	$mol\,s^{-1}$	87
159	$\hat{V}_A$	fV	volumetric flow in x-direction	transport	$m^3\,s^{-1}$	51 142
213	$\dot{n}^d_{zN,S}$	and_z	accumulation due to diffusion in z-direction	transport	$mol\,s^{-1}$	108
158	$c_{A,S}$	c_AS	concentration in convective event-dynamic flow	transport	$m^{-3}\,mol$	50
152	$\hat{q}_{yA}$	fq_y	heat flow in y-direction	transport	$kg\,m^2\,s^{-3}$	44
157	d_A	d	flow direction of convective flow	transport		49
195	$\dot{n}^d_{xN,S}$	and_x	accumulation due to diffusion in x-direction	transport	$mol\,s^{-1}$	88
184	k^c_{yA}	kcA_y	convective mass conductivity in arc and y-direction	properties	$m^{-1}\,s$	77
188	k^q_{zA}	kqA_z	thermal conductivity in arc and z-direction	properties	$kg\,K^{-1}\,s^{-3}$	81

Continued on next page

	var	symbol	documentation	type	units	eqs
182	$k^d_{z\,A,S}$	`kdA_z`	diffusivity in arc and z-direction	properties	$kg^{-1}\,m^{-4}\,mol^2\,s$	75
192	$\hat{k}^{d,Fick}_{z}{}_{A,S}$	`kdAFick_z`	Fick diffusivity in arc and z-direction	properties	ms^{-1}	85
193	$h_{A,S}$	`hA`	partial molar enthalpiies in arc	properties	$kg\,m^2\,mol^{-1}\,s^{-2}$	86
189	ρ_A	`rhoA`	density in arc	properties	$kg\,m^{-3}$	82
219	$R^e{}_N$	`elResistant`	electrical resistant	properties	$kg\,m^2\,A^{-2}s^{-3}$	115
187	$k^q_{y\,A}$	`kqA_y`	thermal conductivity in arc and y-direction	properties	$kg\,K^{-1}\,s^{-3}$	80
180	$k^d_{x\,A,S}$	`kdA_x`	diffusivity in arc and x-direction	properties	$kg^{-1}\,m^{-4}\,mol^2\,s$	73
185	$k^c_{z\,A}$	`kcA_z`	convecive mass conductivity in arc and y-direction	properties	$m^{-1}\,s$	78
181	$k^d_{y\,A,S}$	`kdA_y`	diffusivity in arc and y-direction	properties	$kg^{-1}\,m^{-4}\,mol^2\,s$	74
183	$k^c_{x\,A}$	`kcA_x`	convective mass conductivity in arc and x diretion	properties	$m^{-1}\,s$	76
191	$\hat{k}^{d,Fick}_{y}{}_{A,S}$	`kdAFick_y`	Fick diffusivity in arc and y-direction	properties	ms^{-1}	84
190	$\hat{k}^{d,Fick}_{x}{}_{A,S}$	`kdAFick_x`	Fick's diffusivity in arc and x-direction	properties	ms^{-1}	83
186	$k^q_{x\,A}$	`kqA_x`	thermal conductivity in arc and x-direction	properties	$kg\,K^{-1}\,s^{-3}$	79
203	$n^o{}_{N,S}$	`no`	initial mass	state	mol	98

Continued on next page

	var	symbol	documentation	type	units	eqs
216	$H^o{}_N$	Ho	initial enthalpy	state	$kg\,m^2\,s^{-2}$	111
115	H_N	H	Enthalpy	state	$kg\,m^2\,s^{-2}$	11 112
117	G_N	G	Gibbs free energy	state	$kg\,m^2\,s^{-2}$	13
116	A_N	A	Helmholtz energy	state	$kg\,m^2\,s^{-2}$	12
161	$\mu^o{}_{N,S}$	chemPotStandard	instantiating standard chemical potential	effort	$kg\,m^2\,mol^{-1}\,s^{-2}$	53
217	$U^e{}_N$	Ue	electrical potential – voltage	effort	$kg\,m^2\,A^{-1}s^{-3}$	113
114	$\mu_{N,S}$	chemPot	chemical potential	effort	$kg\,m^2\,mol^{-1}\,s^{-2}$	10 54
112	p_N	p	thermodynamic pressure	effort	$kg\,m^{-1}\,s^{-2}$	8
113	T_N	T	temperature	effort	K	9 121
125	C_{VN}	CV	total heat capacity at constant volume	secondaryState	$kg\,m^2\,K^{-1}\,s^{-2}$	19
222	$T^{ref}{}_N$	T_ref	reference temperature	secondaryState	K	119
140	$x_{N,S}$	x	mole fraction	secondaryState		33
119	v_{yN}	v_y	velocity in y-direction	secondaryState	ms^{-1}	15
124	C_{pN}	Cp	total heat capacity at constant pressure	secondaryState	$kg\,m^2\,K^{-1}\,s^{-2}$	18 117

	var	symbol	documentation	type	units	eqs
120	v_{zN}	v_z	velocity in z-direction	secondaryState	ms^{-1}	16
136	$h_{N,S}$	h	partial molar enthalpies	secondaryState	$kg\,m^2\,mol^{-1}\,s^{-2}$	29
138	$c_{N,S}$	c	molar concentration	secondaryState	$m^{-3}\,mol$	31
139	n^t_N	nt	total number of moles	secondaryState	mol	32
141	c_{pN}	cp	specific heat capacity at constant pressure	secondaryState	$m^2\,K^{-1}\,s^{-2}$	34 120
142	c_{VN}	cV	specific heat capacity at constant volume	secondaryState	$m^2\,K^{-1}\,s^{-2}$	35
118	v_{xN}	v_x	velocity in x-direction	secondaryState	ms^{-1}	14
202	$\tilde{n}_{N,S}$	np	link variable np to interface macroscopic	conversion	$m^{-3}\,mol\,s^{-1}$	97
215	$\dot{H}_N$	dH	accumulation of enthalpy	diffState	$kg\,m^2\,s^{-3}$	110
220	$\dot{U}^e_A$	dUe	Kirkhoffs first law	diffState	$kg\,m^2\,A^{-1}s^{-3}$	116
196	$\dot{n}_{N,S}$	an	differential mass balance without reaction	diffState	$mol\,s^{-1}$	92
218	I^e_N	current	current definition	internalTransport	A	114
224	$\bar{T}_N$	T_meas	temperature measurement	observation		123
223	T^n_N	T_meas_norming	value to norm measurement of temperature	observation	K	122

5 reactions

	var	symbol	documentation	type	units	eqs
198	$K^o{}_K$	Ko	Arrhenius frequency factor	constant	$m^{-3}\,mol\,s^{-1}$	
197	$E^a{}_K$	Ea	Arrhenius activation energy	constant	$kg\,m^2\,mol^{-1}\,s^{-2}$	
26	$N_{S,K}$	N	stoichiometric matrix	constant		
167	$T_{N,p}$	T	link variable T to interface reactions	effort	K	60
165	$x_{N,S,p}$	x	link variable x to interface reactions	secondaryState		58
163	$c_{N,S,p}$	c	link variable c to interface reactions	secondaryState	$m^{-3}\,mol$	56
199	$K_{N,K,p}$	K	Arrhenius reaction "constant"	conversion	$m^{-3}\,mol\,s^{-1}$	94
200	$\tilde{n}_{N,S,q}$	np	production from reaction set	conversion	$m^{-3}\,mol\,s^{-1}$	95
168	$f_{N,S,K,p}$	factor	factor for probability computation	conversion		61
169	$\xi_{N,K,p}$	probability	probability of reaction to take place	conversion		62

6 control

	var	symbol	documentation	type	units	eqs
237	$p_{N,p,q}$	`p`	controller gain	algebraic		
239	$y^{p+}{}_{N,q}$	`y_p_positive`	positive signal only	algebraic		137
238	$y^{p}{}_{N,q}$	`y_p_control`	output of proportional controller	algebraic		136
227	$T_{setpoint\,N,p}$	`T_setpoint`	setpoint for temperatue	algebraic		126
231	$e_{N,p}$	`control_error`	control error in normed temperature	algebraic		130
226	$\bar{T}_{N,p}$	`T_meas`	link variable T meas to interface control	algebraic		125

7 control–macroscopic

	var	symbol	documentation	type	units	eqs
242	$\_y^{p+}{}_I$	`_y_p_positive`	link variable y p positive to interface control »> macroscopic with source:arc	get		140

8 macroscopic–reactions

	var	symbol	documentation	type	units	eqs
162	$\_c_{I,S}$	`_c`	link variable c to interface macroscopic »> reactions with source:node	get	$m^{-3}\,mol$	55
164	$\_x_{I,S}$	`_x`	link variable x to interface macroscopic »> reactions with source:node	get		57
166	$\_T_I$	`_T`	link variable T to interface macroscopic »> reactions with source:node	get	K	59

9   reactions–macroscopic

	var	symbol	documentation	type	units	eqs
201	$\_np_{I,S}$	`_np`	link variable np to interface reactions »> macroscopic with source:node	get	$m^{-3}\,mol\,s^{-1}$	96

10   macroscopic–control

	var	symbol	documentation	type	units	eqs
225	$\_T\_meas_I$	`_T_meas`	link variable T meas to interface macroscopic »> control with source:node	get		124

11 Equations

12 Generic

no	equation	documentation	layer
1	$0 := \mathbf{Instantiate}(\#, \#)$	numerical value zero	root
2	$1 := \mathbf{Instantiate}(\#, \#)$	numerical value one	root
3	$0.5 := \mathbf{Instantiate}(\#, \#)$	numerical value one half	root
4	$t^o := \mathbf{Instantiate}(t, \#)$	starting time	root
5	$t^e := \mathbf{Instantiate}(t, \#)$	end time	root
6	$\Delta t := \mathbf{Instantiate}(t, \#)$	time interval	root
7	$V_N := r_{xN} \,.\, r_{yN} \,.\, r_{zN}$	volume	physical
8	$p_N := \frac{\partial U_N}{\partial V_N}$	thermodynamic pressure	physical
9	$T_N := \frac{\partial U_N}{\partial S_N}$	temperature	macroscopic
10	$\mu_{N,S} := \frac{\partial U_N}{\partial n_{N,S}}$	chemical potential	macroscopic
11	$H_N := U_N - p_N \,.\, V_N$	Enthalpy	macroscopic
12	$A_N := U_N - T_N \,.\, S_N$	Helmholtz energy	macroscopic
13	$G_N := U_N + p_N \,.\, V_N - T_N \,.\, S_N$	Gibbs free energy	macroscopic
14	$v_{xN} := \frac{\partial r_{xN}}{\partial t}$	velocity in x-direction	macroscopic
15	$v_{yN} := \frac{\partial r_{yN}}{\partial t}$	velocity in y-direction	macroscopic

no	equation	documentation	layer
16	$v_{zN} := \frac{\partial r_{zN}}{\partial t}$	velocity in z-direction	macroscopic
17	$R := N^A \cdot k^B$	gas constant	physical
18	$C_{pN} := \frac{\partial H_N}{\partial T_N}$	total heat capacity at constant pressure	macroscopic
19	$C_{VN} := \frac{\partial U_N}{\partial T_N}$	total heat capacity at constant volume	macroscopic
29	$h_{N,S} := H_N \cdot (n_{N,S})^{-1}$	partial molar enthalpies	macroscopic
30	$m_N := \lambda_S \overset{S}{\star} n_{N,S}$	mass	macroscopic
31	$c_{N,S} := (V_N)^{-1} \cdot n_{N,S}$	molar concentration	macroscopic
32	$n^t{}_N := \mathbf{reduceSum}\,(n_{N,S}, S)$	total number of moles	macroscopic
33	$x_{N,S} := (n^t{}_N)^{-1} \cdot n_{N,S}$	mole fraction	macroscopic
34	$c_{pN} := C_{pN} \cdot (m_N)^{-1}$	specific heat capacity at constant pressure	physical
35	$c_{VN} := C_{VN} \cdot (m_N)^{-1}$	specific heat capacity at constant volume	macroscopic
36	$\rho_N := (V_N)^{-1} \cdot m_N$	density	physical
40	$A_{xyN} := r_{xN} \cdot r_{yN}$	cross sectional area xy	physical
41	$A_{xzN} := r_{xN} \cdot r_{zN}$	cross sectional are xz	physical
42	$A_{yzN} := r_{yN} \cdot r_{zN}$	cross sectional area yz	physical
43	$\hat{q}_{xA} := k^q_{xA} \cdot A_{yzN} \cdot F_{N,A} \overset{N}{\star} T_N$	heat flow in x-direction	macroscopic
44	$\hat{q}_{yA} := k^q_{yA} \cdot A_{xzN} \cdot F_{N,A} \overset{N}{\star} T_N$	heat flow in y-direction	macroscopic

no	equation	documentation	layer
45	$\hat{q}_{zA} := k^q_{zA} \cdot A_{xyN} \cdot F_{N,A} \overset{N}{\star} T_N$	heat flow in z-direction	macroscopic
46	$\hat{n}^d_{xA,S} := \hat{k}^{d,Fick}_{xA,S} \cdot A_{yzN} \cdot F_{N,A} \overset{N}{\star} c_{N,S}$	Fick diffusion flow in x-direction	macroscopic
47	$\hat{n}^d_{yA,S} := \hat{k}^{d,Fick}_{yA,S} \cdot A_{xzN} \cdot F_{N,A} \overset{N}{\star} c_{N,S}$	Fick diffusion flow in y-direction	macroscopic
48	$\hat{n}^d_{zA,S} := \hat{k}^{d,Fick}_{zA,S} \cdot \left(A_{xyN} \cdot F_{N,A} \right) \overset{N}{\star} c_{N,S}$	Fick diffusion flow in z-direction	macroscopic
49	$d_A := \mathbf{sign} \left(F_{N,A} \overset{N}{\star} p_N \right)$	flow direction of convective flow	macroscopic
50	$c_{A,S} := \left(0.5 \cdot \left(F_{N,A} - d_A \cdot |F_{N,A}| \right) \right) \overset{N}{\star} c_{N,S}$	concentration in convective event-dynamic flow	macroscopic
51	$\hat{V}_A := \left(\rho_A \right)^{-1} \cdot k^c_{xA} \cdot A_{yzN} \cdot F_{N,A} \overset{N}{\star} p_N$	volumetric flow in x-direction	macroscopic
52	$\hat{n}^c_{xA,S} := \hat{V}_A \cdot c_{A,S}$	molar convective flow in x-direction	macroscopic
53	$\mu^o_{N,S} := \mathbf{Instantiate}(\mu_{N,S}, \#)$	instantiating standard chemical potential	macroscopic
54	$\mu_{N,S} := \mu^o_{N,S} + R \cdot T_N \cdot \mathbf{ln}\left(x_{N,S} \right)$	chemical potential standard model with mole fraction	macroscopic
61	$f_{N,S,K,p} := x_{N,S,p}{}^{\left(\left(|N_{S,K}| \right) \right)}$	factor for probability computation	reactions
62	$\xi_{N,K,p} := \prod_S f_{N,S,K,p}$	probability of reaction to take place	reactions
73	$k^d_{xA,S} := I_{N,A} \overset{N}{\star} \left(\left(\mu_{N,S} \right)^{-1} \cdot \left(v_{xN} \cdot \left(\left(V_N \right)^{-1} \cdot \frac{\partial U_N}{\partial \mu_{N,S}} \right) \right) \right)$	diffusivity in arc and x-direction	macroscopic
74	$k^d_{yA,S} := I_{N,A} \overset{N}{\star} \left(\left(\mu_{N,S} \right)^{-1} \cdot \left(v_{yN} \cdot \left(\left(V_N \right)^{-1} \cdot \frac{\partial U_N}{\partial \mu_{N,S}} \right) \right) \right)$	diffusivity in arc and y-direction	macroscopic
75	$k^d_{zA,S} := I_{N,A} \overset{N}{\star} \left(\left(\mu_{N,S} \right)^{-1} \cdot \left(v_{zN} \cdot \left(\left(V_N \right)^{-1} \cdot \frac{\partial U_N}{\partial \mu_{N,S}} \right) \right) \right)$	diffusivity in arc and z-direction	macroscopic
76	$k^c_{xA} := I_{N,A} \overset{N}{\star} \left(\left(\lambda_S \overset{S}{\star} \left(\mu_{N,S} \right)^{-1} \right) \cdot \left(V_N \right)^{-1} \cdot \frac{\partial U_N}{\partial p_N} \cdot v_{xN} \right)$	convective mass conductivity in arc and x diretion	macroscopic

no	equation	documentation	layer
77	$k^c_{yA} := I_{N,A} \overset{N}{\star} \left(\left(\lambda_S \overset{S}{\star} (\mu_{N,S})^{-1} \right) . (V_N)^{-1} . \frac{\partial U_N}{\partial p_N} . v_{yN} \right)$	convective mass conductivity in arc and y-direction	macroscopic
78	$k^c_{zA} := I_{N,A} \overset{N}{\star} \left(\left(\lambda_S \overset{S}{\star} (\mu_{N,S})^{-1} \right) . (V_N)^{-1} . \frac{\partial U_N}{\partial p_N} . v_{zN} \right)$	convecive mass conductivity in arc and y-direction	macroscopic
79	$k^q_{xA} := I_{N,A} \overset{N}{\star} \left((V_N)^{-1} . C_{pN} . v_{xN} \right)$	thermal conductivity in arc and x-direction	macroscopic
80	$k^q_{yA} := I_{N,A} \overset{N}{\star} \left((V_N)^{-1} . C_{pN} . v_{yN} \right)$	thermal conductivity in arc and y-direction	macroscopic
81	$k^q_{zA} := I_{N,A} \overset{N}{\star} \left((V_N)^{-1} . C_{pN} . v_{zN} \right)$	thermal conductivity in arc and z-direction	macroscopic
82	$\rho_A := I_{N,A} \overset{N}{\star} \rho_N$	density in arc	macroscopic
83	$\hat{k}^{d,Fick}_{x A,S} := I_{N,A} \overset{N}{\star} \left(v_{xN} . \frac{\partial U_N}{\partial \mu_{N,S}} . (n_{N,S})^{-1} \right)$	Fick's diffusivity in arc and x-direction	macroscopic
84	$\hat{k}^{d,Fick}_{y A,S} := I_{N,A} \overset{N}{\star} \left(v_{yN} . \frac{\partial U_N}{\partial \mu_{N,S}} . (n_{N,S})^{-1} \right)$	Fick diffusivity in arc and y-direction	macroscopic
85	$\hat{k}^{d,Fick}_{z A,S} := I_{N,A} \overset{N}{\star} \left(v_{zN} . \frac{\partial U_N}{\partial \mu_{N,S}} . (n_{N,S})^{-1} \right)$	Fick diffusivity in arc and z-direction	macroscopic
86	$h_{A,S} := I_{N,A} \overset{N}{\star} h_{N,S}$	partial molar enthalpiies in arc	macroscopic
87	$\dot{n}^c_{x N,S} := F_{N,A} \overset{A}{\star} \hat{n}^c_{x A,S}$	accumulation of molar mass due to convection	macroscopic
88	$\dot{n}^d_{x N,S} := F_{N,A} \overset{A}{\star} \hat{n}^d_{x A,S}$	accumulation due to diffusion in x-direction	macroscopic
89	$\hat{n}^d_{x A,S} := k^d_{x A,S} . (A_{yzN} . F_{N,A}) \overset{N}{\star} \mu_{N,S}$	Fick diffusion flow in x-direction	macroscopic
90	$\hat{n}^d_{y A,S} := k^d_{y A,S} . (A_{yzN} . F_{N,A}) \overset{N}{\star} \mu_{N,S}$	Fick diffusion flow in y-direction	macroscopic
91	$\hat{n}^d_{z A,S} := k^d_{z A,S} . (A_{xyN} . F_{N,A}) \overset{N}{\star} \mu_{N,S}$	mass diffusion flow in z-direction	macroscopic

no	equation	documentation	layer
92	$\dot{n}_{N,S} := \dot{n}^c_{x\,N,S} + \dot{n}^d_{x\,N,S} + V_N \cdot \tilde{n}_{N,S}$	differential mass balance without reaction	macroscopic
93	$n_{N,S} := \int_{t^o}^{t^e} \dot{n}_{N,S} \; dt + n^o{}_{N,S}$	fundamental state – molar mass	macroscopic
94	$K_{N,K,p} := K^o{}_K \cdot \mathbf{exp}\left((-E^a{}_K) \cdot (R \cdot T_{N,p})^{-1} \right)$	Arrhenius reaction "constant"	reactions
95	$\tilde{n}_{N,S,q} := A_{N,p,q} \overset{p}{\star} \left(N_{S,K} \overset{K}{\star} (K_{N,K,p} \cdot \xi_{N,K,p}) \right)$	production from reaction set	reactions
98	$n^o{}_{N,S} := \mathbf{Instantiate}(n_{N,S}, \#)$	initial mass	macroscopic
99	$\dot{H}^c_{x\,N} := F_{N,A} \overset{A}{\star} \left(\hat{n}^c_{x\,A,S} \overset{S}{\star} h_{N,S} \right)$	enthalpy accumulation due to convective flow in x-direction	macroscopic
100	$\dot{H}^d_{x\,N} := F_{N,A} \overset{A}{\star} \left(\hat{n}^d_{x\,A,S} \overset{S}{\star} h_{N,S} \right)$	accumulation of enthalpy due to diffusional mass flow in x-direction	macroscopic
101	$\dot{H}^d_{y\,N} := F_{N,A} \overset{A}{\star} \left(\hat{n}^d_{y\,A,S} \overset{S}{\star} h_{N,S} \right)$	accumulation of enthalpy due to diffusional mass flow in y-direction	macroscopic
102	$\dot{H}^d_{z\,N} := F_{N,A} \overset{A}{\star} \left(\hat{n}^d_{z\,A,S} \overset{S}{\star} h_{N,S} \right)$	accumulation of enthalpy due to diffusional mass flow in z-direction	macroscopic
103	$\dot{q}_{x\,N} := F_{N,A} \overset{A}{\star} \hat{q}_{x\,A}$	accumulation due to heat flow in x-direction	macroscopic
104	$\dot{q}_{y\,N} := F_{N,A} \overset{A}{\star} \hat{q}_{y\,A}$	accumulation due to heat flow in y-direction	macroscopic
105	$\dot{q}_{z\,N} := F_{N,A} \overset{A}{\star} \hat{q}_{z\,A}$	accumulation due to heat flow in z-direction	macroscopic
106	$\hat{w}_A := \mathbf{Instantiate}(\hat{q}_{x\,A}, \#)$	a fixed work flow to start with	macroscopic
107	$\dot{n}^d_{y\,N,S} := F_{N,A} \overset{A}{\star} \hat{n}^d_{y\,A,S}$	accumulation due to diffusion in y-direction	macroscopic

no	equation	documentation	layer
108	$\dot{n}^d_{zN,S} := F_{N,A} \overset{A}{\star} \hat{n}^d_{zA,S}$	accumulation due to diffusion in z-direction	macroscopic
109	$\dot{w}_N := F_{N,A} \overset{A}{\star} \hat{w}_A$	accumulation of enthalpy due to work flow	macroscopic
110	$\dot{H}_N := \dot{H}^c_{xN} + \dot{H}^d_{xN} + \dot{H}^d_{yN} + \dot{H}^d_{zN} + \dot{q}_{xN} + \dot{q}_{yN} + \dot{q}_{zN} + \dot{w}_N$	accumulation of enthalpy	macroscopic
111	$H^o_N := \textbf{Instantiate}(H_N, \#)$	initial enthalpy	macroscopic
112	$H_N := \int_{t^o}^{t^e} \dot{H}_N \, dt + H^o_N$	Enthalpy	macroscopic
113	$U^e_N := (C_N)^{-1} . U_N$	electrical potential – voltage	macroscopic
114	$I^e_N := \frac{d\,C_N}{d\,t}$	current definition	macroscopic
115	$R^e_N := (I^e_N)^{-1} . U^e_N$	electrical resistant	macroscopic
116	$\dot{U}^e_A := F_{N,A} \overset{A}{\star} (R^e_N . I^e_N)$	Kirkhoffs first law	macroscopic
117	$C_{pN} := m_N . c_{pN}$	total heat capacity at constant pressure	macroscopic
119	$T^{ref}_N := \textbf{Instantiate}(T_N, \#)$	reference temperature	macroscopic
120	$c_{pN} := \textbf{Instantiate}(c_{pN}, \#)$	constant specific heat capacity at constant pressure	macroscopic
121	$T_N := H_N . (C_{pN})^{-1} + T^{ref}_N$	temperature from constant heat capacity	macroscopic
122	$T^n_N := \textbf{Instantiate}(T_N, \#)$	value to norm measurement of temperature	macroscopic
123	$\bar{T}_N := T_N . (T^n_N)^{-1}$	temperature measurement	macroscopic
126	$T_{setpoint\,N,p} := \textbf{Instantiate}(\bar{T}_{N,p}, \#)$	setpoint for temperatue	control

no	equation	documentation	layer
130	$e_{N,p} := T_{setpoint\,N,p} - \bar{T}_{N,p}$	control error in normed temperature	control
133	$\hat{m}_{N,A} := \hat{V}_A \cdot \rho_N$	convective mass flow	macroscopic
136	$y^p{}_{N,q} := (-p_{N,p,q}) \overset{p}{\star} e_{N,p}$	output of proportional controller	control
137	$y^{p+}{}_{N,q} := \mathbf{max}\left(0 \cdot y^p{}_{N,q}, y^p{}_{N,q}\right)$	positive signal only	control
142	$\hat{V}_A := y^{p+}{}_A \cdot (\rho_A)^{-1} \cdot k^c_{x\,A} \cdot A_{yz\,N} \cdot F_{N,A} \overset{N}{\star} p_N$	controlled volumetric flow in x-direction	macroscopic

13 Interface Link Equation

no	equation	documentation	layer
55	$\_c_{I,S} := F^{source}{}_{N,I} \overset{N}{\star} c_{N,S}$	interface equation	macroscopic $->$ reactions
56	$c_{N,S,p} := \left(F^{sink}{}_{N,I} \cdot \_c_{I,S}\right) \overset{I}{\star} S_{I,p}$	interface equation	reactions
57	$\_x_{I,S} := F^{source}{}_{N,I} \overset{N}{\star} x_{N,S}$	interface equation	macroscopic $->$ reactions
58	$x_{N,S,p} := \left(F^{sink}{}_{N,I} \cdot \_x_{I,S}\right) \overset{I}{\star} S_{I,p}$	interface equation	reactions
59	$\_T_I := F^{source}{}_{N,I} \overset{N}{\star} T_N$	interface equation	macroscopic $->$ reactions
60	$T_{N,p} := \left(F^{sink}{}_{N,I} \cdot \_T_I\right) \overset{I}{\star} S_{I,p}$	interface equation	reactions
96	$\_np_{I,S} := \textbf{reduceSum}\left(\left(\left(F^{source}{}_{N,I} \overset{N}{\star} \tilde{n}_{N,S,q}\right) \cdot S_{I,q}\right), q\right)$	interface equation	reactions $->$ macroscopic
97	$\tilde{n}_{N,S} := F^{source}{}_{N,I} \overset{I}{\star} \_np_{I,S}$	interface equation	macroscopic
124	$\_T\_meas_I := F^{source}{}_{N,I} \overset{N}{\star} \bar{T}_N$	interface equation	macroscopic $->$ control
125	$\bar{T}_{N,p} := \left(F^{sink}{}_{N,I} \cdot \_T\_meas_I\right) \overset{I}{\star} S_{I,p}$	interface equation	control
140	$\_y^{p+}{}_I := \textbf{reduceSum}\left(\left(\left(F^{source}{}_{N,I} \overset{N}{\star} y^{p+}{}_{N,q}\right) \cdot S_{I,q}\right), q\right)$	interface equation	control $->$ macroscopic
141	$y^{p+}{}_A := F^{source}{}_{A,I} \overset{I}{\star} \_y^{p+}{}_I$	interface equation	macroscopic