Variables & Equations

ProMo

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Contents

1 Variables

2 root

	var	symbol	documentation	type	units	eqs
5	$F^{source}{}_{A,I}$	`F_AI_source`	incidence matrix AI source	network		
12	$S_{A,p}$	`S_Ap`	selection matrix interface species-related measures	network		
11	$I_{t,u}$	`I_tu`	identity mapping from <t> to <u>	network		
20	$A_{N,t,u}$	`A_Ntu`	mapping from input elements to outputs	network		
27	$I_{N,A}$	`I_NA`	identity mapping from <N> to <A>	network		
10	$S_{I,q}$	`S_Iq`	selection matrix interface to control output	network		
2	$F_{N,A}$	`F`	incidence matrix	network		
4	$F^{sink}{}_{N,I}$	`F_NI_sink`	incidence matrix NI sink	network		
8	$F^{sink}{}_{N,A}$	`F_NA_sink`	incidence matrix NA sink	network		
9	$S_{I,p}$	`S_Ip`	selection matrix interface to control input	network		
16	mv_I	`mv_I`	interface variable macro –> control	network		
19	$A_{N,p,q}$	`A_Npq`	mapping from inputs to outputs	network		
21	$u_{N,t,u}$	`u_Ntu`	input signal in control domain	network		
15	$S_{N,q,t}$	`S_Nqt`	selection matrix or splitter	network		
3	$F^{source}{}_{N,I}$	`F_NI_source`	incidence matrix NI source	network		
13	$S_{I,q}$	`S_Aq`	selection matrix arcs to outputs	network		
22	$y_{N,t,u}$	`y_Ntu`	output signal in control domain	network		
6	$F^{sink}{}_{A,I}$	`F_AI_sink`	incidence matrix AI sink	network		
7	$F^{source}{}_{N,A}$	`F_NA_source`	incidence matrix NA source	network		
18	cz_I	`cz_I`	interface variable macro –> control	network		
17	cz_N	`cz_N`	output from control	network		

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	var	symbol	documentation	type	units	eqs
14	$S_{N,p,q}$	`S_Npu`	selection matrix for stacker	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
102	0	`zero`	numerical value zero	constant		1
101	$\#$	`value`	numerical value	constant		
103	1	`one`	numerical value one	constant		2
104	0.5	`oneHalf`	numerical value one half	constant		3

3 physical

	var	symbol	documentation	type	units	eqs
24	$r_{y\,N}$	`r_y`	y-coordinate	frame	m	
23	$r_{x\,N}$	`r_x`	x-coordinate	frame	m	
25	$r_{z\,N}$	`r_z`	z-coordinate	frame	m	
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	$kg\,m^2\,s^{-2}$	
110	V_N	`V`	volume	state	m^3	7
144	C_N	`C`	fundamental state – charge	state	$A\,s$	
137	m_N	`m`	mass	state	kg	30
121	N^A	`Avo`	Avogadro constant	constant	mol^{-1}	
122	k^B	`Boltz`	Boltzmann constant	constant	$kg\,m^2\,K^{-1}\,s^{-2}$	
123	R	`R`	gas constant	constant	$kg\,m^2\,mol^{-1}\,K^{-1}\,s^{-2}$	17
132	λ_S	`Mm`	molecular masses	constant	$kg\,mol^{-1}$	
149	$A_{xz\,N}$	`Axz`	cross sectional are xz	secondaryState	m^2	41
148	$A_{xy\,N}$	`Axy`	cross sectional area xy	secondaryState	m^2	40
150	$A_{yz\,N}$	`Ayz`	cross sectional area yz	secondaryState	m^2	42
143	ρ_N	`rho`	density	secondaryState	$kg\,m^{-3}$	36

4 macroscopic

	var	symbol	documentation	type	units	eqs
157	d_A	`d`	flow direction of convective flow	transport		49
159	$\hat{V}_A$	`fV`	volumetric flow in x-direction	transport	$m^3\, s^{-1}$	51 142
212	$\dot{n}^d_{y\,N,S}$	`and_y`	accumulation due to diffusion in y-direction	transport	$mol\, s^{-1}$	107
194	$\dot{n}^c_{x\,N,S}$	`anc_x`	accumulation of molar mass due to convection	transport	$mol\, s^{-1}$	87
213	$\dot{n}^d_{z\,N,S}$	`and_z`	accumulation due to diffusion in z-direction	transport	$mol\, s^{-1}$	108
234	$\hat{m}_{N,A}$	`fm`	convective mass flow	transport	$kg\, s^{-1}$	133
207	$\dot{H}^d_{z\,N}$	`aHnd_z`	accumulation of enthalpy due to diffusional mass flow in z-direction	transport	$kg\, m^2\, s^{-3}$	102
154	$\hat{n}^d_{x\,A,S}$	`fnd_x`	diffusion flow in x-direction	transport	$mol\, s^{-1}$	46 89
152	$\hat{q}_{y\,A}$	`fq_y`	heat flow in y-direction	transport	$kg\, m^2\, s^{-3}$	44
208	$\dot{q}_{x\,N}$	`aq_x`	accumulation due to heat flow in x-direction	transport	$kg\, m^2\, s^{-3}$	103
205	$\dot{H}^d_{x\,N}$	`aHnd_x`	accumulation of enthalpy due to diffusional mass flow in x-direction	transport	$kg\, m^2\, s^{-3}$	100
158	$c_{A,S}$	`c_AS`	concentration in convective event-dynamic flow	transport	$m^{-3}\, mol$	50
156	$\hat{n}^d_{z\,A,S}$	`fnd_z`	diffusion flow in z-direction	transport	$mol\, s^{-1}$	48 91
204	$\dot{H}^c_{x\,N}$	`aHnc_x`	accumulation of enthalpy due to convective mass flow in x-direction	transport	$kg\, m^2\, s^{-3}$	99
160	$\hat{n}^c_{x\,A,S}$	`fnc_x`	molar convective flow in x-direction	transport	$mol\, s^{-1}$	52
209	$\dot{q}_{y\,N}$	`aq_y`	accumulation due to heat flow in y-direction	transport	$kg\, m^2\, s^{-3}$	104
243	$y^{p+}{}_A$	`y_p_positive`	link variable y p positive to interface macroscopic	transport		141
210	$\dot{q}_{z\,N}$	`aq_z`	accumulation due to heat flow in z-direction	transport	$kg\, m^2\, s^{-3}$	105
195	$\dot{n}^d_{x\,N,S}$	`and_x`	accumulation due to diffusion in x-direction	transport	$mol\, s^{-1}$	88
155	$\hat{n}^d_{y\,A,S}$	`fnd_y`	diffusion flow in y-direction	transport	$mol\, s^{-1}$	47 90

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	var	symbol	documentation	type	units	eqs
206	$\dot{H}^{d}_{y}{}_{N}$	aHnd_y	accumulation of enthalpy due to diffusional mass flow in y-direction	transport	$kg\, m^2\, s^{-3}$	101
153	$\hat{q}_{z}{}_{A}$	fq_z	heat flow in z-direction	transport	$kg\, m^2\, s^{-3}$	45
151	$\hat{q}_{x}{}_{A}$	fq_x	heat flow in x-direction	transport	$kg\, m^2\, s^{-3}$	43
211	$\hat{w}_{A}$	fw	a fixed work flow to start with	transport	$kg\, m^2\, s^{-3}$	106
214	$\dot{w}_{N}$	aw	accumulation of enthalpy due to work flow	transport	$kg\, m^2\, s^{-3}$	109
187	$k^{q}_{y}{}_{A}$	kqA_y	thermal conductivity in arc and y-direction	properties	$kg\, K^{-1}\, s^{-3}$	80
182	$k^{d}_{z}{}_{A,S}$	kdA_z	diffusivity in arc and z-direction	properties	$kg^{-1}\, m^{-4}\, mol^2\, s$	75
184	$k^{c}_{y}{}_{A}$	kcA_y	convective mass conductivity in arc and y-direction	properties	$m^{-1}\, s$	77
193	$h_{A,S}$	hA	partial molar enthalpiies in arc	properties	$kg\, m^2\, mol^{-1}\, s^{-2}$	86
190	$\hat{k}^{d,Fick}_{x}{}_{A,S}$	kdAFick_x	Fick's diffusivity in arc and x-direction	properties	ms^{-1}	83
181	$k^{d}_{y}{}_{A,S}$	kdA_y	diffusivity in arc and y-direction	properties	$kg^{-1}\, m^{-4}\, mol^2\, s$	74
186	$k^{q}_{x}{}_{A}$	kqA_x	thermal conductivity in arc and x-direction	properties	$kg\, K^{-1}\, s^{-3}$	79
183	$k^{c}_{x}{}_{A}$	kcA_x	convective mass conductivity in arc and x diretion	properties	$m^{-1}\, s$	76
192	$\hat{k}^{d,Fick}_{z}{}_{A,S}$	kdAFick_z	Fick diffusivity in arc and z-direction	properties	ms^{-1}	85
188	$k^{q}_{z}{}_{A}$	kqA_z	thermal conductivity in arc and z-direction	properties	$kg\, K^{-1}\, s^{-3}$	81
219	$R^{e}{}_{N}$	elResistant	electrical resistant	properties	$kg\, m^2\, A^{-2} s^{-3}$	115
185	$k^{c}_{z}{}_{A}$	kcA_z	convecive mass conductivity in arc and y-direction	properties	$m^{-1}\, s$	78
189	ρ_{A}	rhoA	density in arc	properties	$kg\, m^{-3}$	82
180	$k^{d}_{x}{}_{A,S}$	kdA_x	diffusivity in arc and x-direction	properties	$kg^{-1}\, m^{-4}\, mol^2\, s$	73
191	$\hat{k}^{d,Fick}_{y}{}_{A,S}$	kdAFick_y	Fick diffusivity in arc and y-direction	properties	ms^{-1}	84
216	$H^{o}{}_{N}$	Ho	initial enthalpy	state	$kg\, m^2\, s^{-2}$	111
203	$n^{o}{}_{N,S}$	no	initial mass	state	mol	98
116	A_{N}	A	Helmholtz energy	state	$kg\, m^2\, s^{-2}$	12
117	G_{N}	G	Gibbs free energy	state	$kg\, m^2\, s^{-2}$	13

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	var	symbol	documentation	type	units	eqs
115	H_N	`H`	Enthalpy	state	$kg\, m^2\, s^{-2}$	11 112
114	$\mu_{N,S}$	`chemPot`	chemical potential	effort	$kg\, m^2\, mol^{-1}\, s^{-2}$	10 54
113	T_N	`T`	temperature	effort	K	9 121
161	${\mu^o}_{N,S}$	`chemPotStandard`	instantiating standard chemical potential	effort	$kg\, m^2\, mol^{-1}\, s^{-2}$	53
112	p_N	`p`	thermodynamic pressure	effort	$kg\, m^{-1}\, s^{-2}$	8
217	${U^e}_N$	`Ue`	electrical potential – voltage	effort	$kg\, m^2\, A^{-1} s^{-3}$	113
119	${v_y}_N$	`v_y`	velocity in y-direction	secondaryState	ms^{-1}	15
142	${c_V}_N$	`cV`	specific heat capacity at constant volume	secondaryState	$m^2\, K^{-1}\, s^{-2}$	35
139	${n^t}_N$	`nt`	total number of moles	secondaryState	mol	32
140	$x_{N,S}$	`x`	mole fraction	secondaryState		33
136	$h_{N,S}$	`h`	partial molar enthalpies	secondaryState	$kg\, m^2\, mol^{-1}\, s^{-2}$	29
118	${v_x}_N$	`v_x`	velocity in x-direction	secondaryState	ms^{-1}	14
222	${T^{ref}}_N$	`T_ref`	reference temperature	secondaryState	K	119
124	${C_p}_N$	`Cp`	total heat capacity at constant pressure	secondaryState	$kg\, m^2\, K^{-1}\, s^{-2}$	18 117
141	${c_p}_N$	`cp`	specific heat capacity at constant pressure	secondaryState	$m^2\, K^{-1}\, s^{-2}$	34 120
138	$c_{N,S}$	`c`	molar concentration	secondaryState	$m^{-3}\, mol$	31
125	${C_V}_N$	`CV`	total heat capacity at constant volume	secondaryState	$kg\, m^2\, K^{-1}\, s^{-2}$	19
120	${v_z}_N$	`v_z`	velocity in z-direction	secondaryState	ms^{-1}	16
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
196	$\dot{n}_{N,S}$	`an`	differential mass balance without reaction	diffState	$mol\, s^{-1}$	92
220	${\dot{U}^e}_A$	`dUe`	Kirkhoffs first law	diffState	$kg\, m^2\, A^{-1} s^{-3}$	116
218	${I^e}_N$	`current`	current definition	internalTransport	A	114

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	var	symbol	documentation	type	units	eqs
223	${T^n}_N$	T_meas_norming	value to norm measurement of temperature	observation	K	122
224	$\bar{T}_N$	T_meas	temperature measurement	observation		123

5 reactions

	var	symbol	documentation	type	units	eqs
197	${E^a}_K$	`Ea`	Arrhenius activation energy	constant	$kg\, m^2\, mol^{-1}\, s^{-2}$	
26	$N_{S,K}$	`N`	stoichiometric matrix	constant		
198	${K^o}_K$	`Ko`	Arrhenius frequency factor	constant	$m^{-3}\, mol\, s^{-1}$	
167	$T_{N,p}$	`T`	link variable T to interface reactions	effort	K	60
163	$c_{N,S,p}$	`c`	link variable c to interface reactions	secondaryState	$m^{-3}\, mol$	56
165	$x_{N,S,p}$	`x`	link variable x to interface reactions	secondaryState		58
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
199	$K_{N,K,p}$	`K`	Arrhenius reaction "constant"	conversion	$m^{-3}\, mol\, s^{-1}$	94

6 control

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

7 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

8 macroscopic–reactions

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

9 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

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	$0 := \textbf{Instantiate}(\#, \#)$	numerical value zero	root
2	$1 := \textbf{Instantiate}(\#, \#)$	numerical value one	root
3	$0.5 := \textbf{Instantiate}(\#, \#)$	numerical value one half	root
4	$t^o := \textbf{Instantiate}(t, \#)$	starting time	root
5	$t^e := \textbf{Instantiate}(t, \#)$	end time	root
6	$\Delta t := \textbf{Instantiate}(t, \#)$	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

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

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

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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	$\dot{n}^c_{xN,S} := F_{N,A} \overset{A}{\star} \hat{n}^c_{xA,S}$	accumulation of molar mass due to convection	macroscopic
88	$\dot{n}^d_{xN,S} := F_{N,A} \overset{A}{\star} \hat{n}^d_{xA,S}$	accumulation due to diffusion in x-direction	macroscopic
89	$\hat{n}^d_{xA,S} := k^d_{xA,S} . (A_{yzN} . F_{N,A}) \overset{N}{\star} \mu_{N,S}$	Fick diffusion flow in x-direction	macroscopic
90	$\hat{n}^d_{yA,S} := k^d_{yA,S} . (A_{yzN} . F_{N,A}) \overset{N}{\star} \mu_{N,S}$	Fick diffusion flow in y-direction	macroscopic
91	$\hat{n}^d_{zA,S} := k^d_{zA,S} . (A_{xyN} . F_{N,A}) \overset{N}{\star} \mu_{N,S}$	mass diffusion flow in z-direction	macroscopic

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no	equation	documentation	layer
92	$\dot{n}_{N,S} := \dot{n}^c_{x N,S} + \dot{n}^d_{x N,S} + V_N \,.\, \tilde{n}_{N,S}$	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	$K_{N,K,p} := K^o{}_K \,.\, \mathbf{exp}\left((-E^a{}_K) \,.\, (R \,.\, T_{N,p})^{-1} \right)$	Arrhenius reaction "constant"	reactions
95	$\tilde{n}_{N,S,q} := A_{N,p,q} \overset{p}{\star} \left(N_{S,K} \overset{K}{\star} (K_{N,K,p} \,.\, \xi_{N,K,p}) \right)$	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

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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	${H^o}_N := \mathbf{Instantiate}(H_N, \#)$	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	${T^{ref}}_N := \mathbf{Instantiate}(T_N, \#)$	reference temperature	macroscopic
120	$c_{pN} := \mathbf{Instantiate}(c_{pN}, \#)$	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	${T^n}_N := \mathbf{Instantiate}(T_N, \#)$	value to norm measurement of temperature	macroscopic
123	$\bar{T}_N := T_N \, . \, ({T^n}_N)^{-1}$	temperature measurement	macroscopic
126	$T_{setpoint\,N,p} := \mathbf{Instantiate}(\bar{T}_{N,p}, \#)$	setpoint for temperatue	control

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130	$e_{N,p} := T_{setpoint\,N,p} - \bar{T}_{N,p}$	control error in normed temperature	control
133	$\hat{m}_{N,A} := \hat{V}_A \,.\, \rho_N$	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	$y^{p+}{}_{N,q} := \mathbf{max}\,(0 \,.\, y^p{}_{N,q}, y^p{}_{N,q})$	positive signal only	control
142	$\hat{V}_A := y^{p+}{}_A \,.\, (\rho_A)^{-1} \,.\, k^c_{x\,A} \,.\, A_{yz\,N} \,.\, F_{N,A} \overset{N}{\star} p_N$	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