

Examples of Atmospheric Convection Calculation from Chemical Engineering Program PROII

by: Simulation Science

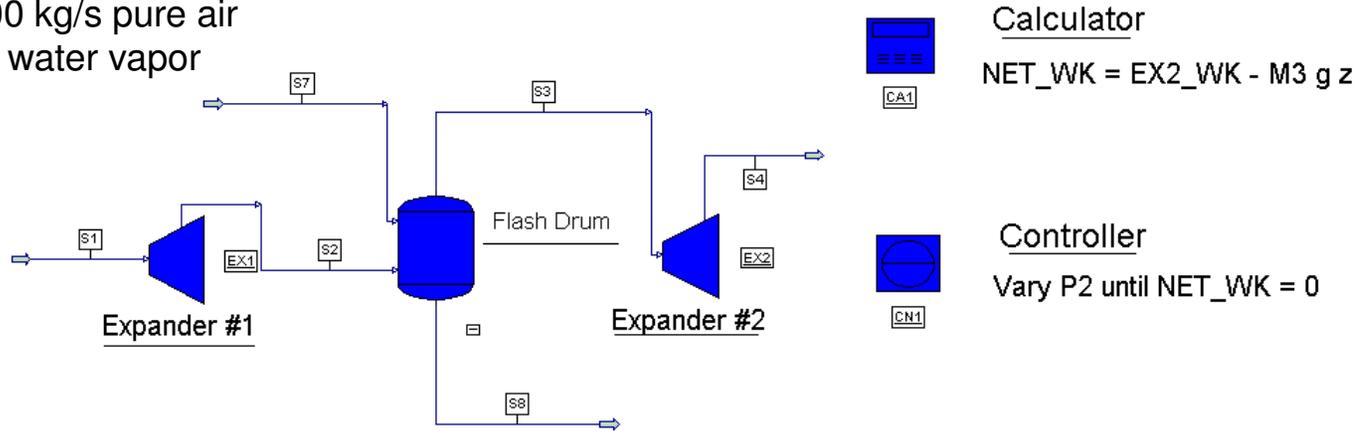
Notes:

- PROII has a built-in libraries of thermodynamic properties and of drag and drop Units of Operation (UOP's).
- The datum for entropy and enthalpy are different from those used in atmospheric science. Entropy and enthalpy values are different from the usual values.
- There is no ice phase – the condensate does not freeze.
- The selected thermodynamic system SIMSCI-SRK is not optimized for the atmospheric process conditions.
- The examples are based on a unit mass air flow of 1000 kg/s of pure air.
- Air mass flow beyond 1000 kg/s is the water content of the air irrespective of its phase.
- The water content of the air in State #1 is 16.87 kg/s corresponding to a relative humidity of 80%.
- Isentropic expansion processes are represented by UOP's Expander #1 and #2.
- Isenthalpic mixing process is represented by the Flash Drum UOP – The air leaving the flash drum is saturated (100% relative humidity).
- The potential energy of the raised air is calculated in the Calculator UOP. The height of the upper level is based on the Jordan Caribbean mean hurricane sounding. A lookup table is used to determine height based on P4.
- The Controller UOP finds the value of P2 required to make the net work in process 3-4 zero.
- The following input parameter (shown in red boxes) are varied: T1, T7, M7, P4.
- New results are calculated by clicking the black arrow on the upper tool bar and are automatically displayed in the stream property table.
- The key results (shown in blue boxes) are Expander #1 outlet pressure P2 and Expander #1 duty or work.
- Expander #1 work shown below the Table was calculated from H1 – H2.
- The simulation used an expander efficiency of 100% but this efficiency can be changed.

Base case

Air temperature T1 25.8 °C

Air flow M1 1000 kg/s pure air
plus 16.87 kg/s water vapor



Stream Name		S1	S2	S3	S4	S7	S8
Stream Description							
Phase		Vapor	Vapor	Vapor	Mixed	Liquid	Liquid
Pressure	KPA	101.10	98.81	98.81	10.00	105.00	98.81
Temperature	C	25.80	23.86	24.54	-80.34	26.50	24.54
Total Sp. Enthalpy	KJ/KG	34.31	32.33	41.09	-121.30	93.99	85.23
Total Sp. Entropy	KJ/KG-C	6.47	6.47	6.49	6.49	5.01	4.98
Total Mass Rate	KG/SEC	1016.87	1016.87	1020.16	1020.16	1000.00	996.71
Total Enthalpy	M*WATT	34.89	32.88	41.92	-123.74	93.99	84.95

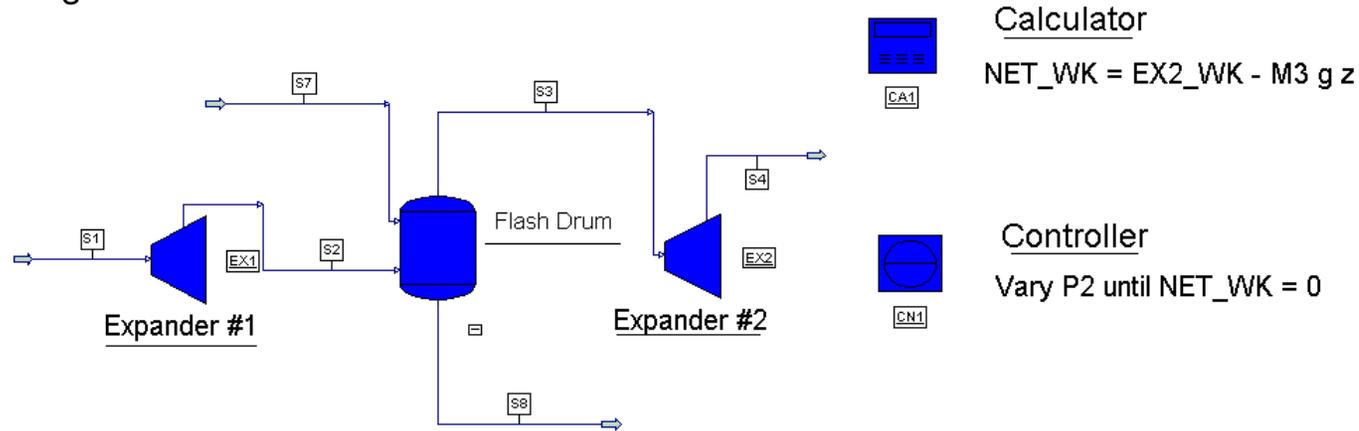
Expander #1 Duty (H1 - H2) = 2.01 MW

Expander #2 Duty (H3 - H4) = Lifting Duty (M3 gz) = 165.66 MW

Heat Duty (H7 - H8) = 9.04 MW

Exhausting Height 16570 m

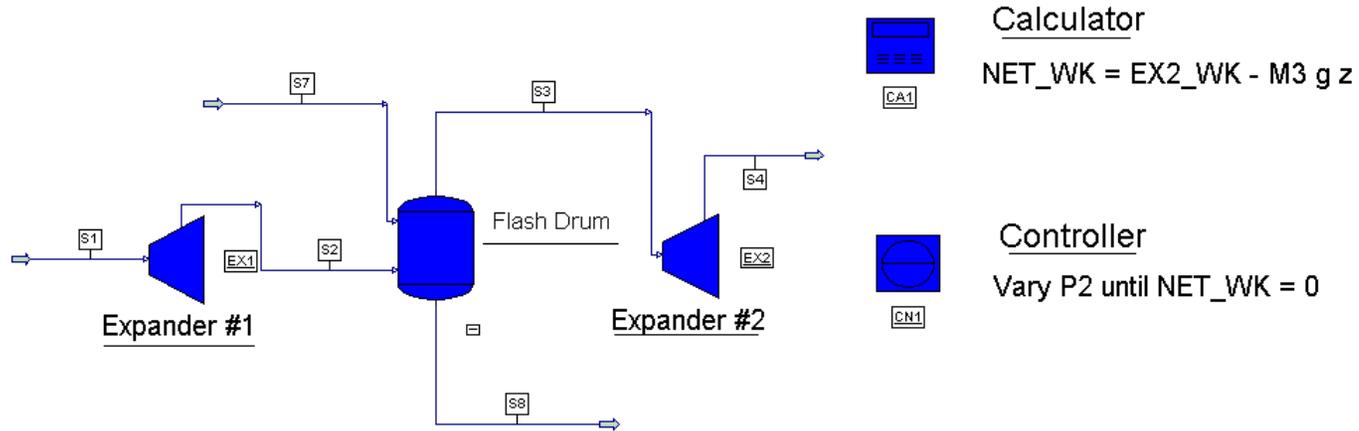
Water temperature T7 27.5 °C.
 Water flow 1000 kg/s



Stream Name		S1	S2	S3	S4	S7	S8
Stream Description							
Phase		Vapor	Vapor	Vapor	Mixed	Liquid	Liquid
Pressure	KPA	101.10	97.69	97.69	10.00	105.00	97.69
Temperature	C	25.80	22.90	24.87	-78.39	27.50	24.87
Total Sp. Enthalpy	KJ/KG	34.31	31.36	43.05	-119.33	98.44	86.73
Total Sp. Entropy	KJ/KG-C	6.47	6.47	6.50	6.50	5.03	4.99
Total Mass Rate	KG/SEC	1016.87	1016.87	1020.82	1020.82	1000.00	996.05
Total Enthalpy	M*WATT	34.89	31.89	43.95	-121.82	98.44	86.38

Expander #1 Duty (H1 - H2) = 3.00 MW
 Expander #2 Duty (H3 - H4) = Lifting Duty (M3 gz) = 165.77 MW
 Heat Duty (H7 - H8) = 12.06 MW
 Exhausting Height 16570 m

Water temperature T7 26.5 °C
 Water flow M7 2000 kg/s



Stream Name		S1	S2	S3	S4	S7	S8
Stream Description							
Phase		Vapor	Vapor	Vapor	Mixed	Liquid	Liquid
Pressure	KPA	101.10	97.18	97.18	10.00	105.00	97.18
Temperature	C	25.80	22.46	25.03	-77.45	26.50	25.03
Total Sp. Enthalpy	KJ/KG	34.31	30.91	43.99	-118.39	93.99	87.43
Total Sp. Entropy	KJ/KG-C	6.47	6.47	6.50	6.50	5.01	4.99
Total Mass Rate	KG/SEC	1016.87	1016.87	1021.14	1021.14	2000.00	1995.73
Total Enthalpy	M*WATT	34.89	31.43	44.92	-120.90	187.99	174.49

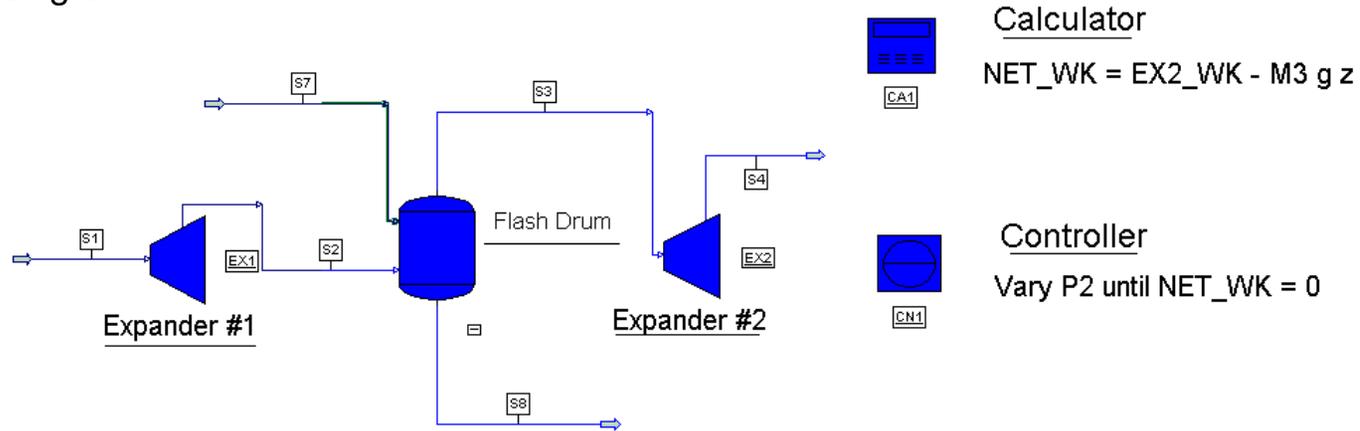
Expander #1 Duty (H1 - H2) = 3.46 MW

Expander #2 Duty (H3 - H4) = Lifting Duty (M3 g z) = 165.82 MW

Heat Duty (H7 - H8) = 13.5 MW

Exhausting Height 16570 m

Air temperature T1 28.5 °C
 Water flow M7 0 kg/s



Stream Name		S1	S2	S3	S4	S7	S8
Stream Description							
Phase		Vapor	Vapor	Vapor	Mixed	Liquid	Unknown
Pressure	KPA	101.10	101.00	101.00	10.00	105.00	n/a
Temperature	C	28.50	28.42	28.41	-85.06	26.50	n/a
Total Sp. Enthalpy	KJ/KG	37.08	36.99	36.99	-125.39	93.99	n/a
Total Sp. Entropy	KJ/KG-C	6.48	6.48	6.48	6.48	5.01	n/a
Total Mass Rate	KG/SEC	1016.87	1016.87	1016.87	1016.87	0.00	n/a
Total Enthalpy	M*WATT	37.70	37.62	37.62	-127.51	0.00	n/a

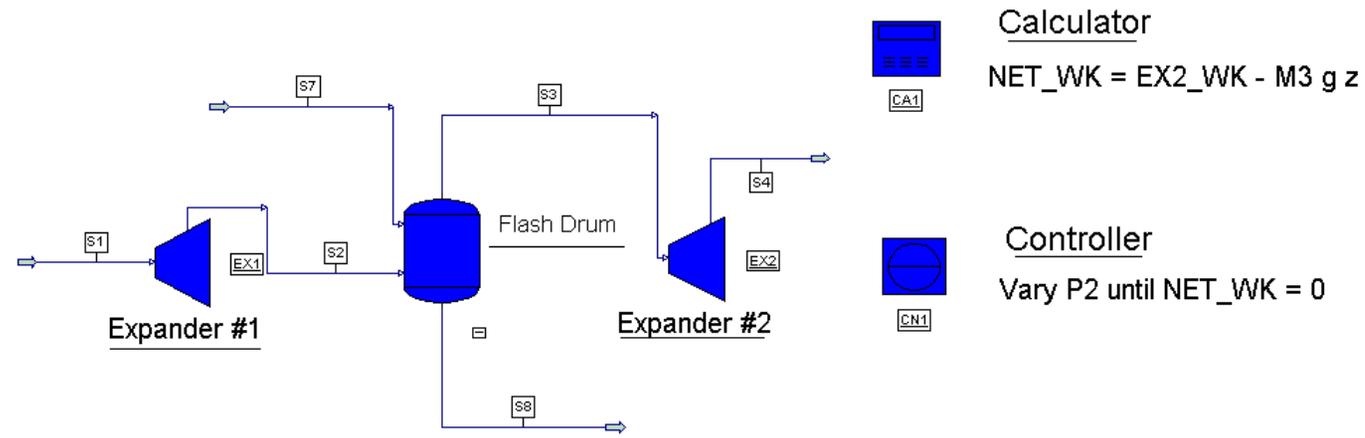
Expander #1 Duty (H1 - H2) = 0.08 MW

Expander #2 Duty (H3 - H4) = Lifting Duty (M3 gz) = 165.13 MW

Heat Duty (H7 - H8) = 0 MW

Exhausting Height 16570 m

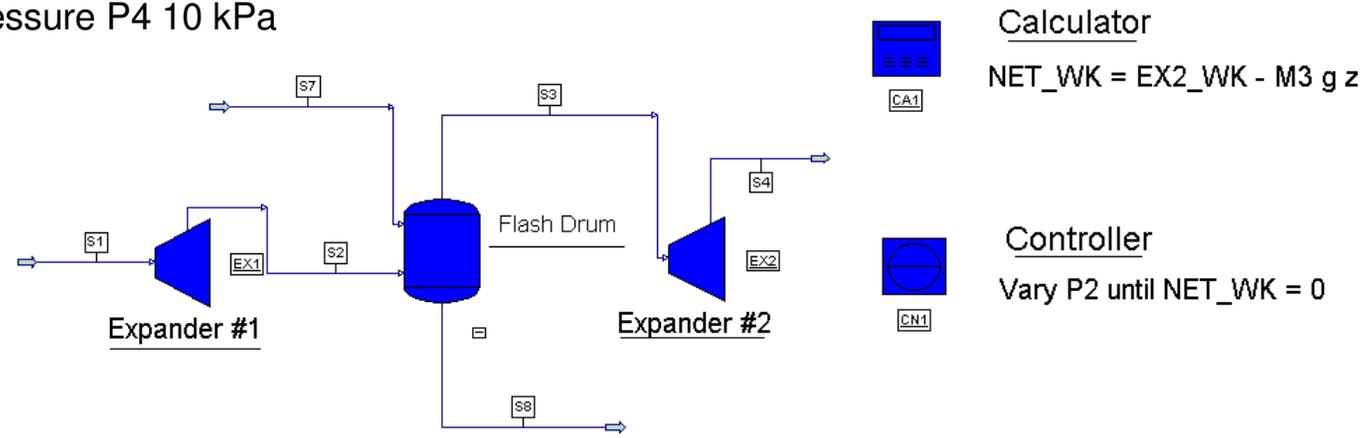
Air Temperature T1 34 °C
 Water flow M7 0 kg/s



Stream Name		S1	S2	S3	S4	S7	S8
Stream Description							
Phase		Vapor	Vapor	Vapor	Mixed	Liquid	Unknown
Pressure	KPA	101.10	98.62	98.62	10.00	105.00	n/a
Temperature	C	34.00	31.84	31.84	-81.87	26.50	n/a
Total Sp. Enthalpy	KJ/KG	42.71	40.50	40.50	-121.88	93.99	n/a
Total Sp. Entropy	KJ/KG-C	6.49	6.49	6.49	6.49	5.01	n/a
Total Mass Rate	KG/SEC	1016.87	1016.87	1016.87	1016.87	0.00	n/a
Total Enthalpy	M*WATT	43.43	41.18	41.18	-123.94	0.00	n/a

Expander #1 Duty (H1 - H2) = 2.25 MW
 Expander #2 Duty (H3 - H4) = Lifting Duty (M3 gz) = 165.12 MW
 Heat Duty (H7 - H8) = 0 MW
 Exhausting Height 16570 m

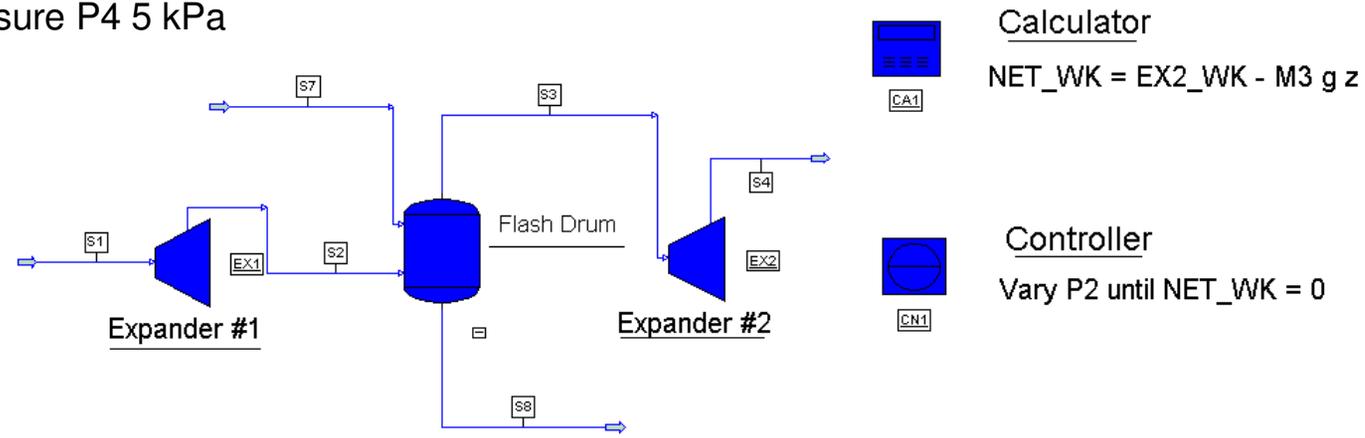
Water temperature T7 35 °C
 Water flow M7 2000 kg/s
 Upper level pressure P4 10 kPa



Stream Name Stream Description		S1	S2	S3	S4	S7	S8
Phase		Vapor	Mixed	Vapor	Mixed	Liquid	Liquid
Pressure	KPA	101.10	85.83	85.83	10.00	105.00	85.83
Temperature	C	25.80	17.29	29.13	-51.34	35.00	29.13
Total Sp. Enthalpy	KJ/KG	34.31	20.39	71.82	-90.56	131.58	105.66
Total Sp. Entropy	KJ/KG-C	6.47	6.47	6.62	6.62	5.13	5.05
Total Mass Rate	KG/SEC	1016.87	1016.87	1030.89	1030.89	2000.00	1985.98
Total Enthalpy	M*WATT	34.89	20.74	74.04	-93.36	263.16	209.85

Expander #1 Duty (H1 - H2) = 14.1 MW
 Expander #2 Duty (H3 - H4) = Lifting Duty (M3 gz) = 167.40 MW
 Heat Duty (H7 - H8) = 53.31 MW
 Exhausting Height 16570 m

Water temperature T7 35 °C
 Water flow M7 2000 kg/s
 Upper level pressure P4 5 kPa



Stream Name Stream Description		S1	S2	S3	S4	S7	S8
Phase		Vapor	Mixed	Vapor	Mixed	Liquid	Liquid
Pressure	KPA	101.10	83.70	83.70	5.00	105.00	83.70
Temperature	C	25.80	16.38	28.85	-83.38	35.00	28.85
Total Sp. Enthalpy	KJ/KG	34.31	18.28	72.20	-128.41	131.58	104.40
Total Sp. Entropy	KJ/KG-C	6.47	6.47	6.63	6.63	5.13	5.05
Total Mass Rate	KG/SEC	1016.87	1016.87	1031.16	1031.16	2000.00	1985.71
Total Enthalpy	M*WATT	34.89	18.59	74.45	-132.41	263.16	207.30

Expander #1 Duty (H1 - H2) = 16.3 MW
 Expander #2 Duty (H3 - H4) = Lifting Duty (M3 gz) = 206.86 MW
 Heat Duty (H7 - H8) = 55.86 MW
 Exhausting Height 20470 m

Inscription in the foyer of the Science building of the Seattle World's Fair of 1962.

To learn about the world around him, a scientist must ask, observe, suppose, experiment and analyze:

- In asking – the right question must be posed
- In observing – the significant must be distinguished from the unimportant
- In supposing – a workable answer (hypothesis) may be predicted, but a scientist must be ready to abandon it
- In experimenting – **the right instrument must be chosen or borrowed from the tool kit of some other branch of science**
- In analyzing – the scientist must, with his mind and his imagination, draw conclusions from the data his research has revealed.

Quote taken from the preface of: *The Science of Swimming*, James Councilman, Prentice Hall, Englewoodf Cliffs, New Jersey, 1968, Page VII, 457 pages.