Evaporator Performance Check (Hugot's Method)

Dessin factor achieved by each effect of a working 3- to 5-effect evaporator from juice and syrup brix, bleeds, surfaces and temperatures (Hugot pp. 600–602).

Method: Hugot; Handbook of Cane Sugar Engineering; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Clear juice to the evaporator	94.080	t/h
Clear juice brix	14.000	%
Syrup brix	56.000	%
Juice temperature entering effect 1	96.000	°C
Number of effects	4.0000	
Heating steam temperature (effect 1)	115.00	°C
Vapour temperature leaving effect 1	105.00	°C
Vapour temperature leaving effect 2	94.000	°C
Vapour temperature leaving effect 3	81.000	°C
Vapour temperature leaving effect 4	54.000	°C
Vapour temperature leaving effect 5	54.000	°C
Boiling-point rise in effect 1 (brix and head)	1.0000	K
Boiling-point rise in effect 2 (brix and head)	1.5000	K
Boiling-point rise in effect 3 (brix and head)	2.0000	K
Boiling-point rise in effect 4 (brix and head)	5.7000	K
Boiling-point rise in effect 5 (brix and head)	5.7000	K
Vapour bled from effect 1	10,000	kg/h
Vapour bled from effect 2	5,000.0	kg/h
Vapour bled from effect 3	0	kg/h
Vapour bled from effect 4	0	kg/h
Heating surface of effect 1	1,000.0	m^2
Heating surface of effect 2	700.00	m^2
Heating surface of effect 3	600.00	m^2
Heating surface of effect 4	550.00	m^2
Heating surface of effect 5	500.00	m^2

Calculated results

Parameter	Value	Unit
Total evaporation	70,560	kg/h
Surface of effect 1 used to heat the juice 0.1 $Q(t_1 - t_0)$	94.080	m^2
Evaporation of effect 1	27,640	kg/h
Evaporation of effect 2	17,640	kg/h
Evaporation of effect 3	12,640	kg/h

Parameter	Value	Unit
Evaporation of effect 4	12,640	kg/h
Evaporation of effect 5	0	kg/h
Dessin factor achieved by effect 1	6.6886e-04	
Dessin factor achieved by effect 2	6.7908e-04	
Dessin factor achieved by effect 3	7.0108e-04	
Dessin factor achieved by effect 4	7.4295e-04	
Dessin factor achieved by effect 5	0	

Notes for this case

• Hugot: factors near 0.001 are good; equal low factors in all effects point to scale, one low effect to a fault (scale, leak, gas or juice level).

Formula and method

$$E = J\left(1 - \frac{B_0}{B_s}\right), \quad x = \frac{E - \sum_{i<n} iP_i}{n}, \quad q_i = x + \sum_{k=i}^{n-1} P_k$$

$$s_1 = 0.1\,J(T_1 + d_1 - t_0), \quad \Delta_i = T_{i-1} - T_i - d_i, \quad f_i = \frac{q_i}{(100 - \bar{b}_i)(T_{i-1} - 54)(S_i - s_1\,[i=1])\,\Delta_i}$$

$$b_i = \frac{100\,B_0 J}{J - \sum_{k\le i} q_k}, \quad \bar{b}_i = \frac{b_{i-1} + b_i}{2}$$

Variables

J	Clear juice to the evaporator	kg/s
B_0	Clear juice brix	-
B_s	Syrup brix	-
t_0	Juice temperature entering effect 1	K
n	Number of effects	-
T_0	Heating steam temperature (effect 1)	K
T_1	Vapour temperature leaving effect 1	K
T_2	Vapour temperature leaving effect 2	K
T_3	Vapour temperature leaving effect 3	K
T_4	Vapour temperature leaving effect 4	K
T_5	Vapour temperature leaving effect 5	K
d_1	Boiling-point rise in effect 1 (brix and head)	K
d_2	Boiling-point rise in effect 2 (brix and head)	K
d_3	Boiling-point rise in effect 3 (brix and head)	K
d_4	Boiling-point rise in effect 4 (brix and head)	K
d_5	Boiling-point rise in effect 5 (brix and head)	K
P_1	Vapour bled from effect 1	kg/s
P_2	Vapour bled from effect 2	kg/s
P_3	Vapour bled from effect 3	kg/s
P_4	Vapour bled from effect 4	kg/s
S_1	Heating surface of effect 1	m²
S_2	Heating surface of effect 2	m²
S_3	Heating surface of effect 3	m²

S_4	Heating surface of effect 4	m²
S_5	Heating surface of effect 5	m²
E	Total evaporation	kg/s
s_1	Surface of effect 1 used to heat the juice 0.1 Q($t_1 - t_0$)	m²
q_1	Evaporation of effect 1	kg/s
q_2	Evaporation of effect 2	kg/s
q_3	Evaporation of effect 3	kg/s
q_4	Evaporation of effect 4	kg/s
q_5	Evaporation of effect 5	kg/s
f_1	Dessin factor achieved by effect 1	-
f_2	Dessin factor achieved by effect 2	-
f_3	Dessin factor achieved by effect 3	-
f_4	Dessin factor achieved by effect 4	-
f_5	Dessin factor achieved by effect 5	-
x	Evaporation each effect would give with no bleeding	kg/s
Δ_i	Net temperature drop of effect i	K
$b_i, \bar{b}_i$	Brix leaving effect i and mean brix in it (%)	-

Method and standards

Hugot's performance check with Dessin's formula.

Assumptions and limits

- Steady operation during the readings.
- In the formulas J is in t/h for s_1 and in kg/h for f_i, temperatures in °C and brix in %, as in Hugot; s_1 uses the juice boiling temperature $T_1 + d_1$ in effect 1.
- Equal-evaporation (Rillieux) split: 1 kg of vapour evaporates 1 kg in the next effect. Flash of juice and condensate and heat losses are ignored. Each net drop must be positive, which also makes the vapour temperatures fall along the set.

References

• Hugot
• Handbook of Cane Sugar Engineering
• 3rd ed. (Elsevier, 1986)
• ch. 32
• checking performance of a multiple effect
• eqn 32.51 and example
• pp. 600–602

Report details

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Release checks	2 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

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https://calc.firecad.com/sugar-ethanol/evaporation/evaporator-performance-check

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