Evaporator Temperature Drops for Minimum Surface

Temperature drops that give the minimum total heating surface of a 3- to 5-effect evaporator from each effect's evaporation and coefficient (Hugot eqns 32.44–32.47).

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

Input parameters

Unit system: SI

Parameter	Value	Unit
Number of effects	4.0000	
Total net temperature drop	54.700	K
Evaporation of effect 1	31,673	kg/h
Evaporation of effect 2	20,469	kg/h
Evaporation of effect 3	16,954	kg/h
Evaporation of effect 4	10,904	kg/h
Evaporation of effect 5	0	kg/h
Specific evaporation coefficient of effect 1, kg/(m²·h·°C)	5.5400	
Specific evaporation coefficient of effect 2, kg/(m²·h·°C)	4.3800	
Specific evaporation coefficient of effect 3, kg/(m²·h·°C)	3.0100	
Specific evaporation coefficient of effect 4, kg/(m²·h·°C)	1.4400	
Specific evaporation coefficient of effect 5, kg/(m²·h·°C)	1.0000	

Calculated results

Parameter	Value	Unit
Drop in effect 1	10.549	K
Drop in effect 2	10.455	K
Drop in effect 3	13.219	K
Drop in effect 4	20.477	K
Drop in effect 5	0	K
Heating surface of effect 1	541.96	m²
Heating surface of effect 2	446.98	m²
Heating surface of effect 3	426.09	m²
Heating surface of effect 4	369.80	m²
Heating surface of effect 5	0	m²
Total heating surface	1,784.8	m²

Notes for this case

• Drops include Hugot's corrections for quadruple and quintuple effects (none given for triples). Surfaces keep the entered coefficients; recompute them for the new temperatures if they move much.

Formula and method

$$t_i = \frac{q_i}{c_i}, \quad \frac{\Delta_{n-1}}{\Delta_n} = \sqrt{\frac{t_{n-1}}{2t_n}}, \quad \Delta_i = \sqrt{\frac{t_i \sum_{k>i} \Delta_k}{2 \sum_{k>i} t_k/\Delta_k}}, \quad S_i = \frac{t_i}{\Delta_i^*}$$

$$\Delta_i^* = \Delta\frac{\Delta_i}{\sum_k \Delta_k} + k_i\Delta, \quad k = (+0.008, +0.006, +0.003, -0.017)\ (n=4), \quad k = (+0.009, +0.007, +0.004, -0.003, -0.017)\ (n=5), \quad k = 0\ (n=3)$$

Variables

n	Number of effects	-
Δ	Total net temperature drop	K
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
c_1	Specific evaporation coefficient of effect 1, kg/(m²·h·°C)	-
c_2	Specific evaporation coefficient of effect 2, kg/(m²·h·°C)	-
c_3	Specific evaporation coefficient of effect 3, kg/(m²·h·°C)	-
c_4	Specific evaporation coefficient of effect 4, kg/(m²·h·°C)	-
c_5	Specific evaporation coefficient of effect 5, kg/(m²·h·°C)	-
Δ_1	Drop in effect 1	K
Δ_2	Drop in effect 2	K
Δ_3	Drop in effect 3	K
Δ_4	Drop in effect 4	K
Δ_5	Drop in effect 5	K
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
S	Total heating surface	m²
t_i	Evaporation capacity q_i/c_i of effect i	m²·°C
Δ_i^*	Drop of effect i after scaling to Δ and the correction	K
k_i	Correction to the drop of effect i, share of the total drop	-

Method and standards

Hugot's recurrence quotients for minimum total surface.

Assumptions and limits

- Coefficients from Dessin's formula at the first-guess temperatures; they are entered and shown in kg/(m²·h·°C) in every unit system.
- The recurrence drops are scaled so that they add up to the total drop, then the corrections k_i (shares of the total drop) are added. If a corrected drop comes out zero or negative the calculation stops with a message. The drops shown as outputs are the corrected ones.

References

• Hugot
• Handbook of Cane Sugar Engineering
• 3rd ed. (Elsevier, 1986)
• ch. 32
• minimum total heating surface
• eqns 32.35–32.47 and example
• pp. 581–595

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.

This calculator online

https://calc.firecad.com/sugar-ethanol/evaporation/evaporator-minimum-surface

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Reopens the calculator with the inputs of this report.