Batch Heating Time: Jacket, Coil or External Exchanger

Time to heat a stirred batch with steam or a hot liquid through a jacket, coil or external exchanger with the batch recirculated (Perry's Eqs. 11-35).

Method: Perry's Chemical Engineers' Handbook; 9th ed. (McGraw-Hill, 2019); ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Arrangement	Jacket or coil, isothermal medium (steam)	
Batch mass	10,000	kg
Batch specific heat	3.5000	kJ/(kg·K)
Overall coefficient	400.00	W/(m²·K)
Heat-transfer area	15.000	m²
Heating medium inlet temperature	140.00	°C
Initial batch temperature	20.000	°C
Final batch temperature	90.000	°C
Heating liquid flow	10,800	kg/h
Heating liquid specific heat	2.3000	kJ/(kg·K)
Batch recirculation through the external exchanger	14,400	kg/h

Calculated results

Parameter	Value	Unit
Heating time	1.4186	h
Heat to the batch	680.56	kWh
Average duty	479.74	kW

Notes for this case

- Constant U, flows and specific heats; well-mixed batch; no heat loss (Perry's assumptions). Add 10–20 % for losses and fouling.

Formula and method

$$\ln\frac{T_1-t_1}{T_1-t_2}=\frac{UA}{Mc}\theta \text{ (isothermal medium)},\quad \ln\frac{T_1-t_1}{T_1-t_2}=\frac{WC}{Mc}\frac{K_1-1}{K_1}\theta,\ K_1=e^{UA/WC}$$

$$\ln\frac{T_1-t_1}{T_1-t_2}=\frac{w}{M}\frac{K_2-1}{K_2}\theta,\ K_2=e^{UA/wc},\quad \ln\frac{T_1-t_1}{T_1-t_2}=\frac{K_3-1}{M}\frac{wWC}{K_3wc-WC}\theta,\ K_3=e^{UA(1/WC-1/wc)}$$

Variables

config	Arrangement	-
M	Batch mass	kg
C	Batch specific heat	J/(kg·K)
U	Overall coefficient	W/(m²·K)
A	Heat-transfer area	m²
T_1	Heating medium inlet temperature	K
t_1	Initial batch temperature	K
t_2	Final batch temperature	K

W	Heating liquid flow	kg/s
C	Heating liquid specific heat	J/(kg·K)
$\mathcal{W}$	Batch recirculation through the external exchanger	kg/s
θ	Heating time	s
Q	Heat to the batch	J
$\bar{P}$	Average duty	W

Method and standards

Perry's batch heating equations (counterflow external exchanger).

Assumptions and limits

- Constant U and flows; counterflow external exchanger.
- Only the inputs the chosen arrangement uses are checked. With a hot liquid, its outlet stays above the batch temperature by the form of the equations.
- Very large UA against a small flow is handled by the limit of the exponential terms (no overflow).

References

- Perry's Chemical Engineers' Handbook
- 9th ed. (McGraw-Hill, 2019)
- sec. 11
- Eqs. (11-35) to (11-35f) (batch heating of vessels; Bowman, Mueller and Nagle; Kern)

Report details

Report reference	FCC-CY1Q-0CQP (the same inputs always give the same reference)
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Calculator	Batch Heating Time: Jacket, Coil or External Exchanger
Method last reviewed	13 November 2026
Software release	FireCAD Calc, release of 17 November 2026
Release checks	4 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/chemical/process-heat-exchangers/batch-heating-time

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.