Heat Exchanger Exergy Destruction and Its Annual Cost

Entropy generated and exergy destroyed by heat transfer across a finite temperature difference in a heat exchanger, and the annual cost of that lost work.

Input parameters

Unit system: SI

Parameter	Value	Unit
Cold stream heat capacity rate	500.00	kW/K
Cold inlet	126.85	°C
Cold outlet	166.85	°C
Hot inlet	176.85	°C
Hot outlet	176.75	°C
Surroundings (dead state) temperature	25.000	°C
Capital cost of equipment per kW of exergy (any currency)	800.00	
Annual interest (capital charge) rate	12.000	%
Energy cost per kW-year (same currency)	400.00	

Calculated results

Parameter	Value	Unit
Heat duty	20.000	MW
Thermodynamic mean temperature, hot	449.95	K
Thermodynamic mean temperature, cold	419.68	K
Entropy generation	3,205.7	W/K
Exergy destruction	955.78	kW
Annual cost of exergy destruction	474,068	

Notes for this case

- Only the irreversibility of heat transfer across the finite temperature difference is counted (no pressure-drop or mixing losses).

Formula and method

$$\dot{S}_{irr} = q\left(\frac{1}{T_{lm,c}} - \frac{1}{T_{lm,h}}\right), \quad T_{lm} = \frac{T_o - T_i}{\ln(T_o/T_i)}$$

$$\dot{I} = T_0 \dot{S}_{irr}, \quad C = \dot{I}\,(c_{eq} r + c_q)$$

Variables

C_c	Cold stream heat capacity rate	W/K
$T_{c,i}$	Cold inlet	K
$T_{c,o}$	Cold outlet	K
$T_{h,i}$	Hot inlet	K
$T_{h,o}$	Hot outlet	K
T_0	Surroundings (dead state) temperature	K
c_{eq}	Capital cost of equipment per kW of exergy (any currency)	-
r	Annual interest (capital charge) rate	-

c_q	Energy cost per kW-year (same currency)	-
q	Heat duty	W
$T_{lm,h}$	Thermodynamic mean temperature, hot	K
$T_{lm,c}$	Thermodynamic mean temperature, cold	K
$\dot{S}_{irr}$	Entropy generation	W/K
$\dot{I}$	Exergy destruction	W
C	Annual cost of exergy destruction	-

Method and standards

Second-law (Gouy–Stodola) analysis of heat transfer.

Assumptions and limits

- Constant specific heats; heat transfer irreversibility only.

Report details

Report reference	FCC-M7R7-YP1W (the same inputs always give the same reference)
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Release checks	3 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/heat-exchanger-exergy-destruction

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Reopens the calculator with the inputs of this report.