Flow Maldistribution: Loss of Heat Exchanger Effectiveness

Temperature effectiveness of a counterflow or parallelflow exchanger with a two-step inlet velocity maldistribution on one side, and the deterioration factor.

Input parameters

Unit system: SI

Parameter	Value	Unit
NTU of the maldistributed fluid (UA/C₁)	8.0000	
Heat capacity rate ratio C₁/C₂	1.0000	
Share of free-flow area with the higher velocity	50.000	%
Velocity in that share relative to the mean	1.3000	
Flow arrangement	Counterflow	
Pressure drop exponent, Δp ∝ uⁿ (1 laminar, about 1.8 turbulent)	1.0000	

Calculated results

Parameter	Value	Unit
Velocity in the remaining area relative to the mean	0.70000	
Share of fluid 1 capacity rate in part A	65.000	%
NTU of sub-exchanger A	6.1538	
NTU of sub-exchanger B	11.429	
Capacity ratio of sub-exchanger A	1.3000	
Capacity ratio of sub-exchanger B	0.70000	
Effectiveness of sub-exchanger A	73.734	%
Effectiveness of sub-exchanger B	99.004	%
Effectiveness with maldistribution	82.579	%
Effectiveness with uniform flow	88.889	%
Deterioration factor (P_ideal − P)/P_ideal	7.0991	%
Approximate pressure drop increase factor	1.3000	

Notes for this case

• Two parallel sub-exchangers with uniform flow on the other side and the same U; any maldistribution can conservatively be reduced to such a two-step profile (Shah). The pressure drop factor assumes Δp ∝ uⁿ in the fastest passages and is only indicative.

Formula and method

$$P_1 = \frac{C_{1,A}}{C_1} P_{1,A} + \frac{C_{1,B}}{C_1} P_{1,B}, \quad \frac{C_{1,A}}{C_1} = \frac{u_A}{u} \frac{A_{o,A}}{A_o}$$

$$NTU_{1,A} = NTU_1 \frac{A_{o,A}/A_o}{C_{1,A}/C_1}, \quad R_{1,A} = R_1 \frac{C_{1,A}/C_1}{A_{o,A}/A_o}, \quad \Delta P_1^* = \frac{P_{1,ideal} - P_1}{P_{1,ideal}}$$

Variables

NTU_1	NTU of the maldistributed fluid (UA/C₁)	-
R_1	Heat capacity rate ratio C₁/C₂	-
$A_{o,A}/A_o$	Share of free-flow area with the higher velocity	-

u_A/u	Velocity in that share relative to the mean	-
flow	Flow arrangement	-
n	Pressure drop exponent, Δp ∝ uⁿ (1 laminar, about 1.8 turbulent)	-
u_B/u	Velocity in the remaining area relative to the mean	-
$C_{1,A}/C_1$	Share of fluid 1 capacity rate in part A	-
$NTU_{1,A}$	NTU of sub-exchanger A	-
$NTU_{1,B}$	NTU of sub-exchanger B	-
$R_{1,A}$	Capacity ratio of sub-exchanger A	-
$R_{1,B}$	Capacity ratio of sub-exchanger B	-
$P_{1,A}$	Effectiveness of sub-exchanger A	-
$P_{1,B}$	Effectiveness of sub-exchanger B	-
P_1	Effectiveness with maldistribution	-
$P_{1,ideal}$	Effectiveness with uniform flow	-
ΔP_1^*	Deterioration factor (P_ideal − P)/P_ideal	-
$\Delta p_{max}/\Delta p_{uniform}$	Approximate pressure drop increase factor	-

Method and standards

Parallel sub-exchanger model of gross flow maldistribution on one fluid side.

Assumptions and limits

- Counterflow or parallelflow, constant U, uniform flow on the other side.

Report details

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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/flow-maldistribution-effectiveness

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Reopens the calculator with the inputs of this report.