Plug-Flow Reactor with Recycle: Conversion

Conversion of a first-order reaction in a plug-flow reactor with product recycle, from rate constant, space time and recycle ratio, against PFR and CSTR.

Method: Levenspiel; Chemical Reaction Engineering; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
First-order rate constant	0.010000	Hz
Space time V/v_0 (fresh feed basis)	200.00	s
Recycle ratio (recycled/fresh)	2.0000	

Calculated results

Parameter	Value	Unit
Conversion with recycle	73.980	%
Without recycle	86.466	%
Fully mixed limit	66.667	%

Notes for this case

• Constant density, isothermal. Recycle is used for autocatalytic reactions or to limit temperature rise; for simple positive-order reactions it lowers conversion.

Formula and method

$$k\tau = (R+1)\ln\frac{1+R(1-X)}{(R+1)(1-X)}$$

Variables

k	First-order rate constant	1/s
τ	Space time V/v_0 (fresh feed basis)	s
R	Recycle ratio (recycled/fresh)	-
X	Conversion with recycle	-
X_{PFR}	Without recycle	-
X_{CSTR}	Fully mixed limit	-

Method and standards

Levenspiel's recycle reactor.

Assumptions and limits

- First order; constant density.

References

• Levenspiel
• Chemical Reaction Engineering
• 3rd ed. (Wiley, 1999)
• ch. 6 (recycle reactor: kτ = (R + 1) ln[(1 + R(1 − X))/((R + 1)(1 − X))])

Report details

Report reference	FCC-QS8J-9V6P (the same inputs always give the same reference)
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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/chemical/reactors/recycle-reactor-conversion

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.