Parabolic Trough Receiver: F', FR, Useful Gain and Outlet Temperature

Collector efficiency factor, heat removal factor, useful gain and outlet temperature of a cylindrical receiver in a linear parabolic trough concentrator.

Input parameters

Unit system: SI

Parameter	Value	Unit
Aperture width	2.5000	m
Collector length	10.000	m
Glass envelope outer diameter (shades the aperture)	90.000	mm
Absorbed radiation per unit aperture area	0.43000	kW/m²
Absorber outside diameter	60.000	mm
Absorber inside diameter	50.000	mm
Absorber tube conductivity	16.000	W/(m·K)
Inside coefficient	300.00	W/(m²·K)
Receiver loss coefficient (on receiver area)	3.8200	W/(m²·K)
Fluid flow	0.053700	kg/s
Fluid specific heat	3.2600	kJ/(kg·K)
Fluid inlet temperature	155.20	°C
Ambient temperature	10.000	°C

Calculated results

Parameter	Value	Unit
Receiver area	1.8850	m²
Unshaded aperture area	24.100	m²
Concentration ratio A_a/A_r	12.785	
Collector efficiency factor	98.368	%
Flow factor	98.004	%
Heat removal factor	96.405	%
Useful gain	8.9825	kW
Outlet temperature	206.51	°C

Notes for this case

- S already includes reflectance, intercept factor and (τα); U_L is based on the receiver area and usually comes from a receiver test or the envelope heat balance.

Formula and method

$$F' = \frac{1/U_L}{\frac{1}{U_L} + \frac{D_o}{h_{fi} D_i} + \frac{D_o}{2k} \ln \frac{D_o}{D_i}}, \quad F_R = \frac{\dot{m} c_p}{A_r U_L} \left[1 - \exp\left(- \frac{A_r U_L F'}{\dot{m} c_p} \right) \right]$$

$$Q_u = F_R A_a \left[S - \frac{A_r}{A_a} U_L (T_i - T_a) \right]$$

Variables

W_a	Aperture width	m
L	Collector length	m
D_g	Glass envelope outer diameter (shades the aperture)	m
S	Absorbed radiation per unit aperture area	W/m²
D_o	Absorber outside diameter	m
D_i	Absorber inside diameter	m
k	Absorber tube conductivity	W/(m·K)
h_{fi}	Inside coefficient	W/(m²·K)
U_L	Receiver loss coefficient (on receiver area)	W/(m²·K)
$\dot{m}$	Fluid flow	kg/s
c_p	Fluid specific heat	J/(kg·K)
T_i	Fluid inlet temperature	K
T_a	Ambient temperature	K
A_r	Receiver area	m²
A_a	Unshaded aperture area	m²
C	Concentration ratio A_a/A_r	-
F'	Collector efficiency factor	-
F''	Flow factor	-
F_R	Heat removal factor	-
Q_u	Useful gain	W
T_o	Outlet temperature	K

Method and standards

Hottel–Whillier analysis applied to a concentrating collector.

Assumptions and limits

- Steady state; uniform flux around the receiver assumed in F'.

Report details

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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/environmental/solar-thermal/parabolic-trough-receiver-gain

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.