Solar Collector Test Data: Inlet Basis, Flow Correction and IAM

Converts collector test results on outlet or mean temperature basis to FR(τα) and FRUL on inlet basis, corrects them to another flow and gives the angle modifier.

Input parameters

Unit system: SI

Parameter	Value	Unit
Temperature basis of the test parameters	Inlet temperature (F_R)	
Test intercept (optical efficiency)	75.000	%
Test slope (loss coefficient)	5.0000	W/(m²·K)
Collector area the test parameters refer to	2.5000	m²
Test flow rate	0.050000	kg/s
Test fluid specific heat	4.1870	kJ/(kg·K)
Flow rate in use	0.030000	kg/s
Fluid specific heat in use	4.1870	kJ/(kg·K)
Incidence angle modifier coefficient (0.1 one cover, 0.17 two)	0.10000	
Angle of incidence for the modifier	45.000	°

Calculated results

Parameter	Value	Unit
Intercept on inlet basis at test flow	75.000	%
Slope on inlet basis at test flow	5.0000	W/(m²·K)
F'U_L from the test	5.1555	W/(m²·K)
Flow-rate correction ratio	0.97996	
Intercept at the use flow rate	73.497	%
Slope at the use flow rate	4.8998	W/(m²·K)
Incidence angle modifier	0.95858	

Notes for this case

• The flow correction assumes F' does not change with flow, which suits liquid collectors in turbulent or near-turbulent flow; for air heaters F' must be recalculated at the new flow. The modifier K = 1 − b_0(1/cos θ − 1) (Souka and Safwat) is poor above about 60°.

Formula and method

$$F_R(\tau\alpha) = F_{av}(\tau\alpha)\left(1+\frac{A_c F_{av} U_L}{2\dot{m}c_p}\right)^{-1}, \quad F_R(\tau\alpha) = F_o(\tau\alpha)\left(1+\frac{A_c F_o U_L}{\dot{m}c_p}\right)^{-1}$$

$$F'U_L = -\frac{\dot{m}c_p}{A_c}\ln\left(1-\frac{F_R U_L A_c}{\dot{m}c_p}\right), \quad r = \frac{\frac{\dot{m}c_p}{A_c F'U_L}\left(1-e^{-A_c F'U_L/\dot{m}c_p}\right)\Big|_{use}}{\frac{\dot{m}c_p}{A_c F'U_L}\left(1-e^{-A_c F'U_L/\dot{m}c_p}\right)\Big|_{test}}, \quad K_{\tau\alpha} = 1 - b_0\left(\frac{1}{\cos\theta}-1\right)$$

Variables

basis	Temperature basis of the test parameters	-

$F_x(\tau\alpha)_n$	Test intercept (optical efficiency)	-
F_xU_L	Test slope (loss coefficient)	W/(m²·K)
A_c	Collector area the test parameters refer to	m²
$\dot{m}_{test}$	Test flow rate	kg/s
$c_{p,test}$	Test fluid specific heat	J/(kg·K)
$\dot{m}_{use}$	Flow rate in use	kg/s
$c_{p,use}$	Fluid specific heat in use	J/(kg·K)
b_0	Incidence angle modifier coefficient (0.1 one cover, 0.17 two)	-
θ	Angle of incidence for the modifier	rad
$F_R(\tau\alpha)_n$	Intercept on inlet basis at test flow	-
F_RU_L	Slope on inlet basis at test flow	W/(m²·K)
$F'U_L$	F'U_L from the test	W/(m²·K)
r	Flow-rate correction ratio	-
$F_R(\tau\alpha)_{n,use}$	Intercept at the use flow rate	-
$F_RU_{L,use}$	Slope at the use flow rate	W/(m²·K)
$K_{\tau\alpha}$	Incidence angle modifier	-

Method and standards

Conversion of collector test results between temperature bases and flow rates.

Assumptions and limits

- Linear efficiency curve; F' independent of flow rate.

Report details

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