Radiation from Flue Gas to Walls (Hottel Gray-Wall Factor)

Net radiant heat flux from hot gas to cooler walls from gas emissivity and absorptivity, the (ε_w + 1)/2 wall factor and the temperatures.

Method: q = σ (ε_w + 1)/2 (ε_g T_g^4 − α_g T_w^4) (Hottel and Sarofim, Radiative Transfer, McGraw-Hill, 1967; McAdams, Heat Transmission, 3rd ed., 1954; Perry's Chemical Engineers' Handbook); Stefan–Boltzmann constant 5.670374419 × 10^{-8} W/m²K^4 (CODATA 2018)

Input parameters

Unit system: SI

Parameter	Value	Unit
Gas temperature	1,100.0	°C
Wall (tube surface) temperature	300.00	°C
Gas emissivity at T_g	25.000	%
Gas absorptivity for wall radiation	30.000	%
Wall emissivity	80.000	%

Calculated results

Parameter	Value	Unit
Net radiant heat flux to the wall	43.707	kW/m²
Radiation coefficient q/(T_g − T_w)	54.634	W/(m²·K)

Notes for this case

- Take ε_g and α_g from the gas composition and mean beam length.

Formula and method

$$q = \sigma \frac{\varepsilon_w + 1}{2} \left(\varepsilon_g T_g^4 - \alpha_g T_w^4 \right), \quad h_r = \frac{q}{T_g - T_w}$$

Variables

T_g	Gas temperature	K
T_w	Wall (tube surface) temperature	K
ε_g	Gas emissivity at T_g	-
α_g	Gas absorptivity for wall radiation	-
ε_w	Wall emissivity	-
q	Net radiant heat flux to the wall	W/m²
h_r	Radiation coefficient q/(T_g − T_w)	W/(m²·K)

Method and standards

Hottel's gray-wall approximation: the net flux from a gray gas to a gray enclosure wall, with the effective wall emissivity $(\varepsilon_w + 1)/2$ for walls of emissivity above about 0.7.

Assumptions and limits

- Gray walls, uniform gas. The flux is per unit of the wall (enclosure) surface the gas sees; for tube banks use it with the area the coefficient is referred to.
- The gas emissivity must be above zero and the net flux positive; inconsistent emissivity and absorptivity are rejected.

References

• q = σ (ε_w + 1)/2 (ε_g T_g^4 − α_g T_w^4) (Hottel and Sarofim, Radiative Transfer, McGraw-Hill, 1967; McAdams, Heat Transmission, 3rd ed., 1954; Perry's Chemical Engineers' Handbook)
• Stefan–Boltzmann constant 5.670374419 × 10^{-8} W/m²K^4 (CODATA 2018)

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/boilers-power-plant/furnace-heating-surfaces/gas-wall-radiation-exchange

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.