Furnace Exit Gas Temperature (Well-Stirred Furnace Model)

Furnace exit gas temperature and wall heat absorption from adiabatic flame temperature, gas flow, wall area, effective emissivity and wall temperature.

Method: Well-stirred furnace model ṁ c̄_p (T_ad − T_e) = σ ε A (T_e⁴ − T_w⁴) (Hottel and Sarofim); Stefan–Boltzmann constant 5.670374419 × 10⁻⁸ W/m²K⁴ (CODATA 2018)

Input parameters

Unit system: SI

Parameter	Value	Unit
Adiabatic flame temperature	1,600.0	°C
Flue gas flow	160.00	t/h
Mean gas specific heat (T_exit to T_ad)	1.3000	kJ/(kg·K)
Effective water-wall area	600.00	m²
Effective furnace emissivity	50.000	%
Wall surface temperature	300.00	°C

Calculated results

Parameter	Value	Unit
Furnace exit gas temperature	957.17	°C
Heat absorbed by the walls	37.141	MW
Share of the available heat absorbed	49.448	%

Notes for this case

- Well-stirred (zero-dimensional) model: the gas leaving is at the uniform radiating temperature; calibrate ε_eff against a measured exit temperature.

Formula and method

$$\dot{m}_g \bar{c}_p (T_{ad} - T_e) = \sigma \varepsilon_{eff} A (T_e^4 - T_w^4) = \dot{Q}_r, \quad \dot{Q}_{ad} = \dot{m}_g \bar{c}_p (T_{ad} - T_w)$$

Variables

T_{ad}	Adiabatic flame temperature	K
$\dot{m}_g$	Flue gas flow	kg/s
$\bar{c}_p$	Mean gas specific heat (T_exit to T_ad)	J/(kg·K)
A	Effective water-wall area	m²
ε_{eff}	Effective furnace emissivity	-
T_w	Wall surface temperature	K
T_e	Furnace exit gas temperature	K
$\dot{Q}_r$	Heat absorbed by the walls	W
$\dot{Q}_r/\dot{Q}_{ad}$	Share of the available heat absorbed	-
$\dot{Q}_{ad}$	heat the gas would give up cooling from T_ad to the wall temperature	W
σ	Stefan–Boltzmann constant	W/(m²·K⁴)

Method and standards

Well-stirred (zero-dimensional) furnace: the heat the gas loses from the adiabatic flame temperature to the exit equals the radiation from gas at the exit temperature to the walls; solved by bisection between the wall and flame temperatures. The share absorbed is relative to cooling the gas to the wall temperature, not to the fuel heat input.

Assumptions and limits

- Uniform gas temperature.

- The mean specific heat over T_e to T_ad depends on the unknown T_e: iterate it if needed.

References

• Well-stirred furnace model $\dot{m}\,\bar{c}_p\,(T_{ad} - T_e) = \sigma\,\varepsilon\,A\,(T_e^4 - T_w^4)$ (Hottel and Sarofim)
• Stefan–Boltzmann constant $5.670374419 \times 10^{-8}$ W/m²K⁴ (CODATA 2018)

Report details

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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/boilers-power-plant/furnace-heating-surfaces/well-stirred-furnace-exit-temperature

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.