Chimney Draught, Hot Gas Column and Chimney Efficiency

Natural draught of a chimney in mm of water and as a column of hot gas, the theoretical gas velocity, and the chimney efficiency against a fan-driven (artificial) draught.

Method: Natural draught by hydrostatics with ideal-gas densities (textbook)

Input parameters

Unit system: SI

Parameter	Value	Unit
Chimney height above the grate	40.000	m
Outside air temperature	30.000	°C
Mean flue gas temperature in the chimney	300.00	°C
Gas temperature leaving if a fan made the draught With artificial draught the gas could be cooled further before the stack; the extra heat spent is what natural draught costs.	150.00	°C
Barometric pressure	1.0132	bar
Molar mass of the flue gas	30.000	kg/kmol
Specific heat of the flue gas	1.0050	kJ/(kg·K)

Calculated results

Parameter	Value	Unit
Density of the outside air	1.1644	kg/m³
Density of the flue gas	0.63787	kg/m³
Theoretical draught	21.062	mmWC
Draught as a column of hot gas	33.019	m
Theoretical gas velocity √(2 g H_g)	25.448	m/s
Chimney efficiency	0.21480	%

Notes for this case

- Theoretical (static) draught; the available draught is lower by the friction and velocity losses in the flues and chimney. Chimney efficiency is always well under 1 %: natural draught is paid for in stack heat.

Formula and method

$$\Delta p = g\,H\,(\rho_a - \rho_g), \quad \rho = \frac{p\,M}{R\,T}$$

$$H_g = H\left(\frac{\rho_a}{\rho_g} - 1\right), \quad V = \sqrt{2 g H_g}$$

$$\eta_{ch} = \frac{g\,H_g}{c_p\,(T_g - T_f)}$$

Variables

H	Chimney height above the grate	m
T_a	Outside air temperature	K
T_g	Mean flue gas temperature in the chimney	K
T_f	Gas temperature leaving if a fan made the draught	K

p_b	Barometric pressure	Pa
M_g	Molar mass of the flue gas	kg/kmol
M	molar mass in the density equation: M_g for the gas, 28.96 kg/kmol (dry air) for the outside air	kg/kmol
R	universal gas constant, 8314.46	J/(kmol·K)
p	barometric pressure p_b	Pa
g	standard gravity, 9.80665	m/s²
c_p	Specific heat of the flue gas	J/(kg·K)
ρ_a	Density of the outside air	kg/m³
ρ_g	Density of the flue gas	kg/m³
Δp	Theoretical draught	Pa
H_g	Draught as a column of hot gas	m
V	Theoretical gas velocity √(2 g H_g)	m/s
η_{ch}	Chimney efficiency	-

Method and standards

Hydrostatic pressure difference between a column of outside air and a column of hot flue gas of the same height, with ideal-gas densities.

Assumptions and limits

- Static (theoretical) draught; friction and velocity losses not deducted.
- Uniform gas temperature in the chimney.

References

- Natural draught by hydrostatics with ideal-gas densities (textbook)

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/emissions-stacks/chimney-draught-efficiency

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.