Flash (Pneumatic) Dryer: Particle Velocity and Residence Time

Terminal velocity of a particle, its velocity in the conveying gas and its residence time in a vertical flash dryer duct, with the particle Reynolds number.

Method: Particle slip in vertical pneumatic transport with Schiller–Naumann drag

Input parameters

Unit system: SI

Parameter	Value	Unit
Particle diameter	300.00	µm
Particle density	1,300.0	kg/m³
Gas density	0.75000	kg/m³
Gas viscosity	2.4000e-05	Pa·s
Gas velocity in the duct	20.000	m/s
Duct length	25.000	m

Calculated results

Parameter	Value	Unit
Terminal velocity	1.4093	m/s
Particle Reynolds number at terminal velocity	13.212	
Particle velocity (gas minus terminal velocity)	18.591	m/s
Residence time in the duct	1.3448	s

Notes for this case

• Once accelerated, a particle rises at the gas velocity less its terminal (slip) velocity, found here with the Schiller–Naumann drag curve. The residence time in the duct is the length over that velocity, typically a few seconds, so flash drying suits surface moisture and small particles. The acceleration zone near the feed point, where the slip is largest, gives most of the heat transfer; this simple estimate ignores it, as well as wall friction and particle interaction.

Formula and method

$$u_t = \sqrt{\frac{4(\rho_p - \rho_g) g d_p}{3 C_D \rho_g}}, \quad C_D = \frac{24}{Re}\left(1 + 0.15 Re^{0.687}\right), \quad \tau = \frac{L}{u_g - u_t}$$

Variables

d_p	Particle diameter	m
ρ_p	Particle density	kg/m³
ρ_g	Gas density	kg/m³
μ_g	Gas viscosity	Pa·s
u_g	Gas velocity in the duct	m/s
L	Duct length	m
u_t	Terminal velocity	m/s
Re_t	Particle Reynolds number at terminal velocity	-
u_p	Particle velocity (gas minus terminal velocity)	m/s
τ	Residence time in the duct	s

Method and standards

Flash dryer.

Assumptions and limits

- Spherical particles; steady upward flow; no wall effects.

References

Particle slip in vertical pneumatic transport with Schiller–Naumann drag

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/chemical/drying/flash-dryer-residence-time

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.