Fluidisation Regime Velocities: Umf, Turbulent, Transport, Slugging

Archimedes number, minimum fluidisation velocity (Grace), turbulent transition velocities, transport velocity and minimum slugging velocity of a bed (Basu ch. 2).

Method: Basu; Circulating Fluidized Bed Boilers: Design; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Mean particle diameter (surface-volume)	0.30000	mm
Particle density	2,500.0	kg/m³
Gas density	0.31600	kg/m³
Gas viscosity	0.045000	cP
Bed (furnace) diameter or equivalent	0.20300	m

Calculated results

Parameter	Value	Unit
Archimedes number	103.28	
Minimum fluidisation velocity	0.036718	m/s
Onset of turbulent fluidisation	3.9655	m/s
Turbulent regime fully developed	6.1856	m/s
Transport velocity (Perales)	6.4948	m/s
Minimum slugging velocity	0.13548	m/s

Notes for this case

- The turbulent-transition correlations (Horio and Morishita) come from small laboratory beds; treat u_c and u_k as indicative for boiler-size beds.

Formula and method

$$Ar = \frac{\rho_g(\rho_p - \rho_g)g d_p^3}{\mu^2}, \quad Re_{mf} = \sqrt{27.2^2 + 0.0408 Ar} - 27.2$$

$$Re_c = 0.936 Ar^{0.472}, \quad Re_k = 1.46 Ar^{0.472}, \quad U_{tr} = 1.45 \frac{\mu}{\rho_g d_p} Ar^{0.484}, \quad U_{sl} = U_{mf} + 0.07\sqrt{gD}$$

Variables

d_p	Mean particle diameter (surface-volume)	m
ρ_p	Particle density	kg/m³
ρ_g	Gas density	kg/m³
μ	Gas viscosity	Pa·s
D	Bed (furnace) diameter or equivalent	m
Ar	Archimedes number	-
U_{mf}	Minimum fluidisation velocity	m/s
u_c	Onset of turbulent fluidisation	m/s
u_k	Turbulent regime fully developed	m/s
U_{tr}	Transport velocity (Perales)	m/s

U_{sl}	Minimum slugging velocity	m/s

Method and standards

Correlations quoted by Basu, ch. 2.

Assumptions and limits

- Spherical-ish particles; correlations from small beds. The turbulent-transition values are indicative for large beds, and slugging does not occur in beds wider than about a metre (notes appear).
- Standard gravity 9.80665 m/s².

References

- Basu
- Circulating Fluidized Bed Boilers: Design
- Operation and Maintenance (Springer, 2015)
- ch. 2
- Eqs. (2.3) (Grace: C_1 27.2, C_2 0.0408)
- (2.7) (Stewart and Davidson)
- (2.10)–(2.11) (Horio and Morishita)
- (2.14) (Perales et al.)

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/fluidised-bed/fluidisation-regime-velocities

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.