Fluidised-Bed Air Distributor: Orifices, Pitch and Nozzles

Distributor pressure drop, orifice velocity, fractional opening, orifices per m², pitch, nozzles and jet length for a bubbling bed grid (Basu Eqs. 8.15–8.22).

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

Input parameters

Unit system: SI

Parameter	Value	Unit
Superficial velocity through the grid	1.5000	m/s
Expanded bed height (at the operating voidage)	0.80000	m
Particle density	2,600.0	kg/m³
Distributor-to-bed pressure drop ratio	30.000	%
Gas density in the bed	0.32000	kg/m³
Gas density at the orifice	0.90000	kg/m³
Orifice coefficient	0.80000	
Orifice diameter	4.0000	mm
Orifices per nozzle	6.0000	
Grid area	20.000	m²
Bed particle size	0.50000	mm
Orifice pitch layout	Triangular	

Calculated results

Parameter	Value	Unit
Bed voidage (King)	71.429	%
Bed pressure drop	5.8280	kPa
Distributor pressure drop	1.7484	kPa
Orifice velocity	49.866	m/s
Fractional opening	1.0695	%
Orifices per m²	851.11	
Orifice pitch	36.833	mm
Nozzles on the grid	2,838.0	
Jet length above the orifice (Merry)	124.80	mm

Notes for this case

- Orifice velocity above 30 m/s: check particle attrition (Pell suggests below 30 m/s).

Formula and method

$$\Delta P_{dist} = k\Delta P_b, \quad \Delta P_b = \rho_p(1-\varepsilon)Hg, \quad \varepsilon = \frac{U+1}{U+2}, \quad U_0 = C_D\sqrt{\frac{2\Delta P_{dist}}{\rho_{g,or}}}$$

$$\phi = \frac{U\rho_g}{U_0\rho_{g,or}} = N\frac{\pi d_0^2}{4}, \quad \frac{l_j}{d_0} = 5.2\left(\frac{\rho_{g,or}d_0U_0}{\rho_p d_p}\right)^{0.3}\left[1.3\left(\frac{U_0^2}{gd_0}\right)^{0.2} - 1\right]$$

$$P = \sqrt{\frac{2}{\sqrt{3}\,N}}\ \text{(triangular)}, \quad P = \sqrt{\frac{1}{N}}\ \text{(square)}, \quad N_n = \left\lceil \frac{N A}{n} \right\rceil$$

Variables

U	Superficial velocity through the grid	m/s
H	Expanded bed height at the operating voidage	m
ρ_p	Particle density	kg/m³
k	Distributor-to-bed pressure drop ratio	-
ρ_g	Gas density in the bed	kg/m³
$\rho_{g,or}$	Gas density at the orifice	kg/m³
C_D	Orifice coefficient	-
d_0	Orifice diameter	m
n	Orifices per nozzle	-
A	Grid area	m²
d_p	Bed particle size	m
pitch	Orifice pitch layout	-
ε	Bed voidage (King)	-
ΔP_b	Bed pressure drop	Pa
ΔP_{dist}	Distributor pressure drop	Pa
U_0	Orifice velocity	m/s
ϕ	Fractional opening	-
N	Orifices per m²	-
P	Orifice pitch	m
N_n	Nozzles on the grid	-
l_j	Jet length above the orifice (Merry)	m

Method and standards

Basu's distributor design procedure: bed pressure drop from King's voidage, the distributor drop as a share of it (Kunii–Levenspiel), orifice velocity with C_D = 0.8 (Zenz), the fractional opening and orifice count, and Merry's jet length.

Assumptions and limits

- King's voidage for velocities up to 5 m/s; above that a warning is given.
- The bed height is the expanded height at that voidage; entering the settled height understates the bed pressure drop.
- The pitch spreads the orifices uniformly over the grid; with nozzle caps of n orifices each, the nozzle pitch is wider. A negative jet length from Merry's correlation is shown as zero.

References

- Basu
- Circulating Fluidized Bed Boilers: Design
- Operation and Maintenance (Springer, 2015)
- ch. 8
- Eqs. (8.15)–(8.23): Kunii–Levenspiel pressure-drop rule
- King's voidage
- Zenz C_D = 0.8
- Merry's jet length

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/fluidised-bed-distributor-design

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.