Fluid-Bed Dryer Air Flow, Bed Area and Residence Time

Air flow from the heat balance, bed area from the fluidising velocity and solids residence time from the bed depth, for a continuous fluid-bed dryer.

Method: Heat balance and hydrodynamic sizing of a continuous fluid-bed dryer

Input parameters

Unit system: SI

Parameter	Value	Unit
Water to evaporate	500.00	kg/h
Dry solids rate	2,000.0	kg/h
Specific heat of the solids (with residual moisture)	1.5000	kJ/(kg·K)
Temperature rise of the solids	40.000	K
Air inlet temperature	150.00	°C
Air outlet temperature	70.000	°C
Heat loss as a share of the useful heat	10.000	%
Superficial air velocity in the bed (at inlet temperature)	0.80000	m/s
Bed density (fluidised)	600.00	kg/m³
Bed depth	300.00	mm

Calculated results

Parameter	Value	Unit
Dry air flow	18,704	kg/h
Heat supplied to the air	425.87	kW
Bed (distributor) area	7.7853	m²
Mean solids residence time	42.040	min
Humidity pick-up of the air	26.733	g/kg
Heat per kg of water evaporated	3,066.2	kJ/kg

Notes for this case

• The air gives up sensible heat between inlet and outlet: ṁ_a c_p(T_in − T_out) supplies the heat to evaporate the water (from feed water at 20 °C to vapour at the outlet temperature), to warm the solids and to cover losses. Humid heat is taken as 1006 + 1860 × 0.01 J/(kg·K). The bed area follows from the air density at the inlet temperature and the chosen superficial velocity, which must lie between minimum fluidisation and the elutriation velocity of the fines. The mean residence time is the bed hold-up divided by the solids rate; plug-flow (multi-cell) beds narrow the spread of residence times.

Formula and method

$$\dot{m}_a c_p (T_{in} - T_{out}) = (1 + f_L)\left[\dot{m}_w (h_v - h_l) + \dot{m}_s c_s \Delta T_s\right], \quad A = \frac{\dot{m}_a}{\rho_{in} u}, \quad \tau = \frac{\rho_b A H}{\dot{m}_s}$$

Variables

$\dot{m}_w$	Water to evaporate	kg/s
$\dot{m}_s$	Dry solids rate	kg/s
c_s	Specific heat of the solids (with residual moisture)	J/(kg·K)
ΔT_s	Temperature rise of the solids	K
T_{in}	Air inlet temperature	K
T_{out}	Air outlet temperature	K

f_L	Heat loss as a share of the useful heat	-
u	Superficial air velocity in the bed (at inlet temperature)	m/s
ρ_b	Bed density (fluidised)	kg/m³
H	Bed depth	m
$\dot{m}_a$	Dry air flow	kg/s
$\dot{Q}$	Heat supplied to the air	W
A	Bed (distributor) area	m²
τ	Mean solids residence time	s
Δx	Humidity pick-up of the air	kg/kg
q_w	Heat per kg of water evaporated	J/kg

Method and standards

Fluid-bed dryer.

Assumptions and limits

- Steady state; well-mixed bed; feed water at 20 °C.

References

Heat balance and hydrodynamic sizing of a continuous fluid-bed dryer

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/chemical/drying/fluid-bed-dryer-sizing

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Reopens the calculator with the inputs of this report.