Spray Dryer Evaporation and Air Flow

Water evaporated, powder produced, dry air flow and outlet humidity of a spray dryer from feed, solids, moisture, air temperatures and heat loss.

Method: Perry's Chemical Engineers' Handbook; 9th ed. (McGraw-Hill, 2019); ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Feed (concentrate)	5,000.0	kg/h
Feed solids	48.000	%
Powder moisture (wet basis)	3.5000	%
Feed temperature	50.000	°C
Air inlet	200.00	°C
Air outlet	90.000	°C
Ambient humidity (kg water per kg dry air)	10.000	g/kg
Heat loss share	10.000	%
Ambient air temperature (to the heater)	25.000	°C

Calculated results

Parameter	Value	Unit
Powder	2,487.0	kg/h
Water evaporated	2,513.0	kg/h
Dry air	60,953	kg/h
Outlet humidity	51.228	g/kg
Heat to the air in the heater	3,036.5	kW
Heat per kg water evaporated	4.3500	MJ/kg

Notes for this case

- Air is heated from the ambient temperature entered; the powder's sensible heat is folded into the loss share.

Formula and method

$$P = \frac{F x_F}{1 - w_P}, \quad E = F - P, \quad \dot{m}_a = \frac{E\,[2501 + 1.88 T_2 - 4.187 T_F]}{(1-\varepsilon)(1.006 + 1.88 Y_0)(T_1 - T_2)}, \quad Q = \dot{m}_a (1.006 + 1.88 Y_0)(T_1 - T_a)$$

Variables

F	Feed (concentrate)	kg/s
x_F	Feed solids	-
w_P	Powder moisture (wet basis)	-
T_F	Feed temperature	K
T_1	Air inlet	K
T_2	Air outlet	K
Y_0	Ambient humidity (kg water per kg dry air)	kg/kg
ε	Heat loss share	-
T_a	Ambient air temperature (to the heater)	K
P	Powder	kg/s
E	Water evaporated	kg/s

$\dot{m}_a$	Dry air	kg/s
Y_2	Outlet humidity	kg/kg
Q	Heat to the air in the heater	W
Q/E	Heat per kg water evaporated	J/kg

Method and standards

Solids, water and heat balances on the drying chamber (temperatures in °C in the bracket).

Assumptions and limits

- Heat loss as a share of the latent load; air heated from the ambient temperature entered (25 °C by default).

References

• Perry's Chemical Engineers' Handbook
• 9th ed. (McGraw-Hill, 2019)
• sec. 12 (spray dryers): mass and heat balances
• Psychrometric enthalpy basis: 2 501 kJ/kg at 0 °C
• vapour 1.88 and dry air 1.006 kJ/(kg·K)

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/unit-operations/spray-dryer-air-balance

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.