Dryer Air Flow and Heat from Measured Exhaust Humidity

Dry air flow, heater duty and heat per kg of water of a hot-air dryer from the evaporation rate and measured ambient, inlet and exhaust air conditions.

Method: Psychrometrics: humidity ratio 0.621945 p_v/(p − p_v); humid enthalpy 1006 t + x(2 501 000 + 1860 t); …

Input parameters

Unit system: SI

Parameter	Value	Unit
Water evaporated	300.00	kg/h
Ambient air temperature	30.000	°C
Ambient relative humidity	60.000	%
Air temperature after the heater	120.00	°C
Exhaust air temperature	60.000	°C
Exhaust relative humidity (measured)	35.000	%
Pressure	1.0132	bar

Calculated results

Parameter	Value	Unit
Ambient humidity ratio	16.043	g/kg
Exhaust humidity ratio	46.021	g/kg
Dry air flow	10,007	kg/h
Exhaust volume flow	10,144	m³/h
Heater duty	259.15	kW
Heat per kg of water	3,109.8	kJ/kg
Heat not accounted for by the adiabatic line (losses)	-26.016	%
Exhaust dew point	38.950	°C

Notes for this case

• Measuring the exhaust temperature and humidity tells how much water each kg of air carries away, so the evaporation rate fixes the air flow. The heater duty is that air flow times its enthalpy rise. If the exhaust is drier than the constant-enthalpy (adiabatic) line from the inlet state predicts, the difference is heat lost from the dryer or used to warm the product; it shows as the loss share. The exhaust dew point warns of condensation in ducts and cyclones.

Formula and method

$$x = 0.621945\frac{\varphi p_s}{p-\varphi p_s},\quad \dot{m}_a = \frac{\dot{m}_w}{x_o - x_a},\quad \dot{Q} = \dot{m}_a\left[h(T_{in}, x_a) - h(T_a, x_a)\right]$$

Variables

$\dot{m}_w$	Water evaporated	kg/s
T_a	Ambient air temperature	K
φ_a	Ambient relative humidity	-
T_{in}	Air temperature after the heater	K
T_{out}	Exhaust air temperature	K
φ_{out}	Exhaust relative humidity (measured)	-
p	Pressure	Pa
x_a	Ambient humidity ratio	kg/kg

x_o	Exhaust humidity ratio	kg/kg
$\dot{m}_a$	Dry air flow	kg/s
$\dot{V}_a$	Exhaust volume flow	m³/s
$\dot{Q}$	Heater duty	W
q_w	Heat per kg of water	J/kg
f_L	Heat not accounted for by the adiabatic line (losses)	-
T_{dp}	Exhaust dew point	K

Method and standards

Air from humidity.

Assumptions and limits

- Steady state; humidity measured after any leaks.

References

Psychrometrics: humidity ratio 0.621945 p_v/(p − p_v), humid enthalpy 1006 t + x(2 501 000 + 1860 t), saturation pressure from IAPWS-IF97

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/dryer-air-flow-humidity-pickup

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Reopens the calculator with the inputs of this report.