Superheated Steam Dryer: Energy Use and Recoverable Steam

Heat input to a superheated-steam dryer and the excess steam it releases, which can be reused, compared with the heat of an air dryer, using IF97 steam properties.

Method: Energy balance of superheated-steam drying with IAPWS-IF97

Input parameters

Unit system: SI

Parameter	Value	Unit
Water evaporated	1,000.0	kg/h
Feed temperature	20.000	°C
Dryer pressure (absolute)	1.0132	bar
Steam outlet temperature	150.00	°C
Dry solids rate	1,500.0	kg/h
Specific heat of the solids	1.5000	kJ/(kg·K)
Share of the excess steam's latent heat recovered	70.000	%
Thermal efficiency of an air dryer for comparison	55.000	%

Calculated results

Parameter	Value	Unit
Heat input to the steam loop	797.90	kW
Heat per kg of water	2,872.4	kJ/kg
Heat recovered from the excess steam	438.77	kW
Net heat per kg of water after recovery	1,292.8	kJ/kg
Heat per kg of water in an air dryer	4,564.1	kJ/kg

Notes for this case

• In a superheated-steam dryer the drying medium is the product's own vapour recirculated and reheated. The water evaporated leaves as extra steam at the dryer pressure, so the heat input per kg of water is roughly the enthalpy rise from feed water to superheated steam. Unlike air dryers, that excess steam is not lost: condensed in a process heater or evaporator it returns most of its latent heat, so the net consumption can be a fraction of an air dryer's. The air-dryer figure uses vapour leaving at about 50 °C over the air dryer's efficiency.

Formula and method

$$\dot{Q} = \dot{m}_w \left[h_v(p, T_o) - h_l(T_f) \right] + \dot{m}_s c_s \Delta T_s, \quad \dot{Q}_r = f_r \, \dot{m}_w h_{fg}(p)$$

Variables

$\dot{m}_w$	Water evaporated	kg/s
T_f	Feed temperature	K
p	Dryer pressure (absolute)	Pa
T_o	Steam outlet temperature	K
$\dot{m}_s$	Dry solids rate	kg/s
c_s	Specific heat of the solids	J/(kg·K)
f_r	Share of the excess steam's latent heat recovered	-
η_a	Thermal efficiency of an air dryer for comparison	-

$\dot{Q}$	Heat input to the steam loop	W
q_w	Heat per kg of water	J/kg
$\dot{Q}_r$	Heat recovered from the excess steam	W
q_{net}	Net heat per kg of water after recovery	J/kg
q_a	Heat per kg of water in an air dryer	J/kg

Method and standards

Superheated steam drying.

Assumptions and limits

- Steady state; heat losses not included; air leakage nil.

References

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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/superheated-steam-dryer-energy

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Reopens the calculator with the inputs of this report.