Air-Cooled Condenser (ACC) Duty and Air Flow

Heat load of an air-cooled steam condenser and the air flow it needs from the exhaust steam flow, dryness, condenser pressure and air temperature rise, with the ITD.

Method: IAPWS R7-97(2012) IF97; NIST Chemistry WebBook Shomate equations (air)

Input parameters

Unit system: SI

Parameter	Value	Unit
Exhaust steam flow	20,000	kg/h
Exhaust steam dryness fraction	92.000	%
Condenser pressure (absolute)	20.000	kPa
Ambient air temperature	35.000	°C
Air temperature leaving the bundles	52.000	°C
Atmospheric pressure	1.0132	bar

Calculated results

Parameter	Value	Unit
Condenser heat load	12.050	MW
Air mass flow (dry air)	2,536,928	kg/h
Air volume flow at ambient (dry air)	2,214,619	m³/h
Initial temperature difference	25.059	K
Condensing temperature	60.059	°C

Formula and method

$$\dot{Q} = \dot{m}_s \left[h(p_c, x) - h_f(p_c) \right] \qquad \dot{m}_a = \frac{\dot{Q}}{h_a(T_{a,2}) - h_a(T_{a,1})}$$

$$\dot{V}_a = \frac{\dot{m}_a}{\rho_a}, \quad \rho_a = \frac{p_{atm}\, M_{da}}{R\, T_{a,1}} \qquad ITD = T_{sat} - T_{a,1}$$

Variables

$\dot{m}_s$	exhaust steam flow	kg/s
x	exhaust steam dryness	–
p_c	condenser pressure, absolute	Pa
$T_{a,1}$	ambient air temperature	K
$T_{a,2}$	air temperature leaving the bundles	K
p_{atm}	atmospheric pressure	Pa
$\dot{Q}$	condenser heat load	W
$\dot{m}_a$	air mass flow	kg/s
$\dot{V}_a$	air volume flow at ambient	m³/s
ITD	initial temperature difference	K
T_{sat}	condensing temperature	K
$h\$, \$h_f$	steam and saturated liquid enthalpy	J/kg
h_a	dry air enthalpy (Shomate)	J/kg
ρ_a	air density at ambient	kg/m³

M_{da}	molar mass of dry air	kg/kmol
R	universal gas constant	J/(kmol·K)

Method and standards

Steam-side energy balance with FireCAD's IAPWS-IF97; air-side enthalpy from NIST Shomate heat capacities of dry air; air density by the ideal-gas law at ambient.

Assumptions and limits

- Dry air (humidity neglected on the air side): the air flows are dry-air values; on hot humid days the real volume flow is slightly larger.
- Condensate leaves saturated (no subcooling); no air in-leakage on the steam side; fan heat is not added to the duty.
- The ITD is reported for comparison only; the condenser pressure is an input, not checked against the ITD the bundles can achieve.
- Dry air enthalpy by Shomate; below 25 °C the CO_2 and Ar terms are extrapolated slightly, a negligible effect for trace species.

References

- IAPWS R7-97(2012) IF97
- NIST Chemistry WebBook Shomate equations (air)

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/boilers-power-plant/condensers-cooling/air-cooled-condenser-duty

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Reopens the calculator with the inputs of this report.