Condenser Air Pump: Air Volume and Ejector Steam

Air to remove from a condenser from vapour condensed and air per kg (Hugot Table 40.16), its volume at the outlet, pump size and ejector steam.

Method: Hugot; Handbook of Cane Sugar Engineering; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Vapour condensed	25,200	kg/h
Air per kg vapour Hugot: central condensers 8–10 g/kg, multiple effects 6–8, pans 5–6.	6.0000	g/kg
Condenser pressure (absolute)	13.337	kPa
Air temperature at the air outlet	30.000	°C
Volumetric efficiency of the pump	70.000	%
Ejector steam per kg of dry air Hugot: two-stage ejector at 6 kg/cm² and 66 cm vacuum about 2.5 + 6 = 8.5 kg/kg.	8.5000	

Calculated results

Parameter	Value	Unit
Dry air	151.20	kg/h
Vapour pressure at t_a	4.2467	kPa
Partial pressure of air	9.0904	kPa
Specific volume of the air	9.5724	m³/kg
Air volume at the outlet	24.123	m³/min
Pump displacement	34.461	m³/min
Steam for a steam-jet ejector	1,285.2	kg/h

Notes for this case

- Hugot's example: 25 200 kg/h of pan vapour at 6 g/kg, 66 cm vacuum and 30 °C air needs about 24 m³/min at the air outlet.

Formula and method

$$\dot{m}_a = aG, \quad p_a = p - p_{sat}(t_a), \quad v_a = \frac{R_a T_a}{p_a}, \quad \dot{V}_a = \dot{m}_a v_a, \quad \dot{V}_d = \frac{\dot{V}_a}{\eta_v}$$

Variables

G	Vapour condensed	kg/s
a	Air per kg vapour	kg/kg
p	Condenser pressure (absolute)	Pa
t_a	Air temperature at the air outlet	K
η_v	Volumetric efficiency of the pump	-
s_e	Ejector steam per kg of dry air	-
$\dot{m}_a$	Dry air	kg/s
p_v	Vapour pressure at t_a	Pa
p_a	Partial pressure of air	Pa
v_a	Specific volume of the air	m³/kg
$\dot{V}_a$	Air volume at the outlet	m³/s

$\dot{V}_d$	Pump displacement	m³/s
$\dot{m}_s$	Steam for a steam-jet ejector	kg/s

Method and standards

Dalton's and Mariotte's laws as used by Hugot.

Assumptions and limits

- Saturated air at t_a. As t_a approaches the saturation temperature at p the air partial pressure tends to zero and the volume grows without limit; a note warns when the air is below a quarter of p.

References

- Hugot
- Handbook of Cane Sugar Engineering
- 3rd ed. (Elsevier, 1986)
- ch. 40
- air extraction (Tables 40.9–40.16, Mariotte's law, example p. 878) and ejectors
- pp. 867–880 and 901–903
- Gas constant of dry air from CODATA R and the air composition

Report details

Report reference	FCC-NH9M-5H3W (the same inputs always give the same reference)
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Release checks	2 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/sugar-ethanol/vacuum-water/condenser-air-pump

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.