Fan Laws (Speed, Size and Density)

New flow, pressure and power of a fan when the speed, the wheel diameter or the gas density changes, by the fan similarity laws.

Method: AMCA Publication 99 (fan laws); ISO 5801 (similarity)

Input parameters

Unit system: SI

Parameter	Value	Unit
Volume flow	72,000	m³/h
Pressure rise	305.91	mmWC
Shaft power	75.000	kW
Speed	980.00	rpm
Gas density	1.2000	kg/m³
New speed	740.00	rpm
Wheel diameter ratio (1 = same fan)	1.0000	
New gas density	1.2000	kg/m³

Calculated results

Parameter	Value	Unit
New volume flow	54,367	m³/h
New pressure rise	174.43	mmWC
New shaft power	32.291	kW
Speed ratio	0.75510	
Density ratio	1.0000	

Formula and method

$$\frac{\dot{V}_2}{\dot{V}_1} = \frac{N_2}{N_1}\left(\frac{D_2}{D_1}\right)^3 \qquad \frac{\Delta p_2}{\Delta p_1} = \frac{\rho_2}{\rho_1}\left(\frac{N_2}{N_1}\right)^2\left(\frac{D_2}{D_1}\right)^2 \qquad \frac{P_2}{P_1} = \frac{\rho_2}{\rho_1}\left(\frac{N_2}{N_1}\right)^3\left(\frac{D_2}{D_1}\right)^5$$

Variables

$\dot{V}_1$	known volume flow	m³/s
Δp_1	known pressure rise	Pa
P_1	known shaft power	W
N_1	known speed	1/s
ρ_1	known gas density	kg/m³
N_2	new speed	1/s
D_2/D_1	wheel diameter ratio of geometrically similar fans	–
ρ_2	new gas density	kg/m³
$\dot{V}_2$	new volume flow	m³/s
Δp_2	new pressure rise	Pa
P_2	new shaft power	W
N_2/N_1	speed ratio	–
ρ_2/ρ_1	density ratio	–

Method and standards

The fan laws of AMCA Publication 99 and the similarity rules of ISO 5801, for geometrically similar fans at the same point of rating (same efficiency).

Assumptions and limits

- The fan stays at the same point of its curve: the system resistance must follow $\Delta p \propto \rho \cdot \dot{V}^2$. A system with a fixed static component does not follow the laws along its own curve.
- Efficiency is taken as constant; this holds for moderate changes (about −50 % to +20 % speed).
- The diameter law applies to geometrically similar fans, not to a trimmed wheel in the same casing.
- Compressibility and Reynolds-number effects are neglected.

References

- AMCA Publication 99 (fan laws)
- ISO 5801 (similarity)

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

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