Fan and Motor Run-Up (Acceleration) Time

Time for a motor to accelerate a fan to speed against its square-law load torque from inertias, belt ratio and the motor's average accelerating torque.

Method: Rotor acceleration against a square-law load

Input parameters

Unit system: SI

Parameter	Value	Unit
Fan rotor inertia	120.00	kg·m²
Motor rotor inertia	6.0000	kg·m²
Fan speed	990.00	rpm
Motor speed	1,485.0	rpm
Fan shaft power at full speed	250.00	kW
Motor rated power	315.00	kW
Average motor torque during run-up (× rated torque)	1.6000	

Calculated results

Parameter	Value	Unit
Inertia referred to the motor shaft	59.333	kg·m²
Average motor torque	3,241.0	N·m
Fan load torque at full speed (motor shaft)	1,607.6	N·m
Run-up time	3.5401	s
Kinetic energy at speed	717.43	kJ

Notes for this case

• J_eq dω/dt = T_m − T_L(ω/ω_m)² with constant average motor torque integrates to t = J_eq/√(aT_m)·artanh(ω_m√(a/T_m)), a = T_L/ω_m². Large induced-draught fans can take 20–60 s; compare with the motor's permitted locked-rotor (hot) time and start the fan against a closed damper or inlet vanes to cut T_L.

Formula and method

$$J_{eq} = J_m + J_f \left(\frac{n_f}{n_m}\right)^2, \quad t_a = \frac{J_{eq}}{\sqrt{aT_m}} \tanh^{-1}\left(\omega_m \sqrt{\frac{a}{T_m}}\right), \quad a = \frac{T_L}{\omega_m^2}$$

Variables

J_f	Fan rotor inertia	kg·m²
J_m	Motor rotor inertia	kg·m²
n_f	Fan speed	rad/s
n_m	Motor speed	rad/s
P_f	Fan shaft power at full speed	W
P_m	Motor rated power	W
k_T	Average motor torque during run-up (× rated torque)	-
J_{eq}	Inertia referred to the motor shaft	kg·m²
T_m	Average motor torque	N·m
T_L	Fan load torque at full speed (motor shaft)	N·m
t_a	Run-up time	s

E_k	Kinetic energy at speed	J

Method and standards

Run-up time.

Assumptions and limits

- Constant average motor torque; square-law fan torque.

References

Rotor acceleration against a square-law load

Report details

Report reference	FCC-CVYW-C6KW (the same inputs always give the same reference)
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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/mechanical/fans/fan-run-up-time

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.