Torsional Natural Frequency of a Two-Rotor Shaft

Torsional natural frequency of two rotors on a shaft (e.g. motor and pump, engine and flywheel), with the node position, from rotor inertias and shaft stiffness.

Method: Rattan; Theory of Machines; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Inertia of rotor A	5.0000	kg·m²
Inertia of rotor B	15.000	kg·m²
Shaft diameter	60.000	mm
Shaft length between rotors	1.2000	m
Shear modulus	79.300	GPa

Calculated results

Parameter	Value	Unit
Shaft torsional stiffness (torque per radian of twist)	84,081	N·m
Torsional natural frequency	23.832	Hz
Critical speed (1 per revolution)	1,429.9	rpm
Node distance from rotor A	0.90000	m

Notes for this case

- Coupling stiffness should be added in series with the shaft for real drive trains. Excitations at multiples of running speed (blade pass, firing order) also count.

Formula and method

$$k_t = \frac{G\pi d^4}{32L}, \quad \omega_n = \sqrt{k_t \frac{I_A + I_B}{I_A I_B}}, \quad L_A = L\frac{I_B}{I_A + I_B}$$

Variables

I_A	Inertia of rotor A	kg·m²
I_B	Inertia of rotor B	kg·m²
d	Shaft diameter	m
L	Shaft length between rotors	m
G	Shear modulus	Pa
k_t	Shaft torsional stiffness (torque per radian of twist)	N·m/rad
f_n	Torsional natural frequency	1/s
N_c	Critical speed (1 per revolution)	1/s
L_A	Node distance from rotor A	m

Method and standards

Two-rotor torsional model.

Assumptions and limits

- Massless uniform shaft.

References

- Rattan
- Theory of Machines

- 4th ed. (McGraw-Hill, 2014); Bhandari
- Design of Machine Elements
- 4th ed. (McGraw-Hill, 2017) (two-rotor torsional system)
- Rao
- Mechanical Vibrations
- 6th ed. (Pearson, 2017)
- ch. 6

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/mechanical/statics-dynamics/two-rotor-torsional-vibration

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.