Ball Screw Thrust, Drive Torque, Critical Speed and Buckling

Thrust from drive torque, critical (whirling) speed and buckling load of a ball or lead screw from its lead, root diameter, length and end supports.

Method: Screw thrust–torque relation; beam whirling and Euler buckling

Input parameters

Unit system: SI

Parameter	Value	Unit
Lead (travel per revolution)	10.000	mm
Screw efficiency (ball 0.9, lead screw 0.3–0.5)	90.000	%
Drive torque	2.0000	N·m
Root (minor) diameter	16.500	mm
Unsupported length	800.00	mm
End supports	Fixed – simple	
Elastic modulus	206.00	GPa
Density	7,850.0	kg/m³

Calculated results

Parameter	Value	Unit
Thrust from the torque 2πηT/l	1.1310	kN
Critical (whirling) speed	4,861.3	rpm
Euler buckling load	23.648	kN
Linear speed at 80 % of n_c	0.64817	m/s
Thrust relative to the buckling load	0.047825	

Notes for this case

- Shaft whirling of a uniform beam on the root diameter (λ = 1.875, π, 3.927, 4.730) and Euler buckling with end factors 0.25, 1, 2.05, 4. Makers apply safety factors of about 0.8 on speed and 0.5 on load.

Formula and method

$$F = \frac{2\pi\eta T}{l}, \quad n_c = \frac{\lambda^2}{2\pi L^2}\sqrt{\frac{EI}{\rho A}}, \quad P_{cr} = k\frac{\pi^2 EI}{L^2}, \quad I = \frac{\pi d_r^4}{64}$$

Variables

l	Lead (travel per revolution)	m
η	Screw efficiency (ball 0.9, lead screw 0.3–0.5)	-
T	Drive torque	N·m
d_r	Root (minor) diameter	m
L	Unsupported length	m
$\mathrm{supports}$	End supports	-
E	Elastic modulus	Pa
ρ	Density	kg/m³
F	Thrust from the torque 2πηT/l	N
n_c	Critical (whirling) speed	1/s
P_{cr}	Euler buckling load	N

v_{max}	Linear speed at 80 % of n_c	m/s
F/P_{cr}	Thrust relative to the buckling load	-

Method and standards

Screw mechanics and beam stability.

Assumptions and limits

- Uniform shaft on the root diameter, ideal supports, no nut stiffness.

References

Screw thrust–torque relation; beam whirling and Euler buckling

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/machine-design/ball-screw-thrust-critical-speed

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.