Belt Tensions and Power (Flat and V-Belt, Capstan Equation)

Tight- and slack-side tensions, centrifugal tension and power of a flat or V-belt from the allowable tension, friction, wrap angle and speed, with the speed for maximum power.

Method: Euler–Eytelwein (capstan) equation; Shigley's Mechanical Engineering Design; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Allowable belt tension	2.0000	kN
Coefficient of friction	0.30000	
Angle of wrap on the smaller pulley	165.00	°
Belt type	Flat belt	
V-groove included angle	40.000	°
Belt mass per metre	0.50000	kg/m
Belt speed	20.000	m/s

Calculated results

Parameter	Value	Unit
Tension ratio e^(μθ) (μ / sin β for a V-belt)	2.3725	
Centrifugal tension m v²	0.20000	kN
Tight-side tension T_max − T_c	1.8000	kN
Slack-side tension	0.75870	kN
Power transmitted ($T_1 - T_2$) v	20.826	kW
Speed for maximum power √(T_max / 3m)	36.515	m/s
Maximum power (at that speed)	28.165	kW

Notes for this case

- Capstan (Euler–Eytelwein) equation with centrifugal tension; belt creep and initial tension are not modelled.

Formula and method

$$\frac{T_1 - T_c}{T_2 - T_c} = e^{\mu_e \theta} \;\rightarrow\; \frac{T_1}{T_2} = e^{\mu_e \theta} \;\; (T_1 = T_{max} - T_c)$$

$$T_c = m v^2, \quad P = (T_1 - T_2)\, v, \quad \mu_e = \frac{\mu}{\sin \beta}$$

$$v_{opt} = \sqrt{\frac{T_{max}}{3m}}$$

Variables

T_{max}	Allowable belt tension	N
μ	Coefficient of friction	-
θ	Angle of wrap on the smaller pulley	rad
belt	Belt type	-
2β	V-groove included angle	rad
m	Belt mass per metre	kg/m

v	Belt speed	m/s
T_1/T_2	Tension ratio e^(μθ) (μ / sin β for a V-belt)	-
T_c	Centrifugal tension m v²	N
T_1	Tight-side tension T_max − T_c	N
T_2	Slack-side tension	N
P	Power transmitted ($T_1 - T_2$) v	W
v_{opt}	Speed for maximum power √(T_max / 3m)	m/s
P_{max}	Maximum power (at that speed)	W

Method and standards

Capstan friction equation with centrifugal tension subtracted from the allowable tension.

Assumptions and limits

- Steady drive; creep neglected.
- No service factor: P is the friction-limited capacity at the allowable tension. Divide it by the drive's service factor (from the belt maker) for the rated power.

References

- Euler–Eytelwein (capstan) equation
- Shigley's Mechanical Engineering Design
- ch. 17

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/belt-tension-power

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Reopens the calculator with the inputs of this report.