Important Design of Belt Drives Formulas PDF

Formulas
Examples
with Units

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Important Design of Belt Drives Formulas

1) Arms of Cast Iron Pulley Formulas

1.1) Bending Moment on Arm of Belt Driven Pulley Formula

Evaluate Formula

Formula

$$M_b = P \cdot R$$

Example with Units

$$44400\,\text{N*mm} = 300\,\text{N} \cdot 148\,\text{mm}$$

1.2) Bending Moment on Arm of Belt Driven Pulley given Bending Stress in Arm Formula

Evaluate Formula

Formula

$$M_b = I \cdot \frac{\sigma_b}{a}$$

Example with Units

$$44399.9963\,\text{N*mm} = 17350\,\text{mm}^4 \cdot \frac{34.957\,\text{N/mm}^2}{13.66\,\text{mm}}$$

1.3) Bending Moment on Arm of Belt Driven Pulley given Torque Transmitted by Pulley Formula

Evaluate Formula

Formula

$$M_b = 2 \cdot \frac{M_t}{N_{pu}}$$

Example with Units

$$44400\,\text{N*mm} = 2 \cdot \frac{88800\,\text{N*mm}}{4}$$

1.4) Bending Stress in Arm of Belt Driven Pulley Formula

Evaluate Formula

Formula

$$\sigma_b = M_b \cdot \frac{a}{I}$$

Example with Units

$$34.957\,\text{N/mm}^2 = 44400\,\text{N*mm} \cdot \frac{13.66\,\text{mm}}{17350\,\text{mm}^4}$$

1.5) Bending Stress in Arm of Belt Driven Pulley given Torque Transmitted by Pulley Formula

Evaluate Formula

Formula

$$\sigma_b = 16 \cdot \frac{M_t}{\pi \cdot N_{pu} \cdot a^3}$$

Example with Units

$$44.3579\,\text{N/mm}^2 = 16 \cdot \frac{88800\,\text{N*mm}}{3.1416 \cdot 4 \cdot 13.66\,\text{mm}^3}$$

1.6) Major Axis of Elliptical Cross-Section of Pulley's Arm given Moment of Inertia of Arm Formula

Evaluate Formula

Formula

$$b_a = \left(64 \cdot \frac{I}{\pi \cdot a}\right)^{\frac{1}{3}}$$

Example with Units

$$29.5774\,\text{mm} = \left(64 \cdot \frac{17350\,\text{mm}^4}{3.1416 \cdot 13.66\,\text{mm}}\right)^{\frac{1}{3}}$$

1.7) Minor Axis of Elliptical Cross-Section of Arm given Moment of Inertia of Arm Formula

Evaluate Formula

Formula

$$a = 64 \cdot \frac{I}{\pi \cdot b_a^{3}}$$

Example with Units

$$13.6287\,\text{mm} = 64 \cdot \frac{17350\,\text{mm}^4}{3.1416 \cdot 29.6\,\text{mm}^{3}}$$

1.8) Minor Axis of Elliptical Cross-Section of Pulley's Arm given Bending Stress in Arm Formula

Evaluate Formula

Formula

$$a = 1.72 \cdot \left(\frac{M_b}{2 \cdot \sigma_b}\right)^{\frac{1}{3}}$$

Example with Units

$$14.7843\,\text{mm} = 1.72 \cdot \left(\frac{44400\,\text{N*mm}}{2 \cdot 34.957\,\text{N/mm}^2}\right)^{\frac{1}{3}}$$

1.9) Minor Axis of Elliptical Cross-Section of Pulley's Arm given Moment of Inertia of Arm Formula

Evaluate Formula

Formula

$$a = \left(8 \cdot \frac{I}{\pi}\right)^{\frac{1}{4}}$$

Example with Units

$$14.4981\,\text{mm} = \left(8 \cdot \frac{17350\,\text{mm}^4}{3.1416}\right)^{\frac{1}{4}}$$

1.10) Minor Axis of Elliptical Cross-Section of Pulley's Arm given Torque and Bending Stress Formula

Evaluate Formula

Formula

$$a = \left(16 \cdot \frac{M_t}{\pi \cdot N_{pu} \cdot \sigma_b}\right)^{\frac{1}{3}}$$

Example with Units

$$14.7887\,\text{mm} = \left(16 \cdot \frac{88800\,\text{N*mm}}{3.1416 \cdot 4 \cdot 34.957\,\text{N/mm}^2}\right)^{\frac{1}{3}}$$

1.11) Moment of Inertia of Pulley's Arm Formula

Evaluate Formula

Formula

$$I = \frac{\pi \cdot a \cdot b_a^{3}}{64}$$

Example with Units

$$17389.8458\,\text{mm}^4 = \frac{3.1416 \cdot 13.66\,\text{mm} \cdot 29.6\,\text{mm}^{3}}{64}$$

1.12) Moment of Inertia of Pulley's Arm given Bending Stress in Arm Formula

Evaluate Formula

Formula

$$I = M_b \cdot \frac{a}{\sigma_b}$$

Example with Units

$$17350.0014\,\text{mm}^4 = 44400\,\text{N*mm} \cdot \frac{13.66\,\text{mm}}{34.957\,\text{N/mm}^2}$$

1.13) Moment of Inertia of Pulley's Arm given Minor Axis of Elliptical Section Arm Formula

Evaluate Formula

Formula

$$I = \pi \cdot \frac{a}{8}^4$$

Example with Units

$$13672.9644\,\text{mm}^4 = 3.1416 \cdot \frac{13.66\,\text{mm}}{8}^4$$

1.14) Number of Arms of Pulley given Bending Moment on Arm Formula

Evaluate Formula

Formula

$$N_{pu} = 2 \cdot \frac{M_t}{M_b}$$

Example with Units

$$4 = 2 \cdot \frac{88800\,\text{N*mm}}{44400\,\text{N*mm}}$$

1.15) Number of Arms of Pulley given Bending Stress in Arm Formula

Evaluate Formula

Formula

$$N_{pu} = 16 \cdot \frac{M_t}{\pi \cdot \sigma_b \cdot a^3}$$

Example with Units

$$5.0757 = 16 \cdot \frac{88800\,\text{N*mm}}{3.1416 \cdot 34.957\,\text{N/mm}^2 \cdot 13.66\,\text{mm}^3}$$

1.16) Number of Arms of Pulley given Torque Transmitted by Pulley Formula

Evaluate Formula

Formula

$$N_{pu} = 2 \cdot \frac{M_t}{P \cdot R}$$

Example with Units

$$4 = 2 \cdot \frac{88800\,\text{N*mm}}{300\,\text{N} \cdot 148\,\text{mm}}$$

1.17) Radius of Rim of Pulley given Bending Moment Acting on Arm Formula

Evaluate Formula

Formula

$$R = \frac{M_b}{P}$$

Example with Units

$$148\,\text{mm} = \frac{44400\,\text{N*mm}}{300\,\text{N}}$$

1.18) Radius of Rim of Pulley given Torque Transmitted by Pulley Formula

Evaluate Formula

Formula

$$R = \frac{M_t}{P \cdot \left(\frac{N_{pu}}{2}\right)}$$

Example with Units

$$148\,\text{mm} = \frac{88800\,\text{N*mm}}{300\,\text{N} \cdot \left(\frac{4}{2}\right)}$$

1.19) Tangential Force at End of Each Arm of Pulley given Bending Moment on Arm Formula

Evaluate Formula

Formula

$$P = \frac{M_b}{R}$$

Example with Units

$$300\,\mathrm{N} = \frac{44400\,\mathrm{N{*}mm}}{148\,\mathrm{mm}}$$

1.20) Tangential Force at End of Each Arm of Pulley given Torque Transmitted by Pulley Formula

Evaluate Formula

Formula

$$P = \frac{M_t}{R \cdot \left(\frac{N_{pu}}{2}\right)}$$

Example with Units

$$300\,\mathrm{N} = \frac{88800\,\mathrm{N{*}mm}}{148\,\mathrm{mm} \cdot \left(\frac{4}{2}\right)}$$

1.21) Torque Transmitted by Pulley Formula

Evaluate Formula

Formula

$$M_t = P \cdot R \cdot \left(\frac{N_{pu}}{2}\right)$$

Example with Units

$$88800\,\mathrm{N{*}mm} = 300\,\mathrm{N} \cdot 148\,\mathrm{mm} \cdot \left(\frac{4}{2}\right)$$

1.22) Torque Transmitted by Pulley given Bending Moment on Arm Formula

Evaluate Formula

Formula

$$M_t = M_b \cdot \frac{N_{pu}}{2}$$

Example with Units

$$88800\,\mathrm{N{*}mm} = 44400\,\mathrm{N{*}mm} \cdot \frac{4}{2}$$

1.23) Torque Transmitted by Pulley given Bending Stress in Arm Formula

Evaluate Formula

Formula

$$M_t = \sigma_b \cdot \frac{\pi \cdot N_{pu} \cdot a^3}{16}$$

Example with Units

$$69980.3538\,\mathrm{N{*}mm} = 34.957\,\mathrm{N/mm^2} \cdot \frac{3.1416 \cdot 4 \cdot 13.66\,\mathrm{mm}^3}{16}$$

2) Crossed Belt Drives Formulas

2.1) Belt Length for Cross Belt Drive Formula

Evaluate Formula

Formula

$$L = 2 \cdot C + \left(\pi \cdot \frac{d + D}{2}\right) + \left(\frac{(D - d)^2}{4 \cdot C}\right)$$

Example with Units

$$4892.7457\,\mathrm{mm} = 2 \cdot 1575\,\mathrm{mm} + \left(3.1416 \cdot \frac{270\,\mathrm{mm} + 810\,\mathrm{mm}}{2}\right) + \left(\frac{(810\,\mathrm{mm} - 270\,\mathrm{mm})^2}{4 \cdot 1575\,\mathrm{mm}}\right)$$

2.2) Center Distance given Wrap Angle for Small Pulley of Cross Belt Drive Formula

Evaluate Formula

Formula

$$C = \frac{D + d}{2 \cdot \sin\left(\frac{\alpha_a - 3.14}{2}\right)}$$

Example with Units

$$1575.4081\,\text{mm} = \frac{810\,\text{mm} + 270\,\text{mm}}{2 \cdot \sin\left(\frac{220^\circ - 3.14}{2}\right)}$$

2.3) Diameter of Big Pulley given Wrap Angle for Small Pulley of Cross Belt Drive Formula

Evaluate Formula

Formula

$$D = 2 \cdot \sin\left(\frac{\alpha_a - 3.14}{2}\right) \cdot C - d$$

Example with Units

$$809.7203\,\text{mm} = 2 \cdot \sin\left(\frac{220^\circ - 3.14}{2}\right) \cdot 1575\,\text{mm} - 270\,\text{mm}$$

2.4) Diameter of Small Pulley given Wrap Angle for Small Pulley of Cross Belt Drive Formula

Evaluate Formula

Formula

$$d = 2 \cdot C \cdot \sin\left(\frac{\alpha_a - 3.14}{2}\right) - D$$

Example with Units

$$269.7203\,\text{mm} = 2 \cdot 1575\,\text{mm} \cdot \sin\left(\frac{220^\circ - 3.14}{2}\right) - 810\,\text{mm}$$

2.5) Wrap Angle for Small Pulley of Cross Belt Drive Formula

Evaluate Formula

Formula

$$\alpha_a = 3.14 + 2 \cdot asin\left(\frac{D + d}{2 \cdot C}\right)$$

Example with Units

$$220.0108^\circ = 3.14 + 2 \cdot asin\left(\frac{810\,\text{mm} + 270\,\text{mm}}{2 \cdot 1575\,\text{mm}}\right)$$

3) Introduction of Belt Drives Formulas

3.1) Angle of Wrap given Belt Tension in Tight Side Formula

Evaluate Formula

Formula

$$\alpha = \frac{\ln\left(\frac{P_1 - m \cdot v_b^2}{P_2 - m \cdot v_b^2}\right)}{\mu}$$

Example with Units

$$160.3553^\circ = \frac{\ln\left(\frac{800\,\text{N} - 0.6\,\text{kg/m} \cdot 25.81\,\text{m/s}^2}{550\,\text{N} - 0.6\,\text{kg/m} \cdot 25.81\,\text{m/s}^2}\right)}{0.35}$$

3.2) Belt Tension in Loose Side of Belt given Tension in Tight Side Formula

Evaluate Formula

Formula

$$P_2 = \left(\frac{P_1 - m \cdot v_b^{\ 2}}{e^{\mu \cdot \alpha}}\right) + m \cdot v_b^{\ 2}$$

Example with Units

$$550.1426\,\text{N} = \left(\frac{800\,\text{N} - 0.6\,\text{kg/m} \cdot 25.81\,\text{m/s}^{\ 2}}{e^{0.35 \cdot 160.2^\circ}}\right) + 0.6\,\text{kg/m} \cdot 25.81\,\text{m/s}^{\ 2}$$

3.3) Belt Tension in Tight Side Formula

Evaluate Formula

Formula

$$P_1 = e^{\mu \cdot \alpha} \cdot \left(P_2 - m \cdot v_b^{\ 2}\right) + m \cdot v_b^{\ 2}$$

Example with Units

$$799.6205\,\text{N} = e^{0.35 \cdot 160.2^\circ} \cdot \left(550\,\text{N} - 0.6\,\text{kg/m} \cdot 25.81\,\text{m/s}^{\ 2}\right) + 0.6\,\text{kg/m} \cdot 25.81\,\text{m/s}^{\ 2}$$

3.4) Center Distance from Small Pulley to Big Pulley given Wrap Angle of Big Pulley Formula

Evaluate Formula

Formula

$$C = \frac{D - d}{2 \cdot \sin\left(\frac{\alpha_b - 3.14}{2}\right)}$$

Example with Units

$$1547.878\,\text{mm} = \frac{810\,\text{mm} - 270\,\text{mm}}{2 \cdot \sin\left(\frac{200^\circ - 3.14}{2}\right)}$$

3.5) Center Distance from Small Pulley to Big Pulley given Wrap Angle of Small Pulley Formula

Evaluate Formula

Formula

$$C = \frac{D - d}{2 \cdot \sin\left(\frac{3.14 - \alpha_s}{2}\right)}$$

Example with Units

$$1615.7782\,\text{mm} = \frac{810\,\text{mm} - 270\,\text{mm}}{2 \cdot \sin\left(\frac{3.14 - 160.67^\circ}{2}\right)}$$

3.6) Coefficient of Friction in between Surfaces given Belt Tension in Tight Side Formula

Evaluate Formula

Formula

$$\mu = \frac{\ln\left(\frac{P_1 - m \cdot v_b^{\ 2}}{P_2 - m \cdot v_b^{\ 2}}\right)}{\alpha}$$

Example with Units

$$0.3503 = \frac{\ln\left(\frac{800\,\text{N} - 0.6\,\text{kg/m} \cdot 25.81\,\text{m/s}^{\ 2}}{550\,\text{N} - 0.6\,\text{kg/m} \cdot 25.81\,\text{m/s}^{\ 2}}\right)}{160.2^\circ}$$

3.7) Diameter of Big Pulley given Wrap Angle for Big Pulley Formula

Evaluate Formula

Formula

$$D = d + 2 \cdot C \cdot \sin\left(\frac{\alpha_b - 3.14}{2}\right)$$

Example with Units

$$819.4619\,\text{mm} = 270\,\text{mm} + 2 \cdot 1575\,\text{mm} \cdot \sin\left(\frac{200° - 3.14}{2}\right)$$

3.8) Diameter of Big Pulley given Wrap Angle of Small Pulley Formula

Evaluate Formula

Formula

$$D = d + 2 \cdot C \cdot \sin\left(\frac{3.14 - \alpha_s}{2}\right)$$

Example with Units

$$796.3717\,\text{mm} = 270\,\text{mm} + 2 \cdot 1575\,\text{mm} \cdot \sin\left(\frac{3.14 - 160.67°}{2}\right)$$

3.9) Diameter of Small Pulley given Wrap Angle of Big Pulley Formula

Evaluate Formula

Formula

$$d = D - \left(2 \cdot C \cdot \frac{\sin(\alpha_b - 3.14)}{2}\right)$$

Example with Units

$$268.9618\,\text{mm} = 810\,\text{mm} - \left(2 \cdot 1575\,\text{mm} \cdot \frac{\sin(200° - 3.14)}{2}\right)$$

3.10) Diameter of Small Pulley given Wrap Angle of Small Pulley Formula

Evaluate Formula

Formula

$$d = D - 2 \cdot C \cdot \sin\left(\frac{3.14 - \alpha_s}{2}\right)$$

Example with Units

$$283.6283\,\text{mm} = 810\,\text{mm} - 2 \cdot 1575\,\text{mm} \cdot \sin\left(\frac{3.14 - 160.67°}{2}\right)$$

3.11) Length of Belt Formula

Evaluate Formula

Formula

$$L = 2 \cdot C + \left(\pi \cdot \frac{D + d}{2} \right) + \left(\frac{(D - d)^2}{4 \cdot C} \right)$$

Example with Units

$$4892.7457\,\text{mm} = 2 \cdot 1575\,\text{mm} + \left(3.1416 \cdot \frac{810\,\text{mm} + 270\,\text{mm}}{2} \right) + \left(\frac{(810\,\text{mm} - 270\,\text{mm})^2}{4 \cdot 1575\,\text{mm}} \right)$$

3.12) Mass per unit length of belt Formula

Evaluate Formula

Formula

$$m = \frac{P_1 - e^{\mu \cdot \alpha} \cdot P_2}{v_b^2 \cdot \left(1 - e^{\mu \cdot \alpha}\right)}$$

Example with Units

$$0.5997\,\text{kg/m} = \frac{800\,\text{N} - e^{0.35 \cdot 160.2^\circ} \cdot 550\,\text{N}}{25.81\,\text{m/s}^2 \cdot \left(1 - e^{0.35 \cdot 160.2^\circ}\right)}$$

3.13) Velocity of Belt given Tension of Belt in Tight Side Formula

Evaluate Formula

Formula

$$v_b = \sqrt{\frac{e^{\mu \cdot \alpha} \cdot P_2 - P_1}{m \cdot \left(e^{\mu \cdot \alpha} - 1\right)}}$$

Example with Units

$$25.8026\,\text{m/s} = \sqrt{\frac{e^{0.35 \cdot 160.2^\circ} \cdot 550\,\text{N} - 800\,\text{N}}{0.6\,\text{kg/m} \cdot \left(e^{0.35 \cdot 160.2^\circ} - 1\right)}}$$

3.14) Wrap Angle for Big Pulley Formula

Evaluate Formula

Formula

$$\alpha_b = 3.14 + 2 \cdot asin\left(\frac{D - d}{2 \cdot C}\right)$$

Example with Units

$$199.6505^\circ = 3.14 + 2 \cdot asin\left(\frac{810\,\text{mm} - 270\,\text{mm}}{2 \cdot 1575\,\text{mm}}\right)$$

3.15) Wrap Angle for Small Pulley Formula

Evaluate Formula

Formula

$$\alpha_s = 3.14 - 2 \cdot asin\left(\frac{D - d}{2 \cdot C}\right)$$

Example with Units

$$160.167^\circ = 3.14 - 2 \cdot asin\left(\frac{810\,\text{mm} - 270\,\text{mm}}{2 \cdot 1575\,\text{mm}}\right)$$

4) Maximum Power Conditions Formulas

4.1) Actual Power Transmitted given Power Transmitted by Flat for Design Purpose Formula

Evaluate Formula

Formula

$$P_t = \frac{P_d}{F_a}$$

Example with Units

$$6.4435\,\text{kW} = \frac{7.41\,\text{kW}}{1.15}$$

4.2) Belt Tension in Loose Side of Belt given Initial Tension in Belt Formula

Evaluate Formula

Formula

$$P_2 = 2 \cdot P_i - P_1$$

Example with Units

$$550\,\text{N} = 2 \cdot 675\,\text{N} - 800\,\text{N}$$

4.3) Belt Tension in Tight Side of Belt given Initial Tension in Belt Formula

Evaluate Formula

Formula

$$P_1 = 2 \cdot P_i - P_2$$

Example with Units

$$800\,\text{N} = 2 \cdot 675\,\text{N} - 550\,\text{N}$$

4.4) Belt Tension in Tight Side of Belt given Tension due to Centrifugal Force Formula

Evaluate Formula

Formula

$$P_1 = 2 \cdot T_b$$

Example with Units

$$800\,\text{N} = 2 \cdot 400\,\text{N}$$

4.5) Belt Velocity given Tension in Belt Due to Centrifugal Force Formula

Evaluate Formula

Formula

$$v_b = \sqrt{\frac{T_b}{m}}$$

Example with Units

$$25.8199\,\text{m/s} = \sqrt{\frac{400\,\text{N}}{0.6\,\text{kg/m}}}$$

4.6) Initial Tension in Belt Drive Formula

Evaluate Formula

Formula

$$P_i = \frac{P_1 + P_2}{2}$$

Example with Units

$$675\,\text{N} = \frac{800\,\text{N} + 550\,\text{N}}{2}$$

4.7) Initial Tension in Belt given Velocity of Belt for Maximum Power Transmission Formula

Evaluate Formula

Formula

$$P_i = 3 \cdot m \cdot {v_o}^2$$

Example with Units

$$696.436\,\text{N} = 3 \cdot 0.6\,\text{kg/m} \cdot {19.67\,\text{m/s}}^2$$

4.8) Load Correction Factor given Power Transmitted by Flat Belt for Design Purpose Formula

Evaluate Formula

Formula

$$F_a = \frac{P_d}{P_t}$$

Example with Units

$$1.1488 = \frac{7.41\,\text{kW}}{6.45\,\text{kW}}$$

4.9) Mass of One Meter Length of Belt given Maximum Permissible Tensile Stress of Belt Formula

Evaluate Formula

Formula

$$m' = \frac{P_{max}}{3 \cdot {v_o}^2}$$

Example with Units

$$1.0338\,\text{kg/m} = \frac{1200\,\text{N}}{3 \cdot {19.67\,\text{m/s}}^2}$$

4.10) Mass of One Meter Length of Belt given Tension in Belt Due to Centrifugal Force Formula

Evaluate Formula

Formula	Example with Units
$m = \frac{T_b}{v_b^2}$	$0.6005\,\text{kg/m} = \frac{400\,\text{N}}{25.81\,\text{m/s}^2}$

4.11) Mass of One Meter Length of Belt given Velocity for Maximum Power Transmission Formula

Evaluate Formula

Formula	Example with Units
$m' = \frac{P_i}{3} \cdot {v'_o}^2$	$1.0712\,\text{kg/m} = \frac{675\,\text{N}}{3} \cdot 0.069\,\text{m/s}^2$

4.12) Maximum Belt Tension Formula

Evaluate Formula

Formula	Example with Units
$P_{max} = \sigma \cdot b \cdot t$	$793.8\,\text{N} = 1.26\,\text{N/mm}^2 \cdot 126\,\text{mm} \cdot 5\,\text{mm}$

4.13) Maximum Belt Tension given Tension Due to Centrifugal Force Formula

Evaluate Formula

Formula	Example with Units
$P_{max} = 3 \cdot T_b$	$1200\,\text{N} = 3 \cdot 400\,\text{N}$

4.14) Maximum Permissible Tensile Stress of Belt Material Formula

Evaluate Formula

Formula	Example with Units
$\sigma = \frac{P_{max}}{b \cdot t}$	$1.9048\,\text{N/mm}^2 = \frac{1200\,\text{N}}{126\,\text{mm} \cdot 5\,\text{mm}}$

4.15) Optimum Velocity of Belt for Maximum Power Transmission Formula

Evaluate Formula

Formula	Example with Units
$v_o = \sqrt{\frac{P_i}{3 \cdot m}}$	$19.3649\,\text{m/s} = \sqrt{\frac{675\,\text{N}}{3 \cdot 0.6\,\text{kg/m}}}$

4.16) Power Transmitted by Flat Belt for Design Purpose Formula

Evaluate Formula

Formula	Example with Units
$P_d = P_t \cdot F_a$	$7.4175\,\text{kW} = 6.45\,\text{kW} \cdot 1.15$

4.17) Tension in Belt Due to Centrifugal Force Formula

Evaluate Formula

Formula	Example with Units
$T_b = m \cdot v_b^2$	$399.6937\,\text{N} = 0.6\,\text{kg/m} \cdot 25.81\,\text{m/s}^2$

4.18) Tension in Belt Due to Centrifugal Force given Permissible Tensile Stress of Belt Material Formula

Evaluate Formula

Formula	Example with Units
$T_b = \frac{P_{max}}{3}$	$400\,\text{N} = \frac{1200\,\text{N}}{3}$

4.19) Thickness of Belt given Maximum Belt Tension Formula

Evaluate Formula

Formula	Example with Units
$t = \frac{P_{max}}{\sigma \cdot b}$	$7.5586\,\text{mm} = \frac{1200\,\text{N}}{1.26\,\text{N/mm}^2 \cdot 126\,\text{mm}}$

4.20) Velocity of Belt for Maximum Power Transmission given Maximum Permissible Tensile Stress Formula

Evaluate Formula

Formula	Example with Units
$v_o = \sqrt{\frac{P_{max}}{3} \cdot m}$	$15.4919\,\text{m/s} = \sqrt{\frac{1200\,\text{N}}{3} \cdot 0.6\,\text{kg/m}}$

4.21) Width of Belt given Maximum Belt Tension Formula

Evaluate Formula

Formula	Example with Units
$b = \frac{P_{max}}{\sigma \cdot t}$	$190.4762\,\text{mm} = \frac{1200\,\text{N}}{1.26\,\text{N/mm}^2 \cdot 5\,\text{mm}}$

5) Synchronous Belt Drives Formulas

5.1) Datum Length of Synchronous Belt Formula

Evaluate Formula

Formula	Example with Units
$l = P_c \cdot z$	$1200\,\text{mm} = 15\,\text{mm} \cdot 80$

5.2) Distance from Belt Pitch Line to Pulley Tip Circle Radius Formula

Evaluate Formula

Formula	Example with Units
$a_p = \left(\frac{d'}{2}\right) - \left(\frac{d_o}{2}\right)$	$8\,\text{mm} = \left(\frac{170\,\text{mm}}{2}\right) - \left(\frac{154\,\text{mm}}{2}\right)$

5.3) Number of Teeth in Belt given Datum Length of Synchronous Belt Formula

Evaluate Formula

Formula	Example with Units
$z = \frac{l}{P_c}$	$80 = \frac{1200.0\,\text{mm}}{15\,\text{mm}}$

5.4) Number of Teeth in Larger Pulley given Transmission Ratio of Synchronous Belt Drive Formula

Evaluate Formula

Formula

$$T_2 = T_1 \cdot i$$

Example

$$60 = 20 \cdot 3$$

5.5) Number of Teeth in Smaller Pulley given Transmission Ratio of Synchronous Belt Drive Formula

Evaluate Formula

Formula

$$T_1 = \frac{T_2}{i}$$

Example

$$20 = \frac{60}{3}$$

5.6) Pitch Diameter of Larger Pulley given Transmission Ratio of Synchronous Belt Drive Formula

Evaluate Formula

Formula

$$d'2 = d'1 \cdot i$$

Example with Units

$$762\,\text{mm} = 254\,\text{mm} \cdot 3$$

5.7) Pitch Diameter of Smaller Pulley given Transmission Ratio of Synchronous Belt Drive Formula

Evaluate Formula

Formula

$$d'1 = \frac{d'2}{i}$$

Example with Units

$$254\,\text{mm} = \frac{762\,\text{mm}}{3}$$

5.8) Pitch given Datum Length of Synchronous Belt Formula

Evaluate Formula

Formula

$$P_c = \frac{l}{z}$$

Example with Units

$$15\,\text{mm} = \frac{1200.0\,\text{mm}}{80}$$

5.9) Power Transmitted by Synchronous Belt Formula

Evaluate Formula

Formula

$$P_t = \frac{P_s}{C_s}$$

Example with Units

$$6.4462\,\text{kW} = \frac{8.38\,\text{kW}}{1.3}$$

5.10) Pulley Outside Diameter given Distance between Belt Pitch Line and Pulley Tip Circle Radius Formula

Evaluate Formula

Formula

$$d_o = d' - (2 \cdot a_p)$$

Example with Units

$$154\,\text{mm} = 170\,\text{mm} - (2 \cdot 8\,\text{mm})$$

5.11) Pulley Pitch Diameter given Distance between Belt Pitch Line and Pulley Tip Circle Radius Formula

Evaluate Formula

Formula	Example with Units
$d' = \left(2 \cdot a_p\right) + d_o$	$170\,\text{mm} = \left(2 \cdot 8\,\text{mm}\right) + 154\,\text{mm}$

5.12) Service Correction Factor given Power transmitted by Synchronous Belt Formula

Evaluate Formula

Formula	Example with Units
$C_s = \frac{P_s}{P_t}$	$1.2992 = \frac{8.38\,\text{kW}}{6.45\,\text{kW}}$

5.13) Speed of Larger Pulley given Transmission Ratio of Synchronous Belt Drive Formula

Evaluate Formula

Formula	Example with Units
$n_2 = \frac{n_1}{i}$	$213.3333\,\text{rev/min} = \frac{640\,\text{rev/min}}{3}$

5.14) Speed of Smaller Pulley given Transmission Ratio of Synchronous Belt Drive Formula

Evaluate Formula

Formula	Example with Units
$n_1 = n_2 \cdot i$	$5760\,\text{rev/min} = 1920\,\text{rev/min} \cdot 3$

5.15) Standard Capacity of selected Belt given Power transmitted by Synchronous Belt Formula

Evaluate Formula

Formula	Example with Units
$P_s = P_t \cdot C_s$	$8.385\,\text{kW} = 6.45\,\text{kW} \cdot 1.3$

5.16) Transmission Ratio of Synchronous Belt Drive given no. of Teeth in Smaller and Larger Pulley Formula

Evaluate Formula

Formula	Example
$i = \frac{T_2}{T_1}$	$3 = \frac{60}{20}$

5.17) Transmission Ratio of Synchronous Belt drive given Pitch Diameter of Smaller and Larger Pulley Formula

Evaluate Formula

Formula	Example with Units
$i = \frac{d'2}{d'1}$	$3 = \frac{762\,\text{mm}}{254\,\text{mm}}$

5.18) Transmission Ratio of Synchronous Belt Drive given Speed of Smaller and Larger Pulley Formula

Evaluate Formula

Formula	Example with Units
$i = \frac{n_1}{n_2}$	$0.3333 = \frac{640\,\text{rev/min}}{1920\,\text{rev/min}}$

6) V Belt Drives Formulas

6.1) Power Transmission Formulas

6.1.1) Belt Tension in Loose Side of V-Belt given Power Transmitted Formula

Evaluate Formula

Formula	Example with Units
$P_2 = P_1 - \frac{P_t}{v_b}$	$550.0969\,\text{N} = 800\,\text{N} - \frac{6.45\,\text{kW}}{25.81\,\text{m/s}}$

6.1.2) Belt Tension in Tight Side of Belt given Power Transmitted using V-Belt Formula

Evaluate Formula

Formula	Example with Units
$P_1 = \frac{P_t}{v_b} + P_2$	$799.9031\,\text{N} = \frac{6.45\,\text{kW}}{25.81\,\text{m/s}} + 550\,\text{N}$

6.1.3) Belt Velocity given Power Transmitted using V-Belt Formula

Evaluate Formula

Formula	Example with Units
$v_b = \frac{P_t}{P_1 - P_2}$	$25.8\,\text{m/s} = \frac{6.45\,\text{kW}}{800\,\text{N} - 550\,\text{N}}$

6.1.4) Drive Power to be Transmitted given Number of Belts Required Formula

Evaluate Formula

Formula	Example with Units
$P_t = N \cdot \frac{F_{c}r \cdot F_{d}r \cdot P_r}{F_{a}r}$	$6.4473\,\text{kW} = 2 \cdot \frac{1.08 \cdot 0.94 \cdot 4.128\,\text{kW}}{1.30}$

6.1.5) Power Rating of Single V-Belt given Number of Belts Required Formula

Evaluate Formula

Formula	Example with Units
$P_r = P_t \cdot \frac{F_{a}r}{F_{c}r \cdot F_{d}r \cdot N}$	$4.1297\,\text{kW} = 6.45\,\text{kW} \cdot \frac{1.30}{1.08 \cdot 0.94 \cdot 2}$

6.1.6) Power Transmitted using V Belt Formula

Evaluate Formula

Formula	Example with Units
$P_t = \left(P_1 - P_2\right) \cdot v_b$	$6.4525\,\text{kW} = \left(800\,\text{N} - 550\,\text{N}\right) \cdot 25.81\,\text{m/s}$

6.2) Selection of V Belts Formulas

6.2.1) Correction Factor for Industrial Service given Design Power Formula

Evaluate Formula

Formula	Example with Units
$F_ar = \frac{P_d}{P_t}$	$1.1488 = \frac{7.41\,\text{kW}}{6.45\,\text{kW}}$

6.2.2) Design Power for V Belt Formula

Evaluate Formula

Formula	Example with Units
$P_d = F_ar \cdot P_t$	$8.385\,\text{kW} = 1.30 \cdot 6.45\,\text{kW}$

6.2.3) Pitch diameter of big pulley of V Belt drive Formula

Evaluate Formula

Formula	Example with Units
$D = d \cdot \left(\frac{n_1}{n_2}\right)$	$90\,\text{mm} = 270\,\text{mm} \cdot \left(\frac{640\,\text{rev/min}}{1920\,\text{rev/min}}\right)$

6.2.4) Pitch diameter of smaller pulley given pitch diameter of big pulley Formula

Evaluate Formula

Formula	Example with Units
$d = D \cdot \left(\frac{n_2}{n_1}\right)$	$2430\,\text{mm} = 810\,\text{mm} \cdot \left(\frac{1920\,\text{rev/min}}{640\,\text{rev/min}}\right)$

6.2.5) Speed of bigger pulley given speed of smaller pulley Formula

Evaluate Formula

Formula	Example with Units
$n_2 = d \cdot \left(\frac{n_1}{D}\right)$	$213.3333\,\text{rev/min} = 270\,\text{mm} \cdot \left(\frac{640\,\text{rev/min}}{810\,\text{mm}}\right)$

6.2.6) Speed of smaller pulley given pitch diameter of both pulleys Formula

Evaluate Formula

Formula	Example with Units
$n_1 = D \cdot \frac{n_2}{d}$	$5760\,\text{rev/min} = 810\,\text{mm} \cdot \frac{1920\,\text{rev/min}}{270\,\text{mm}}$

6.2.7) Transmitted Power given Design Power Formula

Evaluate Formula

Formula	Example with Units
$P_t = \frac{P_d}{F_ar}$	$5.7\,\text{kW} = \frac{7.41\,\text{kW}}{1.30}$

6.3) V Belt Characteristics and Parameters Formulas

6.3.1) Angle of Wrap of V-Belt given Belt Tension in Loose Side of Belt Formula

Evaluate Formula

Formula

$$\alpha = \sin\left(\frac{\theta}{2}\right) \cdot \frac{\ln\left(\frac{P_1 - m_v \cdot {v_b}^2}{P_2 - m_v \cdot {v_b}^2}\right)}{\mu}$$

Example with Units

$$160.5987° = \sin\left(\frac{62°}{2}\right) \cdot \frac{\ln\left(\frac{800\,\text{N} - 0.76\,\text{kg/m} \cdot 25.81\,\text{m/s}^2}{550\,\text{N} - 0.76\,\text{kg/m} \cdot 25.81\,\text{m/s}^2}\right)}{0.35}$$

6.3.2) Belt Tension in Loose Side of V-Belt Formula

Evaluate Formula

Formula

$$P_2 = \frac{P_1 - m_v \cdot {v_b}^2}{e^{\mu} \cdot \frac{\alpha}{\sin\left(\frac{\theta}{2}\right)}} + m_v \cdot {v_b}^2$$

Example with Units

$$544.4056\,\text{N} = \frac{800\,\text{N} - 0.76\,\text{kg/m} \cdot 25.81\,\text{m/s}^2}{e^{0.35} \cdot \frac{160.2°}{\sin\left(\frac{62°}{2}\right)}} + 0.76\,\text{kg/m} \cdot 25.81\,\text{m/s}^2$$

6.3.3) Belt Tension in Tight Side of V-Belt Formula

Evaluate Formula

Formula

$$P_1 = \left(e^{\mu} \cdot \frac{\alpha}{\sin\left(\frac{\theta}{2}\right)}\right) \cdot \left(P_2 - m_v \cdot {v_b}^2\right) + m_v \cdot {v_b}^2$$

Example with Units

$$843.0982\,\text{N} = \left(e^{0.35} \cdot \frac{160.2°}{\sin\left(\frac{62°}{2}\right)}\right) \cdot \left(550\,\text{N} - 0.76\,\text{kg/m} \cdot 25.81\,\text{m/s}^2\right) + 0.76\,\text{kg/m} \cdot 25.81\,\text{m/s}^2$$

6.3.4) Belt Velocity of V-Belt given Belt Tension in Loose Side Formula

Evaluate Formula

Formula

$$v_b = \sqrt{\frac{P_1 - \left(e^{\mu \cdot \frac{\alpha}{\sin\left(\frac{\theta}{2}\right)}}\right) \cdot P_2}{m_v \cdot \left(1 - \left(e^{\mu \cdot \frac{\alpha}{\sin\left(\frac{\theta}{2}\right)}}\right)\right)}}$$

Example with Units

$$25.8038\,\text{m/s} = \sqrt{\frac{800\,\text{N} - \left(e^{0.35 \cdot \frac{160.2^\circ}{\sin\left(\frac{62^\circ}{2}\right)}}\right) \cdot 550\,\text{N}}{0.76\,\text{kg/m} \cdot \left(1 - \left(e^{0.35 \cdot \frac{160.2^\circ}{\sin\left(\frac{62^\circ}{2}\right)}}\right)\right)}}$$

6.3.5) Coefficient of Friction in V-Belt given Belt Tension in Loose Side of Belt Formula

Evaluate Formula

Formula

$$\mu = \sin\left(\frac{\theta}{2}\right) \cdot \frac{\ln\left(\frac{P_1 - m_v \cdot v_b^2}{P_2 - m_v \cdot v_b^2}\right)}{\alpha}$$

Example with Units

$$0.3509 = \sin\left(\frac{62^\circ}{2}\right) \cdot \frac{\ln\left(\frac{800\,\text{N} - 0.76\,\text{kg/m} \cdot 25.81\,\text{m/s}^2}{550\,\text{N} - 0.76\,\text{kg/m} \cdot 25.81\,\text{m/s}^2}\right)}{160.2^\circ}$$

6.3.6) Correcting Factor for Belt Length given Number of Belts Required Formula

Evaluate Formula

Formula

$$F_c r = P_t \cdot \frac{F_a r}{N \cdot F_d r \cdot P_r}$$

Example with Units

$$1.0805 = 6.45\,\text{kW} \cdot \frac{1.30}{2 \cdot 0.94 \cdot 4.128\,\text{kW}}$$

6.3.7) Correction Factor for Arc of Contact given Number of Belts Required Formula

Evaluate Formula

Formula

$$F_d r = P_t \cdot \frac{F_a r}{F_c r \cdot N \cdot P_r}$$

Example with Units

$$0.9404 = 6.45\,\text{kW} \cdot \frac{1.30}{1.08 \cdot 2 \cdot 4.128\,\text{kW}}$$

6.3.8) Correction Factor for Industrial Services given Number of Belts Required Formula

Evaluate Formula

Formula

$$F_a r = N \cdot \frac{F_c r \cdot F_d r \cdot P_r}{P_t}$$

Example with Units

$$1.2995 = 2 \cdot \frac{1.08 \cdot 0.94 \cdot 4.128\,\text{kW}}{6.45\,\text{kW}}$$

6.3.9) Effective Pull in V-Belt Formula

Evaluate Formula

Formula

$$P_e = P_1 - P_2$$

Example with Units

$$250\,\text{N} = 800\,\text{N} - 550\,\text{N}$$

6.3.10) Mass of One Meter Length of V-Belt given Belt Tension in Loose Side Formula

Evaluate Formula

Formula

$$m_v = \frac{P_1 - \left(e^{\mu \cdot \frac{\alpha}{\sin\left(\frac{\theta}{2}\right)}}\right) \cdot P_2}{v_b^2 \cdot \left(1 - \left(e^{\mu \cdot \frac{\alpha}{\sin\left(\frac{\theta}{2}\right)}}\right)\right)}$$

Example with Units

$$0.7596\,\text{kg/m} = \frac{800\,\text{N} - \left(e^{0.35 \cdot \frac{160.2°}{\sin\left(\frac{62°}{2}\right)}}\right) \cdot 550\,\text{N}}{25.81\,\text{m/s}^2 \cdot \left(1 - \left(e^{0.35 \cdot \frac{160.2°}{\sin\left(\frac{62°}{2}\right)}}\right)\right)}$$

6.3.11) Number of V Belts Required for Given Applications Formula

Evaluate Formula

Formula

$$N = P_t \cdot \frac{F_a r}{F_c r \cdot F_d r \cdot P_r}$$

Example with Units

$$2.0008 = 6.45\,\text{kW} \cdot \frac{1.30}{1.08 \cdot 0.94 \cdot 4.128\,\text{kW}}$$

Variables used in list of Design of Belt Drives Formulas above

- **a** Minor Axis of Pulley Arm *(Millimeter)*
- a_p Belt Pitch Line and Pulley Tip Circle Radius Width *(Millimeter)*
- **b** Belt Width *(Millimeter)*
- b_a Major Axis of Pulley Arm *(Millimeter)*
- **C** Centre Distance between Pulleys *(Millimeter)*
- C_s Service Correction Factor
- **d** Diameter of Small Pulley *(Millimeter)*
- **D** Diameter of Big Pulley *(Millimeter)*
- d_o Pulley Outside Diameter *(Millimeter)*
- d' Pulley Pitch Diameter *(Millimeter)*
- $d'1$ Pitch Diameter of Smaller Pulley *(Millimeter)*
- $d'2$ Pitch Diameter of Larger Pulley *(Millimeter)*
- F_a Load Correction Factor
- F_ar Correction Factor for Industrial Service
- F_cr Correction Factor for Belt Length
- F_dr Correction Factor for Arc of Contact
- **i** Transmission Ratio of Belt Drive
- **I** Area Moment of Inertia of Arms *(Millimeter⁴)*
- **l** Datum Length of Belt *(Millimeter)*
- **L** Belt Length *(Millimeter)*
- **m** Mass of Meter Length of Belt *(Kilogram per Meter)*
- **m'** Mass of One Meter Length *(Kilogram per Meter)*
- M_b Bending Moment in Pulley's Arm *(Newton Millimeter)*
- M_t Torque Transmitted by Pulley *(Newton Millimeter)*
- m_v Mass of Meter Length of V Belt *(Kilogram per Meter)*
- **N** Number of Belts
- n_1 Speed of Smaller Pulley *(Revolution per Minute)*

Constants, Functions, Measurements used in list of Design of Belt Drives Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- constant(s): **e**, 2.71828182845904523536028747135266249 *Napier's constant*
- Functions: **asin**, asin(Number) *The inverse sine function, is a trigonometric function that takes a ratio of two sides of a right triangle and outputs the angle opposite the side with the given ratio.*
- Functions: **ln**, ln(Number) *The natural logarithm, also known as the logarithm to the base e, is the inverse function of the natural exponential function.*
- Functions: **sin**, sin(Angle) *Sine is a trigonometric function that describes the ratio of the length of the opposite side of a right triangle to the length of the hypotenuse.*
- Functions: **sqrt**, sqrt(Number) *A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.*
- Measurement: **Length** in Millimeter (mm) *Length Unit Conversion*
- Measurement: **Pressure** in Newton per Square Millimeter (N/mm²) *Pressure Unit Conversion*
- Measurement: **Speed** in Meter per Second (m/s) *Speed Unit Conversion*
- Measurement: **Power** in Kilowatt (kW) *Power Unit Conversion*
- Measurement: **Force** in Newton (N) *Force Unit Conversion*
- Measurement: **Angle** in Degree (°) *Angle Unit Conversion*
- Measurement: **Angular Velocity** in Revolution per Minute (rev/min) *Angular Velocity Unit Conversion*
- Measurement: **Torque** in Newton Millimeter (N*mm)

- n_2 Speed of Larger Pulley *(Revolution per Minute)*
- N_{pu} Number of Arms in Pulley
- **P** Tangential Force at End of Each Pulley Arm *(Newton)*
- P_1 Belt Tension on Tight Side *(Newton)*
- P_2 Belt Tension on Loose Side *(Newton)*
- P_c Circular Pitch for Synchronous Belt *(Millimeter)*
- P_d Design Power of Belt Drive *(Kilowatt)*
- P_e Effective Pull in V Belt *(Newton)*
- P_i Initial Tension in Belt *(Newton)*
- P_{max} Maximum Tension in Belt *(Newton)*
- P_r Power Rating of Single V-Belt *(Kilowatt)*
- P_s Standard Capacity of Belt *(Kilowatt)*
- P_t Power Transmitted by Belt *(Kilowatt)*
- **R** Radius of Rim of Pulley *(Millimeter)*
- **t** Belt Thickness *(Millimeter)*
- T_1 Number of Teeth on Smaller Pulley
- T_2 Number of Teeth on Larger Pulley
- T_b Belt Tension due to Centrifugal Force *(Newton)*
- v_b Belt Velocity *(Meter per Second)*
- v_o Optimum Velocity of Belt *(Meter per Second)*
- v'_o Optimum Belt Velocity *(Meter per Second)*
- **z** Number of Teeth on Belt
- **α** Wrap Angle on Pulley *(Degree)*
- α_a Wrap Angle for Cross Belt Drive *(Degree)*
- α_b Wrap Angle on Big Pulley *(Degree)*
- α_s Wrap Angle on Small Pulley *(Degree)*
- **θ** V Belt Angle *(Degree)*
- **μ** Coefficient of Friction for Belt Drive
- **σ** Tensile Stress in Belt *(Newton per Square Millimeter)*
- σ_b Bending stress in pulley's arm *(Newton per Square Millimeter)*

  Torque Unit Conversion
- Measurement: **Second Moment of Area** in Millimeter⁴ (mm^4)
  Second Moment of Area Unit Conversion
- Measurement: **Linear Mass Density** in Kilogram per Meter (kg/m)
  Linear Mass Density Unit Conversion
- Measurement: **Stress** in Newton per Square Millimeter (N/mm^2)
  Stress Unit Conversion

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