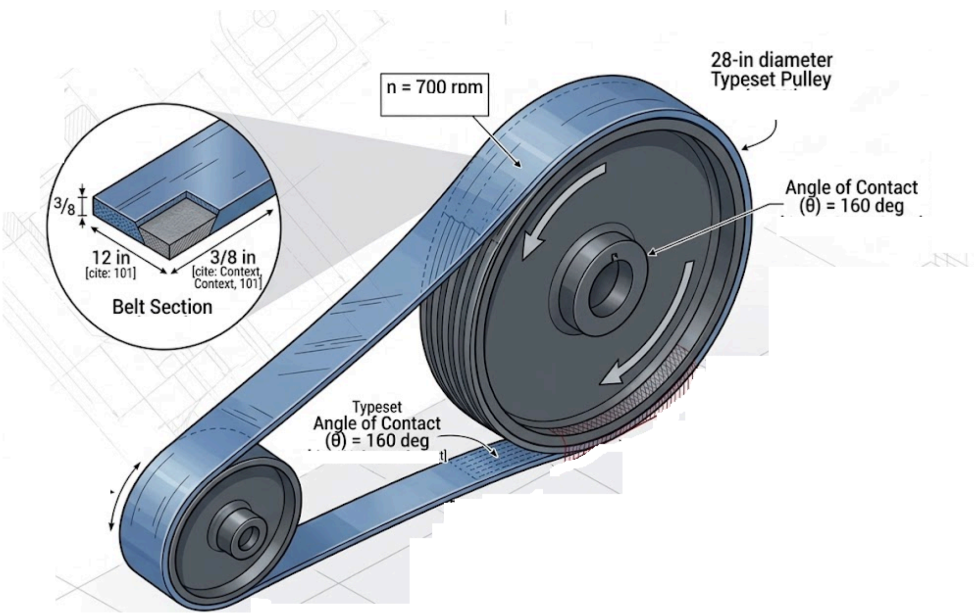
This problem represents a classic **flat belt power transmission problem** that accounts for high-speed operation. When a heavy flexible belt loops around a rapidly rotating pulley, the belt material is forced to continuously travel in a circular arc. This continuous directional change generates an outward inertia effect known as **centrifugal tension** (F_c).

Centrifugal tension reduces the effective wrapping pressure against the pulley rim, meaning it robs the drive of its power-carrying capacity. To properly determine the total transferable horsepower, we must evaluate the maximum allowable tension based on the material's structural stress limit, subtract the parasitic centrifugal force, apply the belt's friction-wrap relationship, and determine the net power transmission capacity.



<u>Step 1:</u> Calculation of Linear Belt Velocity (v)

The absolute power a belt can transmit depends directly on its physical travel speed. Since the belt tracks tightly against the driving pulley rim, its linear speed (v) is identical to the peripheral velocity of the 28-in pulley spinning at 700 rpm.

The standard mechanical relationship for peripheral speed is:

$$v = \pi D n$$

To keep calculations optimized for the standard horsepower formula, we convert the diameter from inches to feet $\left(28\,in = \frac{28}{12}ft\right)$ and rotational speed from revolutions per minute to revolutions per second $\left(700\,rpm = \frac{700}{60}\,rps\right)$:

$$v = \pi\left(\frac{28}{12}ft\right)\left(\frac{700}{60}\,rps\right) = 85.5211\,\frac{ft}{sec}$$

Step 2: Determination of Maximum Allowable Tension (F_1)

The tight-side line experiences the highest load in the system. The maximum safe tension (F_1) the belt can endure is dictated by the material's cross-sectional area (A) and its maximum safe working stress (S_b).

The cross-sectional area of a flat rectangle is its thickness (t) multiplied by its width (b):

$$A = bt = (12\ in)\left(\frac{3}{8} in\right) = 4.5\ in^2$$

$$F_1 = S_b A = \left(380\ \frac{lb}{in^2}\right)\left(4.5\ in^2\right) = 1,710\ lbs$$

Step 3: Isolation of Centrifugal Tension (F_c)

Centrifugal tension acts uniformly across both the tight and slack strands of a belt system, behaving as a purely parasitic load. The formula for centrifugal tension relies on the mass linear density of the belt and the square of its velocity:

$$F_c = \gamma \frac{Av^2}{g_o}$$

Where:

- γ = 0.038 lb_f/in^3 (specific weight)
- A = 4.5 in^2 (cross-sectional area)
- v = 85.5211 ft/sec (linear speed)
- g = 32.2 ft/sec^2 (acceleration due to gravity)

Weight per foot = $\gamma A = \left(0.038\ \frac{lb_f}{in^3}\right)\left(4.5\ in^2\right)\left(\frac{12\ in}{1\ ft}\right) = 2.052\ \frac{lb_f}{ft}$

$$F_c = 2.052\ \frac{lb_f}{ft} \frac{\left(85.5211\ \frac{ft}{sec}\right)^2}{32.2\ \frac{ft}{l\ sec^2}} = 466.11\ lb_f$$

Step 4: Applying Belting Friction Laws to Determine Slack-Side Tension (F_2)

According to the Euler-Belting log-friction equation, the ratio of the net active tensions between the tight and slack sides is exponentially bound by the coefficient of friction (f) and the angle of contact (θ) expressed in radians.

First, transform the angle of wrap from degrees to radians:

$$\theta = 160^o\left(\frac{\pi}{180^o}\right) = 2.7925\ rad$$

Now apply the tension alignment equation:

$$\frac{F_1 - F_c}{F_2 - F_c} = e^{f\theta}$$

$$\frac{1{,}710\ lb_f - 466.11\ lb_f}{F_2 - 466.11\ lb_f} = e^{(0.32)(2.7925\ rad)}$$

$$F_2 = 975.09\ lb_f$$

<u>Step 5:</u> Calculation of Power Output

Finally, horsepower (HP) is calculated by multiplying this net driving force by the velocity and dividing by the standard conversion constant $\left(550\ \frac{ft-lb}{sec} = 1\ HP\right)$:

$$HP = \frac{\left(F_1 - F_2\right)v}{550} = \frac{\left(1{,}710\ lb_f - 975.09\ lb_f\right)\left(85.5211\ \frac{ft}{sec}\right)}{550} = 114.27\ hp$$

Centrifugal tension (F_c = 466.11 lbs) consumes more than **27%** of our maximum allowable belt strength buffer (1710 lbs). If you continue to accelerate this pulley system to higher RPMs, F_c will grow exponentially (v^2) until it equals F_1. At that critical velocity, the belt will stretch so severely from its own inertia that it loses all gripping pressure against the pulley, transmitting 0 HP regardless of its size.