Compression Springs

Note: compression produces shear stress in the spring.

Governing equation:  \( F = k \cdot y \)

Spring Rate \( k \):

End Conditions:

Critical deflection in a compression spring: This is when the deflection becomes too large and the spring buckles. The equation is shown below.

\[
\text{ycr} = L_0 - C_1 \left(1 - \frac{C_2}{\lambda_{\text{eff}}}\right)^{1/2} \quad \text{eqn. 10-11}
\]

The effective slenderness ratio is given by:

\[
\lambda_{\text{eff}} = \alpha \cdot \frac{L}{D} \quad \text{eqn. 10-12}
\]

The chart below describes \( \alpha \), which is the end condition constant.

\[
\text{C1} = \frac{E}{2 \cdot (E - G)} \quad \text{eqn. 10-13}
\]

\[
\text{C2} = \frac{2 \cdot (E - G)}{2 \cdot (E - G) + E} \quad \text{eqn. 10-14}
\]

\[
L_0 = \frac{\pi \cdot D}{4} \left(1 - \frac{1}{2} \right) \quad \text{eqn. 10-15}
\]

This is the free length of the spring.

Extension Springs

Note: loading the Extension Spring creates a shear stress in the spring.

Extension Springs: These must have a way of transferring load from a support to the body of the spring. Using Springs with a hooked end, stress concentration must be considered. This is shown below. The lower spring has a decreased stress concentration because the moment arm is smaller.

Helical Springs

Helical Spring Types:

Compression

Torsion

Extension

Torsion Springs

Note: twisting the Torsion Spring creates a normal stress in the spring.

Helical Torsion Springs:

These are wound in the same manner as extension and compression springs. For torsion springs, the ends are designed to transmit torque.

Stress Concentration Factor on inside of the Spring \( K_i \):

\[
K_i = \frac{4 \cdot \pi \cdot D \cdot N}{2 \cdot D \cdot N} \quad \text{eqn. 10-32}
\]

Bending stress for a round wire torsion spring:

\[
\sigma = \frac{K_i \cdot 32 \cdot \pi \cdot r \cdot e}{\pi \cdot d} \quad \text{eqn. 10-33}
\]

Displacement in torsion springs is described in radians.

\[
\theta = \frac{64 \cdot \pi \cdot D \cdot N}{2 \cdot d \cdot E} \quad \text{eqn. 10-34}
\]

The spring rate, taking into account the curvature of the wire:

\[
\kappa = \frac{d^4 \cdot E}{10.8 \cdot D \cdot N} \quad \text{eqn. 10-37}
\]

Fatigue Loading

Some springs are subjected to fatigue loading. It must be determined whether the spring will need to have infinite life or finite life. Helical springs are never designed to be used in both compression and tension.

Alternating Stress \( F_a \):

\[
F_a = F_{\text{max}} - F_{\text{min}} \quad \text{eqn. 10-26}
\]

Mean Stress \( F_m \):

\[
F_m = \frac{F_{\text{max}} + F_{\text{min}}}{2} \quad \text{eqn. 10-27}
\]

Stress Amplitude \( \tau_a \):

\[
\tau_a = \frac{F_{\text{average}}}{K_b \cdot 8 \cdot F_m \cdot D \cdot \pi \cdot d^3} \quad \text{eqn. 10-28}
\]

Mean Stress \( \tau_m \):

\[
\tau_m = \frac{F_{\text{average}}}{K_s \cdot 8 \cdot F_m \cdot D \cdot \pi \cdot d^3} \quad \text{eqn. 10-29}
\]