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Torsion Spring

Torsion springs are stressed in bending. Rectangular wire is more efficient in bending than round wire, but due to the premium cost of rectangular wire, round wire is preferred. Torsion springs, whose ends are rotated in angular deflection, offer resistance to externally applied torque. The wire itself is subjected to bending stresses rather than torsional stresses, as might be expected from the name. Springs of this type are usually close wound. The coil diameter reduces and body length increases as they are deflected. The designer must consider the effects of friction and arm deflection on the torque.

The number of active turns in a helical torsion spring is equal to the number of body turns, plus a contribution from the ends. For straight torsion ends, this contribution is equal to one-third of the moment arms and is usually expressed as an equivalent number of turns:

$$N_e = \frac{L_1 + L_2}{3\pi D_m}$$

$$L_1 = length\ of\ moment\ arm\ 1$$

$$L_2 = length\ of\ moment\ arm\ 2$$

$$N_a = N_b + N_e$$

$$N_b = number\ of\ body\ turns$$

Diameter Reduction

When the direction of loading tends to reduce the body diameter, the mean diameter changes with deflection according to:

$$D_m = \frac{D_1 N_b}{N_b + \Delta\theta}$$

where D1 is initial mean diameter and D? is deflection in revolutions.

Body Length Increase

Most torsion springs are close-wound, with body length equal to the wire diameter multiplied by the number of turns plus one. When a spring is deflected in the direction that will reduce the coil diameter, body length increases according to:

$$L = d(N_b + 1 + \theta)$$

Spring Rate for Torsion Springs

Spring rate (per turn) for helical round wire torsion springs is given by:

$$Spring\ Rate\ (per\ turn) = R = \frac{\Delta T}{\Delta \theta} = \frac{Ed^4}{10.8 D_m N_A}$$

$$Spring\ Rate\ (per\ degree) = R \cdot \frac{1\ turn}{360\ degrees} = \frac{Ed^4}{3888 D_m N_A}$$

The 10.8 (or 3888) factor is greater than the theoretical factor of 10.2 (or 3670) to allow for friction between adjacent spring coils, and between the spring body and the arbor. This factor is based on experience and has been found to be satisfactory.

Stress

Stress in torsion springs is due to bending, and for round wire is given by:

$$S = \frac{32T}{\pi d^3} K_B$$

$$K_B = Bending\ Stress\ Correction\ Factor$$

During elastic deflection of a curved beam, the neutral axis shifts toward the center of curvature, causing higher stress at the inner surface than the outer. Wahl has calculated the bending stress correction factor at the ID of a round wire torsion spring as:

$$K_{BID} = \frac{4C^2 - C - 1}{4C(C-1)}$$

The following formulas may also be used as an approximate bending stress correction factor at the ID or OD of the spring. For low index springs, the stress concentration will be much higher at the ID than at the OD.

$$K_{BID} = \frac{4C - 1}{4C - 4}$$

$$K_{BOD} = \frac{4C + 1}{4C + 4}$$