Design of Coil Springs

The design of a new spring involves the following considerations:-Space into which the spring must fit and operate. -Values of working forces and deflections. -Accuracy and reliability needed

Design Consideration

The primary consideration in the design of the coil springs are that the induced stresses are below the permissible limits while subjected to or exerting the external force F capable of providing the needed deflection or maintaining the spring rate desired.

Stresses In Helical Springs

The flexing of a helical spring creates torsion in the wire and the force applied induces a direct stress. The maximum stress in the wire may be computed by super position. The result is:

$$t_{max} = + \frac{T_r}{J} + \frac{F}{A}$$

Replacing the terms,

$$T = \frac{FD}{2}, r = \frac{d}{2}, J = \frac{\pi d^4}{32} \text{ and } A = \frac{\pi d^4}{4}$$

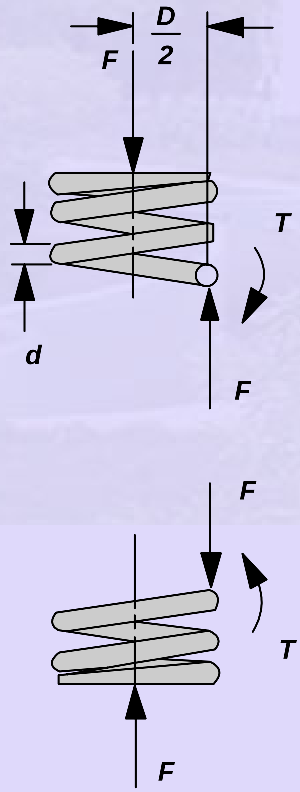


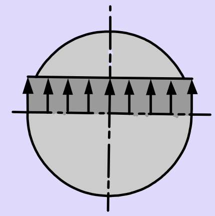
Figure 4.10

And re-arranging,

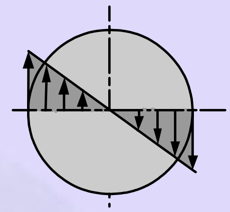
$$\tau = K_s \frac{8FD}{\pi d^3} \quad \text{or} \quad \tau = K_s \frac{8FC}{\pi d^2}$$

Where K_s is the shear-stress correction factor and is defined by the equation:

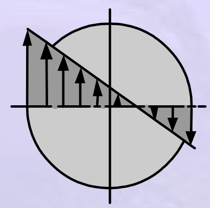
$$K_s = \frac{2C+1}{2C}$$



(a) direct shear stress distribution across section



(b) Torsional shear stress distribution

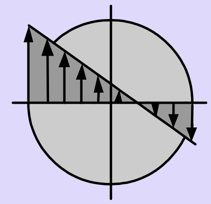


(c) combined direct shear and torsional stress

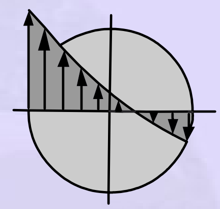
Figure 4.11

Curvature Effect

The curvature of the wire increases the stress on the inside of the spring, an effect very similar to stress concentration but due to shifting of the neutral axis away from the geometric center, as could be observed in curved beams. Consequently the stress on the inside surface of the wire of the spring, increases but decreases it only slightly on the outside. The curvature stress is highly localized that it is very important only fatigue if is present.



(c) combined direct shear and torsional stress



(d) effects of stress concentration

Figure 4.12

This effect can be neglected for static loading, because local yielding with the first application of the load will relieve it. The combined effect of direct shear and curvature correction is accounted by Wahl's correction factor and is given as:

Whal's correction factor

The combined effect of direct shear and curvature correction is accounted by Wahl's correction factor and is given as:

$$K_W = \frac{4C-1}{4C-4} + \frac{0.615}{C}$$

Pre-Setting Or Set Removal

Pre-setting or set removal is a process used in the manufacture of compression springs to induce useful residual stresses. It is done by making the spring longer than needed and compressing it to its solid height. This operation sets the spring to the required final length and, since the torsional yield strength has been exceeded, induces residual stresses opposite in direction to those induced in service. Thus, this set removal increases the strength of the springs and so is especially useful when the spring is used for energy storage purposes. However, this should not be used when springs are subjected to fatigue.

Deflection and Stiffness of the spring

A systems strain energy is related to its force deflection behaviour and using the Castigliano's theorem the deflection of a spring can be estimated using the strain energy stored in it. The total strain energy for a helical spring is composed of torsional component and a shear component. The shear component is quite negligible, and the final equation is,

$$u = \frac{T^2}{2G}\frac{l}{J} + \frac{F^2}{2A}\frac{l}{G}$$

The spring rate and hence,

$$T = F\frac{D}{2};\ 1 = \pi.D.N;\ J = \pi.\frac{d^4}{32}\ \text{ and }\ A = \frac{\pi d^2}{4}$$

$$U = \frac{4F^2D^3N}{G.d^4} + \frac{F^2DN}{Gd^2}$$

Where N is the number of active coils. The deflection in the spring, using Castigliano's theorem

$$y = \frac{\partial U}{\partial F} = \frac{8FD^3N}{Gd^4} + \frac{4FDN}{Gd^2}$$

Substituting C=D/d and rearranging

$$y = \frac{8FD^3N}{Gd^4}\left(1 + \frac{1}{2C^2}\right)$$

For normal range of C, the term within bracket (contribution of direct shear) is so negligible we can write

$$y = \frac{8FD^3N}{Gd^4} \quad \text{or} \quad \frac{8FC^3N}{Gd}$$

$$k = \frac{F}{y} = \frac{G.d}{8C^3N} = \frac{Gd^4}{8D^3N}$$

The spring stiffness or springs rate,

$$k = \frac{F}{y} = \frac{G.d}{8C^3N} = \frac{Gd^4}{8D^3N}$$

Using the equation the number of active coils needed to maintain the desired deflection or spring stiffness will be determined. In order to maintain proper contact and align the force along the spring axis the ends are to be properly shaped.

End Construction

Coil compression springs generally use four different types of ends. These are illustrated in Fig. 4.13. and Table shows how the type of end used affects the number of coils and the spring length. Foe important applications the ends of springs should always be of both squared and ground, because a better or even transfer of the load is obtained.

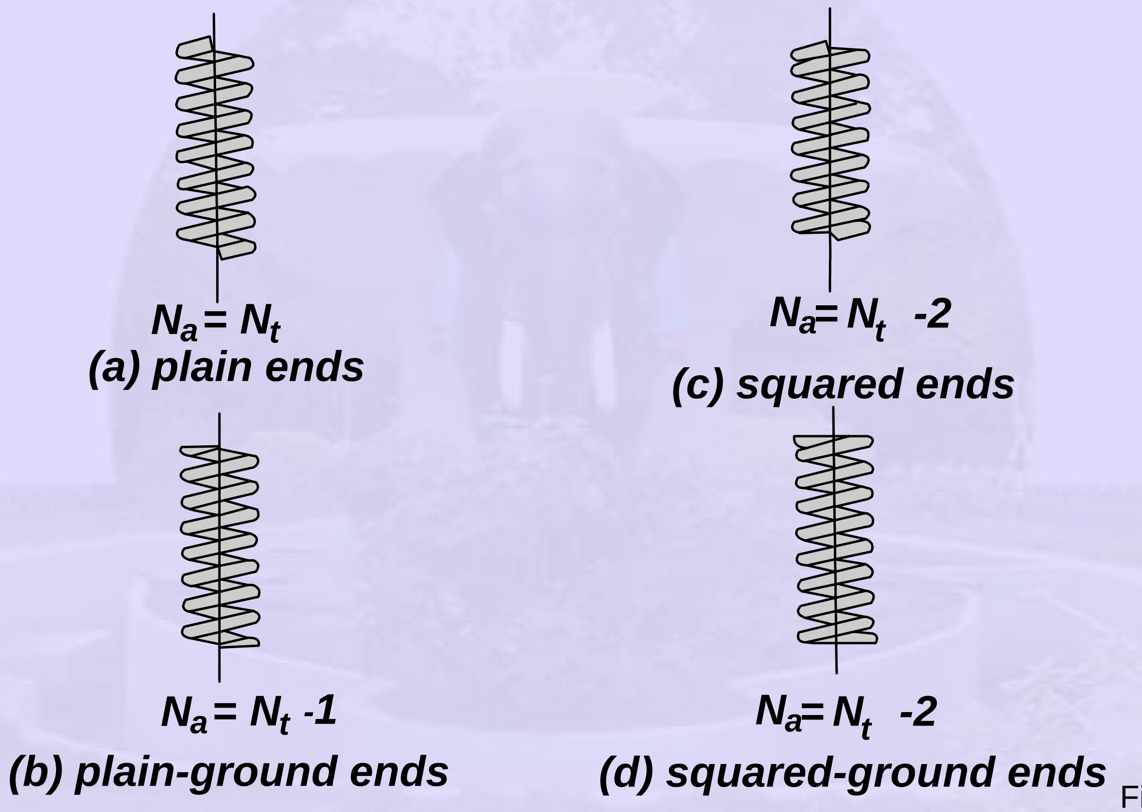


Figure 4.13

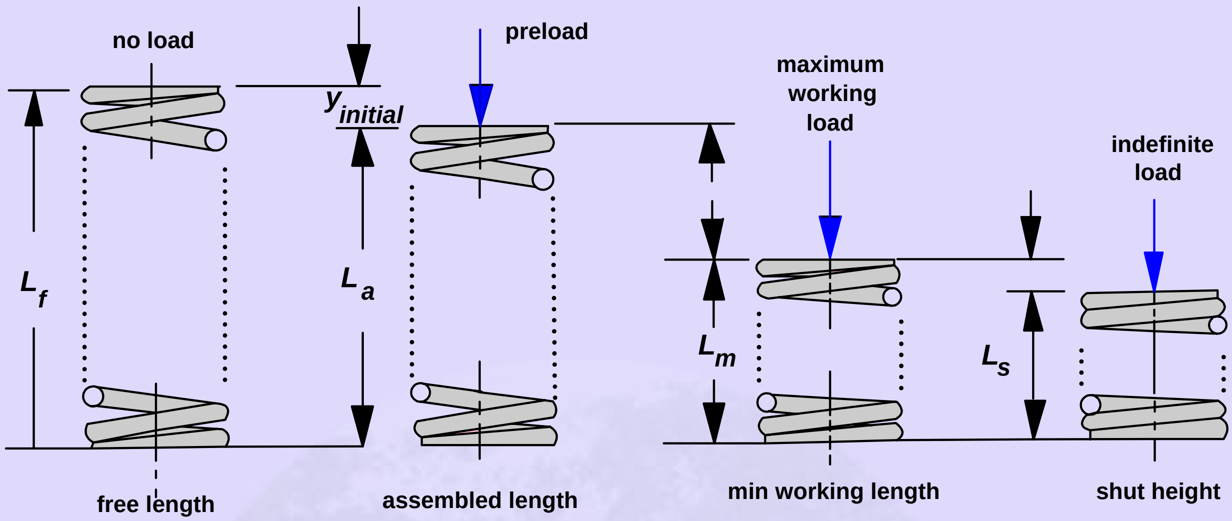


Figure 4.14

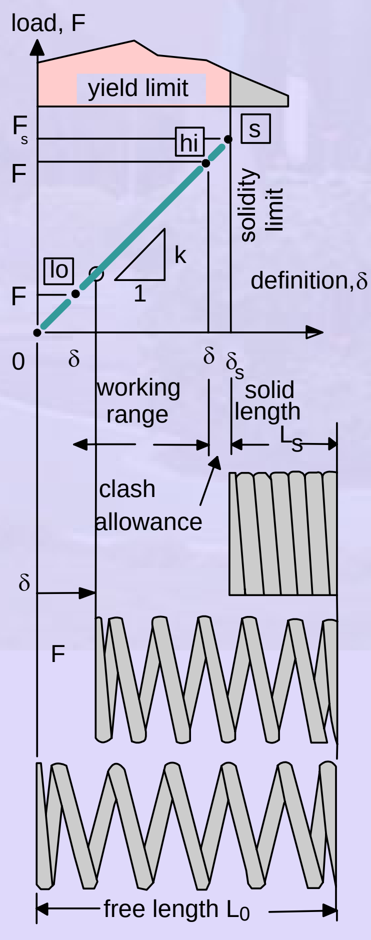


Figure 4.15 **Animate**