Advanced Spring Design Case Study:
Cylindrical Compression Springs with Required Length, Coil Diameter, Stiffness, and Stress at Solid

Suppose we have the following design constraints:
Music Wire
Closed/Ground Ends
Coil OD = 1”
Free Length = 2”
Spring Rate = 15 lbf/in
Corrected Stress % of Minimum Tensile Strength at Solid = 40%

The spring rate equation is

$$k = \frac{P}{f} = \frac{Gd^4}{8D^3N_a}$$

In this case, we have a known value for G (torsion modulus) and we also know the OD which is D+d, however we don’t know D (mean coil diameter) or d (wire diameter). We also don’t know the number of active coils. The rate can also be computed as the load to solid divided by the deflection to solid. The solid height is the product of the wire diameter and the total coils, neither of which are known.

The stress equation at a given load (P) is a function of the coil diameter and wire diameter.

$$S = \frac{8PD}{\pi d^3} K_w$$

Our goal is for the stress at solid to be 40% of the minimum tensile strength (MTS). The MTS is a function of the wire size, which we don’t know.

$$\textbf{Tensile} = \left[\textbf{P0} \cdot \textbf{d}^{\textbf{P4}} + \textbf{P1}\right] \Big/ \left[\textbf{P2} \cdot \textbf{d}^{\textbf{P4}} + \textbf{P3}\right]$$

The Advanced Spring Design program uses an iterative process to solve this snarled mess of equations. We can use an initial guess for the wire diameter which is based on the given coil diameter.

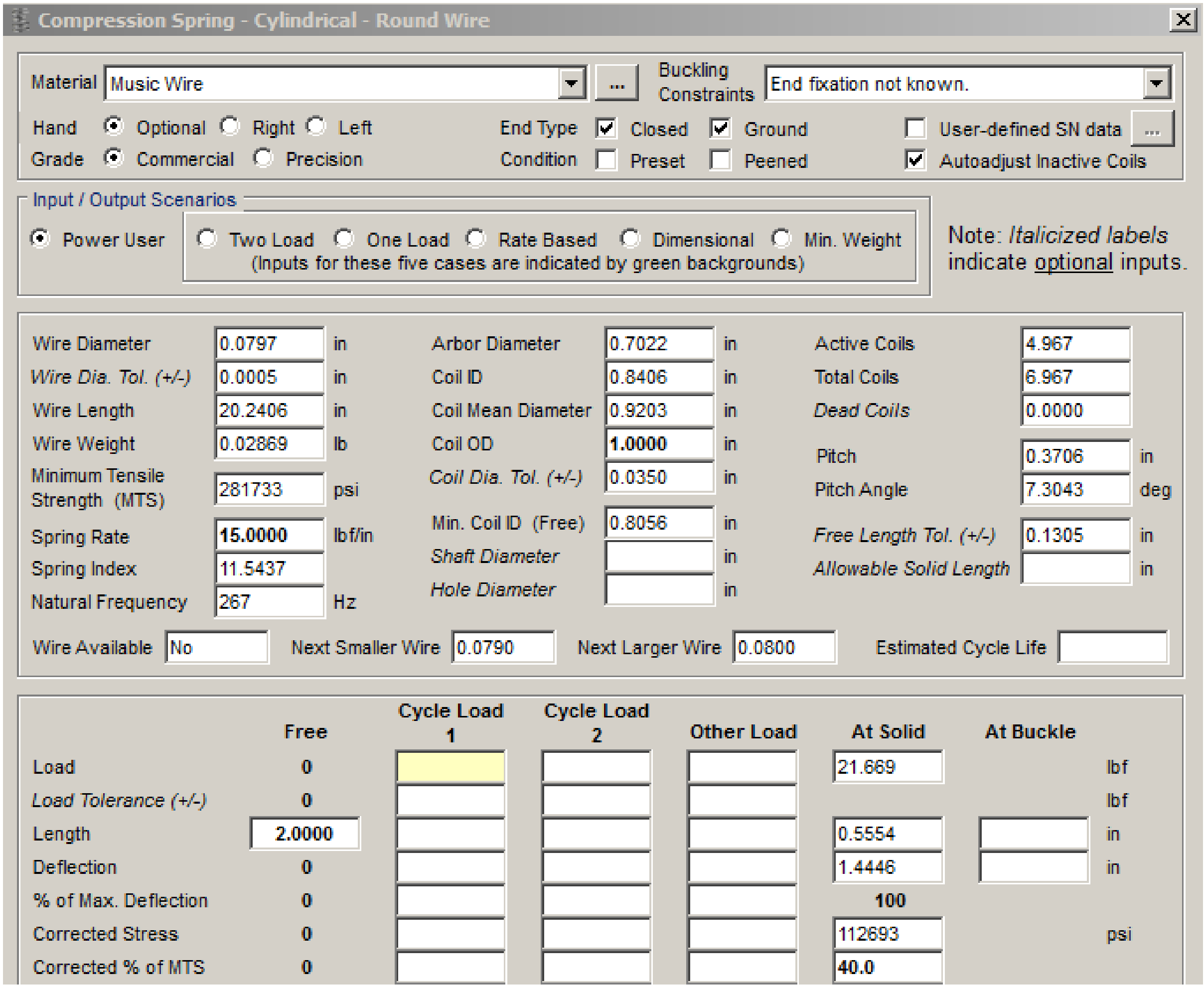
Given that guess along with the known spring rate, the number of active coils is computed. From the number of coils, we get the solid height.

From the solid height, we get the load to solid.

From the load, we get the stress.

This process is repeated until a wire diameter is found which leads to the desired stress at solid.

Here is the ASD solution.



ASD shows a solution with 6.967 total coils and a wire size of 0.0797”. At that point, it’s a simple matter to change the wire diameter to the closest standard size of 0.08 and blank the At Solid Corrected Stress %.

Here is a 3D view of the spring.