## Technically Speaking 19

## Warm Prestressing

A number of users of the “Spring Calculator Professional”- software for designing springs - have recently raised questions about changes in the way prestressing of compression springs is presented in this program compared with that in earlier versions. This article sets out the thinking that has guided these changes.

The process of prestressing, sometimes called setting or scragging, involves deflecting a compression spring to a stress level that will cause plastic deformation – permanent twisting of the active surface of the spring. Users have asked IST about the length used for the prestressing process. The software assumes that the prestressing is carried out to the closed (solid or block) length. It is acknowledged that this is not always the length used in practice, but in providing software it would be difficult to accommodate all production practices, and so the most frequently used practice is adopted.

SCP will estimate the length to which a spring should be coiled prior to prestressing so that the design length is obtained by prestressing. This option is available when using the “Techspring” design rules, and again assumes that the prestressing is accomplished to the closed length. It has to be acknowledged that this estimate is approximate, but it is likely to be more accurate than the spring coiler’s guess about the shortening due to prestressing. For a spring made from 1.2mm diameter EN10270-1 carbon steel wire, the design free length is 15.90mm, SCP advises to coil to the lengths given in Figure 1.

| | | |
|---|---|---|
| As-Coiled Length (SL) | 16.60 | mm |
| As-Coiled Length (SM) | 16.17 | mm |
| As-Coiled Length (DM) | 16.17 | mm |
| As-Coiled Length (SH) | 16.06 | mm |
| As-Coiled Length (DH) | 16.06 | mm |

Figure 1 Springs made from SH or DH wire are predicted to shorten by 0.16mm, but from lower strength wires the shortening will be greater, 0.27mm from SM or DM wire.

In earlier versions of the software it was possible to obtain a Goodman diagram for a prestressed spring even though the stress at the closed length was not high enough for any benefit from prestressing to be obtained. This option has been removed, a change that has been welcomed and applauded. However, one user pointed out that when he warm prestresses springs designed to just below the prestress threshold stress, they shorten and benefits are obtained. This observation is exactly as IST would expect because as the temperature is raised above ambient, but below the temperature at which the steel will soften, the elastic limit will be reduced. IST do not know accurately the design stress thresholds at which warm prestressing will shorten springs – it will be between 10 and 20% below the cold prestress threshold depending upon the warm prestress temperature. This discussion led to questions about IST’s assumption of the warm prestress temperature for the prediction of relaxation. IST assume the warm prestressing is done at 200°C to the closed length. Under these conditions SCP predicts static relaxation of 1.75% at L2 after one year at room temperature. The relaxation prediction screen is shown as figure 2, but for a compression spring without prestress.

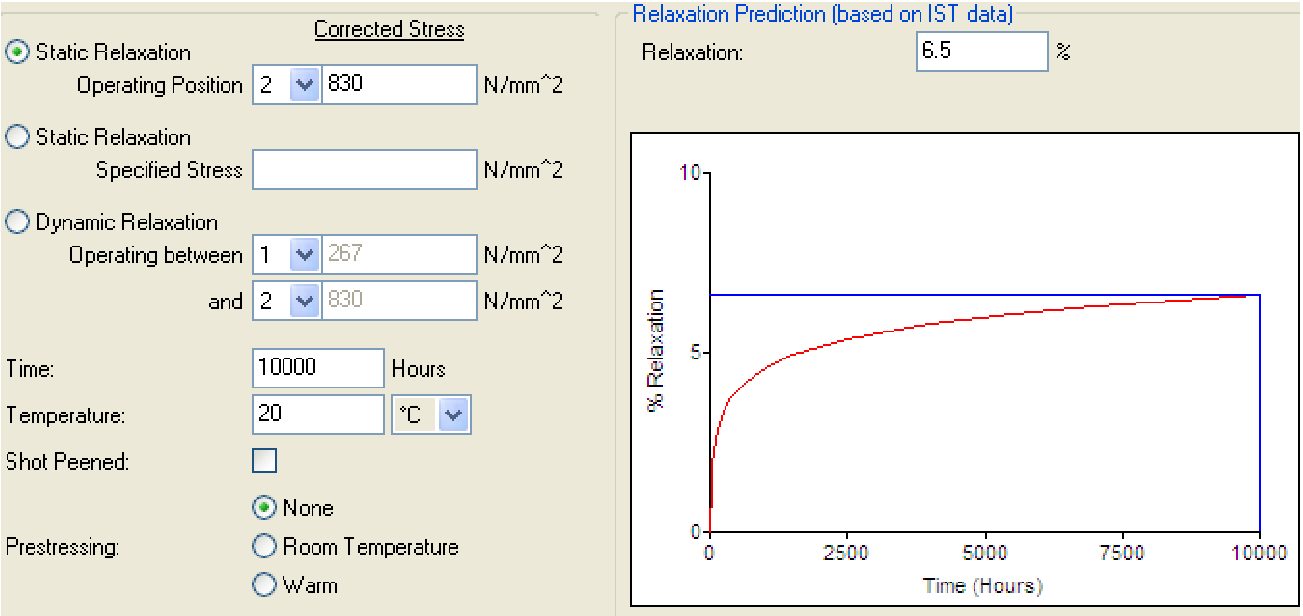


Figure 2 Relaxation of 6.5% is predicted after 10,000 hours at 20°C.

If the spring in figure 2 is prestressed at ambient temperature, the relaxation predicted is reduced from 6.5% to 5%, and if the prestressing is done warm, then relaxation of only 1.75% is predicted. These relaxation predictions caused another client to ask “exactly what do IST mean by 5% relaxation? The answer to this question is that the load at L2 will be 5% less after one year, but the spring rate will not have changed. Therefore the spring must have lost some free length – it loses 5% of its available deflection (free length minus closed length). This explanation caused some confusion because springs shorten due to prestressing, and then shorten again due to relaxation – how can this be? During prestressing the spring surface is being deliberately plastically deformed by twisting, whereas during relaxation the shortening is due to dislocation movement with dislocations running away from the position of highest stress, the spring surface.

Finally, yet another user of SCP, who is a major user of high performance springs, asked whether their spring manufacturer would be able to manufacture a compression spring from SiCr wire that must be warm prestressed, and still obtain an uncorrected closed stress of 56%$R_m$, the usual maximum for this material. The answer is that the 56% limit is not absolute, and it may still be possible, but at this stress the squareness, parallelism and bow tolerances may have to be quite generous. Designing to 54%$R_m$ maximum when using warm prestressing would be prudent – this limit would be attainable and the spring shape should still be satisfactory.

If these explanations prompt more questions about the above subjects or other assumptions that IST make when compiling SCP, then please contact the author as shown below.

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