"Technically Speaking"

Prestressing

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Prestressing of compression springs causes shortening, and springmakers would like to be able to predict by how much so that they can make accurate allowance when coiling. Prestressing creates a beneficial residual stress, and for the first time these residual stresses have been accurately measured. Both of these subjects were studied in Techspring, a research project partly funded by the **European Commission**, and undertaken by a consortium of European companies of which **IST** was one. Before showing a little of these subjects, a few words of explanation would be helpful.

Prestressing is a process used by the spring industry that brings significant benefits to spring performance. Few other industries use the process. For this reason, it is a process that is not always fully understood by springmakers—they usually know that the process improves the available elastic deflection of the springs they make, but do not understand fully the mechanism behind this improvement. Springmaker's customers often understand even less, and question whether it is an essential process. The purpose of this article is to explain some of the theory behind prestressing of compression springs.

Prestressing of compression springs is a process that involves loading the spring to a length that causes the free length to be reduced. After prestressing, the benefits accrued are: elastic deflection range available is increased, so the spring may be designed to a lower weight, usually by selecting smaller diameter wire; fatigue life is improved; and relaxation performance is improved.

Prestressing brings these benefits to compression springs by raising the torsional elastic limit of the wire (**Figure 1**) and by imparting a residual torsional stress into the surface of active coils.

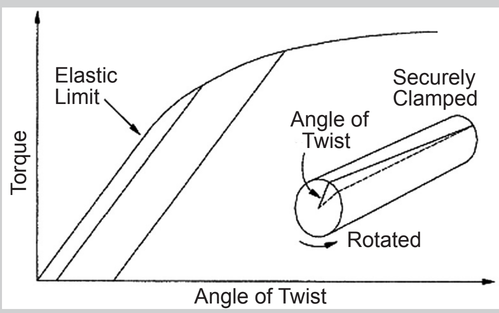


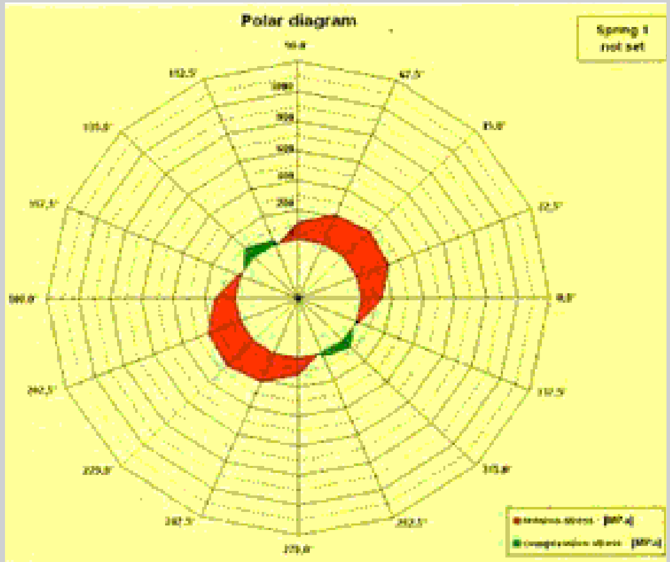
Figure 1.

The residual torsional stress from prestressing is in the opposite direction to the applied torsional stress when the spring is loaded. It is just the surface of the active coils that are improved—the core of the wire remains elastic and is unaffected. The residual stresses can be measured accurately using X-ray methods. Their magnitude at the inside surface are about 25% - 30% of those resulting from shot peening and so, not surprisingly, prestressing brings about 25% - 30% of the benefits to fatigue performance compared to shot peening. It has been shown that the greater the shortening, the greater the benefit to fatigue performance. This applies to springs made from music wire, oil tempered SiCr and 302 stainless steel.

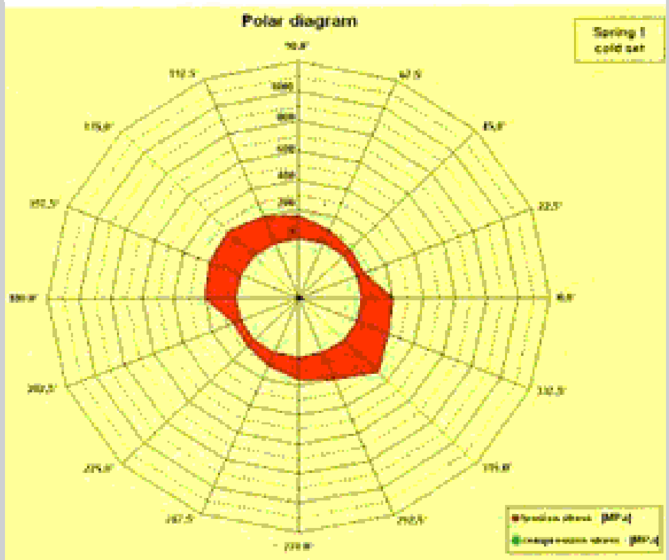
A typical pattern of residual stress in springs before and after cold prestress is shown in **Figure 2**.

Returning to the original question—A spring will shorten during prestressing, but by how much? Taking, as an example, a 1 mm (0.039") diameter patented carbon steel wire (*ASTM A227/A228* or *EN 10270-1*) compression spring with eight coils and outside diameter of 8 mm (0.315"). A free length of 19 mm (0.748") is required, but how long does the as coiled spring need to be? It will depend upon the tensile strength of the wire – the Techspring project predictions are:

Material Strength (MPa/ksi)	As coiled length (mm/in)	% reduction in length
1720 / 249k	20.67 mm / 0.814"	8.1
1980 / 287k	19.81 mm / 0.780"	4.1
2230 / 323k	19.30 mm / 0.760"	1.6



Spring not set



Spring cold set

Figure 2: Residual stress before prestress (top) and after (bottom).

Similar predictions are now available for a range of materials, and these will be incorporated into new versions of spring design CAD software being developed at present.

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Readers are encouraged to contact Hayes with comments about this cautionary tale, and with subjects that they would like to be addressed in future tales, by telephone at **+44 114 252 7984** or by e-mail at **m.hayes@ist.org.uk**. **WFTI**