Technically Speaking 5

Prestressing

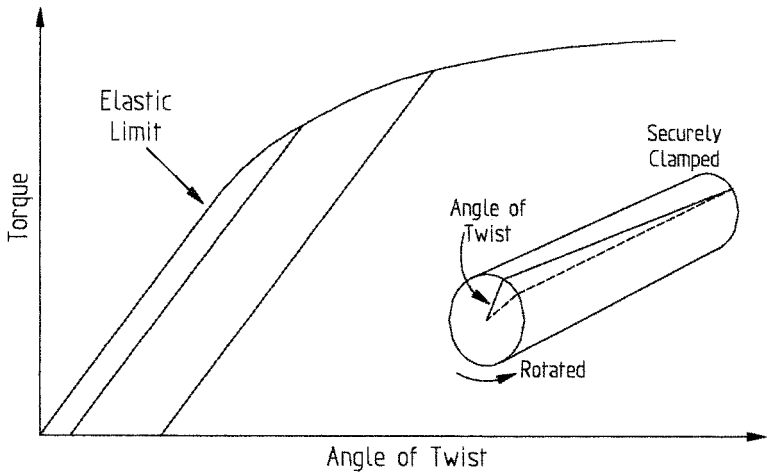
Prestressing of compression springs causes shortening and springmakers would like to be able to predict by how much so that they can make accurate allowance when coiling. Prestressing creates a beneficial residual stress, and for the first time these residual stresses have been accurately measured. Both of these subjects were studied in Techspring, a research project part 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

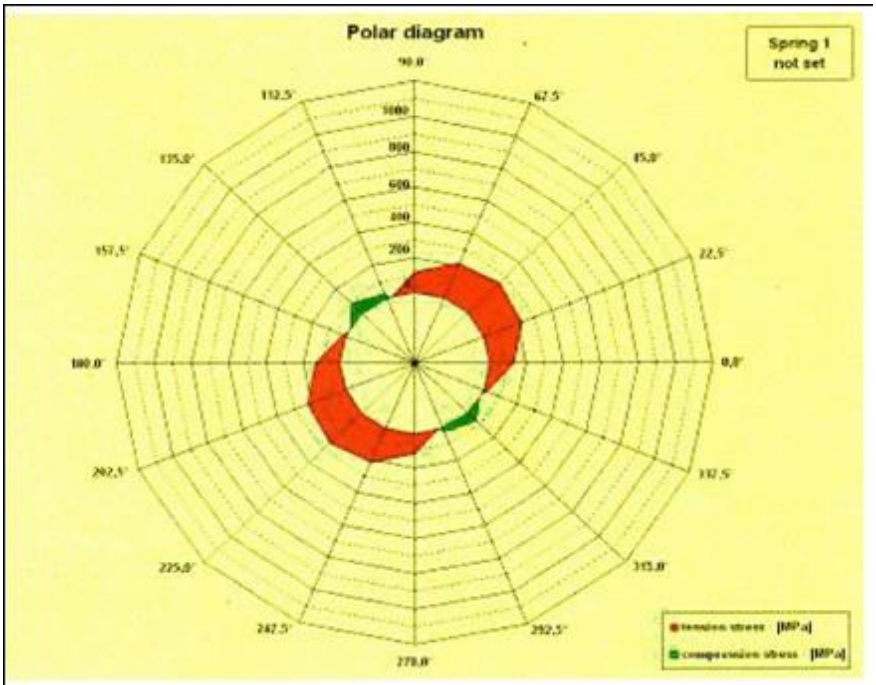
a) The elastic deflection range available is increased. Hence, the spring may be designed to a lower weight, usually by selecting smaller diameter wire.
b) The fatigue life will be improved.
c) The relaxation performance will also be improved.

Prestressing brings these benefits to compression springs by raising the torsional elastic limit of the wire (as shown in figure 1) AND imparting a residual torsional stress into the surface of active coils.



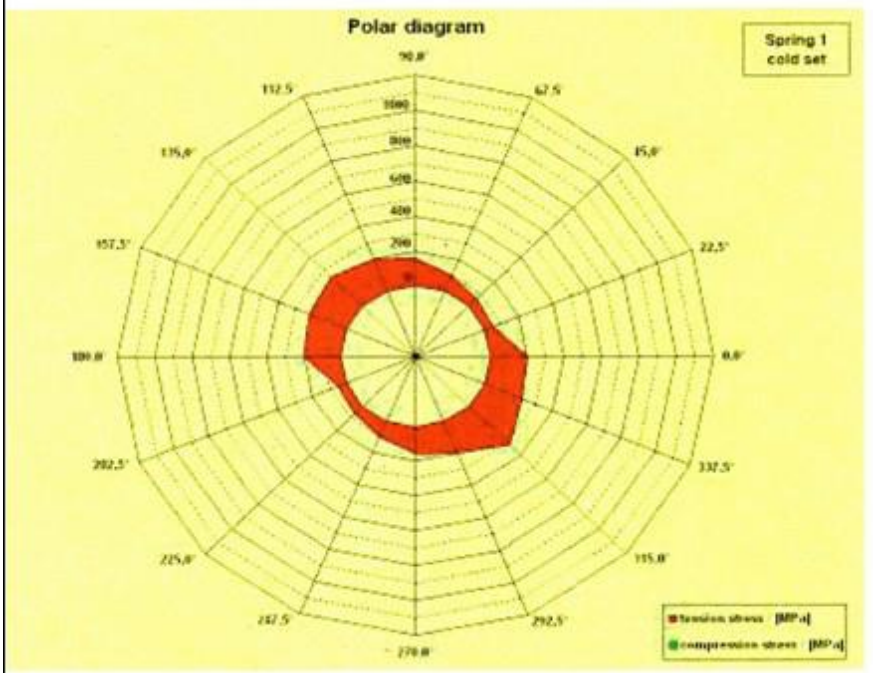
The residual torsional stress from prestressing is in the opposite direction to the applied torsional stress when the spring is loaded. It is just the surface of the active coils that are improved – the core of the wire remains elastic and is unaffected. The residual stresses can be measured accurately 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.



▲**Figure 1:** Spring 1, not set

Before Prestressing in the direction 45° / 225° residual stress is ~ +225MPa



▲**Figure 2:** Spring 1, cold set

After Prestressing residual stress is +45MPa

Returning to the original question – A spring will shorten during prestressing, but by how much? Taking, as an example, a 1mm (0.039”) diameter patented carbon steel wire (ASTM A227/A228 or EN 10270-1) compression spring with 8 coils and outside diameter of 8mm (0.315”). A free length of 19mm (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	20.67mm / 0.814”	8.1
1980 / 287k	19.81mm / 0.780”	4.1
2230 / 323k	19.30mm / 0.760”	1.6

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 him with comments about this cautionary tale, and with subjects that they would like to be addressed in future tales e-mail m.hayes@springexpert.co.uk