Cautionary Tale XXXV Coil Cracks

Two readers of this column have requested that I write about coil cracks because they could not find anything published about them. I welcome such requests, and am pleased to put this subject into the public domain.

Coil cracks occur when the residual tensile bending stress is not relieved soon after coiling. They occur mainly in pre-hardened and tempered silicon chromium wire that has been cold coiled. These facts are not in dispute, but the mechanism by which these cracks occur is not fully understood.

My former colleague, Len Reynolds, contended that coiling cracks are caused by the residual hydrogen content of the steel, and are a manifestation of hydrogen embrittlement. I am inclined to agree with him because:

a) Only a proportion of a batch of spring have cracks.
b) There appears to be a delay between coiling and cracking.
c) The crack is probably intergranular in nature.
d) There is a stress threshold below which coil cracks do not occur.

Whatever the mechanism that causes coil cracks, it is uncontentious to show what they look like both physically and in a metallographic section.

A typical coiling crack is shown in Figure 1.

Figure 1 **x 6.6**

The crack is transverse to the wire axis and is at the inside surface of the spring and are as likely to be found in the end coils as the active coils. In the spring shown in Figure 1 there were at least five coil cracks randomly spaced with the seven coils of the compression spring. The cracks were almost half way through the wire section - at the mouth the crack had gaped (Figure 2) and at its end had a thin layer of temper oxide (Figure 3).

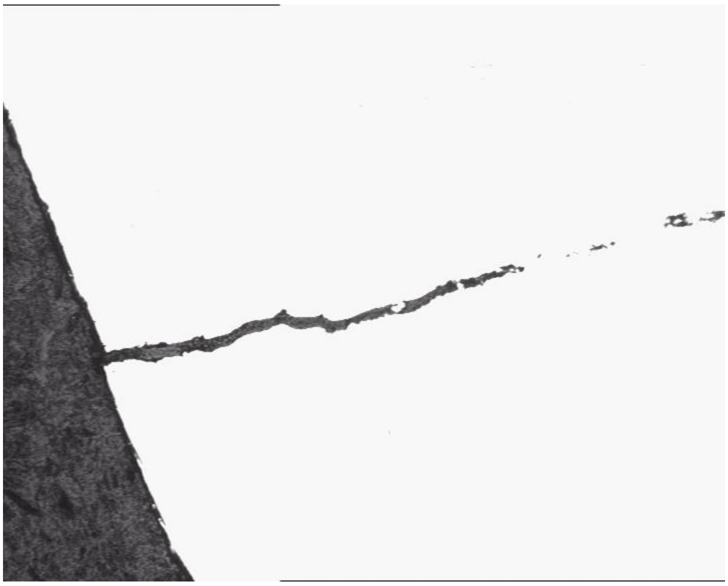

Figure 2 **x 87**

Figure 3 **x 430**

The existence of oxide shows that the cracks were already present before the spring was stress relieved - i.e. the crack formed after coiling, was due to the residual tensile bending stress from coiling (much greater than the residual torsional stress) and had oxidised during the stress relieving heat treatment.

Avoidance of coil cracks can only be reliably achieved by stress relieving very soon after coiling - ideally stress relieving on-line. The risk of these cracks is increased when

- The tensile strength (and hence the elastic limit of the wire) is high.
- The spring index is small (and hence the residual tensile bending stress is high).
- When springs get cold between coiling and stress relieving.
- When the delay between coiling and stress relieving is long.
- When the spring coiling process marks the inside surface of the spring and provides stress raisers.
- When the surface quality of the wire is poor.

Which leads me back to the spring materials susceptible to coil cracks. In the introduction I described coil cracks as occurring in oil tempered SiCr wire, and this type of cracking is more likely in this material than any other, but is not exclusive to this material. Of course SiCrV and SiCrNi will be prone to coil cracks as will induction hardened and tempered SiCr.

In SiCr or SiCrV springs coiled on a single point coiler the mandrel provides sufficient damage to the wire cross section as to promote very shallow coil cracks - 100 micros deep on average - it is supposed that the crack stops running once the spring receives heat from the on-line oven. To avoid these cracks people who make engine valve and clutch springs generally use two point coiling machines today. By now readers are thinking that only SiCr alloys suffer coil cracks, but readers, it is worth reading the whole of my cautionary tales. IST have seen coiling cracks in music wire springs of index 3 and in 17/7PH springs of index 3½. In both instances there was a very long delay between coiling and stress relieving - usually not a problem, but be wary of delays beyond the end of the shift when coiling these high elastic limit materials to a very small index.

During a recent training course the author gave in Eastern Asia he was asked to write about the effect of inclusions in spring steel, and this will be the subject of the next cautionary tale, but further subjects for this column would be welcomed.

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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, by telephone at (011) 44 114 252 7984, fax (011) 44 114 2527997 or e-mail m.hayes@ist.org.uk.