CAUTIONARY TALES

Part VI Heat Treatment Problems

It is *IST*'s experience that heat treatment is the process that spring manufacturers are least likely to fully understand, whether the process is

- harden and temper
- austemper
- stress relieving

If understanding of the process is incomplete, it can be very difficult to investigate problems logically when they arise. Three cautionary tales are related here and in Parts VII and VIII of this series, which illustrate some aspects of commonly occurring problems in each of the heat treatment processes described above. This first deals with harden and temper after hot coiling.

The author was recently on the shop floor of a factory that made hot coil springs when the Chief Inspector came up to him to ask why he was finding quench cracks in 2% of CrV alloy springs made out of 40mm ground bar. The coiler heard this question and said he was sure that the ground raw material still had surface defects. The inspector was concerned that it was the handling of hot springs with cold tools that was causing the problem. The manager, who was showing me his new production equipment, expressed concern that the quench oil might be to blame. Now all these explanations could have been correct, but further investigation revealed that the three fingers of blame were all pointing in the wrong direction.

IST investigation revealed that the cracks were caused by a combination of:

a) Heating some bars for too long prior to coiling
b) Delaying too long before tempering

This type of bar is always heated in air and so scale forms, but eventually the scale will start to grow between the grains of the austenitic structure.

After quenching, the oxide between the surface grains (that grew during heating) has the effect of putting the surface under a residual tensile stress and this "oxide penetration" appears, as shown in figure 1, when examined metallographically.

This residual tensile stress will be additive to the residual hoop stress that inevitably arises when steel is quenched and transforms from austenite to martensite, a transformation associated with a 4% volume expansion.

Together these two residual stresses could cause quench cracking, but, usually, will not.

However, the length of time and the ambient temperature whilst the steel had these residual stresses also have a bearing on the risk of quench cracking. *IST* investigation showed that it was the time delay between quench and temper that was causing the cracking – it was the springs that took the longest time to reach the tempering oven that were most at risk of forming quench crack – the characteristics of which are that it will be radial in direction, 2-20mm deep and slightly gaping at the bar surface, largely unbranched, and will have temper oxide along most of its length. Figure 2 shows a typical quench crack initiated by a seam in the raw material and figure 3 shows the relatively straight direction and intergranular nature of this type of crack, but this crack had no decarburisation or other abnormality at its root.

The moral of this cautionary tale is to keep all aspects of your harden and temper heat treatment under strict control, whether carried out after hot coiling, as in the above tale, or after cold coiling. Another moral is that all hot coil manufacturers have quench crack problems from time to time, but these problems can be virtually eliminated by careful process control.

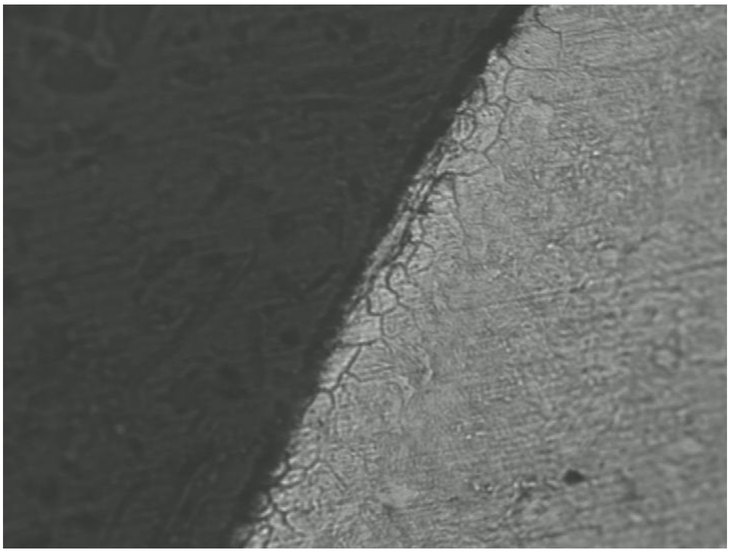

Fig. 1 Oxide penetrating the grains at the surface of a hot coiled spring X 889

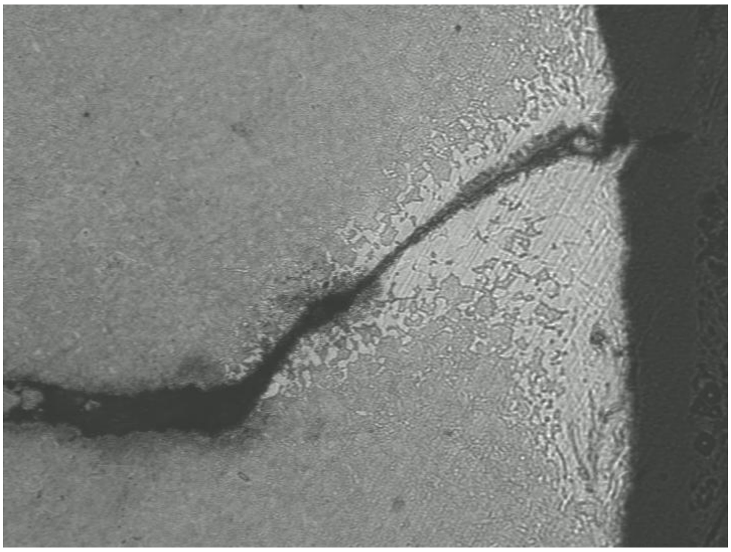

Fig. 2 Quench crack initiated by a seam   x175

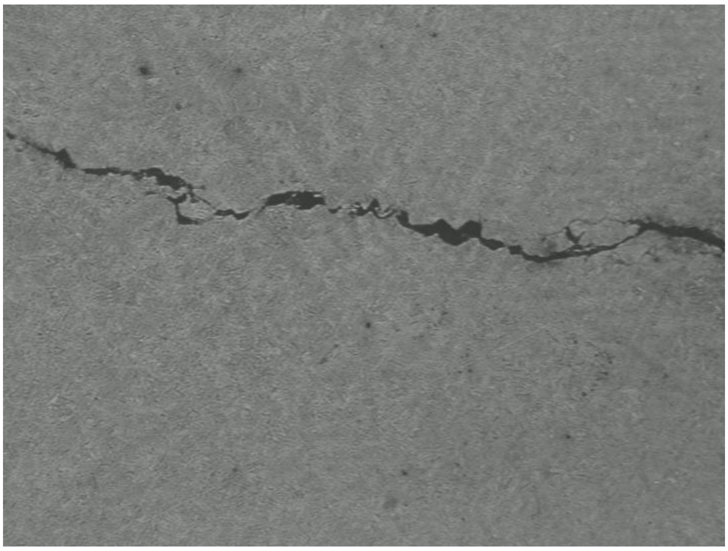

Fig. 3 Quench crack, intergranular and with   X 175
evidence of temper oxide throughout