Technically Speaking

Tempered martensite

In the last column in this series the microstructure of wires with a drawn pearlitic structure were illustrated. A majority of springs have this microstructure when you include bedding and seating springs, and you consider the wires used to reinforce rubber in tires.

This column will deal with the second most frequently used microstructure for springs, which is tempered martensite. Almost all silicon chromium springs have this microstructure, as do all hot formed springs. Tempered martensite is the resultant microstructure from the heat treatment process called harden and temper, which may be undertaken by wire drawers or strip rollers once the required size has been achieved, or may be accomplished by spring manufacturers after forming springs to the required shape.

Whoever undertakes the harden and temper process, it will involve:

1. Raising the temperature high enough to convert the microstructure to austenite for long enough such that carbides in the starting structure are taken into solution in the austenite.
2. Cooling the austenite rapidly (quenching) to cause more than 95% of the austenite to transform to martensite – a microstructure too hard and brittle to have useful spring properties.
3. Re-heating the martensite to produce tempered martensite. During tempering carbides grow, and the more they grow the softer the steel becomes.

Figure 1 shows SiCr spring wire that was conventionally hardened and tempered by a wire drawer. The constituent parts of the structure are extremely small. They would be smaller still if induction heating methods had been utilised.

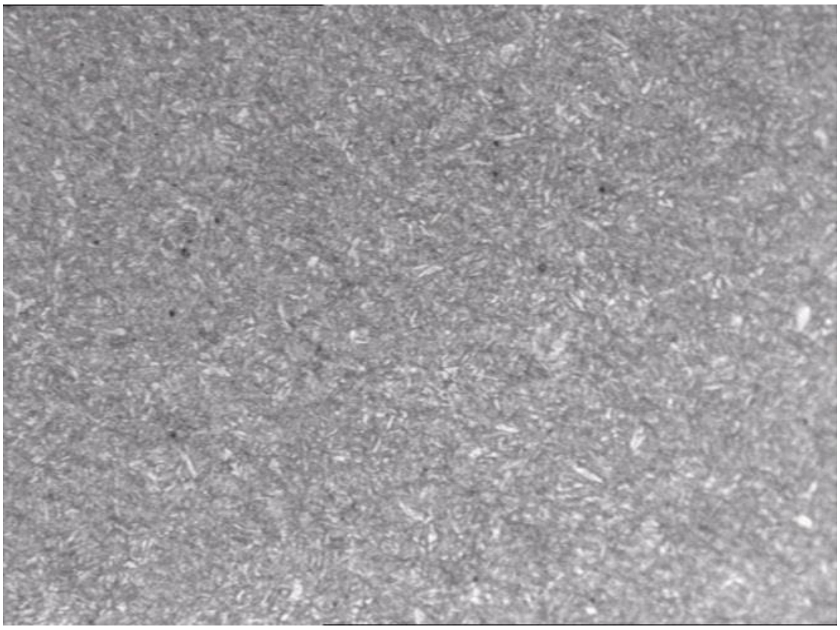

Figure 1 SiCr wire with a tempered martensite microstructure x 420

Figure 2 shows SiCr bar that has been hot coiled and then immediately hardened and tempered to produce tempered martensite. The constituent parts of the microstructure are coarser than in figure 1 because the heating temperature and time prior to quenching are necessarily larger, and this would still be true if a rapid heating method such as induction or resistance heating had been used.

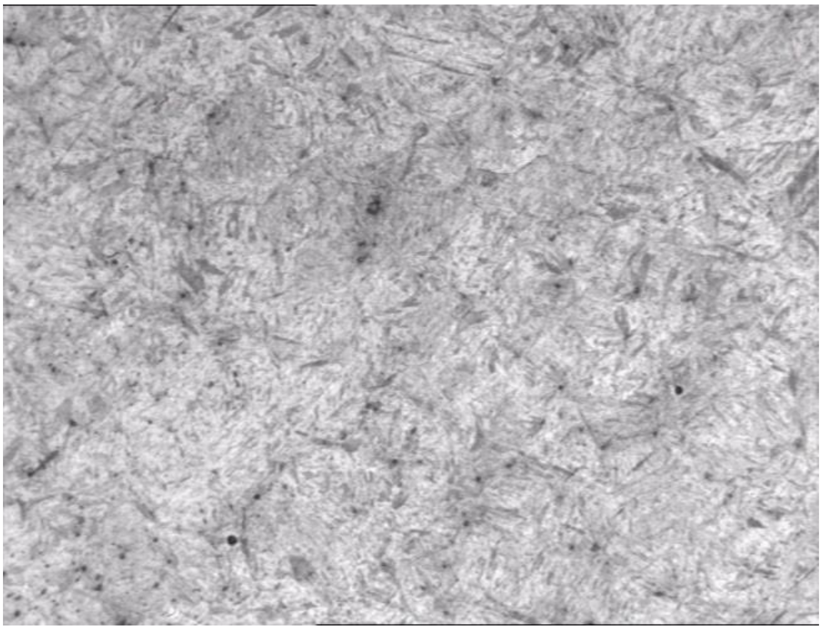
Figure 2 SiCr bar that has been hardened and tempered after hot coiling x 420.

The smaller the constituent parts of the microstructure and the higher the hardness, the better the fatigue performance of the resultant spring will be in most cases. However, the performance of the springs represented in figures 1 and 2 was satisfactory. It should also be noted that the above microstructures would have the same appearance whether a longitudinal or transverse section had been taken, which is not the case for the drawn pearlite shown in the last column, or the stainless steel that will feature in the next.

Mark Hayes is Technical Advisor to the Institute of Spring Technology (IST): The International Centre of Excellence for Spring Technology. He is the main instructor for the spring training courses that the IST offers globally.

Readers are encouraged to contact the author with comments about this technically speaking column, and with subjects that they would like to be addressed in future.
[*m.hayes@springexpert.co.uk*](mailto:m.hayes@springexpert.co.uk)