Technically Speaking

Stainless Steel

In the last column in this series the microstructure of wires with a tempered martensite structure were illustrated. Now it is the turn of spring hard stainless steels, but firstly there needs to be an explanation of the various types of stainless steel, and which ones have advantageous spring properties.

There are four different types of stainless steel, as defined by their microstructures.
Austenitic – with about 18%Cr and 8%Ni that requires cold reduction (wire drawing or cold rolling) to produce spring properties. The cold work causes some transformation of austenite to martensite, and it is the martensite that means this type of stainless steel is slightly magnetic, even in its Mo bearing version, 316.
Martensitic – with about 13%Cr and some level of carbon. Spring properties would be achieved by harden and temper heat treatment, but the high risk of stress corrosion cracking means that this type of stainless steel is seldom used for springs. Used for cutting implements.
Ferritic – with about 17%Cr. This type of stainless steel can never be made strong enough for it to have useful spring properties. Used for car exhausts.
Duplex – with more than 20%Cr, 1.4 - 7%Ni, 0.10%N, and often some level of Mo. This grade has a mixed microstructure of ferrite and austenite, and can have good spring properties as a result of cold work. It is more corrosion resistant than austenitics.

By far the most frequently used stainless steel for springs is the austenitic grade 302 or 304, and its microstructure is revealed by electrolytic etching in oxalic acid.

Figure 1 Highly elongated grains of austenite, which have been partially transformed to martensite, typical of 302 stainless steel. It is not possible to say from its microstructure the proportion of austenite remaining after cold reduction.

The austenitic stainless steel has a precipitation hardening variant, 17/7PH, which has aluminium added to cause precipitation hardening after spring coiling by heating to 480°C for on hour. This grade has higher strength than 302, excellent dynamic properties, but less corrosion resistance than 302. Its microstructure always shows numerous non-metallic inclusions (see figure 2) of alumina and/or titanium carbo-nitride, which very seldom affect the performance of springs.

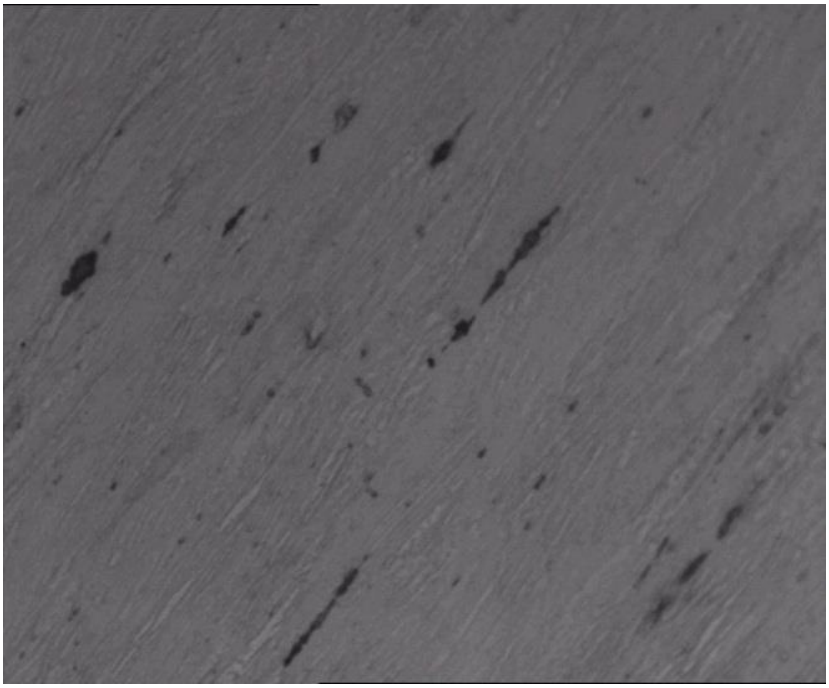

Figure 2 Highly elongated grains of austenite that have mostly transformed to martensite, and numerous elongated inclusions, typical of 17/7PH stainless steel

The structure of spring hard duplex is shown in figure 3.

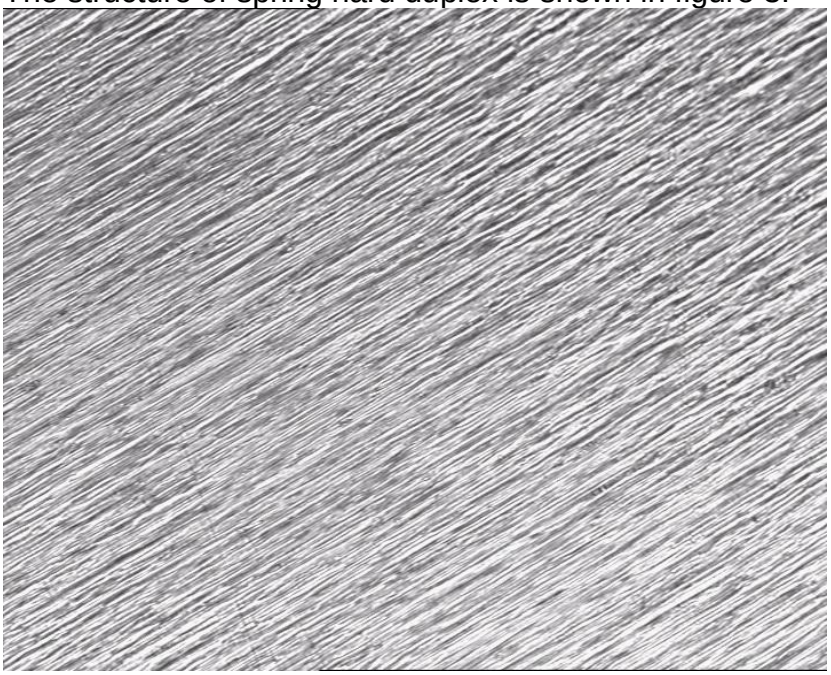

Figure 3 Duplex stainless steel, etched electrolytically in oxalic acid showing highly elongated alternating grains of ferrite (white) and austenite (darker).

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Readers are encouraged to contact Mark with comments about this technically speaking column, and with subjects that they would like to be addressed in future.
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