Cautionary Tales

Part V Hydrogen Embrittlement Myths

The fifth in this series is prepared from *IST*'s experience of dubious stories that are related about hydrogen embrittlement. It confirms the advice given in the third tale, and aims to dispel myths that abound, usually based upon an element of truth, but which do not tell the whole truth.

'My electroplating process is 100% efficient, and so there is no risk of hydrogen embrittlement and no need to de-embrittle after plating.'
The more efficient a process is, the less hydrogen will be evolved, but 100% efficiency is, of course, a myth. Electroplaters, should be encouraged to keep their efficiency as high as possible, but *IST*'s advice is that de-embrittlement after plating is definitely beneficial – de-embrittlement rules in ISO 9588 were drawn up to help you – ignore them at your peril.

'Austempered steel can be safely electroplated and there is no risk of hydrogen embrittlement after de-embrittlement heat treatment.'
Certainly austempered microstructures (i.e. lower bainite) are significantly less susceptible to hydrogen embrittlement than tempered martensite at the same hardness, but the risk of hydrogren embrittlement is not zero. De-embrittlement heat treatments are very beneficial, but whatever the microstructure, the risk of the occasional spring from a large batch failing by hydrogen embrittlement is still present. In fact, structures of cold worked pearlite (e.g. music wire) are even more resistant to hydrogen embrittlement than bainite at the same hardness. None of the international specifications relate the risk of embrittlement to microstructure, only tensile (or hardness) is acknowledged as a contributing risk, which is an over-simplification, but nonetheless *IST* believe the de-embrittlement rules should always be followed for maximum security against failure in service.

'My customer reports fracture on assembly of a plated spring clip, and so hydrogen embrittlement is suspected – can IST confirm that hydrogen caused the problem.'
Of course *IST* can do this – we do so two or three times per month on average, for someone around the world, and about 50% of the cases we investigate are not primarily due to hydrogen embrittlement. The latest example submitted to our laboratory was found to be a simple overload failure due to excessive force applied to the part during assembly. The fracture was as shown in figure 1.

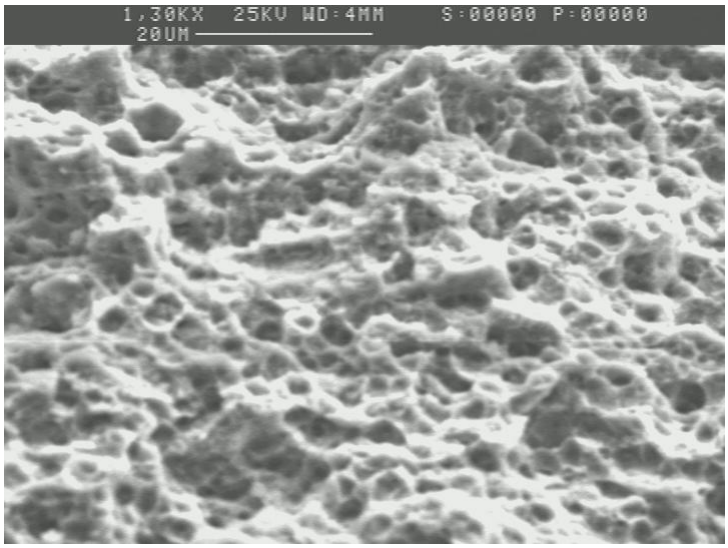

Fig 1 X 1,100
Fracture mechanism of a plated austempered CS70 spring clip. This ductile fracture is by microvoid coalescence.

Another recent example of a fractured spring clip was found to be due to hydrogen embrittlement despite all processing being carried out correctly including de-embrittlement. However, zinc was found on the fracture surface – this part had failed during electroplating due to the parts becoming tangled in a barrel, thereby putting some parts under stress during the electroplating.

'Mechanical Plating gives no risk of hydrogen embrittlement'
Now this is not a myth – *IST* have never found evidence that the mechanical plating process itself leaves a spring at risk. However, acid cleaning in 50% hydrochloric acid immediately prior to mechanical plating was blamed recently for the fracture appearance in figure 2.

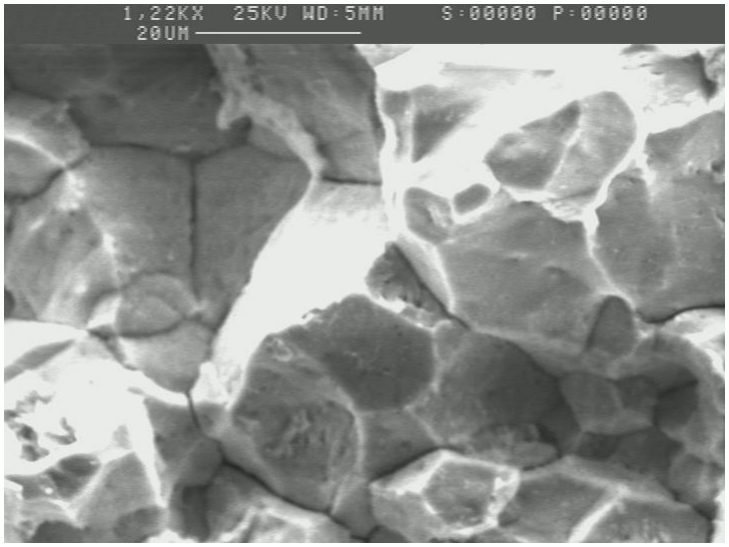

Fig 2 X 1,100
Fracture mechanism of a mechanically plated spring clip that had been acid cleaned prior to plating. This brittle fracture mechanism is mostly intergranular.

I suspect that some readers will have found this subject matter familiar, and the author would welcome your questions or observations on the advice offered or implied. The subject of hydrogen embrittlement is dealt with in *IST*'s training courses on 'Spring Manufacture', 'Spring Material Selection' and 'Failure Analysis', which are given regularly in the UK, can be given as in-house courses anywhere in the world.

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