Technically Speaking XI

Stress Corrosion Cracking

“In what circumstances may springs fail due to stress corrosion cracking? Is this a mechanism confined to exotic spring materials?” The Institute of Spring Technology recently received these questions from a customer and so Mark Hayes, from the IST, carried out a search to find a published answer to these questions. Hayes’s search drew a blank, suggesting that it would make a good subject for this column.

So what is stress corrosion cracking? The name is largely self explanatory, but it still needs explanation. To cause this failure mode there needs to be simultaneous stress and active corrosion. Stress without active corrosion might cause relaxation, but not fracture. Corrosion without stress may cause rust or rust pitting, but again no fracture, although corrosion pitting may provide a stress raiser for later stress corrosion cracking (SCC).

It is generally accepted that there is a stress threshold below which SCC does not occur. That threshold is quite low for car suspension springs - the self weight of the vehicle will put a stress on the springs. Putting a car away in a nice warm garage after a day out on salty roads has been known to cause suspension springs to go bang in the night due to SCC, and next morning the driver notices immediately because the jagged fracture surface of the spring punctures a tire. This is why some cars are fitted with ‘spring catchers’ to prevent failing springs puncturing tyres in this way. Maybe if you see a spring catcher fitted, there is more of a history of suspension spring failures than usual with that model. However, SCC is by far the most common failure mechanism for suspension springs on all makes of car, and in all countries where salt is used on the roads. This risk is ever present, particularly in winter, once the protective paint finish on the spring has been penetrated.

The foregoing answers both of the questions first posed. Ordinary low alloy spring steel is susceptible to SCC- its not just stainless steel and nickel alloys, and you need active corrosion and a high enough stress, but that is not the full picture. Some corrodents don’t lead to SCC - some springs go very rusty indeed and never fail until the material section is almost corroded away. This is particularly true of drawn carbon steel and music wire, which have a very high stress threshold for SCC, and is consequently very resistant to SCC in most corrosive situations.

302 stainless steel fails by SCC in some environments. Chlorine containing chemicals tend to cause intergranular (between the grains) SCC. Sulphur containing chemicals tend to cause transgranular (across the grains) SCC. Sometimes the corrosion is so slight that it is undetectable with the naked eye, but the spring suddenly fails with no more stress than its assembly pre-load. Yet stainless steel springs can go quite rusty and still function perfectly well. This paradox is what makes SCC difficult to predict and understand fully.

NACE (The US National Association of Corrosion Engineers) have devised a vast rule book to help designers to avoid SCC in sour environments- that is to say natural oil and gas reservoirs that are associated with some hydrogen sulphide. Their specification MR0175 tells you that Inconel® X750 is not susceptible to SCC if the springs have a hardness of <50HRC (no.1 temper), but are susceptible at >50HRC (spring hard). This is demonstration of the last key element affecting the risk of SCC - the higher the hardness of the spring steel, the greater the risk. So if you want SCC in your springs (and I don’t know anyone who does) then make the springs from really high strength steel, don’t protect them against corrosion adequately, give them a big stress in service, and make sure the conditions are corrosive. I’ll leave readers to work out how to avoid SCC - there are enough clues here, but there is no foolproof recipe to completely avoid SCC in springs.

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

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