Cautionary Tales Part XXIII Springs Everywhere

Springs are used in all forms of transport, road, rail, air, sea, space (to deploy the solar panels), snow, and it is often quoted that 40 – 50% of all springs are used in these industries. Springs are used in all white goods (washing machines, cookers etc….), toys, computers, televisions, telecommunications, audio equipment and mechanical, electrical and electronic equipment. They are used in the electrical and mechanical fittings of buildings, and sometimes even in building foundations as in the concert hall in Manchester, England, which is mounted on springs to isolate the inside of the hall from noise and vibrations on the outside. Factories for assembly, food production, power generation and mining rely upon them. It seems extremely likely that every manufacturing industry utilizes springs in most, if not all, of their products, and that fact has been admirably demonstrated by other articles in this edition. The title "Springs Everywhere" prompted *IST* to think of the many environments in which springs are used, and in particular the fact that some spring designs are used in many different locations.

One of the services provided by *IST* is failure analysis, but the results of the many examinations that are carried out (at least one broken spring is received from somewhere in the world every working day), have to be kept confidential. Nonetheless it is inevitable that generalised conclusions will be drawn from these investigations, and one of those conclusions is that a common design fault that leads to spring failure is inadequate consideration of the operating environment. Indeed it is often heard that a spring works without problem in most sites around the world, but gives problems in only one or two. It is nearly always the case that the working environment will be the cause of the problem, and that there will be some corrosion on the failing springs, but none at all on the springs that are operating satisfactorily.

An example of the working environment causing a spring failure problem has been quoted so often in *IST*'s training course on "Spring Failure and Prevention" that it seems reasonable now to put the results in print, albeit anonymously. A stainless steel compression spring made from 4.4 mm diameter wire was working within ink in a printing machine. After a few months of use the springs would fall into three to six pieces and the problem was happening only at one plant despite being used in many. Visual examination of the fracture showed immediately that the spring had failed due to fatigue, as shown in figure 1. The fracture is rather green in colour, but that is due to the green ink!

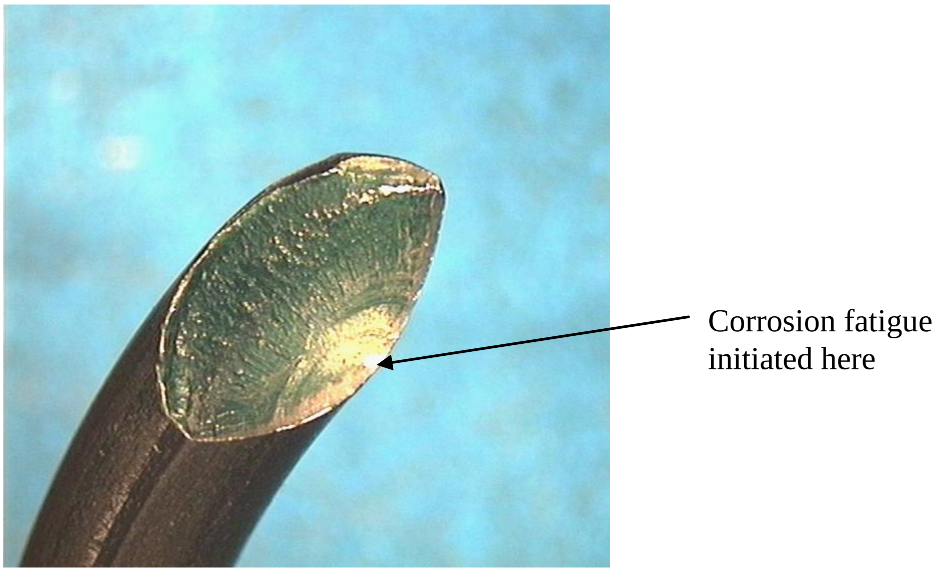

Figure 1 Fatigue initiated at the inside surface x 6.1

IST's conclusion was that failure was due to corrosion fatigue, which astonished the spring maker who saw no rust and knew that the spring didn't fail when fatigue tested. Further investigation, though, revealed that the ink, suspended in alcohol, was becoming acidic in use and it was only then that the spring failed. The ink should have been neutral and when the pH came under control the spring lasted forever and the springmaker received no further orders. Failure analysis can have unwelcome results for spring manufacturers, but this is not the main point I wanted to make in this cautionary tale. The most important point is that control of the environment is vital for satisfactory spring performance and the secondary point is that simultaneous corrosion and fatigue can cause failure where either fatigue or corrosion alone would not and in stainless steel it might not be possible to see any red rust at all, but with corrosion fatigue you often see several fractures in one spring, whereas most ordinary fatigue failures are at one position only.

A similar story can be told for suspension springs for cars. These springs are more susceptible to failure in some countries than others, and the most frequent failure mechanism is stress corrosion cracking or corrosion fatigue. In countries where the weather is hot and dry, the paint protection may be sand blasted off, but the springs last for the life of the vehicle. In hot and humid countries the paint finish remains intact and the springs last very well. In countries where the weather is cool and wet and where salt is used on the roads in winter, the risk of failure occurs once the paint finish has been penetrated, which is why OEM specifiers require especially thick paint today that will last > 720 hours in salt spray testing. However, once the spring starts rusting the risk is always there, especially if the strength of the steel is high. Tests at *IST* have shown that suspension springs last three times as long before they fail by a stress corrosion mechanism if the spring steel hardness is reduced by 50Hv.

Mark Hayes is the Senior Metallurgist at the Institute of Spring Technology (IST) in Sheffield, England. Hayes manages IST's European Research Projects, the spring failure analysis service, and all metallurgical aspects of advice and training courses given by the Institute.

Readers are encouraged to contact him with comments about this cautionary tale, and with subjects that they would like to be addressed in future tales, by telephone at (011) 44 114 252 7984 (direct dial), fax (011) 44 114 2527997 or e-mail at m.hayes@ist.org.uk.