Cautionary Tales

Part XIII Technology, the state of the art.

There are very many aspects of technology used by, and accessible to the spring industry that could be discussed in this column. These include

- Finite Element Analysis
- Residual stress analysis
- Measurement of non-axial forces from compression springs
- Use of information technology in various ways
- Induction heating
- Coilability and friction measurements
- R & R Charting
- Computer aided design of springs
- Fatigue data prediction
- Three dimensional CAD
- Energy Dispersive X-ray Analysis

It is clear that the spring industry is confronted by many technologies, and I don't suppose that I have listed half of them above, but these are the technologies that IST know something about, and for this cautionary tale I have chosen to write about the last on the list.

Energy Dispersive X-ray Analysis (EDX) is a method used in conjunction with scanning electron microscopy. Its main areas of usefulness to spring manufacturers lies in the analysis of rust deposits, surface coatings, inclusions that caused failure, and contaminants left on spring surfaces. It is only a semi-quantitative method and so is not useful for accurate chemical analysis of the steel used to make springs.

EDX is a technology that involves scanning a surface with electrons, and detecting the energy of the X-rays that are emitted as a consequence. The energy of the X-rays is characteristic of the elements present in the target being scanned, and a typical spectrum produced by EDX analysis is as shown in figure 1, which is from a stainless steel spring that had been coiled, stress relieved and cleaned. The stainless steel spring will have had an oxide coating, but the analysis produced is from about 2 microns of the surface, and the oxide is very much thinner than that, so the analysis is of the oxide and some of the steel below the oxide – hence the spectrum being dominated by iron (Fe), chromium (Cr) and nickel (Ni) in approximately the expected proportions for 18/8 or 302 stainless steel. Note that two or three "peaks" will appear for those elements in larger concentrations such as Fe, being the K alpha, K beta and L alpha peaks.

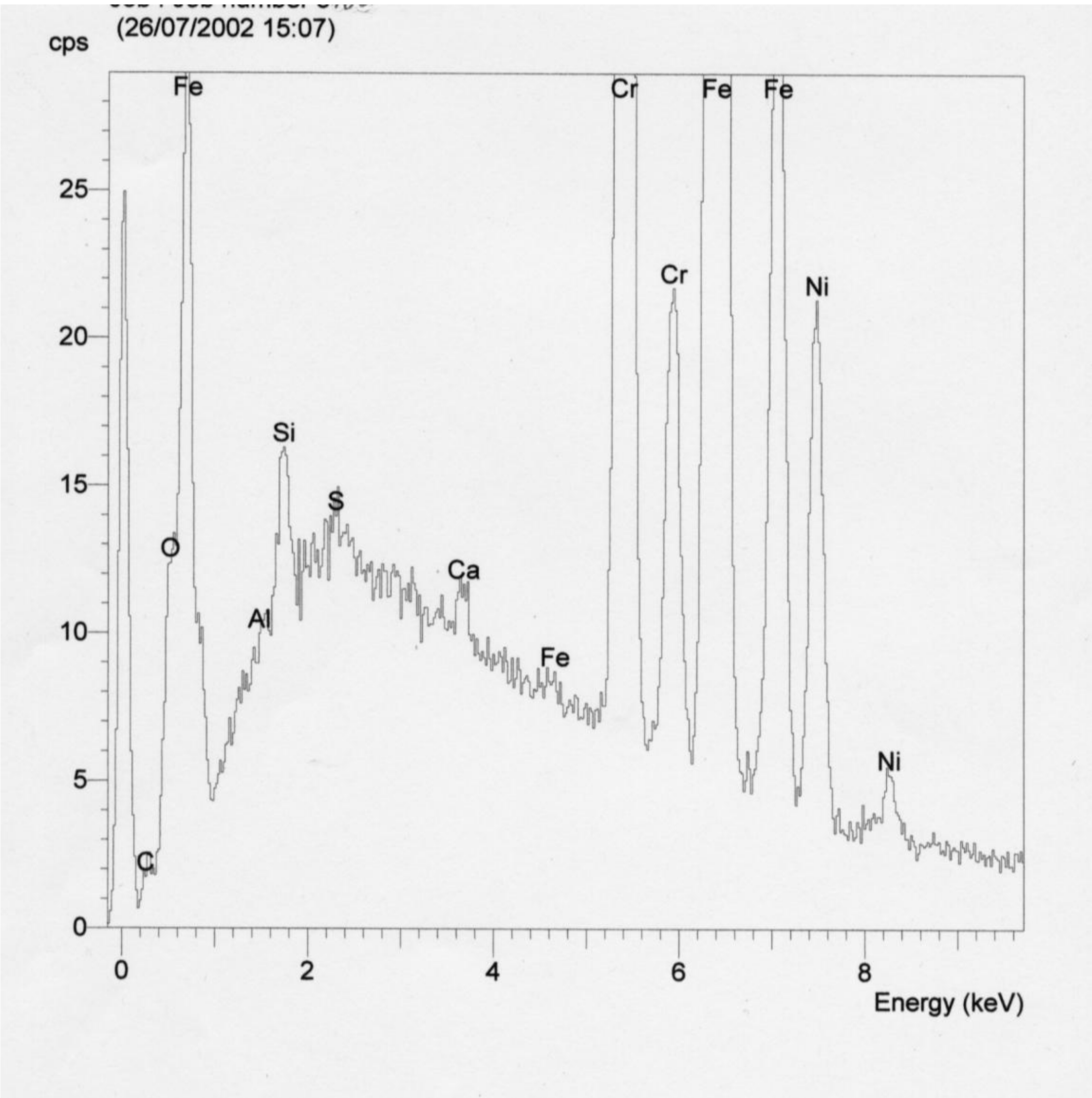

Figure 1 EDX spectrum from the surface of a 302 stainless steel spring

The oxygen (O) is from the oxide, and so the only significant contaminants on this sample were silicon (Si), Sulfur (S) and Calcium (Ca), and these are at low levels. The silicon will be a combination of the silicon content of the steel and dust left on the spring surface. The calcium will have arisen from incomplete cleaning off of the calcium stearate soap used in wire drawing, and the sulfur probably arose from an oil added during coiling to aid that process. However, the source of these elements can only be guessed at from the results of an EDX analysis. One can make intelligent guesses, for instance when the only contaminants found are sodium and chlorine, then common salt (NaCl) is the most likely contaminant, but this is just a guess. The above analysis is typical of stainless steel that has been well cleaned, but not perfectly cleaned – it is very difficult to clean stainless steel perfectly, and EDX is ideal for defining the level of cleaning that has been achieved.

It can also be used to identify the elements associated with corrosion damage providing that the surface hasn't been cleaned any better than would occur in degreasing in a solvent such as acetone (propanone).

If it is important to know the composition of the oxide only, without any of the steel beneath, then EDX is not useful, and so another electron optic method such as Auger electron spectroscopy would have to be used. This method only analyses 2nm of surface, or ten atomic layers, so only the surface of the oxide would be analysed initially.

The moral of this cautionary tale is that you should be aware of what EDX can achieve, but also of the intelligent guesswork that will be necessary when the results are received. For instance, a recent analysis revealed high potassium contamination and it took some detective work to realise that this element arose from detergent, but once that was realised, the problem became solvable.

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