Cautionary Tale: 50 years

Congratulations to “Springs” on its Golden Anniversary. This column is only 12 years old, but IST are able to look back 50 years and more, and make an appraisal of what has changed in the spring industry during this time. It is tempting to respond to the question “What has changed?” with the simple answer, “Not a lot”, but 50 years ago your author was a schoolboy and remembers helping his father to repair the family car. It was a Ford, and one of the engine valve springs had failed. The engine was stripped down, and the valve springs were replaced. I remembered being told that they were made from the same steel as used in the Spitfire that my father flew in the last World War, that is oil tempered CrV steel. One of my jobs was to grind in the valve seats, and a really tedious job it was too.

From this story, it is clear that engine valve springs used to fail, and my father was lucky that his engine was not destroyed. Today, engine valve spring failures are very rare – one in ten million fail, or so its estimated, and some manufacturers claim reliability better than this.

This improvement has been brought about by;

a) better spring materials
b) more accurate and controlled spring manufacture
c) improved knowledge of the design limits to ensure very high reliability.

It is interesting to look at these three aspects of spring technology in turn to recognise that the changes made were gradual and evolutionary, rather than revolutionary. Certainly my father’s car was built in the UK and the replacement valve springs were also purchased from a UK manufacturer, but today it would be quite hard to trace where the car was built or where the springs were made. The car and spring industries have become truly global, but the spring technologies used in USA, Japan, China, Europe and everywhere else, are practically identical.

Better Spring Materials

In 1962 spring manufacturers the following wire types were the most important; drawn carbon steel including bedding and seating and music grades, oil tempered carbon and CrV steel, 302 stainless steel and nickel alloys. Today, the carbon and CrV oil tempered has become SiCr or SiCrV, or similar, because the tensile strength is higher without incurring significant cost disadvantages For the highest performance, essential for valve springs, the SiCr family are available as superclean. The SiCr is also available as induction hardened in the size range 7 – 17mm approximately, and this wire is gradually replacing the hot coil grades in this size range. Apart from the SiCr, the spring materials are the same. The manufacturing control has improved significantly over the last 50 years, leading to more consistent and better quality, but the grades are largely the same.

More Accurate and Controlled Spring Manufacture

In 1962 an engine valve spring would have been coiled on an automatic coiling machine, heat treated in a batch oven, ground, shot peened and prestressed. Clearly nothing has changed fundamentally. Today the coiler would be computer controlled and will bristle with controls to ensure consistent dimensions in the product, but the use of computers has not de-skilled the process of setting up the coiler, just made it easier and quicker. The heat treatment will almost certainly be in-line today, but the other processes have just gained better controls. The prestressing would be done warm, but the author is uncertain whether this method was already in use in 1962 – it may have been.

Improved Knowledge of Design limits

In 1962, springs would have been designed using pen and paper, or perhaps the earliest slide rules. The formulae used were those of classical mechanics including sophistications

like curvature correction factors. Today, springs would be designed on a computer using exactly the same classical mechanics formulae. There are more advanced design methods available today such as Finite Element Analysis(FEA), but the spring industry doesn't need them. Indeed IST was once challenged by a major American spring user to verify a new barrel shaped spring at the same time as an FEA engineer. The methods yielded stress results within 3% of each other at all positions, but the FEA engineer took a few hours to set up the model and run the analysis, but IST's analysis was done in front of an audience in just over half an hour. The FEA engineer was then asked what performance could be expected as a result of these stresses. He replied candidly that he did not know – that was beyond his remit. The IST analysis came with performance predictions, which proved to be accurate for fatigue and relaxation, and that is the improvement in design methods today – performance can be predicted accurately leading to phenomenal reliability, quite unimaginable in 1962, and that is the point of this cautionary tale.

Evolutionary development of spring materials, manufacture and design has lead to the ability to design springs today that are close to 100% reliable.

Mark Hayes is Technical Advisor to the Institute of Spring Technology (IST) in Sheffield, England. He is also the principal trainer for the spring training courses that the Institute offers globally.

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 - e-mail m.hayes@springexpert.co.uk