Cautionary Tale: Shot Peening Compression Springs

***Cautionary Tale: Shot Peening Compression Springs* has been reprinted with permission from *Springs* magazine, April 2009.**

Shot peening is a process used by the spring industry that brings significant benefits to spring performance. It is a process that is not always fully understood. Springmakers usually know that the process improves the fatigue resistance of the springs they make, but do not always fully understand the mechanism behind this improvement. The purpose of this cautionary tale is to explain some of the theory behind shot peening of compression springs, which will help springmakers and their customers understand the process and the benefits it brings.

Shot peening of compression springs is a process that involves bombarding the whole surface of the spring with very many particles of rounded shot. The impact from the shot is so numerous that at least 80 percent of the spring surface is covered with small dents. Often 90 or 100 percent coverage is specified, but IST (Institute of Spring Technology) recommends an absolute minimum of 80 percent to be effective. Each impact produces a small dent and around that dent there will be a layer of material that has been work hardened by the impact and a deeper layer that has a residual compressive stress. After shot peening, the benefits accrued are:

a) The spring surface is harder (stronger).

b) The original wire surface is smoother with the original wire drawing marks being largely obliterated.

c) There will be a residual compressive stress on the inside surface of the compression spring where the applied stress in service will be a maximum.

All three of these benefits will contribute to the improvement in fatigue performance. But it is the last, the generation of a residual compressive stress that is the most important by far. It should be the strategy of spring manufacturers to maximize the residual stress. It should be noted that the residual compressive stress from shot peening offsets the resolved tensile component of the applied or operational stress.

Maximizing residual stress presents a problem to most springmakers because they have no machine for measuring this parameter in the springs they peen. Manufacturers of engine valve springs probably have the X-ray equipment necessary for measuring residual stress.

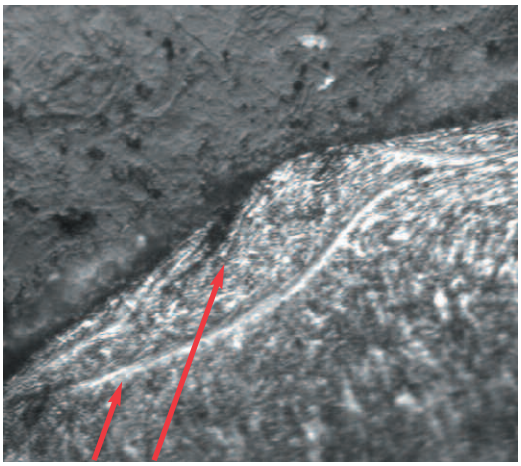

Figure 1: White lines and lap due to shot peening

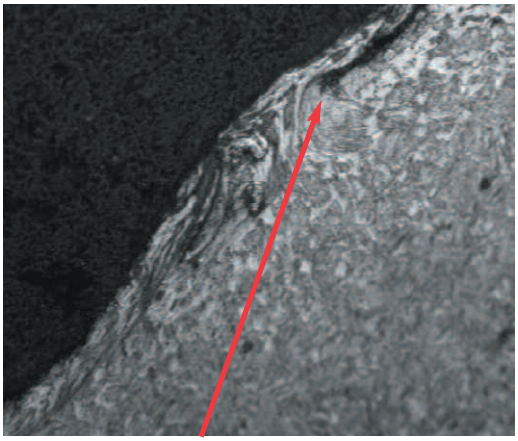

Figure 2: Cold working of the spring surface due to shot peening and lap

If you don't make these very high performance springs, you probably have the means to measure the intensity of your shot peening using Almen strips. If the shot you use is between 2 and 20 percent of the spring wire diameter, then the higher the Almen arc rise the better the peening will be. However, there is a possibility of over-peening using this clumsy approach to optimize your process. Over-peening is not a disaster, because spring performance will always be better with over-peening than

with no peening at all. However some buyers of springs are concerned about over-peening. This is particularly true when a company's metallurgist finds laps and a white layer at the surface of shot peened spring, as shown in the two photographs. Figure 1 shows the white layer and a shallow lap, and figure 2 shows a lap.

Would your customer be worried by the shot peening shown in the photographs? A recent inquiry to IST asked whether the white layer was friction martensite (adiabatic martensite)? Another asked if the damage shown in figure 2 was excessive.

The answer to these very reasonable questions was that the performance of the springs photographed above was satisfactory. So you should not be particularly worried by this appearance. The white layer is due to work hardening and is not friction martensite (which would be a disaster if present). Laps are inevitable with good shot peening and if the depth is less than 5 microns for cold-formed and 10 microns for hot-formed springs, they probably don't matter. Reassured? I hope so, but there are several other cautionary tales that the author could write on this subject if there is sufficient interest. ●

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