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Cautionary Tale: Shot Peen Stress Relief

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THE MANAGER of a spring manufacturing company recently asked why his company always gave compression springs a stress relief heat treatment after shot peening, except when the springs are warm prestressed or painted after peening. Once the effect of this process had been explained, and confirmation had been given that the heating for warm prestressing or paint curing (at 180-200°C) did the same job as the stress relief, the manager then wanted a technical explanation of exactly how the stress relief worked.

In a similar vein, the manager of a shot peening company expressed surprise when he heard that springs should be stress relieved after peening. His company peened many aircraft components, and never applied any heat after peening for fear of a reduction in the residual compressive stress achieved during peening. This is a subject the company knew a lot about because they are obliged to measure residual stress profiles achieved by their peening process. Indeed, once it had been explained that IST had data showing that spring fatigue performance was not reduced when a temperature of 220°C was used, the company measured the residual compressive stress at 45° to the inside surface of compression springs, and found, to their surprise, how little the residual stress was reduced by this stress relief heat treatment.

A novelty for this column is the inclusion of test results specifically generated to confirm the benefits of post-peening stress relief of springs. Compression springs made from 1.5mm diameter pre-hardened and tempered silicon chromium wire were stress relief heat treated at 400°C after coiling, and then shot peened with 0.3mm steel shot. Half of the batch of springs were given a stress relief at 220°C after peening, and half were not. The two batches were load tested to quantify the length at which significant load was lost, and the reduction in free length due to prestressing to the closed length (load ~50% greater than τ_c.)

These results clearly show that the compression springs will take a significant set on first application of load if they are not stress relieved after peening. The explanation for this is that the shot peening generates numerous dislocations within the material microstructure, which contribute to the residual compressive stress at the spring surface. However, these dislocations are mobile and some will "run away" from the surface when the spring is loaded. If the springs are heat treated at between 200 and 250°C, the mobile dislocations become decorated with strain age hardening precipitates, which render them much less mobile. That is a rather more technical explanation than is usually given in this column, but a spring manufacturer asked the question and there is no simpler answer!

The moral of this cautionary tale is that observations made by spring manufacturers about the behavior of springs may be fully explained by the leading experts in this field of technology, and at a simpler level, the stress relief heat treatment after peening is strongly recommended.

LTHT (°C)	Length at loss of 0.5N load (mm)	Shortening after prestress to 180N (mm)	Spring Rate (N/mm)	Outside Diameter (mm)	Free Length (mm)
400	15.5	0.52	1.50	19.20	65.5
400 + P	36	2.00	1.46	19.33	65.5
400 + P+ L	16	0.55	1.46	19.33	65.5

Figure 1. Results for silicon chromium springs. P = shot peened, P+L = peened then a low temperature heat treatment (LTHT) at 220°C.