Cautionary Tale: Shot Peen Stress Relief

The manager of a spring manufacturing company recently asked the author why his company always gives compression springs a stress relief heat treatment after shot peening except when they warm prestress or they paint the springs. Once I had explained the effect of this process, and confirmed that the heating for warm prestress or the paint cure (at180-200°C) did the same job as the stress relief, he wanted a technical explanation of exactly how the stress relief worked.

In a similar vein, I was reminded of the surprise expressed to me by the manager of a shot peening company when he heard that springs should be stress relieved after peening. His company peened many aircraft components, and they never apply any heat after peening for fear of a reduction in the residual compressive stress achieved during peening – a subject the company knew a lot about as they are obliged to measure residual stress profiles achieved by their peening process. Indeed, once I had explained that IST had data to show 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, here are test results generated specifically to confirm the benefits of stress relieving springs after peening. Compression springs made from 1.5mm diameter SiCr were stress relief heat treated at 400°C and shot peened with 0.3mm steel shot. Half were stress relief heat treated at 220°C after peening, and half were not. The two spring batches were load tested progressively 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.)

LTHT / °C	Length @ loss of 0.5N mm	Shortening mm after prestress to 180N	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 SiCr springs. P = shot peened, P+L = peened + LTHT @220°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. Other conclusions could also be drawn from these results.

The explanation for this is that the shot peening generates numerous dislocations, 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 these mobile dislocations will become decorated with strain age hardening precipitates, which will 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 behaviour 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.

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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