In the SPOTLIGHT

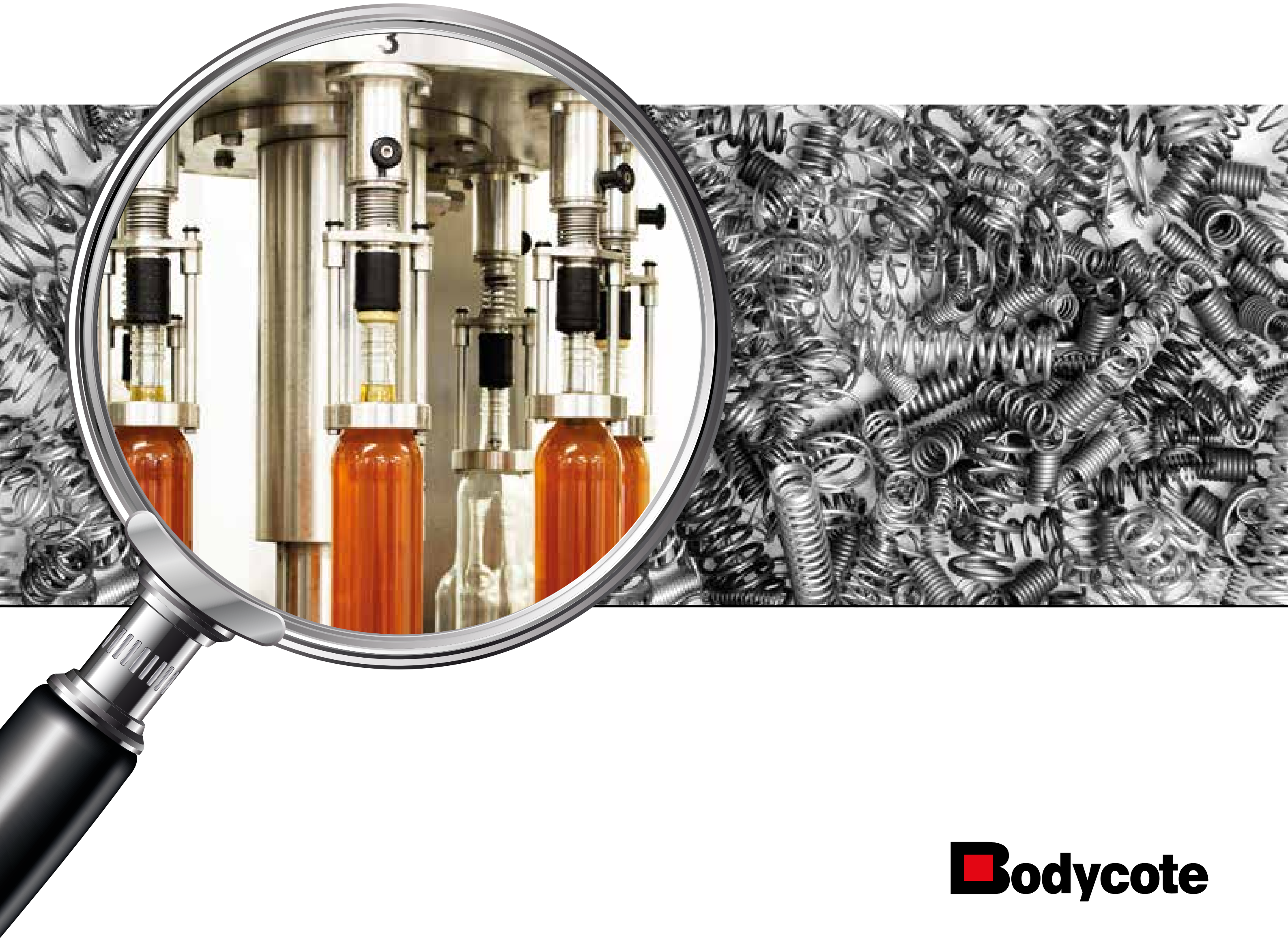
S^3P IN SPRING APPLICATIONS

INCREASED ENDURANCE LIMIT

HIGH COMPRESSIVE RESIDUAL STRESSES

UNCHANGED SURFACE TOPOGRAPHY

IMPROVED FATIGUE STRENGTH



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S³P – Specialty Stainless Steel Processes
Spring Applications

The special property of technical metal springs is their reversible change of shape under load. Stainless steel springs are utilized in almost all industries where special requirements are placed on the corrosive or non-magnetic properties. Unfortunately, these stainless alloys exhibit poor fatigue characteristics limiting their life or range of application. S³P (Specialty Stainless Steel Processes) featuring Kolsterising®, are proprietary processes developed to significantly increase the tribological and fatigue performance of such alloy systems, while maintaining their corrosion resistant behaviour. This improvement is achieved by interstitial embedding of carbon and/or nitrogen atoms, which leads to enormous compressive residual stresses at the surface.

Fatigue of Stainless Steel Springs

Fatigue is a common failure mode of industrial used springs due to the formation and propagation of cracks, mostly at areas with small defects such as scratches or grooves by frequent cycling, as seen in the example shown in Fig. 1. This can be one of the challenges when designing an appropriate spring for an application.

S³P vs. Shot Peening

Conventionally, such components will be shot peened, a mechanical surface treatment, to strengthen the surface by introducing compressive residual stresses and work hardening via repeated impacts on the material surface with specific shots. However, this results in a changed topography, introducing notches or gaps, which in turn can lead to premature failure. To compare the effect of this mechanical treatment with those of the diffusion-based S³P treatment, austenitic stainless steel springs made out of 1.4310 (AISI 302) in different conditions were tested in parallel to 100 % failure. The final fatigue failure results for untreated, shot peened, S³P Kolsterising® K10 and K33 treated springs are shown in Fig. 2. Traditional shot peening showed an improvement of 120 % compared to untreated springs, while the S³P Kolsterising® processes K10 and K33, provided even greater improvements of 334 % and 521 %, respectively. These differences can be explained by comparing the surface hardness values, which correlate to the compressive residual stress conditions: While shot peening increases the surface hardness from an initial value of 468 $HV_{0.05}$ to 563 $HV_{0.05}$, the S³P-treated samples end up at significantly higher values of 860 $HV_{0.05}$ and 980 $HV_{0.05}$ for S³P Kolsterising® K10 and K33, respectively.

Advantages of S³P

- Increased fatigue properties
- Higher spring factor (for small springs)
- Use thinner wire diameters – with higher spring rate
- No impact on surface finish

Fig. 1 Unused spring (left). Aged and fractured spring (right).

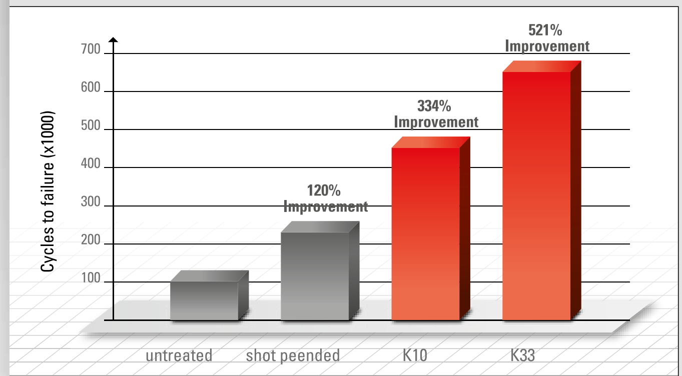

Fig. 2 Fatigue failure test results of 1.4310 (AISI 302) stainless steel coil springs with 1.6 mm (.063") wire diameter, 15.6 mm (.615") outer diameter and 279.4 mm (1.10") free length in different conditions: untreated – shot peened – S³P Kolsterising® K10 – S³P Kolsterising® K33. Test terms: 928.8 kg/m (52lbs/in) spring rate, 12.4 mm (.49") deflection (adjusted to 70 % of the wire's minimum tensile strength) and 360 cycles/min.

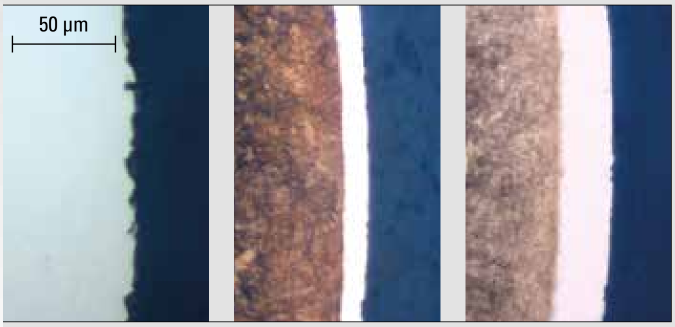

Fig. 3 Metallographic cross section of untested springs in different conditions: Shot peened (non-etched) – Kolsterising® K10 – Kolsterising® K33 (etched). With shot peening, gaps and notches are generated while S³P Kolsterising® creates a bright, precipitation-free diffusion zone of 11 µm (K10) and 29 µm (K33).

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05.2023/EN 15044-0098