In the SPOTLIGHT

S³P – MAINTAINING IMPACT TOUGHNESS OF STAINLESS STEELS AT LOW TEMPERATURE

HARD AND DUCTILE

AVOID BRITTLENESS

SUITABLE FOR CRYOGENIC APPLICATIONS

CHEMICAL RESISTANCE

Bodycote

SPOTLIGHT

S³P – Specialty Stainless Steel Processes
Impact Toughness

Excellent toughness

Ductile materials have the ability to absorb large amounts of energy upon impact before fracturing, whereas brittle materials may shatter on impact leading to catastrophic results. Some alloys are even known to be very sensitive to changes in temperature, experiencing a transition from ductile-to-brittle fracture if the temperature is lowered. Austenitic stainless steels do not experience this ductile-to-brittle transition, thus making them well suited for cryogenic applications. The downside is that austenitic stainless steels exhibit poor galling and wear resistance. Fortunately Bodycote's Specialty Stainless Steel Processes (S³P) have a solution.

Ductile at cryogenic temperatures

In designing applications for low-temperature use, it is critical to be aware that temperatures can affect the toughness of stainless steels. Duplex, ferritic and martensitic stainless steels experience a ductile-to-brittle transition at low temperatures, see Fig. 1. Austenitic stainless steels do not experience this ductile-to-brittle transition and remain ductile even at low temperatures. For this reason, austenitic stainless steels are well suited for cryogenic services.

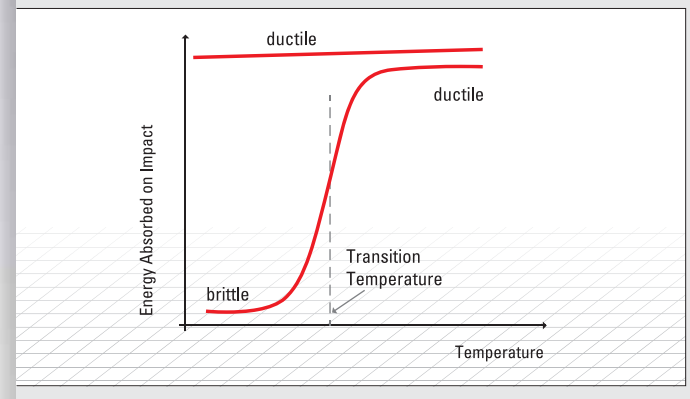

Fig. 1 Ductile-to-brittle transition (schematic).

Unfortunately, austenitic stainless steels exhibit poor galling and wear resistance properties, limiting their life or range of application. These shortcomings can be overcome with S³P technologies, featuring Kolsterising®. These proprietary processes improve the galling, wear, and fatigue behaviour of austenitic stainless steels all whilst maintaining their corrosion resistance and toughness, even at cryogenic temperatures.

This ductile behaviour can be displayed by a simple test at room temperature. The surface of a 316 (1.4404) sample treated in the Kolsterising® process was struck with a hammer and nail resulting in deformation. The integrity of the surface was analysed and the hardened layer was fully intact displaying no delamination or cracks, see Fig. 2. A more severe and quantitative approach to assess toughness was performed at cryogenic temperatures (-196 °C / -320 °F) using Charpy impact testing on 316 (1.4404) and 926 (1.4529) samples per ASTM E23-12C. This test measures the energy absorbed by the fractured specimen; the more energy absorbed, the tougher the material. S³P-treated and untreated samples were evaluated, see Fig. 3. The results show that S³P treated austenitic stainles steels show slightly higher toughness values than untreated samples.

Fig. 2 316 (1.4404) stainless steel sample, impact of hammer and nail test showing good deformability.

The excellent toughness properties of austenitic stainless steel remains unchanged, in particular at low temperatures after the Kolsterising® process.

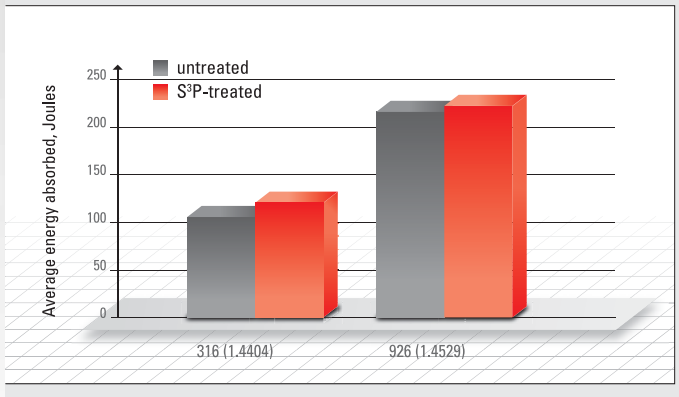

Fig. 3 Charpy Test ASTM E23-12C; test temperature -196 °C (-230 °F).

Advantages of S³P

- Homogeneous diffusion layer
- No cracking or flaking-off of hardened layer
- Maintains corrosion resistance
- High surface hardness > 900 $HV_{0.05}$
- Eliminates fretting and galling
- Improves cavitation erosion resistance
- Improves wear resistance
- Increases fatigue resistance

Bodycote

www.bodycote.com
S3P@bodycote.com

10.2018 / EN 422-1866