BENDING, COLD FORMING, AND SPRINGBACK OF DUPLEX STAINLESS STEELS

Duplex stainless steels exhibit good formability. Most applications of duplex stainless steels have required relatively simple forming, such as the rolling of cylindrical sections, press forming, and vessel and tank head forming by pressing or rolling. In these applications, a primary concern is the high strength of duplex stainless steel and the power of the forming equipment. A first estimate is that a duplex stainless steel will respond to forming similar to a 300-series austenitic grade at twice the thickness. A comparison of the minimum force required to begin plastic deformation in bending for two duplex stainless steels and Type 316L is shown in Figure 1.

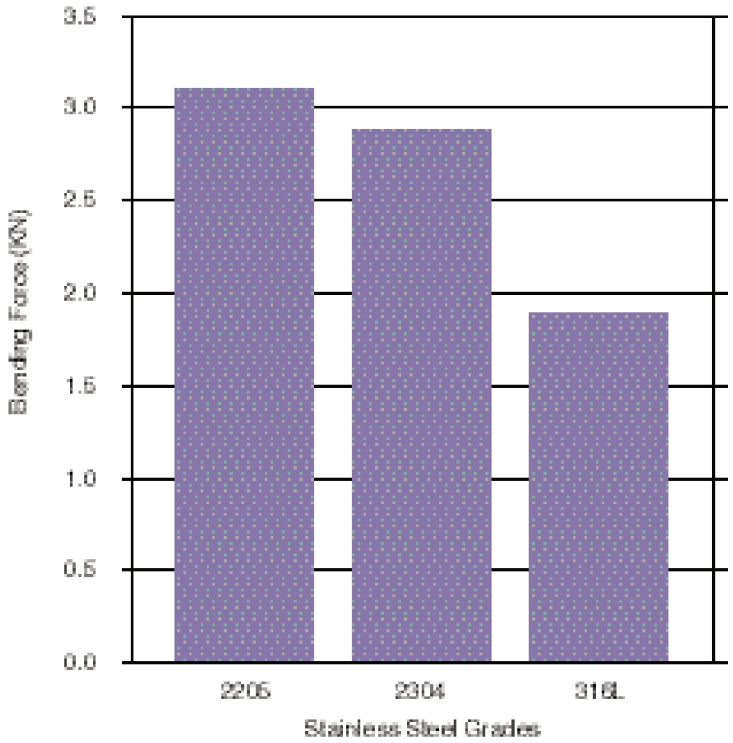

Figure 1. Minimum Force Required to Begin Plastic Deformation in Bending of 2304, 2205, and 316L Test Samples 50 mm (1.97 inch) Wide and 2 mm (0.079 inch) Thick (Source: Avesta Sheffield AB)

The lower ductility of duplex stainless steels compared with austenitic stainless steel must also be taken into account. Duplex grades have a minimum required elongation in most specifications of 15 to 25% in comparison with the 40% minimum elongation required for the austenitic grades. Because of their lower ductility compared with austenitic grades, the duplex grades require a more generous bend radius or need intermediate solution annealing in severe or complex forming. Minimum solution annealing temperatures for duplex stainless steels are summarized in Table 1.

Grade	Minimum Annealing Temperature	
	°C	°F
Lean Duplex (2304)	980	1800
2205	1040	1900
25 Cr Duplex	1040	1900
Superduplex (depending on grade)	1025 to 1100	1875 to 2010

Table 1. Minimum Solution Annealing Temperatures for Duplex Stainless Steels.

While the high yield strength of duplex stainless steel can be used to an advantage in lighter gauge designs, it can also pose challenges during fabrication. Because of their higher strength, plastic deformation requires higher forces. The springback in bending operations is larger than with austenitic stainless steels because of the higher bending forces required for duplex stainless steels. A springback comparison of two duplex stainless steels and Type 316L austenitic stainless steel is shown in Figure 2.

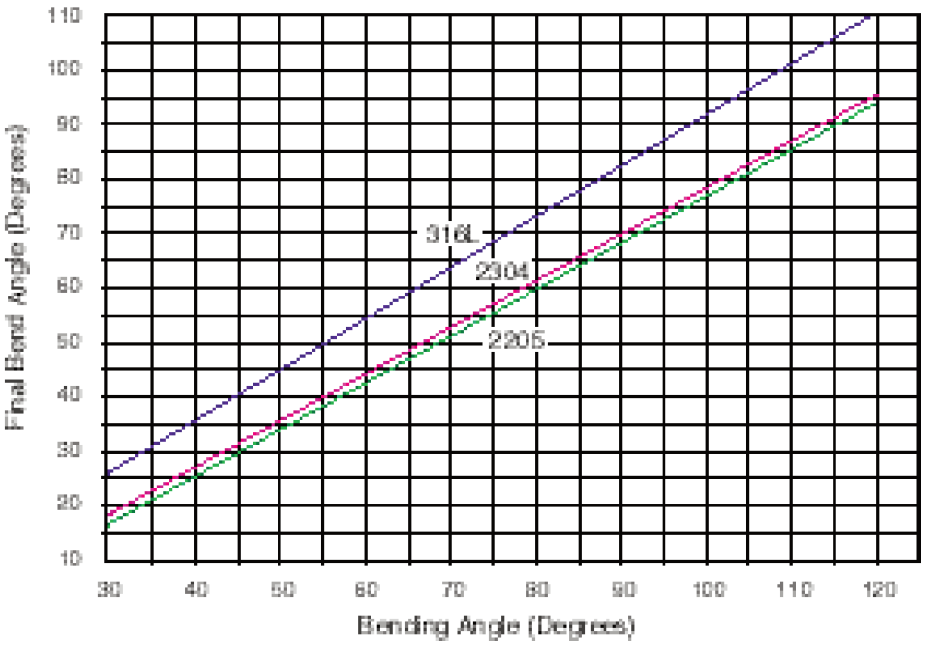

Figure 2. Comparison of Springback of Duplex Stainless Steels and Type 316L for 2 mm (0.079 inch) Thick Sheet (Source: Avesta Sheffield AB)

The use of stress relief treatments to reduce the cold work of forming or straightening operations is not advisable. The duplex stainless steels inherently have very good chloride stress corrosion cracking resistance and this can be only marginally improved by reducing residual cold work. There is no satisfactory temperature below the solution annealing temperature at which stress relief can be employed without the danger of formation of intermetallic phases which will lower corrosion resistance and reduce toughness. See Shop Sheet 101.

Excerpted from “Practical Guidelines for the Fabrication of Duplex Stainless Steels”

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