Q: What filler metal should I use to braze 2205 duplex stainless steel?

A: Selecting a filler metal for brazing requires the consideration of a number of factors, including the specific brazing process that will be used, compatibility with the base metal(s), metallurgy of the base metal(s), joint clearance requirements, brazement service conditions, cost, and availability.

2205 is a duplex (austenitic-ferritic) stainless steel that is highly alloyed and processed to produce a balanced microstructure of approximately 50% austenite and 50% ferrite. Typical composition of 2205 compared with 316L is shown in Table 1. This alloy is selected where resistance to corrosion, specifically pitting and stress corrosion cracking, are required. The steel also offers the advantages of higher strength and improved erosion resistance vs. the 3XX series austenitic stainless steels. The high alloy content of this material makes the metallurgy somewhat complicated and, as a result, the whole brazing process must be carefully considered.

In this application, vacuum brazing will be used. Vacuum brazing can be done with precious metal, copper, nickel, or a limited number of silver-based filler metals. Nickel-based filler metals can be used for the starting point in this case as they are well suited for vacuum brazing, offer a range of options, and are typically compatible with stainless steels. Nickel-based filler metals are reasonable in cost and in most cases have good availability.

To further limit the filler metal selection, the brazing temperature should be defined based on the metallurgy of the steel. 2205 duplex is heat treated (solution annealed) at 1500°–1750°F (1040°–1080°C), followed by water quenching. It is desirable to have the brazing temperature in this range as it aligns with the standard heat treatment practices, thus minimizing potential deleterious metallurgical effects from the brazing. Heating above 1000°F (1100°C) may increase the ferrite content (Ref. 1). If copper filler was a possibility for the service conditions, this limitation would preclude its use. The cooling rate from brazing must also be considered, and will be discussed later.

2205 duplex stainless steel has nitrogen with a range of 0.14–0.20 wt-% added to the alloy. The nitrogen in the base metal can react with boron in the filler metal to form boron nitride, which will inhibit wetting. If wetting was not inhibited, the formation of chromium borides in the base metal must be considered as they could impair corrosion resistance adjacent to the braze joint. As a result of these factors, nickel-based filler metals with boron should be avoided.

Figure 1 shows the AWS standardized nickel-based brazing alloys ordered by recommended brazing temperature range and the elements used for melt point suppression. Limiting the brazing temperature to 1750°F (1080°C) or below and omitting any selections that contain boron narrows the list to five candidates.

The relatively low solidus temperatures of BNI-6, 7, and 12 must be taken into consideration, as the rapid quenching that is required for metallurgical reasons would impart stresses on an unsolidified braze filler, which would likely result in cracking of the joint. BNI-7 has been reported as being successfully used for brazing other duplex alloys (Ref. 2). The remaining candidates are BNI-8 and BNI-14. BNI-8 can be excluded for concerns over corrosion resistance as it does not contain any chromium, which is key to corrosion resistance of stainless steels. BNI-14 is a good candidate as it was developed for corrosion resistance.

An additional metallurgical-related process consideration beyond filler metal selection should be noted. Duplex stainless steels are prone to inter-
metallic phase formation due to their high alloy content. Cooling rate off of the solution anneal is critical to avoiding these phases. Sigma and chi phases, in particular, will impair the corrosion resistance of the alloy. Figure 2 shows an isothermal precipitation diagram for 2205 duplex stainless steel. According to this diagram, cooling to below approximately 1500°F (825°C) within two minutes is required to completely avoid deleterious phase precipitation. The brazing procedure employed and equipment to be utilized must consider cooling rate to ensure the corrosion resistance of the material is retained.

Summary

Filler metals BNi-7, BNi-12, and BNi-14 should be suitable for brazing 2205 duplex stainless. Testing would be needed to identify the specific best candidate for the application. Corrosion resistance of the braze joint and base metal must be considered in the process development, so corrosion testing would also be advisable in addition to standard braze joint evaluations.

References

5. Historical data from material certifications.

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Readers are requested to email their questions for use in this column to the authors, cweihl@aws.org, or send to their attention at Welding Journal, 8869 NW 36 St. #130, Miami, FL 33166.