Scope

Dissimilar metal welding (DMW) has generated a number of technical papers and large detailed filler metal selection tables. Many DMW’s in the Process Industry do not involve demanding service requirements where special filler metal selection would be in order. This Bulletin is a guide for commonly encountered DMW’s and cites areas of caution where special welding considerations might be needed.

Metallurgical Considerations

In a DMW the properties of three metals must be considered; the two base metals being joined and the filler metal/base metal composite resulting from joining them. Figure 1 is a simple illustration of a weld between two different metals and a 15% base metal dilution from each metal while the filler metal contributes 70% to the total weld nugget composition. This illustrates the point that dilution from the base metals can make a significant contribution to the weld nugget composition and subsequently to the weld properties. The actual amount of base metal dilution will vary (higher or lower) depending on the welding process, welding parameters, and the base metal.

Another important consideration in DMW’s is the heat affected zone (HAZ) in both metals being joined. The rule is to use the same welding parameters in making the DMW that would be used in welding one of the metals to itself. An example would be where one metal is a low alloy steel and preheat and/or post weld heat treatment is required in welding to itself, the same practice should be followed in making a DMW. On occasion there may be a conflict in that the optimum control for one metal is undesirable for the other in which case a compromise is needed.

Weld Corrosion/Oxidation Residence

The weld should have corrosion/oxidation resistance equal to the least resistant base metal being joined. It is fortunate that in most all instances the weld will be of a higher alloy content (better corrosion and oxidation resistance) than the least resistant base metal being joined. When a DMW is in an environment where the liquid can be an electrolyte, the weld metal should be cathodic to (more corrosion resistant than) both base metals. If the weld is anodic (less corrosion resistant), it can suffer accelerated galvanic corrosion due to area effects. The Owner must, however, consider the specific application as corrosion effects might have little significance in some applications while strength differences may be of far greater importance.

Welding Processes:

A welding process and procedure capable of producing welds of low dilution is beneficial. This is consistently obtainable with SMAW (stick welding), GMAW (MIG short circuiting or pulsed arc) and FCAW (flux core) welding processes. With GTAW (TIG) welding the amount of filler metal is controlled by the welder and they may need instruction to make the proper and consistent amount of filler-metal addition for the particular welding procedure.

Frequently Asked Questions

1) When does the difference in coefficient of thermal expansion (CTE) become a factor? A common example would be welds between carbon steel and 304 (L) stainless steel with an austenitic

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2) What metals can not be fusion welded to iron, nickel or copper base alloys? Aluminum, titanium, zirconium and tantalum to name the more common metals can not be fusion welded to iron, nickel and copper base alloys. They may be joined by processes such as explosion bonding, bolting or brazing.

3) Is a welding procedure required for each DMW procedure? If a code such as ASME is involved, a procedure qualification is required even though qualification tests have been made for two like metals welded to each other. The tensile strength (TS) of a DMW should be the minimum TS of the weaker of the two base metals or the weld metal or if the break occurs outside the weld, not more than 5% below the minimum TS of the base metal. For non-code work, a procedure qualification is always advisable.

4) In making a transverse bend test for a welding qualification test, why does a fracture consistently occur in the HAZ of one of the base metals? This may occur in a base metal that is of much lower strength than the weld or other base metal and when the test specimen might slip in the bending die. A longitudinal bend specimen makes all three metals elongate the same amount and in this case is a better test.

5) In making a transverse bend test for a welding qualification test, why does a fracture consistently occur at the centerline of the weld? This may occur if the base metals and the weld filler are not fully compatible. Segregation of reaction products like CrCbN to the centerline may reduce its strength or ductility. A longitudinal bend test may hide this problem.

References:

1) Nickel Institute No. 14 014, Pay attention to dissimilar metal welds
2) Haynes International, Fabrication of Hastelloy® Corrosion-Resistant Alloys
3) Special Metals, Joining Brochure

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