Craftsman's Cribsheet

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Material Influences on the Weldability of Carbon Steel

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The weldability of steels is influenced primarily by the carbon content. Carbon equivalents of 0.35 or less are safe to weld without any pre-weld or post-weld heat treatments required. At higher carbon levels, steels may require either pre- or post-weld heat treatment in order to prevent stress buildup and weld cracking.

The weldability is negatively influenced by free machining additives such as sulfur. Weldability can also be influenced by grain size. Thickness of the welded section is also a factor in determining the need for pre- and post-weld thermal treatments.

Carbon Equivalent

Carbon is a major factor in determining a steel's carbon equivalency. However, other elements that are contained in the steel also have an effect on the steel's carbon equivalence. These additional elements can really add up in scrap-fed electric arc furnace steels that now predominate in our market.

Here are two formulas for calculating carbon equivalents. For best results, CE should be 0.35 or less regardless of the formula used.

Formula 1:

CE=%C+(%Mn/6)+(%Cr+%Mo+%Va)/5 (%Si+%Ni+%Cu)/15

In this formula, every six points of manganese in the steel equals one point of carbon, so a 0.60-percent manganese would add an additional 10 points of carbon equivalence. The sum of chrome, moly and vanadium divided by 5, gives another portion of carbon equivalence, as does the sum of silicon, nickel and copper divided by 15. The sum of all of these calculated factors added to the actual carbon content gives the total carbon equivalent for the steel. If the carbon equivalent totals more than 0.35, you might need to pre- or post-weld heat treat, depending on section thickness.

Formula 2 (GE Formula):

CE= C+(Mn/6)+(Ni/20)+(Cr/10)+(Cu/40)+(Mo/50)+(Va/10).

This formula does a finer tune on the individual residual elements (look at the denominators for copper and moly in this formula compared to the first.)

Sulfur can contribute to poorer weld quality because the gases produced will create a more porous, slaggy and less-sound weld. Manganese sulfides, the form of the sulfur in the steel, can also hold hydrogen.

Coarse grain steels can further coarsen adjacent to the weld by the additional heat (heat = grain growth) creating abnormally large grains in the heat-affected zone and dramatically altering mechanical properties in that area. Choosing fine grained steels for welding can help eliminate this risk.

To assure fewest problems when welding carbon steels, choosing steels below 0.35 percent carbon equivalency steels that are also non-re-sulfurized and fine-grained, will eliminate many problems and the need for pre- or post-weld thermal treatment to relieve stresses induced by welding.

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