Design File

Thicker Steel Permits the Use of Opposing Arcs

Practical Ideas for the Design Professional by Duane K. Miller, P.E.

An Efficient Technology

A welding system featuring opposing arcs is commonly used to weld stiffeners to webs on bridge members. In concept, opposing arc systems can be used to fabricate any tee joint configuration requiring fillet welds on both sides of the vertical member. Originally developed by Ogden Engineering and promoted as the "Dart Welder," this highly efficient technology permits horizontal fillet welds to be made simultaneously on either side of a tee joint. Since welding is done in the horizontal position, the maximum fillet weld leg size is typically 5/16 in (8 mm). It is commonly applied in stiffener-to-web connections, and may also be used for web-to-flange connections. The system is illustrated in Figure 1.

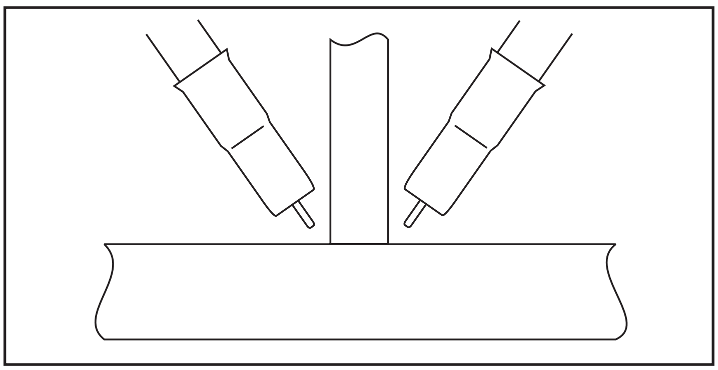

Figure 1.

Cracking Problems

The drawback of this approach is that a unique type of cracking can occur when high energy opposing arcs are applied to relatively thin vertical members. The crack is longitudinal in nature, and occurs slightly below the upper toe of the fillet weld, as shown in Figure 2.

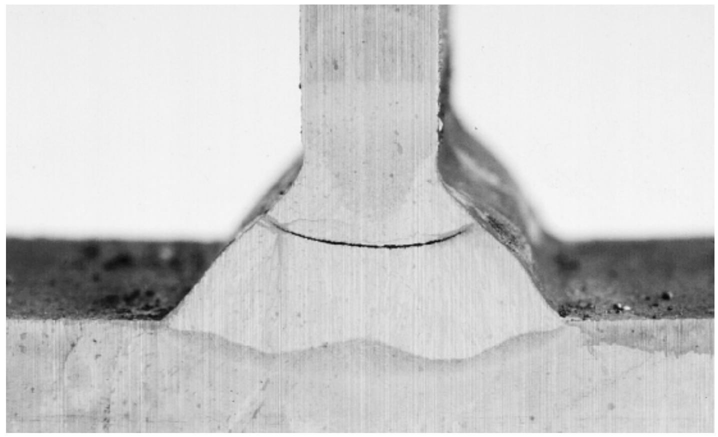

Figure 2.

The cause of this type of crack is fairly simple to understand when the cross-section is analyzed, as depicted in Figure 3. While the two welds are simultaneously made, a tremendous amount of thermal energy is imposed upon the parts being joined. The conduction of heat into the horizontal member is always biaxial in nature. Heat flow is rapid, generating a typical penetration pattern. Conduction through the vertical member, however, is nearly uniaxial in nature, and the thermal energy from two welds must be conducted up through the relatively thin vertical member. As the energy is conducted into the vertical member, the temperature of the base metal rises, decreasing the thermal conductivity. This has a compounding effect, causing less heat to be conducted up through the narrow member. As a result, it is common for the thermal energy to become concentrated in the region between the two beads, raising the temperature of the base

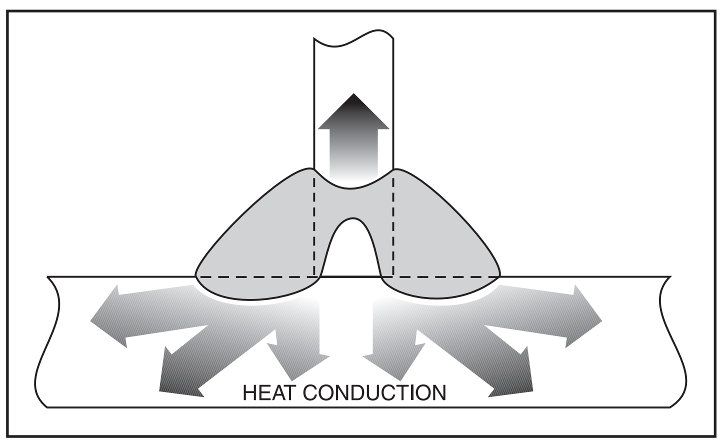

Figure 3.

metal to the melting point. When this occurs, the two weld beads may actually join together, forming a "bridge" of molten metal between the two fillet welds as shown in Figure 4.

When this molten material begins to solidify, grains of solidified material grow roughly perpendicular to the surface, as shown in Figure 4. As the grains growing down from the top surface intersect with those growing up from the region

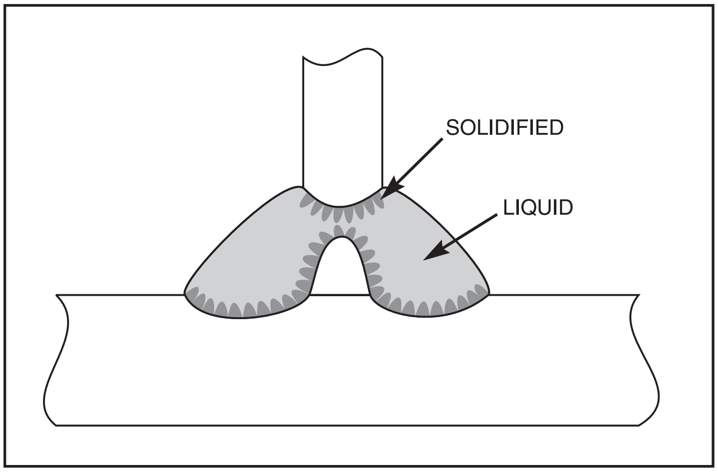

Figure 4.

below, fusion may not be achieved between the two approaching, solidifying planes. This is not unlike the problems associated with improper width-to-depth ratio weld beads that are subject to center line cracking. In this type of cracking, illustrated in Figure 5, the grains form planes that approach from either side and fail to fuse across the center, resulting in a characteristic center line crack. Another look at Figure 4 shows that similar physical principles can cause a crack to develop in the region slightly below the upper toe.

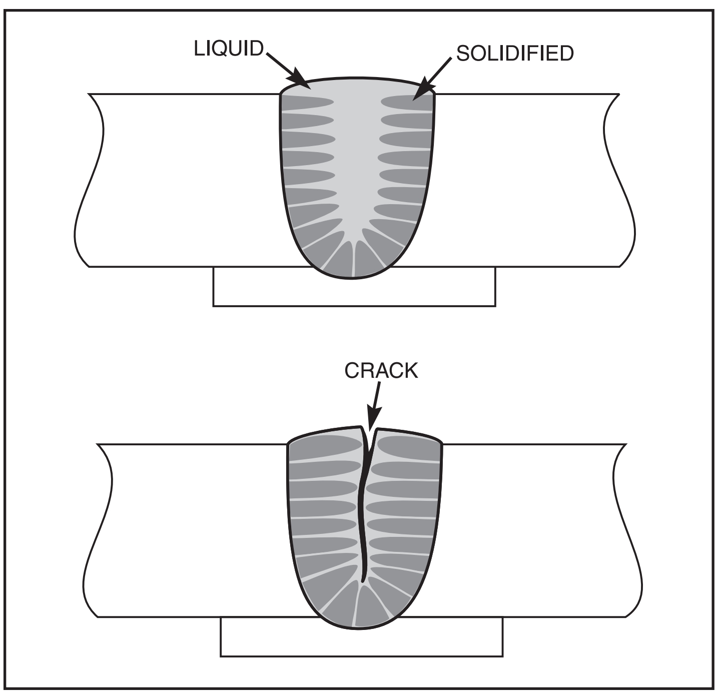

Figure 5.

Eliminating Cracking

To avoid this type of cracking, the "bridging" of metal between the two beads must be eliminated. This is best accomplished by utilizing heavier material for the vertical member. Experience has shown that this condition is quite common when 1/4 in (6 mm) stiffeners are used, but almost never occurs when the stiffeners are 3/8 in (10 mm) thick. When the stiffener is 5/16 in (8 mm) thick, on the other hand, the probability of cracking is directly related to the welding procedure used.

Designers should be encouraged to specify at least 3/8 in (10 mm) thick steel for stiffeners wherever possible. Indeed, many fabricators have found that substituting heavier stiffeners for thinner materials is an economical solution in the long run.

When thinner members must be welded, the "bridging" usually can be overcome by utilizing one or more of the following techniques:

- Directing the energy of the arc more toward the bottom plate by moving the electrode away from the joint root.
- Moving the electrode to a more vertical orientation.
- Lowering the welding current.
- Utilizing negative polarity procedures for submerged arc welding.

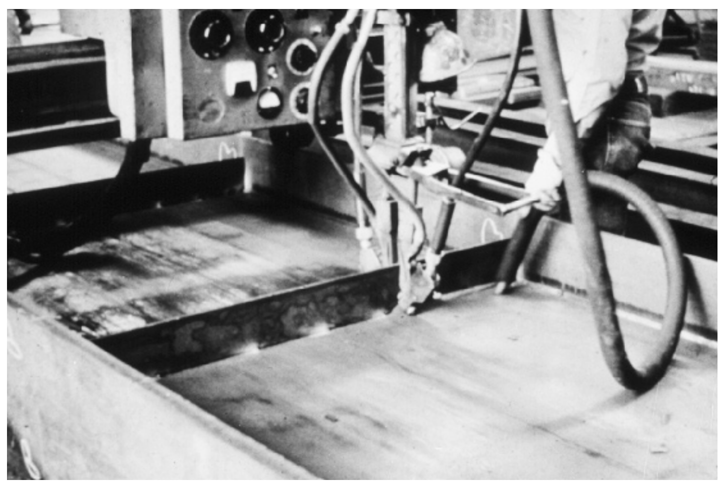

Figure 6.

Conclusion

The use of opposing arcs as shown in Figure 6 can reduce welding costs by as much as 50 percent. A slight increase in the thickness of the vertical member, often only 1/16th (1.5 mm) of an inch, can eliminate significant production problems. The increase in material costs can be easily justified by the avoidance of ongoing problems.