Lesson 2: Controlling Distortion in Arc Welding

To improve the quality of welds, a welder must be able to recognize common welding defects and implement methods for preventing them. Distortion of metal is a common problem in arc welding, but it can be prevented with the use of certain techniques. This lesson describes the causes of distortion and the techniques that can be used before, during, and after the weld to minimize or prevent distortion.

Effects of Temperature Change on Welds

Shielded metal arc welding exposes metals to very high temperatures so they will melt and fuse together. Like many other materials, metal expands when it is exposed to heat and contracts when it is exposed to cooler temperatures. If the entire piece of metal is heated to the same temperature during the process of welding and is then evenly cooled, the whole piece can return to its original shape. However, if only part of the metal is heated and then cooled, the uneven expansion and contraction of the piece can lead to changes in its shape. Such changes are called distortion.

Common Causes of Distortion

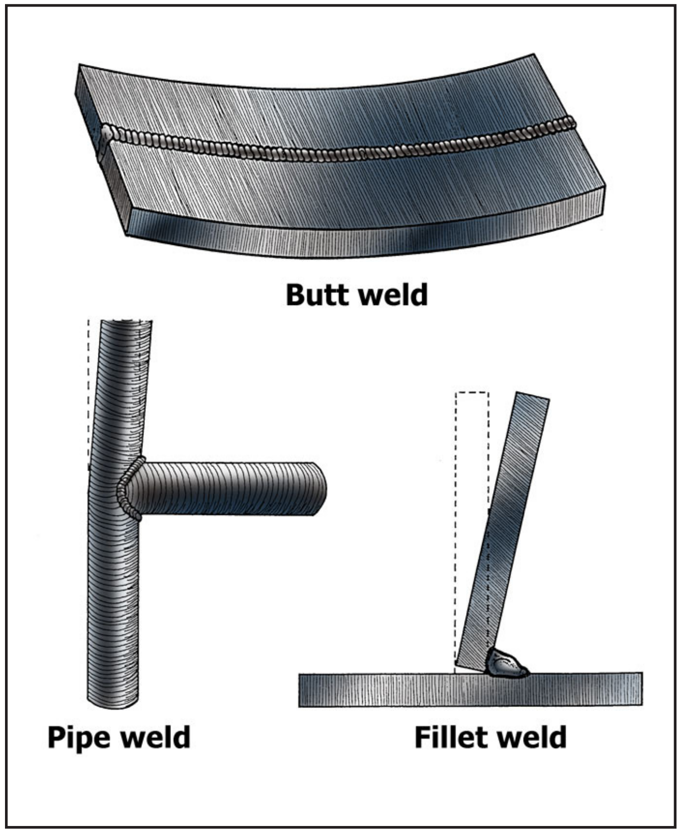
Heating the metal unevenly, running a bead, and then cooling the metal unevenly are steps in the arc welding process that can cause distortion. For example, the part of the metal being welded is much hotter than the metal farther from the weld. As the weld cools, the weld bead itself restricts movement, which may cause distortion.

Distortion in welding may be seen as the development of warping, or a curve upward, in a flat piece of metal. Other examples of distortion include a bend in a previously straight piece, such as a pipe, and a vertical piece pulling away from the weld. See Figure 2.1.

Techniques for Distortion Control

Welders must consider many factors and plan their work carefully to control distortion. Techniques for distortion control have been developed for use before, during, and after the weld. The techniques below are listed separately, but several techniques can be used together or in sequence to control distortion.

Figure 2.1 – Three Examples of Distortion



Before Welding

Heat treating: The whole piece of metal can be heated before welding (preheating), during welding (interpass heating), and after welding (postheating). Interpass heating is usually used for thicker metals. The process of raising and maintaining the temperature of the whole piece and allowing it to cool slowly promotes uniform expansion and contraction of the piece. See Figure 2.2.

Positioning: By setting the pieces slightly out of alignment opposite the pull of contraction, the contraction force can be used to pull the pieces into position and prevent distortion. See Figure 2.3. For example, with cooling of a weld, the gap between two pieces in a butt joint can become uneven from contraction. To maintain a parallel weld, the two pieces of flat metal can be positioned at an

Figure 2.2 – Preheating Base Metal to Control Disotortion

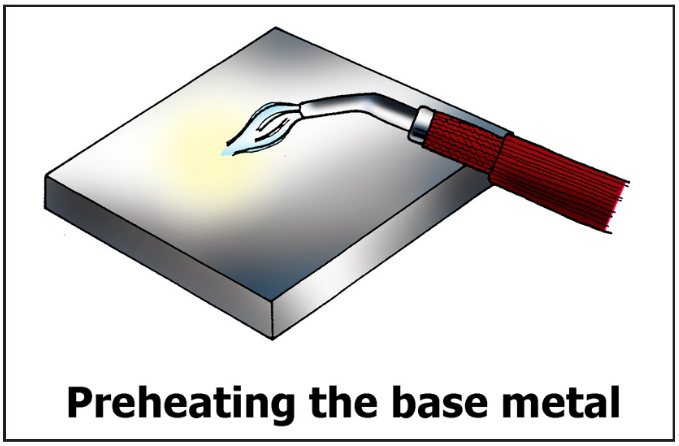
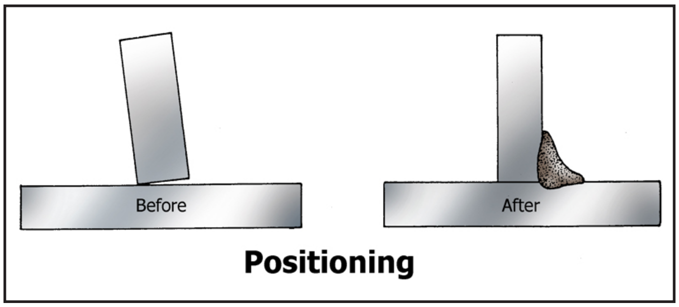


Figure 2.3 – Using Contraction to Control Distortion



angle to each other, with a narrower gap at the start of the weld. This adjustment in positioning before beginning the weld can correct for any contraction that will occur.

Tack welding: Small welds can be made along the seam to hold the pieces in place. See Figure 2.4. The number of tack welds needed depends on the length of the weld. For example, to control distortion in a tee joint, the vertical piece can be tack welded in a position that is slightly off 90 degrees and then welded along the joint. The weld should produce a 90-degree angle after the bead cools.

Prebending: Pieces can be bent before welding so that the contraction force pulls them into position. See Figure 2.5. With the use of this technique, warping in a butt joint can be controlled by prebending the pieces to be welded in the opposite direction of the weld, clamping the pieces in position, welding the pieces, and then allowing the work to cool while the pieces remain in the fixture. After the welded piece is taken out of the fixture, it changes to correct alignment.

Figure 2.4 – Tack Welding to Control Distortion

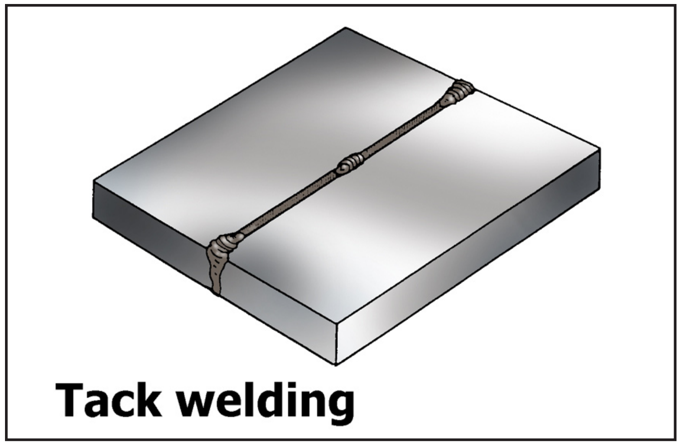
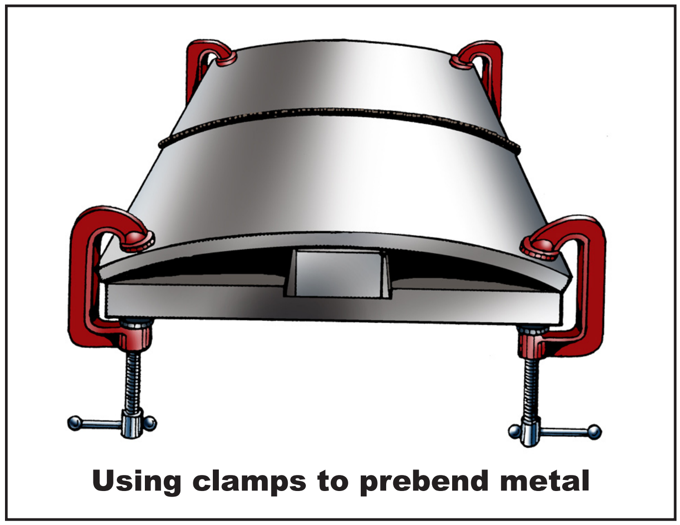


Figure 2.5 – Bending the Metal to Control Warping



Using welding jigs and fixtures: Jigs and fixtures can be used to hold pieces in place for welding, thus minimizing distortion due to movement. See Figure 2.6. However, after the jig or fixture is removed, the development of distortion is still possible if stress remains in the piece.

During Welding

Minimizing passes: Welding should be accomplished with as few passes as possible to avoid adding excessive material during the welding process. See Figure 2.7. Additional passes and filler add more heat to the weld, increasing the likelihood of distortion. The amount of filler in a weld can be minimized with the use of the smallest bevel, electrode size, and joint gap necessary to complete a good quality

Figure 2.6 – Using Clamps and Jigs to Control Distortion

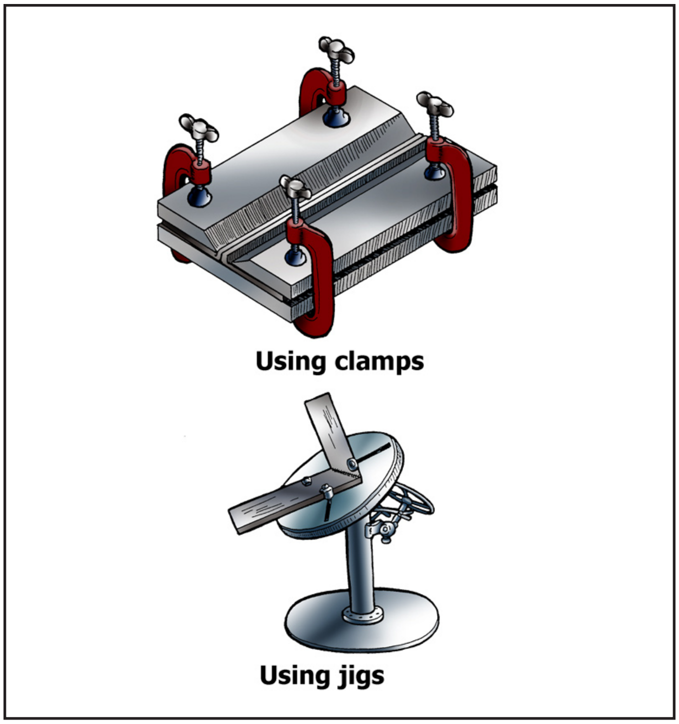
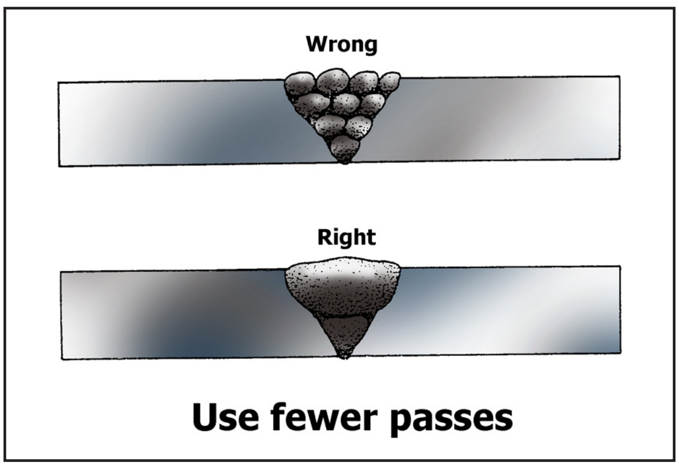


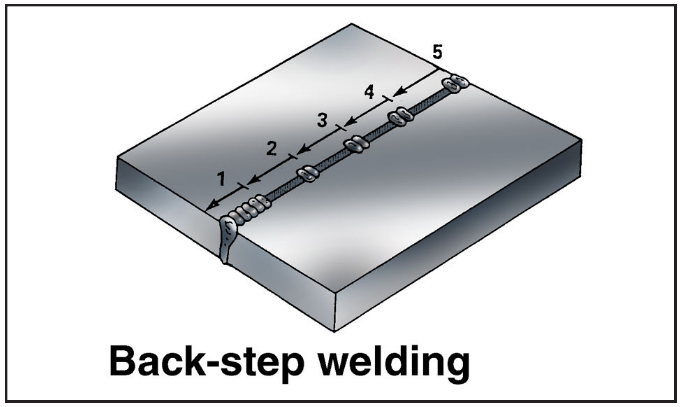
Figure 2.7 – Limiting the Number of Passes to Control Disortion



weld. Use of a larger electrode may help to minimize the number of passes.

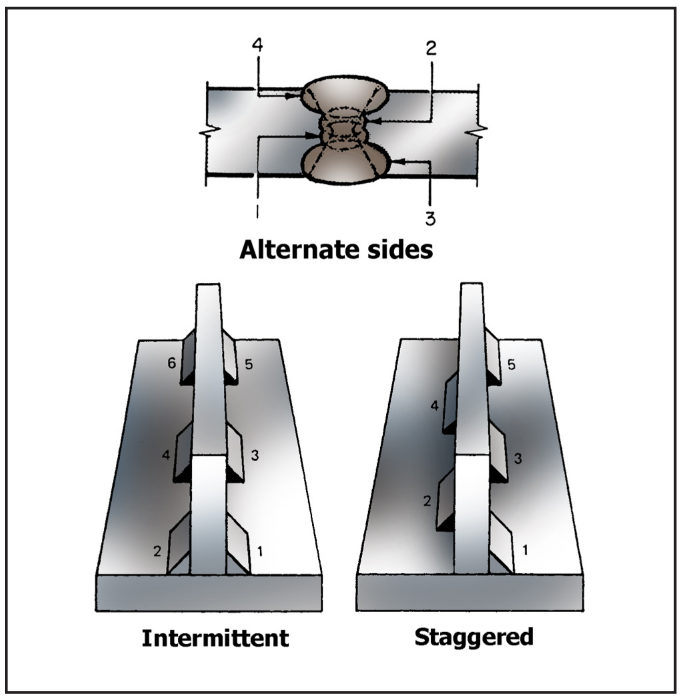
Back-step welding: With back-step welding, the joint is completed from left to right, but it is made up of smaller beads put down from right to left. This technique redistributes the stress and minimizes distortion. See Figure 2.8.

Figure 2.8 – Back-Step Welding to Control Distortion



Alternating sides: Welding on alternating sides is accomplished by running a bead on one side of a joint, then running a bead on the other side, and continuing to alternate sides until the weld is complete. By welding on both sides of the material, the contraction forces on one side offset those on the other side. See Figure 2.9.

Figure 2.9 – Alternating Sides of Welding to Control Distortion



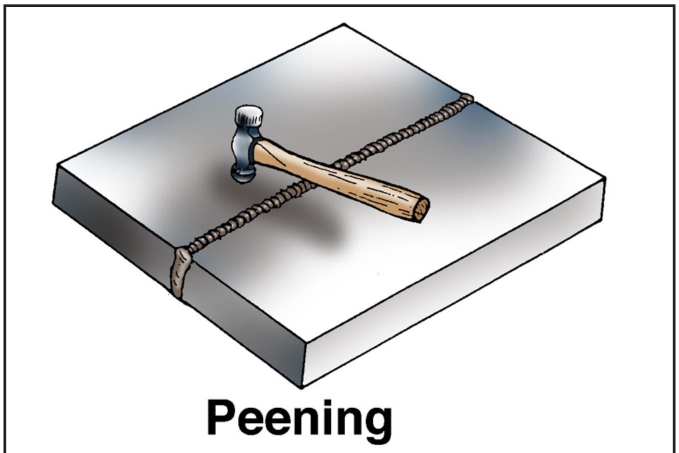
After Welding

Shrinkage: In this technique, distorted pieces are alternately heated and cooled to counteract the distortion.

Shrink welding: Beads are added to the opposite side of the distorted weld. This added weld and the contraction force it produces as it cools helps to pull the original weld into alignment. The additional beads can then be ground off, if desired.

Peening: Hammering the weld bead can alleviate stress and offset distortion. See Figure 2.10. Peening can be done by hand with a ball-peen hammer, but a pneumatic hammer that is fitted with a suitable tool is preferred. Peening can be completed faster with a pneumatic hammer and the hammering is consistent and more easily controlled. Whatever method is used, care should be taken to not overpeen the work, which can cause the weld to become brittle or hard and develop cracks or new stresses.

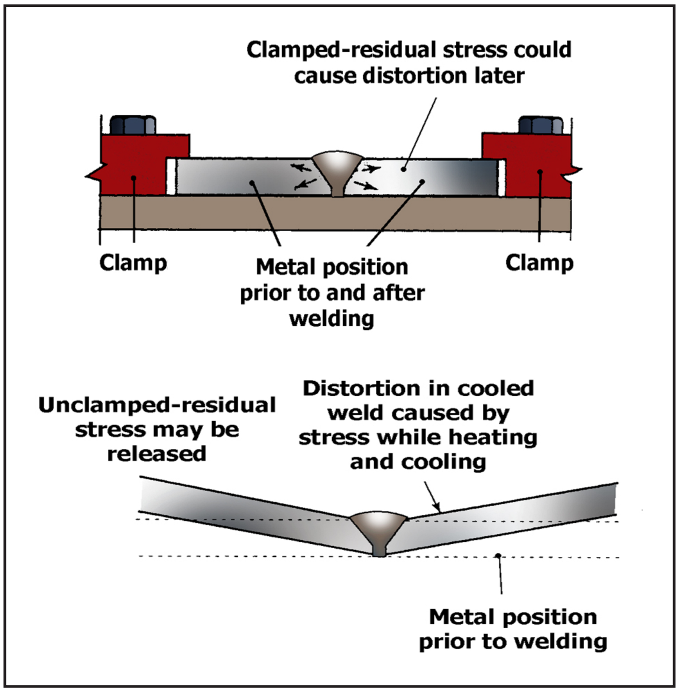
Figure 2.10 – Peening the Weld to Control Distortion



Techniques for Control of Residual Stress

Residual stress is the force that remains in the piece after welding is completed. It can cause cracks or distortion at the weld or elsewhere on the piece. For example, a piece that was secured in a clamping device to control distortion during welding may seem sound after it is unclamped, but it still might contain stresses that could cause defects later. See Figure 2.11. On the other hand,

Figure 2.11 – Distortion After Removal of Clamps as a Result of Residual Stress



a welded joint may be distorted but contain no residual stress. Residual stress contributes to buckling, curling, cracking, fatigue, or distortion of the weld or the work and these defects can happen at any time. Residual stress can be relieved by techniques used to prevent or correct distortion, including preheating, postheating, and peening. With postheating, the entire piece is placed in a furnace and gradually heated to a uniform temperature. The cooling process must be gradual and uniform as well.

Summary

The high temperatures used in the arc welding process cause metal to expand in the welded area and then shrink as the weld cools. Uneven heating and cooling of the piece can lead to distortion. The first step in controlling distortion is understanding its causes and effects. The second step is knowing how to use different techniques before, during, and after the weld to prevent or minimize the development of distortion. These techniques can also help reduce the amount of residual stress in the welded piece. The longevity of the weld and overall quality of the welded piece depend on it.

Credits

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