TECHSUPPORT #46
Magnetic arc blow

During welding a magnetic field is created around the arc. If the magnetic field is disturbed by external sources a deflection of the arc may take place. When present this phenomenon is called magnetic arc blow. This effect can cause many types of discontinuities. However the emergence of a magnetic arc blow can be obstructed. This TechSupport addresses issues regarding magnetic arc blow and how it can be counteracted.

Introduction

Welding with an electric arc creates a magnetic field around the electrode, according to figure 1. The intensity of its lines of force, also called the magnetic flux density, gradually lowers as the distance from the electrode increases. If the magnetic field is disturbed by external sources, it may cause deflection of the arc during welding. This phenomenon is called magnetic arc blow, or arc blow. It can lead to several kinds of discontinuities in the joint, including lack of root penetration, lack of fusion, undercuts and pores. It may not be possible to totally eliminate arc blow but steps can be taken in order to reduce its negative effect.

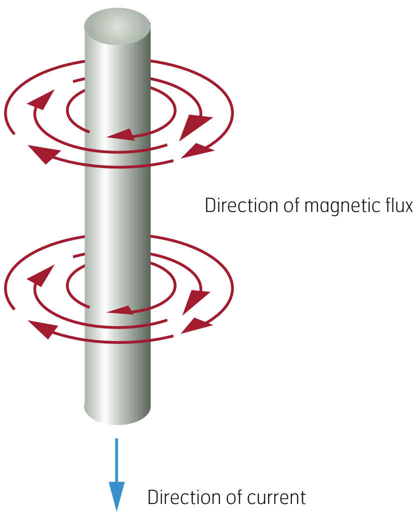

Figure 1: The direction of the magnetic field in relation to the current during welding with D.C.

The deflection of the arc can be more or less stable during magnetic arc blow. The source of the interference is what influences its behavior. A deflection of forward arc blow and backward arc blow is illustrated in figure 2.

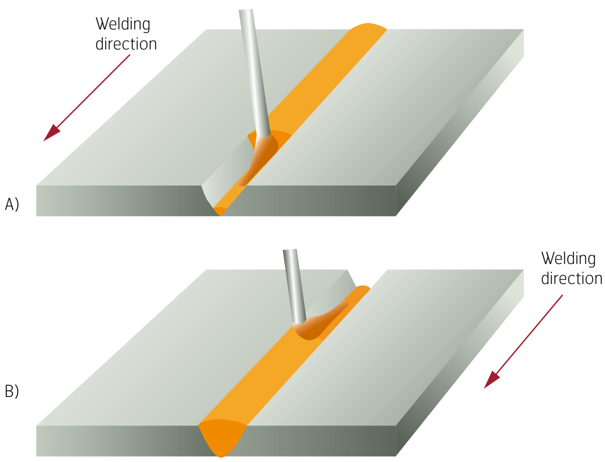

Figure 2: Forward arc blow is illustrated in the upper figure A) and backward arc blow in the lower figure B).

Essential sources that can achieve, or contribute to, magnetic arc blow are:

- Residual magnetism in the steels subjected to welding.
- The appearance of the joint.
- Welding with multiple electrodes.

Residual magnetism is primarily an issue related to tack welds and root runs. After these sequences, the residual magnetism in the joint is normally low enough to reduce arc blow.

Residual magnetism in steels

Ferromagnetic steels, including the Hardox®, Strenx®, Armox® and Toolox® grades, can contain varying levels of residual magnetism. If the intensity of the lines of force is high enough, this magnetism can interfere with the magnetic field from the welding torch and cause magnetic arc blow. Common sources that enhance the magnetism of the steel include magnets used in jacking equipment or storage in a place with high levels of magnetic flux densities.

Low levels of magnetism in the joint will not influence the stability of the arc. Arc blow disturbances can occur when the magnetic flux density is approximately 40 Gauss or above.

The Hardox®, Strenx®, Armox® and Toolox® grades are high strength steels with favorable resistance to residual magnetism, even though there are instances when they can obtain magnetic flux densities of 40 Gauss or more. The sensitivity towards magnetic arc blow, caused by residual magnetism in the steel, is generally more emphasized with Hardox®, Armox® and Toolox® grades of higher hardness and higher strength Strenx® grades.

The appearance of the joint

The resistance to magnetic flux depends on the characteristics of the medium through which it flows. Steel has a substantially lower resistance in this respect than air. Consequently, free ends of plates can have a lower level of magnetism than a joint including the same plates.

The level of residual magnetism can vary through-out the joint when the distances between the steels in the joint vary. For instance, in a single-V joint, the distance between the parent metals in the joint are shortest at the root section. Therefore, there is a higher level of magnetism compared to other parts of the joint where the space between the steels is greater, see figure 3.

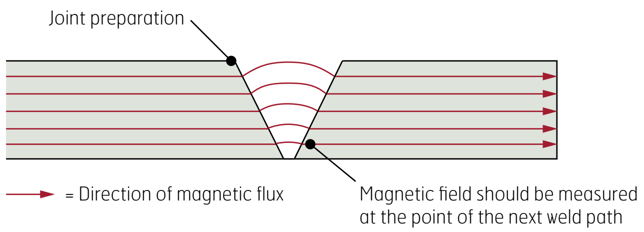

Figure 3: Magnetic fields in a single-V prepared joint.

The magnetic flux density, therefore, should be measured at the location of the next weld pass in order to determine the risk for magnetic arc blow. A hand held gauss meter is a typical instrument used for this purpose.

The geometry in joints of larger plate thicknesses can cause an increased risk for magnetic arc blow. Welding in this condition means that a substantial fraction of the arc can be surrounded by the parent metals at a close vicinity, especially during root passes and tack welds. Since the magnetic field flows easier through steel than air, an unsymmetrical magnetic field can be formed around the torch, which may cause arc blow.

Similarly, arc blow can occur when welding plates of different thicknesses, according to figure 4. In this situation, the arc may deflect towards the thicker plate in the joint.

Figure 4: Arc blow due to different plate thicknesses in the joint.

Welding with multiple arcs

Multiple electrodes normally lead to increased welding productivity in comparison to welding with a single electrode.

Welding with multiple arcs using D.C., where there is only a small distance between the electrodes, may cause arc blow since the magnetic field from each electrode can influence the performance of the adjacent arc.

If arc blow is encountered, equal polarity between the electrodes supports inward arc deflection and unequal polarity supports outward arc deflection, according to figure 5.

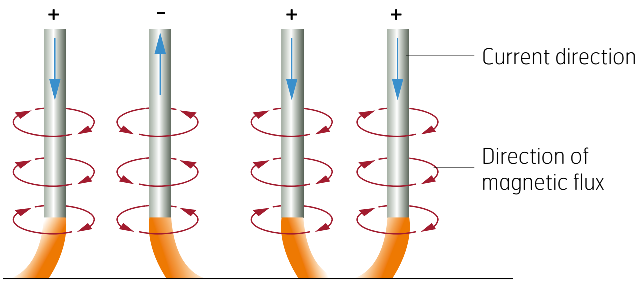

Figure 5: Arc deflections during welding with two electrodes.

Measures to counteract magnetic arc blow

When magnetic arc blow is encountered or suspected, steps can be taken to attain suitable conditions for welding.

The angle of the torch

A magnetic arc blow that deflects the arc at a specific direction can be counteracted by inclining the electrode angle opposite to the direction of the arc blow, see figure 6.

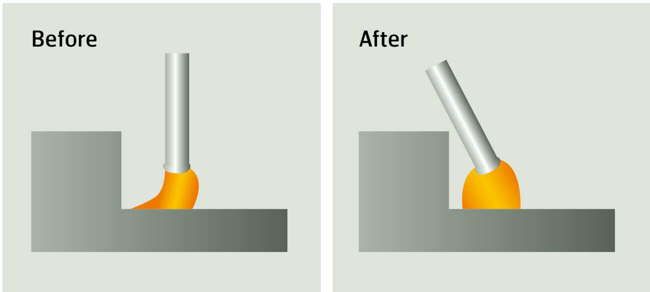

Figure 6: Straightening of the arc by angling the electrode.

Welding sequences

Tack welds and root runs diminish and/or redistribute the magnetic fields in the joint.

This effect is brought on by:

- Heating of the joint due to welding.
- A redistribution of the magnetic field. This is facilitated if weld metal is present in the joint because it acts as a bridge for the magnetic flux flow.

The following two steps can be utilized to plan the welding sequences appropriately so that the level of magnetism is below 40 Gauss in sections of the joint: First, mark the locations in the joint where the local magnetism is below 40 Gauss. Then place tack welds at suitable locations along the marked areas. Long individual lengths of tack welds are preferred and their individual lengths should be set to a minimum of 50 mm each. Repeat this procedure until the magnetism is below 40 Gauss in the complete joint, after which, the rest of the welding procedures can be performed.

Welding sequences

Electrodes connected to A.C. are less prone to arc blow in the joint compared to those coupled with D.C. Pulsed arc welding, where the current polarity changes can be regarded as A.C. in the following context. If the current polarity is continuously the same the conditions stated for D.C. apply, see diagram 1-2.

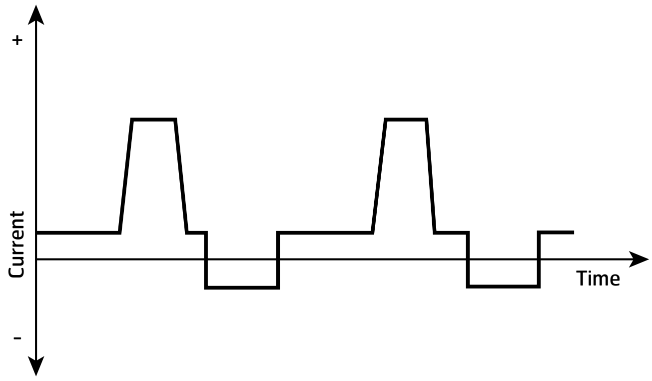

Diagram 1: Pulsed arc welding with a current that continuously changes polarity. Source: Karlebo Svetshandbok by Klas Weman.

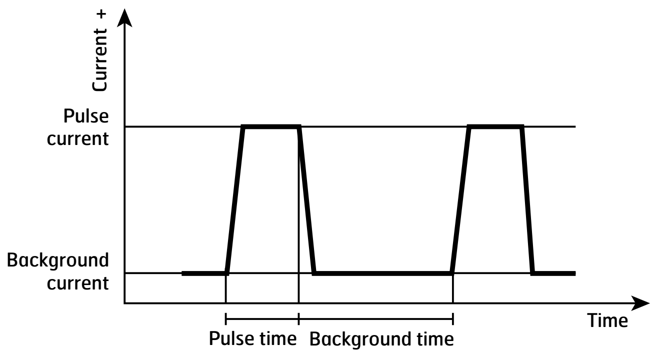

Diagram 2: Pulsed arc welding with a current that constantly has the same polarity. Source: Karlebo Svetshandbok by Klas Weman.

The reasons are that:

- The direction of the magnetic field around the electrode continuously changes making it less susceptible to external sources of magnetism.
- Welding with A.C. introduces eddy currents into the joint, see figure 7, which reduces the negative effect from an external magnetic field.

The selection of welding parameters

The stability of the arc depends on the welding parameters. A short arc length and low current value can stabilize the arc. If needed, a reduced diameter of the consumable further assists in reducing the current level. However, observe that a lowered current level promotes lowered welding productivity.

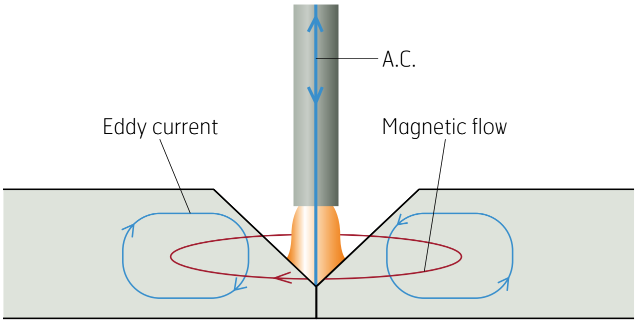

Figure 7: Induction of eddy currents in the joint.

Measures for multiple arc welding

Arc blow encountered when using multiple electrodes can be counteracted by feeding one or more electrodes with A.C. In this case, the electrode with A.C. continuously changes the direction of its magnetic field, counteracting arc blow, according to figure 9.

A beneficial technique to use during multiple arc welding is to combine the positive aspects from both A.C. and D.C. welding. The first electrode is fed by a D.C. current with positive polarity in order to attain a deeper penetration profile. The other electrode/electrodes are supported by A.C. When applying two electrodes connected to A.C., the current phase shift between them can be set to approximately 90 ° for a high resistance to arc blow.

Workpiece connections

Proper placement of the workpiece connection can diminish magnetic arc blow. This technique introduces a magnetic field in the opposite direction to the one causing the arc blow.

The cause is that the current return from welding goes through the workpiece, which causes a magnetic field in its path. This magnetic field supports an arc deflection away from the workpiece connection, according to figure 8.

If back blow of the arc is encountered, it can be counter-acted by positioning the workpiece connection away from the direction of welding. If forward arc blow occurs, locate the workpiece connection towards the direction of welding. The use of more than one workpiece connection might further improve this method. The effect from the location of the workpiece connection is limited, so this measure is normally done together with other complimentary measures in order to avoid arc blow.

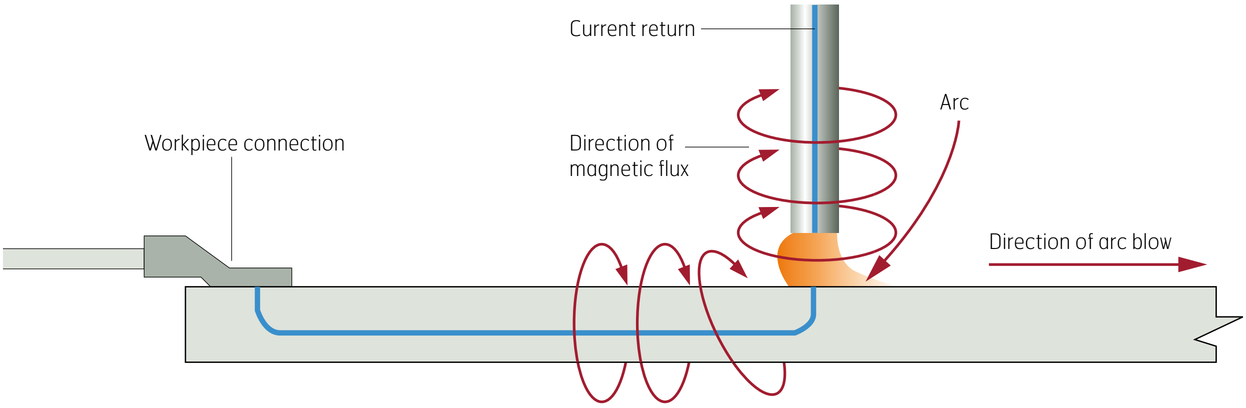

Figure 8: The position of the workpiece connection supports an arc deflection in accordance to the figure.

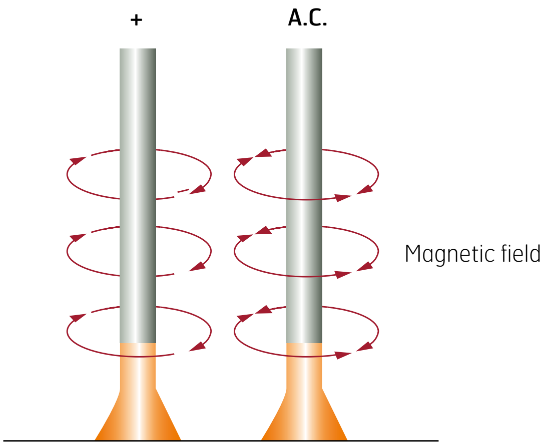

Figure 9: Welding performances with two electrodes using a combination of D.C. and A.C.

Welding joints of larger plate thicknesses

If arc blow is encountered due to large plate thicknesses in the joint, and the level of residual magnetism is insignificant, then widening the joint at the root section may be beneficial. One example is to change the V-prepared joint to a U-prepared joint.

Demagnetizing equipment

The steel in the joint can be demagnetized from residual magnetism. There are different types of techniques and equipment available for this purpose. The appropriate solution is situation based.

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SSAB
SE-613 80 Oxelösund
Sweden

T +46 155 25 40 00
F +46 155 25 40 73
contact@ssab.com

www.ssab.com