Wire Feed
(FLUX CORE)

Weld Tech News

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WELD TECH NEWS is a newsletter for welders working primarily in maintenance and repair. Each issue contains useful information on materials (cast irons, steels, aluminum, copper alloys, etc.), welding products and welding techniques. By collecting each issue, the reader will soon have a handy reference manual covering all aspects of welding, brazing and soldering for maintenance repair.

WIRE FEED

Flux Core Arc Welding (FCAW)

The term Flux Core Arc Welding covers two of the three basic wire feed welding processes. The other process that is distinct from flux core wire is the Gas Metal Arc Welding process, or GMAW. This process is defined by the use of a solid wire with arc shielding obtained entirely from an externally supplied gas (See Weld Tech News #10). The Flux Core process has shielding provided by a flux within the tubular wire. Defined as per the ANSI/AWS A3.0-85 standard:

"Flux Core Arc Welding (FCAW) – an arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal electrode and the work. Shielding is provided by a flux contained within the tubular electrode. Additional shielding may or may not be obtained from an externally supplied gas or gas mixture."

This welding process evolved into its present form in 1957. Initially flux core wires required the use of CO₂ shielding gas. In the early 1960's self-shielded flux core wires were introduced. It wasn't until the 1970's that manufacturing technology allowed the production of small diameter flux core wires.

The two variations of FCAW are distinguished by the requirement of shielding gas. Some FCAW electrodes require the use of a shielding gas to help protect the arc and weld puddle from the atmosphere. These wires can be referred to as Flux Core-gas required or FCAW-G. The other variation does not require additional gas shielding and can be referred to as Flux Core-self-shielded or FCAW-S. These two variations actually make for two processes of flux core welding. The welder needs to determine whether the flux core wire to be used requires gas shielding or not. Both these variations produce a slag on the surface of the weld bead.
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Metal cored wires are considered to be distinct from FCAW because they produce a deposit with only small islands of slag on the face of the weld. The core of these wires contains primarily alloying elements instead of flux.

Flux core wires can be thought of as an inside-out stick welding electrode. Instead of having a flux bound to a core wire as in stick rod the flux is contained within a thin metal sheath that is formed into a tube to contain the flux core material. The flux coating for a stick electrode needs a binder to hold it to the core wire of the rod. Since the flux for a tubular wire is held by the metal sheath no binder in the flux is needed. Therefore the flux content of a flux core wire is less (15% by weight) than that of a comparable size arc rod (24% by weight). For both of these welding processes the heat of the arc vaporizes the flux causing it to form a gas which helps to protect the arc and molten weld puddle from atmospheric contamination.

**Flux Cored Electrode** – a composite tubular filler metal electrode consisting of a metal sheath and a core of various powdered materials, producing an extensive slag cover on the face of a weld bead. External shielding may be required. AWS Standard Term.

Besides shielding the weld, the flux in the wire serves other purposes. It works as a deoxidizer or scavenger, removing contaminants released from the base metal by the arc heat. It forms a slag which covers the weld bead during cooling to protect the hot weld metal from the atmosphere. The flux can also contain alloying elements, which in the heat of the arc combine with the molten metal sheath and then the molten base metal to give improved properties to the weld metal. Finally, compounds in the flux help to stabilize the arc, smoothing out the metal transfer across the arc and reducing spatter.

The core flux is the key advantage of this weld process. A typical flux core electrode consists of a low-carbon steel sheath formed into a U-shape. Granular shielding elements are poured into this as well as alloying elements. This sheath is then drawn through rolls which close it into a tube and it then goes through dies which draw it down into its final diameter.

Some elements used as flux, mainly to provide shielding, are aluminum, calcium, potassium, silicon, sodium, zirconium. These act as deoxidizers or dentifiers. Alloying type elements used in fluxes are carbon, iron, manganese, molybdenum, nickel, titanium, vanadium. These alloying elements affect the chemical properties of the weld metal and provide desired metallurgical, mechanical and corrosion resistant qualities. Being able to add many alloying elements to the flux makes hardfacing applications a prime area for flux core wire feed applications.

The FCAW process has many advantages over stick electrode welding (SMAW) and the solid wire feed process (GMAW):

1. Flux core wires can be run at higher current densities. This allows faster travel speeds and higher deposition rates while maintaining good weldability. When compared to large diameter solid wires with gas shielding a flux core wire offers much better running characteristics.
2. Welding can be done in all positions when the smaller diameter wires are used.
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3. Higher deposit efficiency is achieved by flux core wire versus stick electrodes, FCAW deposit efficiency is about 85% versus 75% for SMAW.

4. FCAW has better penetration than stick welding.

5. Self shielded flux core wires can run on much simpler and more portable equipment than GMAW.

6. Self shielded wire is less susceptible to drafts than GMAW, and therefore easier to use outdoors.

7. Continuously fed electrode wire doesn't take as much time changing electrodes as does stick electrodes.

8. FCAW handles contamination on the base metal better than GMAW because of the deoxidizers and scavenging agents contained in the flux.

VARIABLES

1. Amperage

Amps or welding current refers to the rate of current flow. Amperage is directly proportional to the electrode feed rate or wire feed speed. As wire feed speed is increased, amperage is increased. This variable is usually controlled by a dial on the wire feeder. Increasing the amps (wire feed speed) increases electrode deposition rate, penetration and will increase weld bead size – when other variables are constant. Too much amperage gives poor appearing welds with convex beads. Not enough current gives excessive spatter with large globular transfer. Most flux core electrodes have a globular type metal transfer but at high current settings a near spray type transfer can be achieved. Flux core gas shielded wires with mixed gas shielding can provide a spray transfer at higher amperage settings.

2. Volts

The distance between the end of the electrode and the work determines the welding voltage. A constant voltage power source typically has a knob on the front panel which controls the voltage. This type of power source automatically maintains a set voltage which then maintains a certain arc length. A constant current power source requires a voltage sensing wire feeder. These are sometimes referred to as "suitcase welders" and have a small wire running to a spring clip which is attached to the base metal. This "senses" the voltage and the feeder adjusts the wire feed speed to maintain the arc length to maintain the chosen arc voltage.

A given welding current requires a correct voltage setting to provide the optimum welding arc. The properties of a weld made with a flux core electrode can be affected by the arc voltage. An application's optimum voltage depends on the size of the electrode, base metal thickness, welding position, shielding gas (if any), and type of joint.

If arc voltage is set too high wide, irregularly shaped weld beads with excessive spatter will result. Too low arc voltage causes excessive spatter with reduced penetration and narrow convex beads. Excessive voltage with flux core gas shielded wires can cause "worm track" type porosity in the weld bead surface.

3. Stickout
The stickout or electrode extension is the length of wire extending from the end of the contact tube or tip to the arc. In the flux core process the stickout can greatly affect the resulting weld because the current flowing down the electrode preheats the flux before it reaches the arc. If the electrode extension is too short the enclosed flux is not hot enough when it reaches the arc. It then may not clean or alloy properly with the molten weld puddle. Slag inclusions may also occur. If the stickout is too long the flux may be burned up before it can act within the arc. This can create an unstable arc and excessive spatter. If wire feed speed is not increased and the stickout is lengthened the current will be reduced. Shortening the stickout creates the opposite effect. Changing the electrode extension can require a change in both the wire feed speed and voltage settings to maintain proper parameters and good results.

Manufacturers recommendations should be followed for proper stickout lengths. Remember that stickout is from the end of the tip to the arc, not the end of the nozzle. Typical gas shielded flux core stickouts range from 3/4 inch to 1-1/2 inches. Self-shielded electrodes commonly use longer stickout because all the shielding comes from the components in the flux and this gives them a better preheat and better activation. Stickout for self-shielded electrodes is normally from 3/4 inch to 3-1/2 inches.

**Procedures** – the following are key, specific aspects of the flux core wire process.

**Polarity:** Unlike gas metal arc welding, which is typically done with electrode positive (DCEP) or reverse polarity, some flux core wires are run with electrode negative (DCEN) or straight polarity. The wires designed to run DCEN are joining wires usually intended for welding thinner gauge steels and are self-shielding. Most flux core wires do run DCEP. Gas-shielded flux core wires operate on DCEP. The welder needs to check the manufacturer's requirement for the wire being used.

**Travel angle:** This is the angle between the joint and electrode in the longitudinal plane. When the electrode is pointed in the direction of travel it is a "push angle". A "drag angle" is when the electrode points in the opposite direction of travel. During welding the angle of the electrode affects how the arc force at the end of the electrode acts on the weld pool. Electrode angles can shape the weld bead. The arc force can also prevent the slag from running ahead of the molten weld pool and becoming trapped in the weld. Push angles are generally not used for flux core welding to minimize problems with possible slag entrapment. Proper travel angle is a function of type of flux core wire, welding position and base metal thickness. When welding in the flat position, less angle generally provides better penetration. Travel angle for gas shielded flux core wires generally range from about 2° to 25° for flat welds. Self shielded wires when run flat use a drag angle ranging from 20° to 45°.

**Single pass wire:** Some of the smaller diameter self-shielded flux core wires are intended for single pass applications on thinner steels. Basically, due to the alloying and fluxing agents of these wires, they can only be used with one pass. Multiple passes with these types of wires will result in porous welds or welds with inferior mechanical properties.

**Electrode size:** The thickness of the base metal to be welded is a determining factor of the best diameter size wire to be used for an application. This weld process is the best method for welding thick metals, using...
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correspondingly larger diameter electrodes and giving correspondingly higher deposition rates. However, it can be used to weld steels as thin as 18 gauge (1.2mm).

A smaller diameter wire electrode will give a higher deposition rate and deeper penetration than a larger diameter electrode of the same type run at the same current. This is because the current density will be higher for the smaller electrode. But the larger size electrode can be run at higher currents if the base metal thickness is great enough.

**Feed roll tension:** Be careful not to overtighten the feed rollers. If too tight, they can crush or deform flux core wires causing jamming of the wire in the liner or contact tip because the wire is out of round.

**Gases:** Shielding gas selection is simpler for the flux core process than it is for solid wire or GMAW. Shielding gases for FCAW generally are either straight C0₂ or a mix of 75% argon and 25% C0₂. The basic purpose of shielding gas is to protect the arc and molten weld puddle from contamination from the atmosphere. Oxygen and nitrogen in the air if allowed to come into contact with the molten weld puddle can cause porosity and weld brittleness. Hydrogen from the atmosphere as well as from moisture and other surface contaminants can cause an erratic arc as well as being detrimental to the properties of the weldment.

The shielding gas used can affect the running characteristics of a particular electrode. C0₂, when used for welding carbon steel, is low cost and provides deep penetration with a globular transfer. This gas can increase the carbon content of the weld metal which may be detrimental for stainless applications. Self-shielded flux core wires can sometimes be run with C0₂ gas shielding to improve their running characteristics. The gas shielded flux core wires generally require either C0₂ shielding gas or a 75% argon and 25% C0₂ mix. The 75-25 mix allows a fine globular metal transfer that is close to a spray transfer. It also provides better out-of-position running characteristics. This mix generally gives higher tensile and yield strengths to the weld deposit.

Flux core stainless wires can be run with a 75-25 mix. Solid stainless wire feed with the GMAW process requires special gas mixes.
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JOINING WIRES

**Polaris Ultra Flux Core** (95,000 p.s.i.) is used for welding mild, medium and high carbon steels. It is also suitable for low alloy steels and wear resistant types. A self-shielded type wire, it has excellent out-of-position characteristics. Ideal for single or multi-pass applications, it has a low spatter spray transfer. Excellent for "suitcase" type portable feeders.

**Polaris Maximum Shield** (90,000 p.s.i.) is designed for easy all position welding of mild, medium carbon, low alloy and high strength steels. It has a unique highly active flux which with shielding gas allows for welding vertical up or down, overhead and horizontal with ease. Excellent results even when welding through contamination. Provides high elongation welds.

**Tartan Flux Core** (80,000 p.s.i.) is a flux core self-shielded type wire superior for single pass applications on thin gauge mild and medium alloy steels. Ideal for galvanized steel. All position with smooth arc and excellent wetting action. Perfect for "suitcase" type wire feeders and 115 volt "plug in" type wire feeds.
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Gemini-B Flux Core (85,000 p.s.i.) can be used to weld most types of stainless steels. It is a high alloy, molybdenum bearing gas shielded wire that provides superior corrosion resistance with great running characteristics in all positions. Runs on 75-25 gas mix or CO₂.

BUILDUP AND HARDFACE WIRES

Apollo Flux Core (120,000 p.s.i.) is a self-shielded high manganese alloy wire suitable for joining manganese and manganese to low alloy steels. Ideal as a buildup alloy it deposits 200 Brinnel (15RC) and under impact will work harden to 550 Brinnel (55RC). Outstanding metal to metal wear resistance, it is also an extremely sound base for an overlay of hardfacing. Unlimited deposit thickness.

Olympia-A Flux Core (Hardness 55-60RC) gas shielded hardface wire resists abrasion and impact and provides great operating parameters. Good out-of-position, it has very low slag and high efficiency. Suitable for thick overlays.

Olympia-B Flux Core (Hardness 62-65RC) is a self-shielded hardface wire with an exceptionally high alloy content for extreme abrasion resistance. The deposits are very hard but also resist mild impact and high heat. Deposits are slag free and should be limited to two passes. The use of shielding gas will enhance running characteristics and will allow spray arc transfers. Will run vertical down.

Omega Flux Core (Hardness 50-54RC) is a self-shielded general purpose hardfacing wire with an exceptionally high chrome content. This provides resistance to the combined forces of abrasion and impact. Large diameter electrodes provide high deposition rates for larger applications.

Zeta Flux Core (Hardness 55-60RC) is a gas shielded flux core wire that is very easy to run, especially in vertical applications. Its special, very high alloy content provides very dense deposits that give superior abrasion resistance even when combined with heavy impact loads. High chrome resists stress cracking and provides corrosion resistance.

For more specific information on these or other products, refer to the Rockmount Research & Alloys Welding Manual.

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