LOOKING TO IMPROVE WELD SEAMS?

Try fluxes for tube, pipe production

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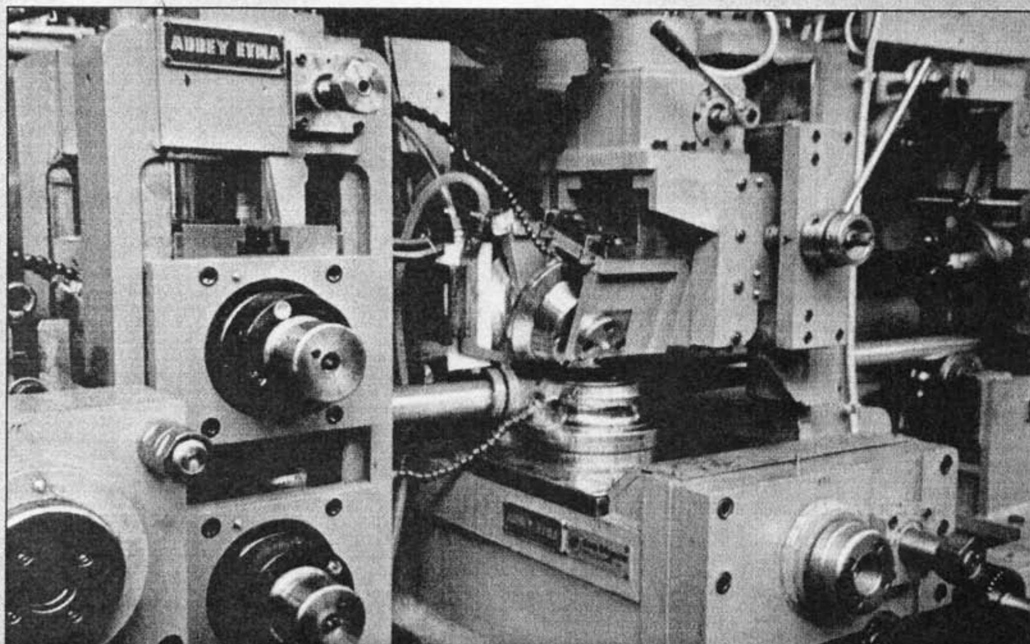

Photo courtesy of Abbey International Ltd., Perrysburg, Ohio.

TECHNOLOGICAL improvements often are simple concepts that can have profound effects on existing processes. New technologies and process efficiencies allow manufacturers to improve products or increase throughput. For example, developments in high-frequency power supplies allow tube and pipe manufacturers to select the optimal frequency for the application. Consumables also continue to evolve and find new applications. Welding flux is one such consumable. Many tube and pipe manufacturers have found that using a flux reduces defects, thereby improving yield.

Fluxes for tube welding processes are available in two forms: paste and liquid. Both have pros and cons, and the choice depends on several factors. Introducing fluxes is easy in the tube and pipe production process, and the result often is a cost-effective return in quality, efficiency, consistency, and time management.

Before choosing a paste or a liquid, it is necessary to learn about the chemical makeup and vitreous (glassy) nature of tube and pipe welding fluxes; the chemical mechanisms whereby the flux removes refractory oxides from the surfaces of 409 stainless steel, 409 aluminized stainless steel (MO), and 439 stainless steel; and the role of fluorine.

FLUX TYPES

Fluxes are essential when joining metals in ambient air, whether by soldering, brazing, or welding. When heated, fluxes perform four tasks:

1. Dissolve or react with surface oxides.
2. Protect the cleaned surfaces against re-oxidation.
3. Transfer heat from the heat source to the joint.
4. Remove surface oxides, allowing surface or filler metals to flow and wet the joining surfaces.

It is important to distinguish brazing fluxes from welding fluxes. The difference is a matter of temperature: Brazing takes place from 900 degrees F to 2,200 degrees F; welding is from 1,500 degrees F to 3,000 degrees F.

Tube and pipe mill weld boxes develop very high temperatures (2,600 to 2,800 degrees F), so a welding flux seems to be appropriate for this application. However, the heat cycle used in tube and pipe production is too short and too intense to activate welding fluxes. Moreover, the fluoride content of these fluxes is quite low. High fluoride content is critical in tube and pipe welding applications.

In fact, various silver brazing flux formulations are suitable for this operation. These fluxes are active in the temperature range of 1,000 to 1,600 degrees F and have numerous industrial uses. The formulations activate in the intense heat of the weld box and remain active during the very short exposure time. The most common inorganic raw materials used in these fluxes are:

- Boric acid
- Potassium tetraborate
- Potassium pentaborate
- Potassium fluoborate
- Potassium bifluoride
- Potassium carbonate
- Potassium fluoride
- Sodium tetraborate (borax)

Formulations for tube and pipe welding fluxes are available in paste and liquid forms. The flux is applied to the mating surfaces. Paste is applied directly on both coil edges, while liquids are sprayed onto the joining surfaces immediately prior to entering the weld box.

FLUX FUNCTIONS

Ferrous alloys, especially mild steel, are the most common materials for manufacturing tube and pipe. These metals exhibit surface oxides. For mild steel these are iron oxides such as FeO and F_2O_3. Generally, iron oxides are either reduced at elevated temperatures or are displaced in the welding process. An exception is 409 stainless steel, which contains approximately 12 percent chromium. The chromium oxidizes to chromium oxide (Cr_2O_3), a tenacious and refractory oxide that tends to remain on the joining surface and interferes with the welding process. This is an even greater problem with 439 stainless steel, which contains approximately 18 percent chromium. The aluminum in alloys such as 409 aluminized stainless steel exacerbates the problem: Heating this material causes both aluminum oxide *and* chromium oxide to form. Aluminum oxide is also refractory and remains on the joining surface. Using argon gas or another inert shielding gas affords some protection against high-temperature oxidation. However, these gases do not remove the original metal oxide tarnish, and they are only partially protective in the dynamic environment of the weld box.

This is where fluxes perform their fundamental process function. At approximately 1,000 degrees F, the assemblage of inorganic chemicals is transformed into a glassy complex. Glass viscosity is important: It must be high enough to serve as a protective blanket, keeping oxygen diffusion to a minimum, while at the same time low enough to dissolve surface oxides effectively.

The primary means for oxide removal by alkali fluoborate fluxes is dissolution. Oxides are absorbed into the glass, leaving a very clean, deoxidized metal surface, which is properly prepared and protected for the welding stage. Flux activity reaches its peak in the short induction welding cycle.

Boron oxide (B_2O_3) is the glass former in the silver brazing flux formulation. It provides the protective blanket for the base metals and the filler alloys, lowering the rate of oxygen diffusion to the metal surface so that it is below the rate of oxide removal from the joining surfaces. Potassium oxide (K_2O) and sodium oxide (Na_2O) are the glass modifiers, lowering the melting point and viscosity of the glass, improving flow. Fluorides reduce the melting point and viscosity further because they disrupt the cross-linkages in the borate glass structure. However, the improved fluxing action results mainly from the greater oxide dissolution capability of the glass because of its fluorine content. Fluorine is especially important because it aggressively attacks such oxides as Al_2O_3 and Cr_2O_3, accelerating their solution in the borate glass.

Silver brazing fluxes usually are used in conjunction with silver-based (BAg) alloys. The flux cleans and protects both the base metal and the filler alloy, allowing the filler alloy to flow and wet the base metal. This is not the case with the tube and pipe welding application because it uses no filler alloys or electrodes. Yet the outcome is the same. The flux removes oxides and protects the surface against re-oxidation, yielding a strong, consistent weld seam. The simple addition of flux improves metallurgy, cosmetics, consistency, and stability of the tube welding process.

FLUX SELECTION AND USE

Tube and pipe welding fluxes come in two forms: paste and liquid (low-solids and high-solids). Paste is applied by brush to both sides of the steel coil and is ready for use after all solvents evaporate. For liquid application, flux is sprayed onto joining surfaces just before the edges enter the weld box. Conventional tube and pipe pastes are effective on 409 stainless steel, 409 aluminized stainless steel, and 439 stainless steel. On the other hand, conventional low-solids liquid fluxes work effectively on 409 stainless steel but aren't compatible with 409 aluminized stainless steel. A new high-solids liquid flux has been developed that solves this problem—it is effective on 409 aluminized stainless steel and 409 stainless steel.

In terms of choosing a flux, some operators prefer the paste because it requires just one step; they do not have to do anything after applying the flux. The downside is that this process does not use the flux effectively; a fair amount flakes off before reaching the weld box. The flaking is associated with material moving through the accumulator, where it travels up to 220 feet per minute. These flakes and particles must be removed from the area continuously to prevent health, safety, and equipment efficiency problems.

Spraying flux onto joining surfaces is a simple process, but it requires constant monitoring. For example, if the spraying is inconsistent, the result is a visual difference between the fluxed and unfluxed weld seams. The liquid results in a cleaner operation because flux is applied close to the weld box and it does not flake.

FIVE REASONS FOR USING FLUX

Learning about what flux does and how it does it isn't enough. One more question remains: How does flux benefit a tube and pipe operation?

1. Better, Stronger Welds. Removing the centerline oxides results in a better weld. The weld has fewer voids, fewer microcracks, and greater consistency. This is reflected in a sharp reduction of seam splits. Further, when using flux, the mill is more forgiving in terms of line speed, heat, and pressure.

2. Lower Tube Reject Rates. Reductions of up to 40 percent in tube reject rates have been reported. This reduces scrap, resulting in a large monthly cost reduction.

3. Reduced Scarf Scrap. Without flux, many operators use higher-than-necessary welding temperatures to produce a good weld. This can cause a bulge at the seam that must be removed by scarfing. A welding flux allows operators to keep the heat at a normal level, which reduces the amount of material that must be scarfed. It therefore reduces scarfing tool consumption.

This enhances product throughput because it reduces downtime, particularly concerning the ID tooling.

4. Lower Electricity Consumption. Some flux users have reported substantial reduction in electricity consumption. This is because applying flux to the joining surfaces results in cleaner, oxide-free surfaces, which need less current. In some cases, when flux has been added to the process, operators have been able to increase the line speed, thereby boosting throughput, without increasing the welding current.

5. Cost Savings. The lower tube reject rates and reduced ID scarf scrap result in cost savings. Flux-spraying equipment for liquid application is simple and relatively inexpensive, and brushing flux onto the surface is an inexpensive manual operation.

Finally, because it reduces tube rejects, it frees engineers and operators to spend more time on manufacturing and process improvements and less time dealing with problems. TPJ

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