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Welding Reactive Metals like Titanium – What's Different?

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Having the capability to weld reactive metals like titanium, zirconium and tantalum is a differentiator for fabricators. Having skilled welders is not enough – a shop needs to be set up for reactive metals fabrication. This blog post will go into some of those differences for titanium. Zirconium and tantalum are even more complex.



When most people first witness reactive metals fabrication, they are surprised at how much time is spent doing things other than welding. It's true, and that may be the biggest difference, although I would never minimize the skill required to be a good reactive metals welder. Many things have to be done correctly before an arc is even struck for a reactive metals welder to have a chance at making a good weld.

First, let's talk about material handling. Titanium needs to be completely clean for welding and it should be maintained reasonably clean from the mill through completed fabrication. All titanium materials should be handled and stored so that they are protected from contact with iron or nickel-containing materials. Storage racks should be lined with wood or plastic. Titanium should not be set directly on concrete surfaces. Fork protectors must be used on fork trucks. Work surfaces need to be covered to avoid contamination.

The workshop has special requirements too. A separate welding area should be set aside for titanium fabrication. This area needs to be isolated from dirt, smoke and other airborne contaminants from welding, cutting and grinding operations. The welding area also needs protected from wind and drafts that could interfere with the inert gas shielding. A positive pressure air system for this area is preferred. The humidity should be closely controlled as well as high humidity conditions are a source of oxygen and hydrogen.

The purging requirements will be discussed later, but one aspect related to the shop capabilities in the quality of the purge gas. Titanium needs 99.995% minimum purity Argon gas with a dew point of -60°F (-50°C). This level of purity really requires the use of portable dewers or large stationary, insulated tanks. Gas cylinders require special considerations and are not ideal.



Preparation of the surfaces for welding are different as well. After cutting, edges must be rotary or draw-filed with tungsten-carbide burrs (rotary files) and/or metal draw files. Filing ensures the removal of contaminants such as embedded steel or abrasive particles that could have been introduced during the preliminary surface preparation. After filing, mechanical cleaning of the surface should be within a minimum of 1 inch on either side of the weld joint with a stainless steel wire wheel. Then the surface

should be thoroughly cleaned with a clean, lint-free cloth dampened in a solvent with no residue or chlorides, like 100% pure Acetone. All tools and materials used, including burr files, wire wheels, rags, etc., must be clean and only be used on titanium. After final cleaning, the surfaces must not be touched unless wearing clean, dry cotton gloves. Fingerprints, rubber gloves, and other materials can leave trace impurities on the surface that will contaminate the weld. Recleaning is required if any contamination has occurred. For this reason, it is best practice to weld the joint soon after the prep is complete.

When fitting-up titanium, accuracy is more critical than it is for other materials to reduce the possibility of contamination and to control underbead contour. Joints should be clamped rather than tacked where possible with clean, grease-free clamps. If tacks are used, all of the same cleaning and shielding requirements for titanium welds must be followed, including the use of trailing and backup shielding. Cracked or contaminated tack welds must be removed and the area cleaned before proceeding with final welding.

Purging is especially important for reactive metals. The weld pool, solidified weld, heat affected zones and root side of the weld all must be protected by a purge until the temperature cools to below 800°F (427°C). Only Argon with some Helium mixed in at times, is used as shielding gases. Gas hoses must be PTFE, PP, HDPE or FEP. Rubber hoses absorb air and moisture and must not be used in titanium welding operations. When welding titanium outside of a purge box, purging requirements are extensive. A trailing shield must be used to blanket the solidified weld and adjacent heat-affected zone until temperatures have dropped to a safe value. A backup shield must be used to protect the root side of the weld as well. An oversized cup and gas lens are mandatory for the welding torch itself to provide uniform, non-turbulent gas coverage around the weld pool. The shields must be constructed of proper materials and have provisions to diffuse the shielding gas to eliminate high gas velocities and ensure uniform flow over the shield area. Purging must be established and verified before welding commences.



If you've got all of those boxes checked, it's time to weld. It should be clear now, being able to weld reactive metals is not just about having a talented welder. Like many things in life, that talented individual needs to be in the right environment, with all of the necessary tools and support systems to be successful.

References:

"Guide for the Fusion Welding of Titanium and Titanium Alloys, AWS G2.4/G2.4M:2021", American Welding Society.

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