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Q: Why is electrolytic nickel plating of base metals required prior to brazing Alloys 738, 617, X750, and similar base metals that contain alloying elements of aluminum and titanium? Titanium and its alloys do not require electroplating with nickel prior to brazing.

A: Titanium and its alloys are critical base metals that readily absorb most metal and gas elements during foundry melting and fabrication. Gases such as oxygen or nitrogen, when absorbed into titanium base metals, severely lower the ductility and make the resulting base metal unsuitable for fabrication.

Therefore, titanium and titanium alloys must be melted and fabricated under extremely well-controlled conditions.

Processes such as vacuum melting, and sometimes double vacuum melting, are required to remove gases and residual elements that would reduce the quality of the titanium and its alloys. Highly purified argon that contains an extremely low partial pressure of oxygen may also be used.

Stainless and heat-resistant base metals that contain alloying elements of aluminum and titanium to enhance their high-temperature properties do cause brazing problems. When heating the assembly to perform the brazing operation, the assembly goes through an oxidizing range, even in the best vacuum atmosphere. Most production vacuum furnaces are not well controlled, and the vacuum atmosphere may have a higher than desired partial pressure of oxygen during the time the brazement is heated through the oxidizing range. This allows highly oxidizable elements, such as aluminum and titanium, to form an undesirable layer of oxides on their surfaces. While the oxides of Fe, Ni, and Cr are readily dissociated of their oxides at the higher brazing temperatures, the oxides of aluminum and titanium do not dissociate, and therefore, the surface oxide layer interferes or prevents brazing of the assembly.

The manufacture of high-production stainless steel base metals, on the other hand, is not as minutely controlled, and therefore more residual elements are present in the final products. In general, the small amount of residuals does not affect the properties of the stainless steels during fabrication or service; but, unfortunately, they can interfere with the brazing of an assembly.

In the high-quality atmospheres required for vacuum brazing, some of the residual elements vaporize into the atmosphere, and residual oxides of many elements in the base metal, as well as the occluded oxides that are brought into the vacuum furnace on the assemblies, outgas and cause oxidation of the aluminum and titanium.

It has been found that electrolytic nickel plating of the base metal before assembly and brazing is essential to assist in the wetting and flow of the brazing filler metal. The electrolytic nickel plating, which is very readily dissociated of its oxides, shields the aluminum and titanium from the atmosphere, thus allowing the brazing filler metal to readily wet and flow into the joints.

It is this minute degree of difference in purity between the stainless steels, heat-resistant base metals, and the base metals of titanium and its alloys, that makes application of the electrolytic nickel plating a requirement.

It is essential that the vacuum furnace be properly conditioned prior to brazing titanium and its alloys. This requires a check of the furnace using a helium mass spectrometer leak detector or equivalent, and an adequate furnace burnout to remove any contaminating elements from the furnace and heat shields.

Brazing problems can also occur with 321, 409, and similar base metals. One heat of these base metals may braze excellently and come out of the furnace bright and clean, while the next heat may come out of the brazing operation with a light gray to brown oxide coating. This coating is a layer of titanium oxide. As the color darkens, the angstrom thickness of the oxide layer increases. This oxide layer interferes with or prevents the wetting and flow of the brazing filler metal into the joint, thus compromising the quality of the brazement.

The addition of nitrogen to stainless base metals also causes brazing difficulties, resulting in the need to electrolytically nickel plate the base metals as the nitrogen level increases.

As the need for higher-quality brazements increases, it is important for the brazing engineer to have knowledge of the residual elements and additives to base metals that affect the brazing quality.

Additional information on brazing atmospheres can be found in the AWS *Brazing Handbook,* 4th Edition, Chapter 4, Fluxes and Atmospheres. Also, visit *www.brazingandsoldering.com,* the AWS Brazing & Soldering Manufacturers Committee Web site. ♦

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