BRAZING Q&A

Q: We manufacture steel heat exchangers using copper paste in a belt furnace. Our customer has an application where copper as the filler metal is undesirable. They are asking if it is possible to convert to either nickel or silver. We use a combusted gas atmosphere with a dew point of more than 50°F (10°C). The components are carbon steel and are currently being brazed with copper paste conforming to AWS A5.8 BCu—la. The furnace zone settings are between 2040° and 2050°F (1115°—1121°C). What alternative material would be as seamless as possible?

A: There are a number of issues that come into play with this request. The first is the acceptable temperature of a potential alternative. Pure copper melts at 1981°F (1083°C). When you switch to silver or a silver alloy, going to a lower temperature is inherent. This is because the melting point of silver is 1761°F (960°C). Alloying additions can drive the temperature even lower. At this point, I am going to assume that any alternative filler metal under consideration will be acceptable from a temperature perspective.

Next, we can consider the dew point. A dew point of +50°F (10°C) would be considered a wet atmosphere in brazing circles. It is a measure of moisture in the atmosphere. Your atmosphere is good enough to reduce the iron oxide from the steel base material and the oxide from the copper in the braze paste. The water vapor in the atmosphere also provides a way to remove the hydrocarbon residue from the braze paste binder. So, in your current situation, the wet atmosphere is appropriate. When considering a change, it will play a major role.

The ferrous base metal has metallurgical considerations. Iron and silver do not like each other from a solubility point of view. This is an indicator of how poorly pure silver will work as a braze alloy on ferrous base metals. Pure silver is used in very limited applications and not on ferrous materials. Nickel and iron are a better combination but have limitations.

In your application, the combination of ferrous base metal, copper filler metal, and paste binder works well in your furnace. To find an alternative, you need to look at filler metal compositions that will have their oxides reduce in a +50°F (10°C) atmosphere and work metallurgically with ferrous base metals.

Silver

Let’s take a close look at pure silver. The AWS classification for the use of pure silver as a braze filler metal is AWS A5.8 BVAg—0. The main issue with switching to pure silver is that it does not wet ferrous base materials. It would be okay in your process as the oxide would be reduced and would only require heating to 1850°—1900°F (1010°—1037°C). In my experience, I would expect it to wet poorly on carbon steel. You could plate your components (with copper, unfortunately).
and I think it would work acceptably. However, this is costly and adds copper back into the mix. Silver does not like to alloy with nickel, so Ni plating would be questionable. It’s probably a dead end.

To get silver to wet ferrous alloys, you have to add something. As copper is very soluble in silver, and works well on ferrous base metals, it is the most common alloying element for silver braze filler metals. This is advantageous because the copper provides the wetting ability.

If you peruse the BAq classifications in AWS A5.8, you will find a wide variety of materials that cover a broad range of applications. All except one contains copper. The only common silver braze alloy without copper is AWS A5.8 BAq-23 with a composition of 85% Ag–15% Mn. The temperature is nice, 1760°–1780°F (960°–970°C), but your atmosphere will not reduce the manganese oxide. There are a few others, but they are not common and would not be compatible with the parameters of your application.

It would seem that silver or silver alloys without copper are not an option.

**Nickel**

There is no AWS classification for pure nickel as a braze filler metal. There would be no metallurgical issue, but the temperature is too high. Nickel has a melting point of 2651°F (1455°C). You would need to reach the 2700°–2800°F (1482°–1537°C) temperature range to braze with it. This must be approaching, if not exceeding, the melting point of your base metal. This takes it out of the question. Your atmosphere would reduce nickel oxide, as it and copper oxide are easier to reduce than iron oxide, but it is unacceptable due to the temperature required.

As a result, to use nickel as a base, you have to add something to reduce its melting temperature. The most effective temperature depressants for nickel to be used as a brazing filler metal are silicon and boron. There are a few alloys that use phosphorus to depress the melt range. To enhance the corrosion resistance and make them usable across a broad spectrum of nickel and iron base metal systems, chromium is added to a large percentage of them.

Upon examination, most of these get eliminated straight away. The oxides of chromium, silicon, and boron will not be reduced in a wet atmosphere. These filler metals are typically brazed in vacuum furnaces or dry hydrogen furnaces. There are two common nickel filler metals that contain phosphorus. One of them contains chromium, so that one gets eliminated immediately. The one filler metal that is simply nickel and phosphorus has an AWS classification of A5.8 BNi-6. Its specifics are the following:

- 89% Ni–11% P
- Melt Point 1610°F (876°C)
- Class AWS A5.8 BNi-6

This filler metal has been found to be effective in marginal atmospheres and can be brazed anywhere from 1700°–2000°F (926°–1093°C). The downside is that phosphorus and iron form a brittle inter-metallic phase that normally precludes its use in joining ferrous materials. In a heat exchanger, depending on the design, impact re-
sistance, internal pressure, and end-use environment, this may or may not be acceptable. Your customer would need to sign off as to its potential use, and extensive testing would need to be performed. As I look at available options, the BNi-6 is the only Ni based filler metal that may work in your furnace. It may require a drying of the atmosphere to some lower dew point.

**Options**

As it stands, assuming nothing changes on the process side, the filler metal options to investigate further would seem to be the following:

1. A silver filler metal with an addition of copper. If copper could be allowed in some percentage, the options are numerous. Silver-copper filler metals with either a nickel or tin addition (or both) are excellent materials and can be brazed at a much lower temperature.

2. A nickel filler metal conforming to AWS A5.8 Classification BNi-6.

If process changes are on the table, I would look at

(A) Making modifications to lower the dew point. Any reduction will make filler metal selection more flexible. We could take another look once we know what level is possible.

(B) Switch to a different atmosphere, whether that means using/ modifying the existing furnace, purchasing a different unit, or subcontracting the work. Companies run dry nitrogen and hydrogen atmospheres with low dew points that open the discussion to other options.

(C) You could add a flux to the paste. It’s most likely not acceptable in your application, but adding a high-temperature flux may make other filler metals workable.

(D) You could possibly plate the base metals with copper or to try to make a high silver content material work.

**Conclusion**

All of these options come with the need for significant evaluations of process, application constraints, and possible capital investment. The size of the market and/or seriousness of the need will determine if you will move forward.