Frequently asked questions #1

Can plated surfaces be brazed?

The first thing that has to be said about this procedure is that it is ***nearly always*** technically unsatisfactory to braze to a layer of plating, and is a procedure that is best avoided! The exception to this rule relates to very costly, and intricate procedures, that are sometimes carried out when vacuum brazing very specialised aerospace components with nickel-base filler materials. In such cases the primary objective to use a two-stage brazing technique where the first stage is to cause the ultra-thin electro nickel plating to bond metallurgically to the substrate of a gamma prime casting which has a relatively high aluminium/titanium content. After cooling the parts are inspected. If the bonding process is seen to have been a success a second furnace cycle using a suitable nickel-base alloy is used to make the required joint(s). During this procedure the bonded nickel surface is dissolved by the filler material as it wets the substrate Engineers should, therefore, remember that it will be a serious mistake to make if, having previously read something about the pre-plating of gas-turbine components prior to brazing, they believe that to simulate the procedures in a lower cost environment will lead to success. You can be about 100% sure that it won't!

The fundamental consideration in 99.99% of cases is that since the plated layer itself is *invariably* very thin, typically 0.0125mm or less, the adhesion of the layer to the surface on which it has been electro-deposited is invariably weak in comparison to the normal strength expected of a properly brazed joint. It can therefore be seen that the strength of a joint where brazing to a plated surface has been carried out, and assuming that the solubility of the plated layer in the molten filler material is low, will ***only be equal to the strength of the adhesion between the plated layer and its substrate!***

We will now consider two cases that might sometimes arise:

- Reducing atmosphere furnace brazing of mild steel to nickel-plated mild steel with copper
- Brazing in air to an electroplated surface.

Section 1. Brazing in a reducing atmosphere furnace

As a general rule, when one thinks of 'furnace brazing' one generally has those situations in mind where heating of the parts to brazing temperature is accomplished in a furnace under a protective atmosphere so avoiding the necessity to use a fusible chemical flux. However since the technical and practical aspects of furnace brazing are covered in detail **Documents 3.1 and 3.2** in the EABS Technical Library in the Member's Area of our website, they will not be revisited here. In the case under review it is necessary to consider the metallurgy of the wetting of the nickel-plated layer with copper since it is this factor that provides the first step along the road to ***'user dissatisfaction'*** with the process of brazing to a plated layer.

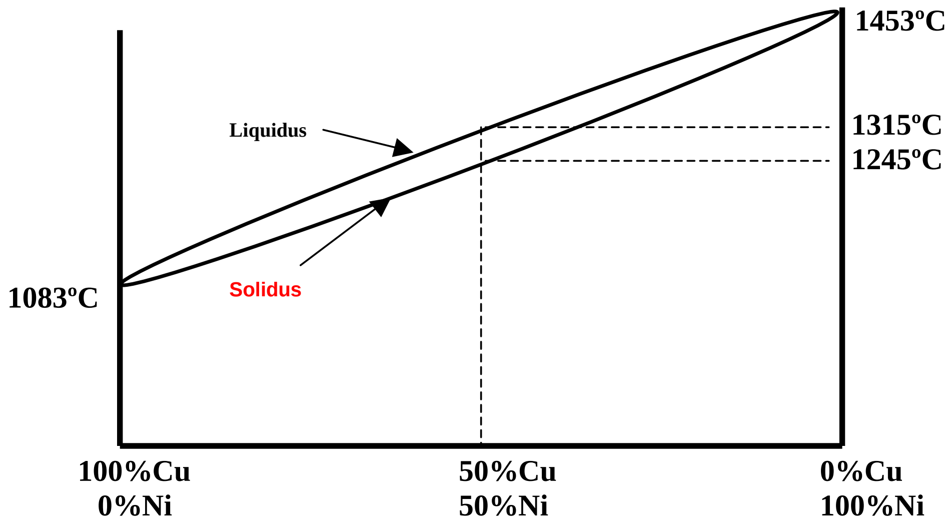
As is widely known the mechanism of the wetting process is quite complex. The process is, perhaps, more easily understood if one appreciates that when a molten filler material begin to dissolve a small amount of the parent material upon which it is standing it is considered that the filler metal has wetted that parent material. Naturally, this means that when wetting occurs, during the time that the filler material is molten *and in contact with the parent material*, it will continue to dissolve small amounts of the parent material over which it is flowing. As a result the *composition of the filler metal in the joint* undergoes continuous change in its composition until it solidifies!

The ***amount*** of inter-alloying that occurs between the molten filler material and the parent metal(s) during the wetting process to form a 'new' (parent metal + filler material) alloy is intimately related to:

*The **time** for which the alloy is molten and in contact with the parent material and*

The ***temperature*** *of the molten filler material*

The overall effect is that the inter-alloying that occurs during this time *can* have a major influence upon the fluidity of the filler material and its ability to flow by capillarity.



Pure copper has a *single* melting point at 1083ºC
Pure nickel has a *single* melting point at 1453ºC
An alloy of 50% Copper: 50% Nickel has a *melting range* of 1245-1315ºC

Fig 11.1: The copper- nickel thermal equilibrium diagram

In some cases the parent material dissolved by the molten filler results in the melting point of that filler ***rising*.** This can lead to the situation where the melting point of the 'new' alloy rises to a point where it becomes *higher* than the temperature at which the brazing operation is being carried out! In these situations the fluidity of the filler metal is reduced, its flow characteristics will become seriously impaired and, eventually, it '*freezes*', and flow ceases. This is precisely what is likely to occur when molten copper flows on the surface of a nickel-plated component. This effect is illustrated in **Fig 11.1**

From a study of **Fig 11.1** it is clear that as the copper dissolves the parent material there is a progressive change in the fluidity of the filler material as it flows through the joint. A further occurrence is the fact that both the *solidus* and the *liquidus* temperature of the filler material *increases***.**

Depending upon the length of the joint, the time taken for the filler metal to flow into it, and the temperature at which the furnace is operating, any premature 'freezing' of the filler material that results can lead to the formation of a joint that is only partially filled

It is very easy to demonstrate that the higher the temperature the greater is the amount of inter-alloying that results. Clearly, in the example being considered there is the metallurgical fact that the melting point of the brazing filler material might rise to a temperature that is *greater than the operating temperature of the furnace.* This will lead to premature freezing of the filler material, and if not all of the plated layer is dissolved by the copper, to the risk that the strength of the resultant joint will only be that of the strength of the adhesion between the plated layer and the substrate. See **Fig 11.2**

On the positive side, the probability is that the molten copper will dissolve all of the nickel with which it makes contact. In this case one has to hope that the amount of copper available would be so great that even when it had dissolved the nickel plating the composition of the 'newly produced' copper-nickel alloy would be such that its liquidus temperature would still be *below* the furnace operating temperature. In these conditions premature freezing of the filler alloy would be avoided, and wetting to the steel substrate would be the norm, the resultant joint possessing satisfactory strength. The reality is, however, that this is the ***best** result* that can be hoped for!

Not to scale

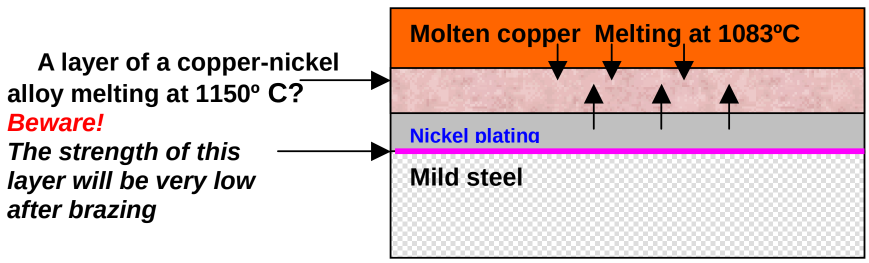


Fig 11.2: One metallurgical result of brazing to a plated surface!

As we have seen, a much less satisfactory result would be if only a portion of the nickel layer were dissolved. This would inevitably lead to progressive ‘thinning’ of the nickel-plating in the vicinity of the copper coupled to the production of only a partially filled, relatively weak, joint.

These alternatives are probably not a way that anyone would knowingly wish to go, and why it is a general rule that attempts to braze to a layer of plating need to be strongly discouraged!

Section 2: Brazing in air

It is about certain that the plated layer would oxidise during the heating stage of the process and that the resultant oxide would be dissolved by the flux. In such cases it would be clear that brazing would, in effect, be undertaken directly to the surface of the material that had been plated. This would be acceptable from the point of view of joint strength, but *might* be unacceptable from the point of view of the corrosion resistance of the component.

The strength of adhesion to the substrate of any portion of the plated layer still remaining would be severely reduced. This would be the case even if only modest heating had occurred. The oxidised surface of the plating might *not* have been dissolved by the flux but the inevitable result of atmospheric oxygen diffusing through the plating during the heating process would cause severe oxidation of the substrate and this would be cause of the serious reduction in the reliability of adhesion of the plating to the substrate.

Clearly, the two situations discussed above demonstrate why there is an outstanding case to avoid trying to braze to the surface of plated components!

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