

LA-UR-02-6227

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Submitted to: Proceedings of the 2nd International Brazing and Soldering
Conference, San Diego, CA February 17-19, 2003



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CATHODIC ARC SURFACE CLEANING PRIOR TO BRAZING

V.R. Davé*, K. J. Hollis*, R. G. Castro*, F. M. Smith*, D. A. Javernick*

ABSTRACT

Surface cleanliness is one the critical process variables in vacuum furnace brazing operations. For a large number of metallic components, cleaning is usually accomplished either by water-based alkali cleaning, but may also involve acid etching or solvent cleaning / rinsing. Nickel plating may also be necessary to ensure proper wetting. All of these cleaning or plating technologies have associated waste disposal issues, and this article explores an alternative cleaning process that generates minimal waste. Cathodic arc, or reserve polarity, is well known for welding of materials with tenacious oxide layers such as aluminum alloys. In this work the reverse polarity effect is used to clean austenitic stainless steel substrates prior to brazing with Ag-28%Cu. This cleaning process is compared to acid pickling and is shown to produce similar wetting behavior as measured by dynamic contact angle experiments. Additionally, dynamic contact angle measurements with water drops are conducted to show that cathodic arc cleaning can remove organic contaminants as well. The process does have its limitations however, and alloys with high titanium and aluminum content such as nickel-based superalloys may still require plating to ensure adequate wetting.

KEYWORDS

Brazing, Surface Cleaning, Cathodic Arc Cleaning

INTRODUCTION

There are at least three types of surface contaminants that impact brazing: organic, inorganic, and native surface oxide. Chemical cleaning processes such as acid pickling have traditionally been used to remove oxide layers and methods such as alkali cleaning to remove organic and inorganic contaminants. Although effective, chemical cleaning has several disadvantages: worker exposure to hazardous materials, environmental health and safety costs, waste disposal costs, and problems with process control of large chemical cleaning tanks. Several alternative precision cleaning technologies have been successfully applied in recent years: low pressure plasma cleaning, CO₂ cleaning, and solvent-based cleaning using chemicals that are more environmentally acceptable. These techniques address organic and sometimes inorganic contaminants, but generally do not remove oxides films with the possible exception of plasma cleaning. Furthermore, solvent-based cleaning even with less harmful solvents may be phased out in the future. Therefore, new approaches are still warranted for cleaning prior to brazing. This work investigates CA-cleaning as a potential braze preparation method and an alternative to chemical cleaning.

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EXPERIMENTAL APPROACH

Water contact angle measurements were performed on IN 718 and type 304 stainless substrates using a VCA (video contact angle) measurement system made by AST Products, Inc. Three surface conditions were tested: as received, acetone-rinsed, and CA-cleaned. Figure 1 shows typical results for IN718. The increased contact angle for the acetone-rinsed sample is attributed to the fact that there was a residue left behind from the cleaning process. These results do suggest however that CA-cleaning does have a dramatic effect on surface cleanliness as measured by water contact angle, which will predominantly indicate the presence or absence of organic contaminants.

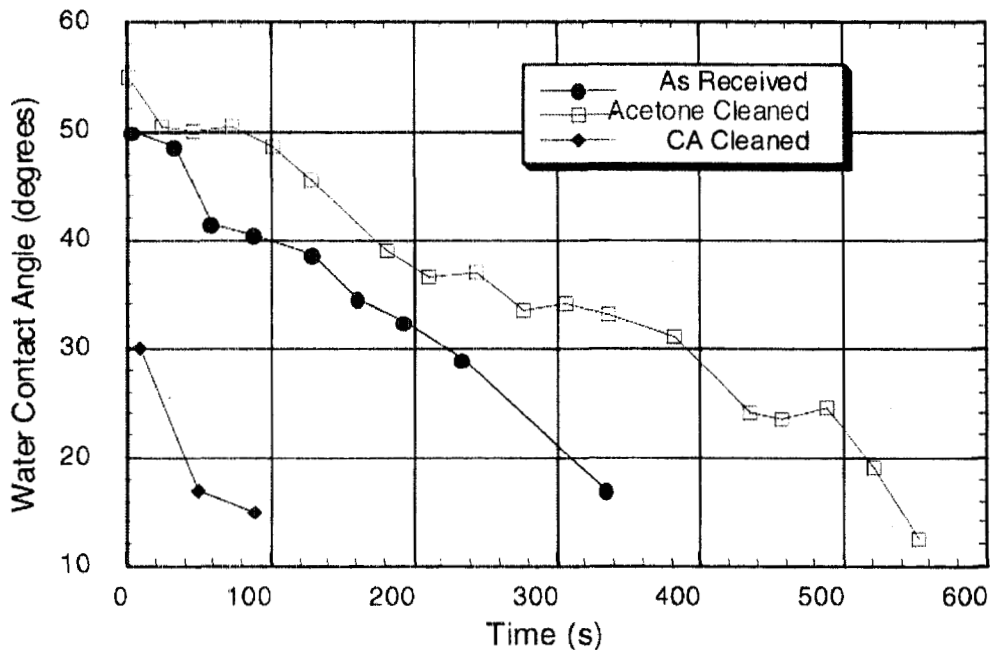


Figure 1: Water dynamic contact angle data for IN-718

Braze contact angle measurements were made in a vacuum furnace using a Canon XL1 digital video camera to record the droplet images viewed through a quartz view port on the door of the vacuum furnace. A typical series of pictures from the digital camera is shown in Figure 2. Table 1 shows the elapsed time and contact angle for the cases shown in Figure 2. The braze cycle consisted of a 30 min. hold at 760 deg. C followed by a ramp up to 875 deg. C and a 10 min. hold at 875 deg. C. Ag-28% Cu was the braze filler material. Type 304 stainless steel samples were used and three surface conditions were tested: chemically cleaned by alkali (NaOH) followed by acid pickle (nitric acid), oxidized surface exposed to 700 deg. C air for 5 min., and this same oxidized surface that was CA-cleaned. The CA cleaning apparatus is shown below in Figure 3 and a photo during cleaning is shown in Figure 4. The results of these contact angle measurements are shown in Figure 5. It is seen that CA-cleaning is as effective as chemical etching in terms of promoting braze wetting, but there is a time lag between the two.

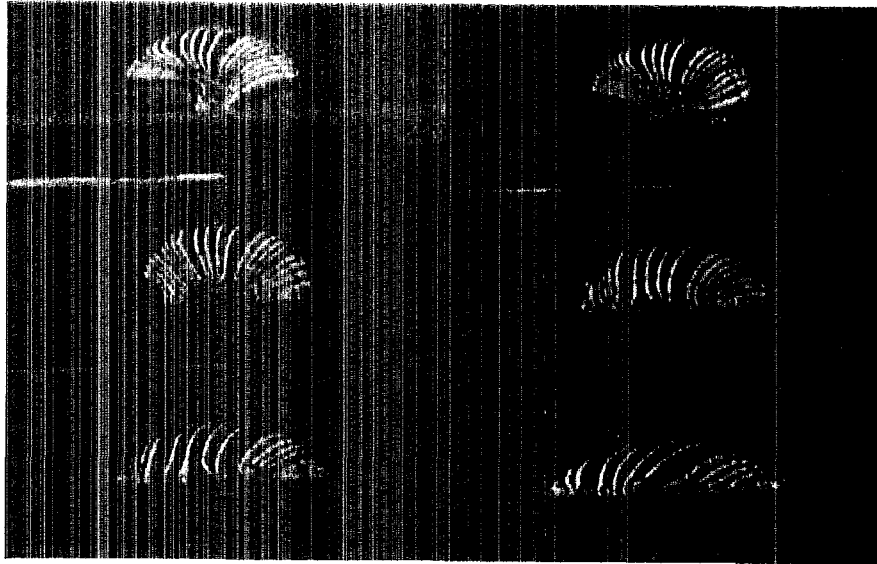


Figure 2: Dynamic contact angle measurements from Ag-28%Cu braze on type 304 Stainless Steel.

Sequence No. In Figure 2	Elapsed Time, seconds	Contact Angle, degrees
1	0	119
2	144	108
3	173	86
4	198	70
5	215	56
6	231	49

Table 1: Contact angles corresponding to sequence shown in Figure 2.

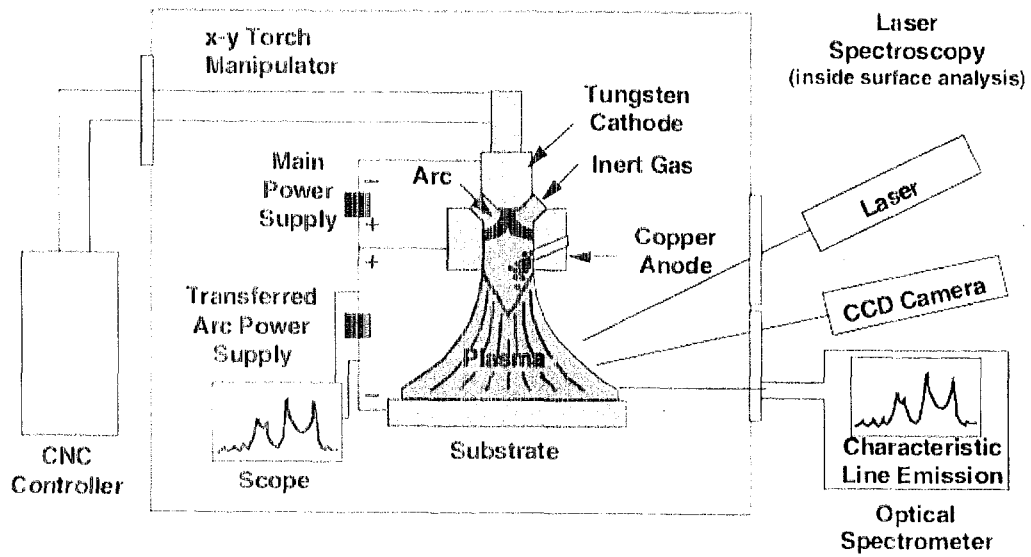


Figure 3: Schematic of Cathodic Arc (CA) cleaning apparatus.

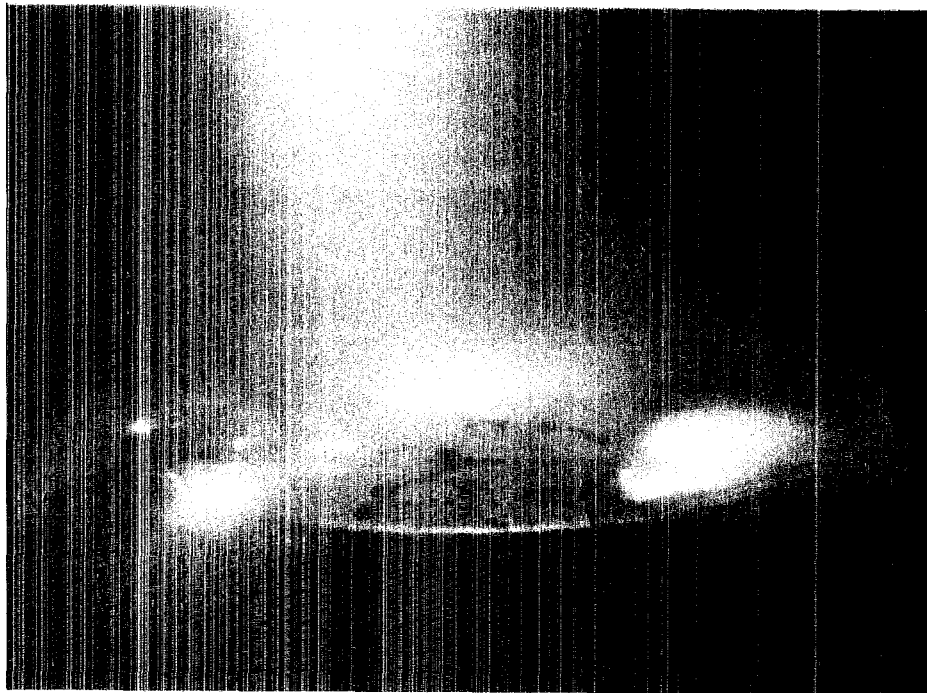


Figure 4: Cathodic Arc (CA) Cleaning of type 304 Stainless Steel in progress.

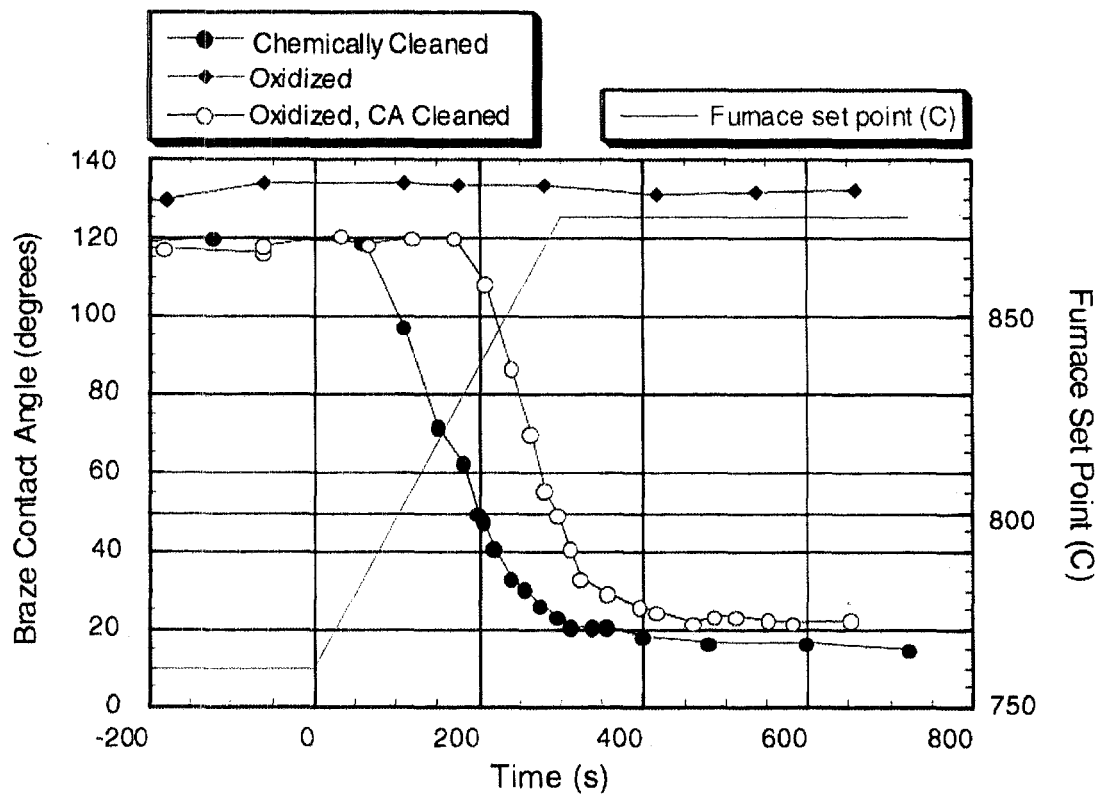


Figure 5: Dynamic contact angle measurement data of Ag-28%Cu on type 304 Stainless Steel.

DISCUSSION AND CONCLUSIONS

This work has demonstrated several key aspects of utilizing CA cleaning as a surface preparation method prior to brazing. Cathodic Arc cleaning can effectively remove organic contaminants as quantitatively determined by dynamic water drop contact angle measurements (see Figure 1). Cathodic Arc cleaning can effectively remove native oxide layers in 304 stainless steel as quantitatively determined by dynamic braze alloy contact angle measurements (see Figure 5).

This suggests that CA cleaning would result in brazes that are comparable to what is obtained with chemical cleaning. Additional work is required to assess the effect of CA on inorganic contaminants, as well as investigating other substrates (nickel alloys). CA warrants further investigation as a low-cost, controllable, localized, solvent-free, manufacturing cell-local surface cleaning method for braze preparation.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the support of the University of California, which operates Los Alamos National Laboratory for the National Nuclear Security Administration of the U.S. Dept. of Energy.