E. EXPERIMENTAL TECHNIQUE FOR THE INVESTIGATION OF LIQUID FILLER METAL FLOW PROCESS THROUGH A BRAZE GAP AND FILLET FORMATION

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1. INTRODUCTION

An experimental technique to study the molten filler metal flow in brazed joints has been developed. Of prime importance in brazing processes, liquid filler metal flow in braze joints can be characterized by fundamental physical and chemical principles in terms of capillary action. This experimental method provides an important tool to analyze the flow properties in-situ, producing more realistic data than the traditional laboratory methods used in analyzing filler metal flow, such as area-of-spread testing and other destructive methods. Not only can the data obtained using this technique explain how the molten filler metal flows, they can also provide information on wetting, spreading, density and viscocity change with temperature, chemical reactions occurring at the substrate/filler metal interface, and fillet formation. The intent of this document is to present this technique for studying the fluid mechanics of molten filler metals on brazing.

2. EXPERIMENTAL PROCEDURE

The experimental setup consists of three main parts: a furnace, a high-speed, high magnification imaging system and a temperature controller. Each test specimen contains two reservoirs joint by a horizontal and parallel gap of height approximately 100 µm, length of 5 mm and a depth of 5 mm. The solid filler metal is placed in the left reservoir of the gap and flows to the right once it reaches its molten state. The acquired data, substrate surface temperature distributions, furnace temperature and flow images up to 1000 frames per second, are collected and analyzed for the determination of the dynamic flow properties of the filler metal. The experiments are carried out in a controlled inert gas atmosphere to promote wetting and provide oxidation protection to the substrate. Each specimen is analyzed using metallographic techniques, light microscopy, scanning microscopy and energy dispersive spectroscopy.

3. RESSULTS AND CONCLUSIONS

The flow of the filler metal through the braze gap is recorded during the whole experiment, beginning from heating the test specimen, melting the filler metal, flow of the filler metal, fillet formation and solidification of the filler metal. Different tests are carried out to study the effect of substrate surface roughness on the flow dynamics of the filler metal. The acquired filler metal flow images, like the one shown in figure 1, are analyzed frame by frame using video analysis and digital imaging analysis techniques. Data such as the relative position of the filler metal as a function of time, filler metal advancement as a function of the substrate temperature variations, internal flow pattern within the liquid film are obtained. These data allow us to determine the flow velocity, the effect of local temperature on density, viscocity and surface energy that affect the flow by capillary action of the filler metal. During fillet formation, the effect of the flow velocity and contact angle is explained. This experimental method is used to study not only brazing of similar materials but also dissimilar material joining. The data clarify and expand the understanding of the fundamentals of the filler metal flow dynamics and is applied to produce more reliable and better performing brazed joints.

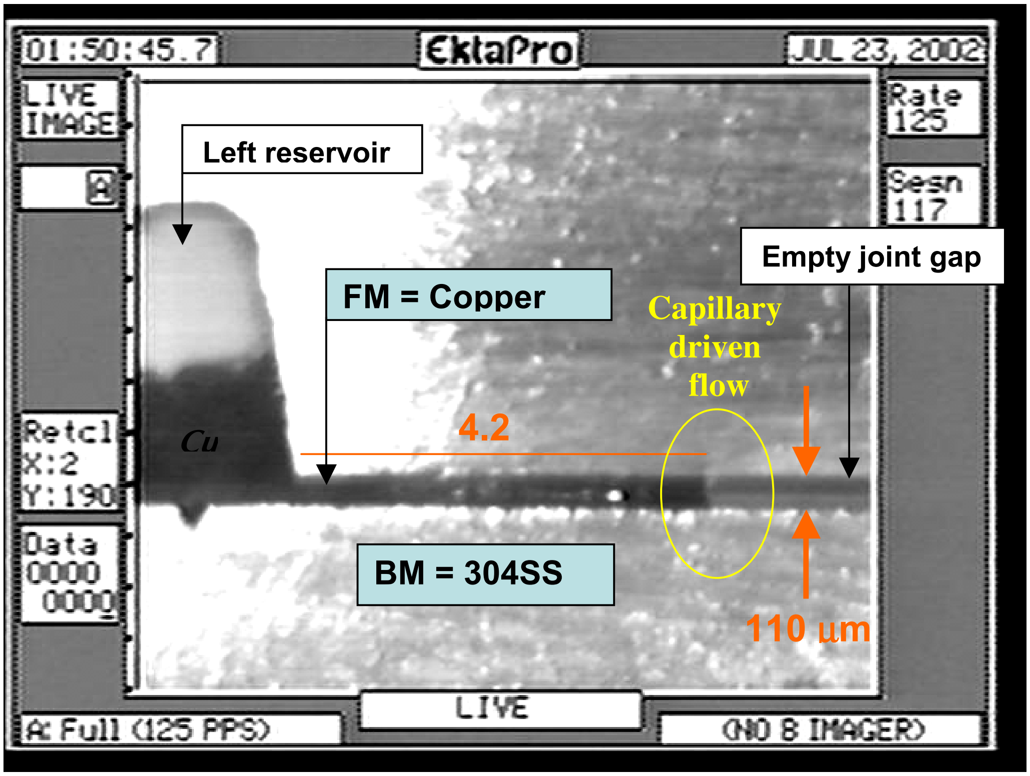

Figure 1. Image of the braze flow of copper filler metal on 304SS substrate, at 1100°C in a high purity argon environment. Flow advancement and capillary driven flow can be observed in the picture. (FM = filler metal, BM = base metal)

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