A.12: Brazing of unplated SS316L to copper

Brazed transition joints between OFE copper and type 316L stainless steel (SS) are extensively used in particle accelerators all over the world. It is well known that SS surface has poor wettability whereas OFE copper has excellent wettability for the most popular braze filler metal (BFM) BVAg-8 (Ag-72%, Cu 28%, melting point – 780°C) at its brazing temperature of ~ 800 ºC. High wettability of a surface is believed to be necessary to drag molten BFM into the capillary gap between the interfacing metallic surfaces. Therefore, the most widely accepted practice for vacuum brazing of such transition joints involves electroplating of SS parts with nickel or copper to enhance its wettability.

A recently concluded in-house study, involving Nb to Ni-plated 316L SS brazing, has demonstrated that satisfactory ingress of BFM into a capillary joint, comprising of two dissimilar metals, can be achieved if the poor wettability of one of the mating surfaces is compensated by the good wettability of its counterpart. In the light of these observations, the present study has been undertaken to explicitly evaluate the requirement of electroplating of SS interface for establishment of sound OFE copper-316L SS brazed joints suitable for service in ultra-high vacuum (UHV).

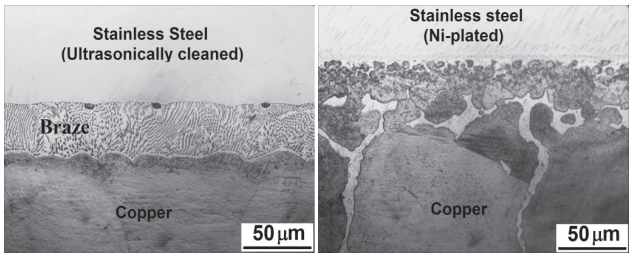

Fig. A.12.1: Comparison of OFE copper-316L SS brazed joints made with ultrasonically cleaned and Ni-plated SS parts.

The results of the study have demonstrated that for vacuum brazing of OFE copper-316L SS transition joints with BVAg-8 BFM, it is not necessary to electroplate SS interface, provided a clean vacuum environment is maintained during brazing. Simple cleaning procedure, involving degreasing in a 2% aq. phosphate-free detergent solution (EXTRAN MA03®), followed by rinsing in running water and ultrasonic cleaning in an organic solvent (e.g. 2-propanol) at 60 °C, has been found to be sufficient for subsequent brazing. The brazing cycle used ramp rate of 5 °C/min with 1 hr soaking at 760 °C. The brazed joints made with ultrasonically cleaned SS part, not only displayed (i) required level of hermeticity (helium leak rate ≤ 2 x 10^{-10} mbar.lit/s) and bakeablility at 250°C for UHV application and (ii) good tensile strength (172-200 MPa), comparable to the joints made with Ni-plated SS (163-181 MPa) but also exhibited significantly suppressed extent of intergranular penetration of BFM into copper with respect to brazed joints made with Ni-plating (Fig.A.12.1). Fig.A.12.2 shows a typical vacuum port joint, involving brazing of OFE copper pipe (DN90 SCH 40) to ultrasonically cleaned CF100 316L SS flange (pre-braze radial gap = 45 µm). The joint displayed complete BFM penetration across 18 mm long capillary joint (Fig.A.12.3). It was also established that the observations remain valid for OFE copper-304L SS brazing. Apart from excellent wettability of OFE-copper, the clean vacuum environment offered by the new brazing furnace has also made positive contribution in this process development. Elimination of electroplating of SS interface is expected to bring significant reduction in total product development time.

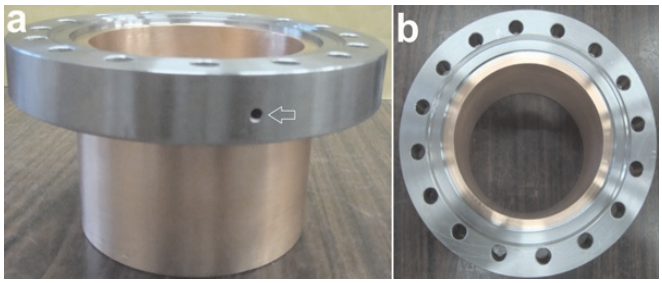

Fig. A.12.2: (a) Side and (b) top views of vacuum brazed OFE copper-316L SS port joint, made with ultrasonically cleaned SS flange.

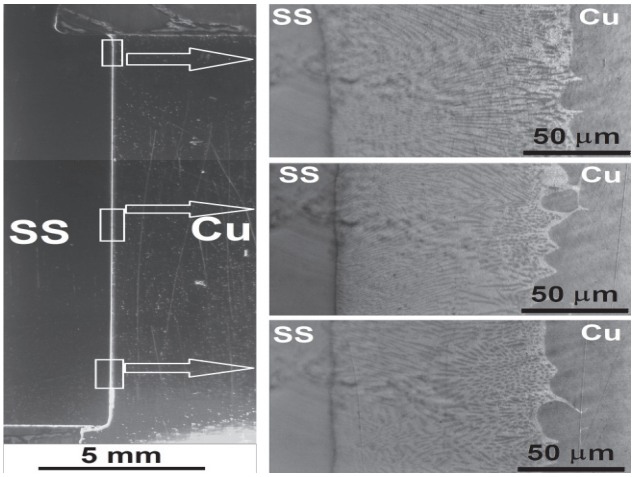

Fig. A.12.3: Cross-section of brazed component, presented in Fig. A.12.2, showing complete penetration of BFM across 18 mm long capillary joint.

For more details, please refer RRCAT report *RRCAT/2015-07*.

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