A.13: A new brazing route for niobium-AISI 316L stainless steel transition joints for superconducting RF cavities

Raja Ramanna Centre for Advanced Technology is pursuing an extensive program on development of superconducting radio frequency (RF) technology for setting up Indian Spallation Neutron Source. Superconducting niobium cavities of high gradient particle accelerators would be submerged in a helium tank of titanium maintained at 2 K. There are serious attempts to replace Ti with austenitic stainless steel (SS) to make fabrication process simpler and cost effective. This necessitates a transition joint between Nb and SS. CERN has developed Nb-SS transition joint with pure copper as the braze filler metal, although the brazed joints carried a layer of brittle intermetallic compounds of Nb and Fe on the surface of niobium. Fermi National Lab and Argonne National Lab have adopted the same route for brazing Nb and SS.

In a recent in-house study, leak tight, strong and more ductile Nb-316L SS transition joints, were obtained through a new brazing route. The study employed lower brazing temperature and a suitable diffusion barrier (Ni) to suppress Nb-Fe inter-metallic formation. It involved vacuum brazing of Nb and Ni-plated SS with CuSil-ABA (63Ag/35.25Cu/1.75Ti) active brazing alloy at 1123 K. The specimen, selected for helium leak testing, comprised of an Nb pipe brazed to a SS flange (Fig. A.13.1).

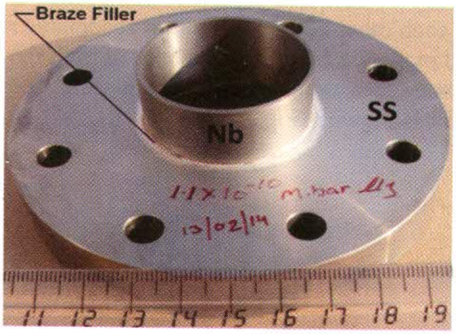

Fig. A.13.1: Vacuum brazed Nb-SS assembly

Vacuum brazed Nb-SS specimens displayed sound transition joint, without any brittle intermetallic layers on any the two associated interfaces viz. Nb/braze and SS/braze (Fig. A.13.2). The transition joint, with well-distributed intermetallic compounds and ductile matrix, displayed considerably improved ductility as compared to that reported for joints made through global vacuum brazing practice of using OFE copper as the filler. Electroplated layer of Ni on SS part not only suppressed Fe migration towards Nb to form brittle Fe-Nb intermetallic compounds, but also prevented formation of brittle intermetallic compounds of Fe & Ti on SS/braze interface, without introducing any change in relative magnetic permeability of the transition joint. Nb-SS transition joints displayed tensile and shear strengths of 122-143 MPa and 80-113 MPa, respectively. In both the tests, the site of fracture was in the brazing alloy, thereby ruling out any brittleness at Nb/braze and SS/braze interfaces.

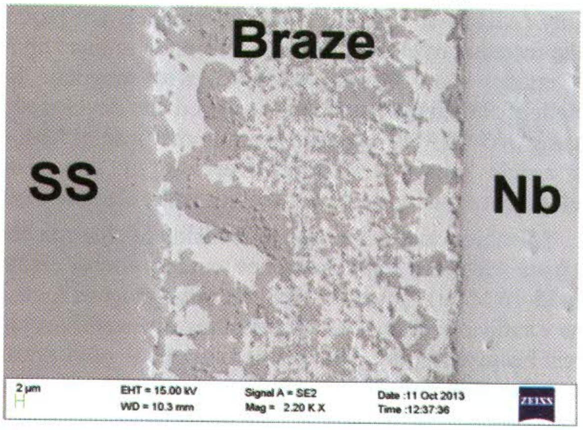

Fig. A.13.2: Cross-section of vacuum brazed Nb-SS transition joint

The brazed specimens exhibited acceptable level of helium leak rate (less than 1.1 x 10-10 mbar.l/s) at room temperature as well as at liquid nitrogen temperature at 77 K (Fig. A.13.3). The brazed specimen withstood (i) twelve hour long degassing heat treatment at 873 K (for suppressing "Q-disease) as well as (ii) ten numbers of thermal cycles between 300 K and 77 K without experiencing any degradation in joint's hermeticity; thereby establishing suitability of the transition joint to operate in low cycle fatigue service conditions. On the basis of the results of the study, a new lower temperature brazing route is proposed to form niobium/316L SS transition joints, with improved micro-structural characteristics and ductility, for application in superconducting RF cavities. Developmental efforts are underway to (i) further improve joint strength and ductility through precise control on braze-assembly fits and modified filler composition, (ii) qualify the joint at 2K and (iii) develop transition joints for low beta cavity.

Fig.A.13.3: (A) Helium leak testing of braze assembly at liquid nitrogen temperature (B) Braze assembly

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