Seminar

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Institute for Plasma Research

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Title: Characterization and integrity assessment of friction-welded joints between copper and stainless steel for ion extractor grid fabrication

Speaker: Dr. Hardik Vyas
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Date: 15th May 2025 (Thursday)

Time: 10:30 AM

Venue: Seminar Hall, IPR

Abstract

This study presents two corresponding investigations on the friction welding of dissimilar metal joints between electrolytic tough pitch copper (ETP-Cu) and stainless steel 304L (SS304L), conducted to support fabrication of ion extractor grid for NBI system. Both plate-to-rod and rod-to-rod configurations were studied under different sets of experimental conditions and objectives.

In the first part, a rod-to-rod configuration (16 mm SS304L and Cu rods) was explored to estimate the coefficient of friction (COF) during continuous drive friction welding by varying friction and upset pressures. The COF was calculated in the range of 0.18–0.40, influenced by welding torque (12.13–16.2 Nm) and power (2094–2902 W). It was found that higher COF values correlated with improved tensile strength, highlighting the significance of real-time frictional behavior in optimizing weld quality.

In the second part, the friction welding of an asymmetrical ETP-Cu plate (100 mm × 100 mm × 10 mm) to an SS304L rod (16 mm diameter × 58 mm length) was performed and assessed through a combination of non-destructive and destructive testing techniques. Non-destructive evaluations included visual inspection, in-situ hardness, ultrasonic C-scan, high-pressure testing and leak testing. Destructive methods such as tensile testing, SEM, EDS, and XRD confirmed joint quality. The average tensile strength was 143 MPa, yielding a joint efficiency of 77.6% compared to the base ETP-Cu. Microstructural analysis revealed deformation and grain refinement on the Cu side, partial peripheral de-bonding on the SS rod (74–116 μm), and strong bonding at the bottom interface. Intermetallic compounds ($FeCu_4$ and Cu_9Si) were identified at the weld interface.

Together, these investigations offer critical insight into the mechanical integrity, thermal behavior, and metallurgical characteristics of dissimilar Cu–SS friction welded joints in different configurations. The findings contribute to the qualification of these joints for use in the ion extractor grid assembly of the Neutral Beam Injection (NBI) system in fusion research.