A.5: Investigation on Failed Septum Magnet Coils of Indus-2

Failure of the in-service septum coils of Indus-2 was noticed in August 2009. These alumina-coated copper coils fabricated in 2005 provided satisfactory performance during their four year long service. Subsequent to their failure, four numbers of new coils were machined and coated with alumina by detonation spray process at M/s Sai Coating Technologies, Hyderabad. The newly coated coils, when subjected to electrical testing, started arcing at 800 V. In view of premature failure of the newly coated septum coils, a study involving coating and characterization of septum coils was carried out. In addition, the RRCAT Scientists also visited vendor's site to get first hand information about the coating process. This article presents a brief overview of the investigation carried out on the failed coils to suggest modifications for their improved performance.

The failure of septum coils was noticed in the form of arcing at different locations in thin section of the coil. Defect locations were marked with removal of alumina coating with or without signs of localized surface melting (Fig. A.5.1). Failure sites were associated with abrupt transition in cross-section along with internal and external 90^0 corners. Alumina coating on the external 90^0 corner was found to be associated with lack of bonding while machined notch provided at the inside 90^0 corner remained poorly filled with numerous cracks and lack of bonding (Fig. A.5.2).

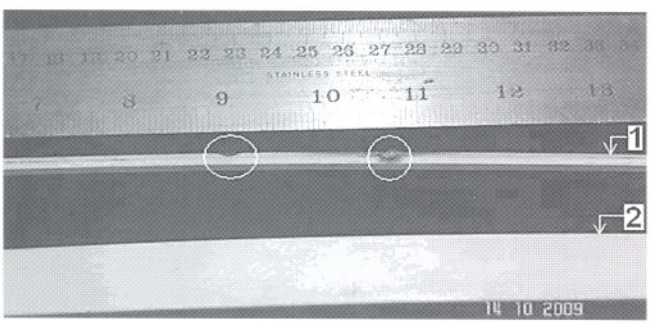

Fig. A.5.1: Defect locations (encircled) in the failed septum magnet coil. Thin and thick sections of the coil are marked as "1" and "2", respectively

Characterization of detonation-sprayed specimens demonstrated that the coating deposited with fine alumina powder (5-22 μm) was associated with relatively larger degree of melting and lower surface stress, although with largely similar hardness and porosity contents, as compared to that deposited with coarser alumina powder (22-45 μm). Relatively lower amount of α-Al_2O_3 in the coating, deposited with fine powder (Fig. A.5.3), is indicative of relatively higher degree of melting. In alumina-coated profiled specimens, surface normal to the spray direction exhibited thick and well-bonded Al_2O_3 coating while surface parallel to the spray direction carried highly porous and loosely bonded coating. The coating exhibited discontinuity at internal 90^0 corners. On the curved surface, thickness of Al_2O_3 coating continuously varied with change in inclination of the surface with respect to spray direction (Fig. A.5.4).

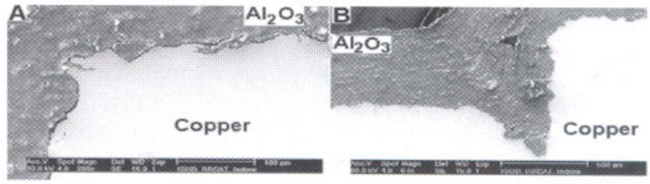

Fig. A.5.2: Magnified view of defects at (A) external and (B) internal corners

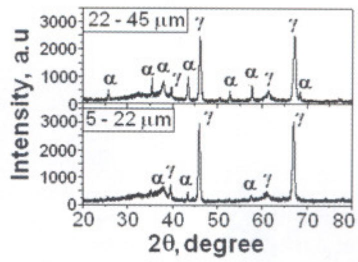

Fig. A.5.3: X-ray diffraction patterns of alumina coatings deposited with powders of different particle size

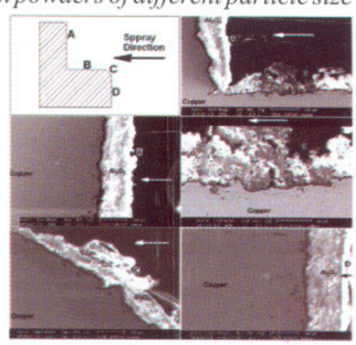

Fig. A.5.4: Cross-section of profiled Al_2O_3-coated copper specimen. Spray direction is marked with arrow

On the basis of the results of the study, it was inferred that no notch should be machined at the internal 90^0 corner of the coil while sufficient rounding (radius ≥ 0.75 mm) should be provided on the 90^0 corner edges. The inclination of specimen's surface with respect to spray direction strongly influences adhesion, thickness and porosity content of the coating.

Reported by:
R. S. Shinde (shinde@rrcat,gov.in) and Rakesh Kaul
Other team members: S. S. Prabhu, S. K Shukla