A.16: Indigenous development of welding glove box and first dressing of a HB650 β=0.92 five-cell SCRF cavity

An important milestone was achieved in March 2020 with successful 'jacketing' of 650 MHz, β=0.92 five-cell superconducting radio frequency (SCRF) cavity in the indigenously developed controlled environment welding glove-box. Welding of helium vessel, bellows and end caps, all made of Ti Grade 2 material on bare high residual resistivity ratio (RRR) niobium SCRF cavity and integration of tuner is termed as dressing.

Crucial technical requirements for SCRF cavity dressing include preventing the degradation of multi-cell cavity field flatness and keeping the drift in cavity frequency within the range of slow tuner. Further, as the jacketed cavity is also a pressure vessel, all the welding and the vessel qualification is to be carried out in accordance with ASME BPV code.

Special infrastructure: A dedicated controlled environment (O_2 < 20 ppm, RH < 15%) welding glove box was developed indigenously and commissioned, which is an important import substitute (Figure A.16.1). An online frequency monitoring and alarm system was specially developed to keep a close watch on cavity frequency during welding and cool down cycle. A dedicated assembly fixture was designed and developed for insertion of bare cavity over helium vessel, satisfying a controlled and precision alignment requirements (Figure A.16.2).

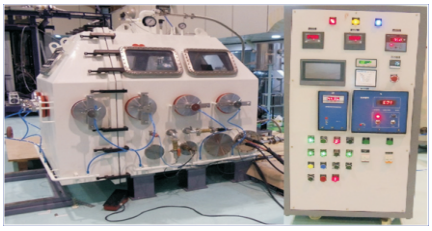

Fig. A.16.1: Indigenously developed welding glove-box.

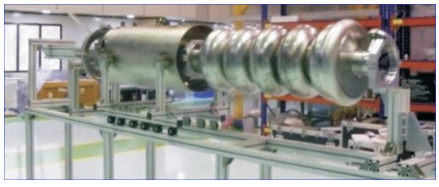

Fig. A.16.2: Cavity alignment and assembly fixture.

Cavity dressing: Cavity dressing was carried out for four circular joints, viz, J-1 bare cavity to bellow, J-2 helium vessel to main coupler transition spool, J-3 helium vessel to field probe (FP) end cap, and J-4 FP end cap to bellow. As a first step towards dressing, bellow to bare cavity joint (J1) is carried out inside the glove box. A transient frequency shift of 58 kHz was recovered to base value of 648.915 MHz with no permanent drift. The cavity was further mounted with temperature sensors to facilitate measurement on the cavity under cryogenic condition. Then the cavity was assembled with helium vessel and adopter ring using insertion fixture (Figure A.16.2) and J2 and J3 joints were tack welded and J4 joint was shimmed to accommodate welding shrinkage. This assembly was placed on rotating fixture and inserted into glove box. The dressing activity of remaining joints (J2, J3 and J4) was again carried out inside the glove box (Figure A.16.3 (a)). The heat produced in cavity assembly during welding and associated weld shrinkages drifts the cavity frequency. The welding was carried out in short and distributed sequence before cavity frequency alarming system indicated to stop the welding. The dressed cavity was taken out and visual inspections were performed (Figure A.16.3 (b)).

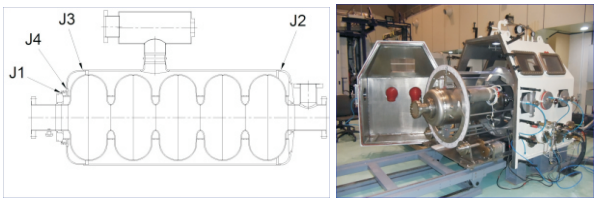

Fig. A.16.3: (a) Cavity dressing joints J1 to J4. (b) Dressed cavity coming out of glove-box.

Dressed cavity qualification: Jacketed cavity was subjected to vacuum leak, RF and pressure test qualifications (Figure A.16.4). The cavity has qualified for vacuum leak test $<1\times10^{-10}$ mbar-lit/s. The post dressing field-flatness was found to be 92% (meeting criteria > 90%) and the measured frequency is 648.915 MHz with change in frequency -86 kHz, (within tuning range of 0 to 200 kHz). The cavity bellow was secured with safety bracket before start of pressure test. The cavity successfully passed the pneumatic pressure test, at 1.15 times mean average working pressure, with no pressure drop during test and negligible (0.5 kHz) frequency change.

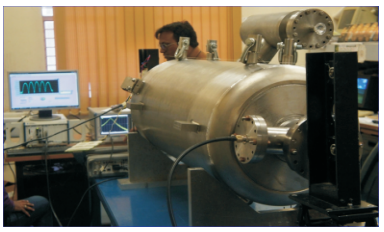

Fig. A.16.4: RF qualification of dressed cavity.

Development of associated infrastructure, cavity dressing procedure, training of manpower and first successful dressing of HB650, β=0.92 five-cell SCRF cavity is an important step in SCRF cavity development cycle. The contribution and support of many divisions/ sections is duly acknowledged. The dressed five-cell SCRF cavity shall now be taken for Horizontal Test Stand for high power testing.

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