A.5: Development of first 650 MHz (β=0.92) five-cell Niobium SCRF cavity

First 650 MHz (β=0.92) five-cell Niobium Superconducting Radio Frequency (SCRF) cavity has been successfully fabricated at Proton Linac & SC cavities Division, RRCAT. Large number of such multi-cell SCRF cavities will be required for the proposed SC proton linac for the Spallation Neutron Source project. Additionally, these 650 MHz five-cell cavities are also the deliverable to Fermilab under Indian Institution Fermilab Collaboration (IIFC).

Owning to very high Q, SCRF cavities are extremely sensitive to geometrical changes and due care is required at every stage of fabrication to control them. Based on the experience gained during earlier work on 1.3 GHz multi-cell SCRF cavity development, a detail manufacturing process sequence plan was made for 650 MHz five-cell SCRF cavity. Detail production and QA plan was made to monitor the frequency and dimensional variation during various stages of manufacturing. Various machining and welding fixtures were also designed and fabricated. The forming of 4 mm thick high RRR Niobium sheets was done in-house using a 120 ton press. Pull-out die and punch was designed and developed in-house and pull-out in main coupler beam tube is successfully carried out. Cavity components were machined and fitment were made within 50 μm tolerance. Stage inspection of all the cavity components and sub-assemblies were carried out to monitor and control dimensional parameters.

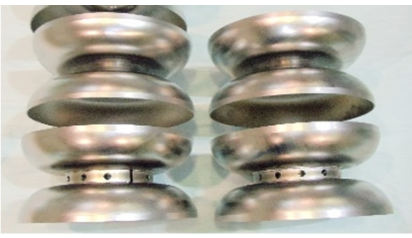

Fig. A.5.1:Dumbbells fabrication progress

Fig. A.5.2: End-Groups fabrication progress

The cavity is welded using in-house 15 kW EBW machine facility. All the parts were subjected to 20 μm Buffered Chemical Polishing (BCP) before welding. Half-cells are back to back welded at iris to form dumbbells. Further stiffening rings are welded on dumbbells to impart mechanical rigidity required to mitigate detuning due to Lorenz force and Microphonics. The length and cavity RF frequency were targeted for 300 K values. RF measurements were carried out at half-cell and dumbbells stages to estimate the trimming length to achieve the desired frequency. Special tuning fixture was designed and developed to tune the dumbbell to achieve the target frequency and length. Parts of both the end-groups were machined and EB welded. End groups were also tuned for RF frequency. Figures A.5.1 and A.5.2 show the progress on dumbbell and End-Group respectively. RF analysis of each dumbbell and both End-Groups was done to finalise the proper sequence for optimum RF frequency. Subsequently, the five crucial equator weld were performed with full penetration as shown in Fig. A.5.3.

Fig. A.5.3: First 650 MHz (β=0.92) five-cell SCRF cavity welding in progress

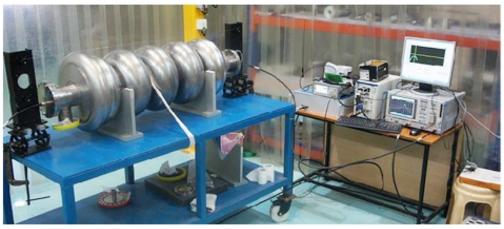

Fig. A.5.4: RF measurement of HB 650 MHz five-cell SCRF cavity

The 650 MHz five cell SCRF cavity was subjected to various testing and qualification upon completion that included mechanical, RF measurement and vacuum leak testing. Figure A.5.4 shows the RF measurement set up. The results are as given in Table A.5.1.

Table A.5.1: Cavity length, frequency and vacuum test leak rate at room temperature.

Parameter	Target	Achieved
Cavity Length(mm)	1400.25 ± 3	1403.942
π mode Frequency at 300 K (MHz)	649.592± 0.5	649.5922
Vacuum test leak rate (mbar.L/s)	$< 1x10^{-11}$	$< 1x10^{-11}$

The work was carried out by team members from Industrial Accelerator Division (IAD), Design and Manufacturing Technology Division (DMTD), Pulsed High Power Microwave Division (PHPMD) along with Proton Linac and Superconducting Cavities Division (PLSCD).

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