A.3: First Development of 650 MHZ (β=0.9) Single-cell Bulk Niobium SCRF cavity

Under Indian Institution Fermilab Collaboration (IIFC), a prototype 650 MHZ (β=0.9) single-cell Superconducting Radiofrequency (SCRF) cavity has been successfully fabricated at RRCAT. These activities are major part of XII plan project on "R&D Activities for High Energy Proton Linac based Spallation Neutron Source". The single cell cavity has various parts like beam pipes, half-cells, end flanges fabricated using electron beam welding.

SCRF Cavity Fabrication

For this new technology development a forming tooling (die to form the cavity half cells) was first designed and developed. The forming tool was made of high strength aluminium alloy AA7075-T6. The forming of 4 mm thick high RRR niobium sheets was done in-house using a 120 Ton press. Initially prototype half-cells were formed in aluminum and copper. These were inspected and analysed for form errors which are very important for achieving final frequency of the formed and welded cavity. Proper tweaking at the forming tool counter was done to correct and accommodate the spring back errors. The profile accuracy of 264 μm was achieved on formed cells.

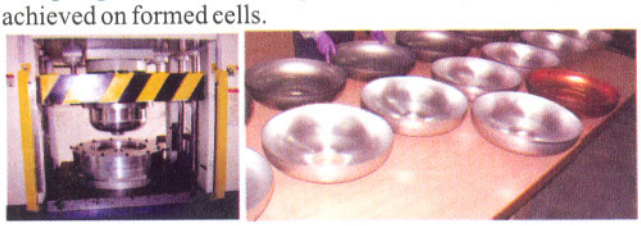

Fig. A.3.1: (a) Half-cell forming; and (b) Formed half cell in aluminium, copper and niobium.

The design for manufacturing was done followed by development of production and QA plan with inspection on intermediate steps. The machining and welding fixtures for the cavity parts were also designed and fabricated in-house. Beam pipes were fabricated from sheets rolled at RRCAT on a dedicated indigenously designed and fabricated precision rolling machine. Precision machining of forming tooling were carried on CNC VTL. Stage inspection of the forming tooling and half cells were carried on in-house CMM, during forming developments

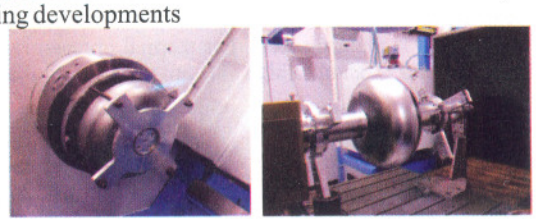

Fig.A.3.2: The stage wise preparations for cavity fabrication for (a) machining and (b) electron beam welding.

Machining of half-cells was carried out on a turning centre commissioned recently. Geometrical tolerances on all machined parts were achieved within 30 μm.

These cavities were fabricated by the process of electron beam welding (EBW) requiring precise weld joint preparations. All the parts were subjected to 20 μm Buffered Chemical Polishing (BCP) before welding to remove all the manufacturing process contamination. The EBW of high RRR niobium parts of the cavity was carried out in collaboration with Inter University Accelerator Centre (IUAC) New Delhi. A pre-weld etch of 3 μm was done at weld joint location prior to welding. Welding at equator was performed from both sides as it is the most vulnerable weld joint being in high magnetic field area during operation of the cavity. The iris welding was done with full penetration weld from outside with proper control of the under bead to achieve desired RF performance.

Pre-qualification

The 650 MHz single cell SCRF cavities was subjected to various testing & qualification upon completion that included mechanical measurement, vacuum leak testing, frequency and quality factor (Q) measurements. Dedicated RF measurement setups were also designed and developed at RRCAT. RF measurements were also carried out at half-cell stage to estimate the trimming length to achieve the goal final frequency at operating temperature.

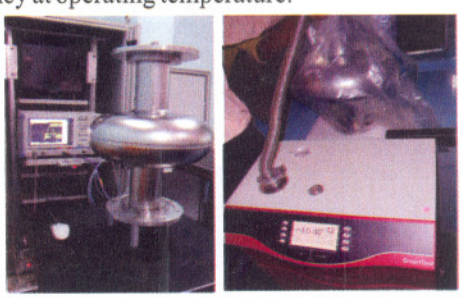

Fig.A.3.3: (a) The prototype cavity undergoing RF inspection and (b) Cavity under vacuum leak testing.

Table A.3.1: Cavity frequency and vacuum test leak rate at room temperature.

Pi mode Frequency	*648.58474MHz*
Vacuum test leak rate	*< 1x10^{-11} mbar.L/sec*

The work was carried out by a team of engineers of Industrial and Medical Accelerator Section (IMAS), Accelerator Components Design and Fabrication Section (ACDFS), Pulsed High Power Microwave Section (PHPMS) and Proton Linac and Superconducting Cavities Division (PLSCD)

Future plans:

After all the pre-qualification testes at 300K and 77K and the cavity will be taken up for further processing and testing at 2K for the performance evaluation.

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