A.7: Processing and 2 K testing of first five-cell high beta 650 MHz superconducting RF cavity

Development of five-cell high beta 650 MHz superconducting RF (SCRF) cavities have been taken up at RRCAT as an R&D activity for Indian Spallation Neutron Source programme. Five-cell 650 MHz (HB 650) SCRF cavities are also one of the important deliverables from Department of Atomic Energy to Fermilab under Indian Institutions Fermilab Collaboration (IIFC). The first high beta five-cell 650 MHz SCRF cavity, fabricated in niobium using the electron beam welding facility, was reported earlier in RRCAT Newsletter Vol 30, Issue 2, 2017.This five-cell cavity was successfully processed and tested at 2K using the in-house infrastructure facilities developed at RRCAT. A standard SCRF cavity processing recipe was followed for processing and polishing of the cavity. Around 120 microns material was removed using electropolishing from the internal surface of the cavity to remove the damaged surface layer and to obtain the required surface roughness of around 30-40 nm. The electropolishing setup for the cavity polishing is shown in Figure A.7.1.

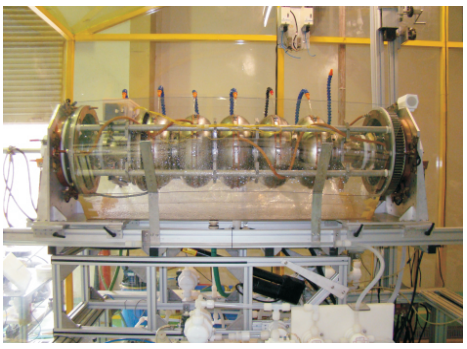

Fig. A.7.1: Electropolishing setup for five-cell 650 MHz SCRF cavity.

The electropolishing process induces copious amount of hydrogen impurity into the niobium, which causes drop in quality factor (Q-decease) at medium to high accelerating field. To degas the absorbed hydrogen, the cavity was annealed at 800 °C for 3 hours in high vacuum using annealing furnace.

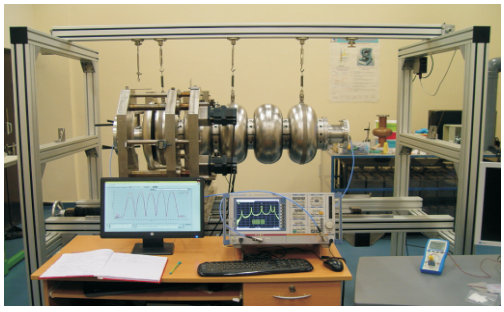

Fig. A.7.2: Room temperature tuning of the cavity.

The cavity was tuned at room temperature for the required field flatness and frequency on the semi-automatic tuning machine. The tuning of the cavity is shown in Figure A.7.2.

The final step of polishing involves light electropolishing to remove additional ~15 micron material. The cavity was then high pressure rinsed with ultra-pure water at ~100 bar pressure in class 100 cleanroom. Subsequently, the cavity was also dried, assembled with RF couplers and vacuum leak tested in class 100 cleanroom. The cavity was baked in low-temperature baking oven at 120 °C for 48 hours.

The cavity was mounted on vertical test stand (VTS) insert and dressed with Cernox temperature sensors. The assembly of five-cell cavity in VTS cryostat for 2 K testing is shown in Figure A.7.3.

Fig. A.7.3: Cavity loading in VTS cryostat.

Around 2800 litre of liquid helium was stored in the VTS cryostat for testing of the cavity. The cavity was tested using indigenously developed solid state RF amplifier and LLRF system. The cavity achieved a low field quality factor 4 x 10^{10} and an accelerating gradient of 17.5 MV/m.The results of the VTS test is shown in Figure A.7.4.

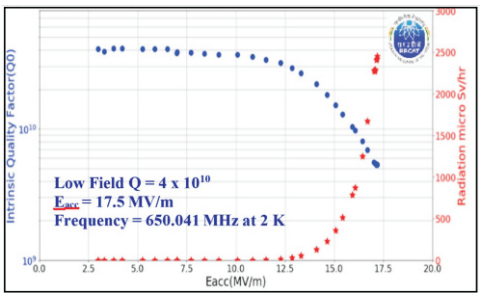

Fig. A.7.4: VTS test result (Q vs E) at 2 K.

The successful processing and testing of the first five-cell 650 MHz superconducting cavity using the infrastructure facility of RRCAT is a major step towards development of superconducting cavities for long term DAE programmes.

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