Infrastructure for SCRF Cavity Development at RRCAT

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a) SRF Facility/Infrastructure development and commissioning at RRCAT

EXISTING FACILITIES

RRCAT has setup facilities for fabrication, inspection, processing & testing od SCRF cavities.

Dedicated Building for SCRF Cavity Development

Cavity Fabrication Facility

Facility for Forming & Machining

Forming

Inspection

120 T - HYDRAULIC PRESS

Machining

Formed Niobium Half cell

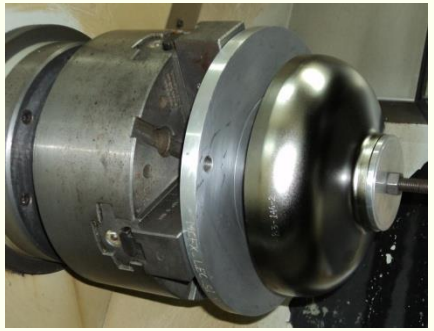
Machining Facility

UP65 Turn –mill Centre

4-Axes machine
Make - Spinner, Germany
Working Range: Φ210X640mm ABC
8 live tools
Positional accuracy < 2µm
Run-out < 1µm
CNC control: Siemens 840-D

Forming Die-Punch Assy

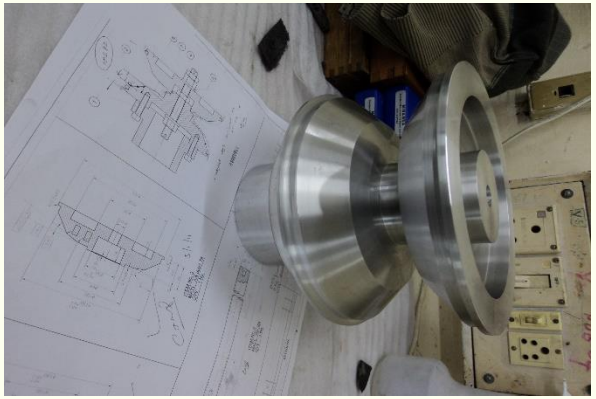
End-Group components



Half-cell Trimming

Machining facility

Machined half cells of five- cell SCRF cavity

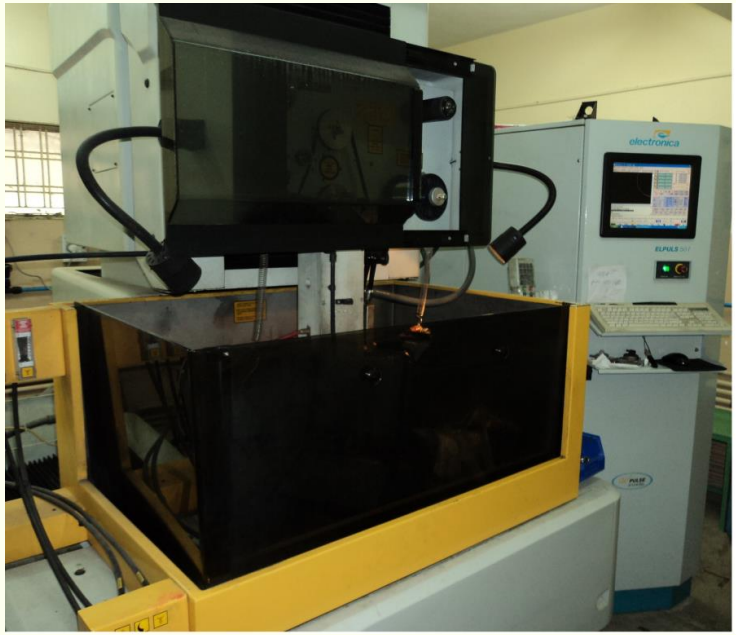


Dumbell Machining fixture development

Machining of dumbells on precision lathe

Inspection of machined components

Machining facility



5-Axes EDM Wire Cut Machine
(Flush Type)

Model- Ultra cut –F2
X stroke -600mm
Y stroke - 400mm
Z stroke - 400mm
Accuracies - ± 10 μm

5-Axes EDM Wire Cut Machine
(Submerged type)

Model- Ultra cut –S2
X stroke -600mm
Y stroke - 400mm
Z stroke - 400mm
Accuracies - ± 10 μm

Machining facility

Hollow Spindle Lathe

M/s Miven, Model- WSU-40x1.5m with Fanuc Controller
Spindle Through Bore-210mm,
Swing-over bed Dia.-1000 mm
X stroke -485mm, Z stroke - 1500mm
Accuracies - 10 µm

Electron Beam Welding Machine

Major specifications of EBW Machine

Beam power	15 kW
Gun Voltage	90 to 150 kV
Duty cycle	100%
Beam current range	0 - 100 mA or wider
Beam current setting resolution	0.1 mA
Beam oscillations	1 – 1000 Hz or more
Beam focus diameter	0.25 mm
Inner size of chamber	3650 x 1500 x 1800 mm^3
X-Y table size	1780 m x 710 mm
Vacuum ready pressure	< $1x10^{-4}$ mbar in 15 min
Ready for welding pressure	< $1x10^{-6}$ mbar in 60 min

Cavity Fabrication Facility

Nd-YAG laser beam welding facility – for 1.3 GHz single-cell cavity

A novel technique of fabrication of SCRF cavities using Nd-YAG laser welding process, has been developed at RRCAT. The process has received patent from Japan.

A 1.3 GHz single-cell cavity fabricated using the facility was processed and tested at Fermilab. The cavity produced an accelerating gradient > 31 MV/m

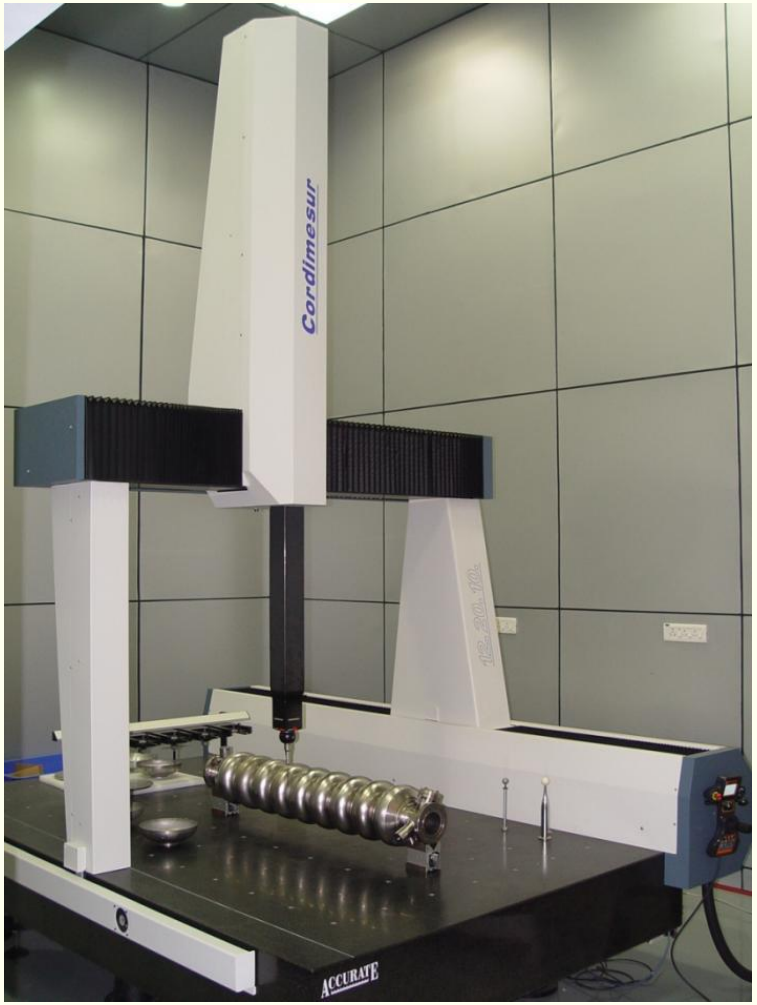
3D CNC Coordinate Measuring Machine

Applications :

Dimensional inspection of SCRF cavity components like half cells, dumb-bells, multi-cells etc

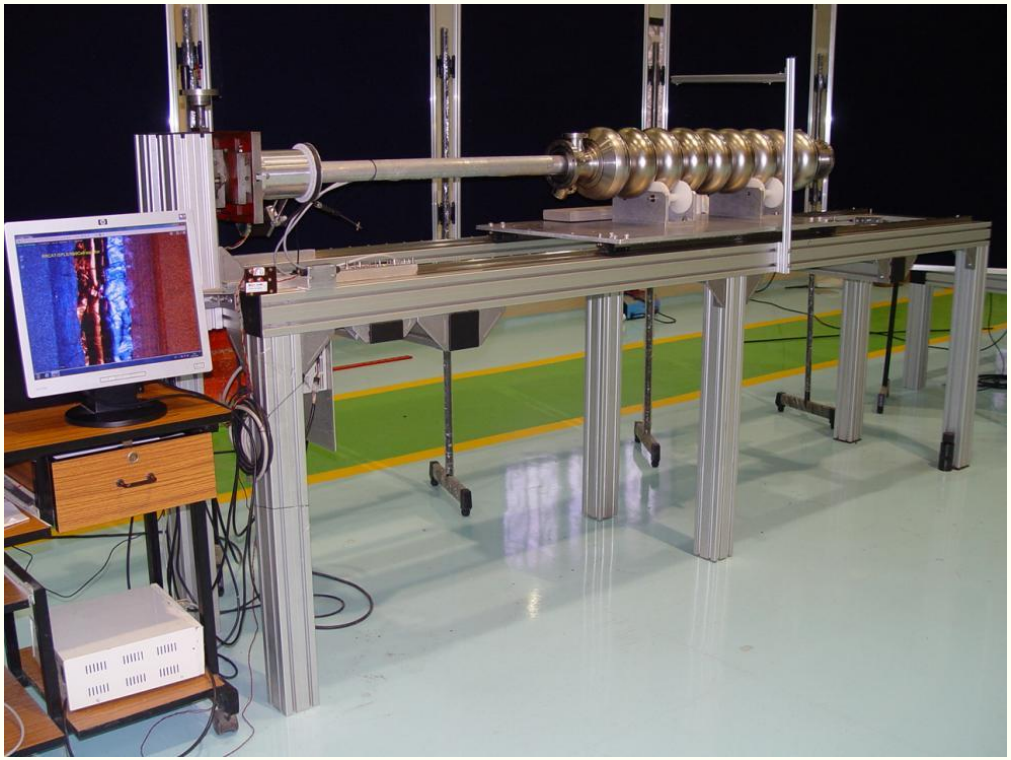
Accuracy :

1.6 + L/400 microns



Optical Inspection Bench

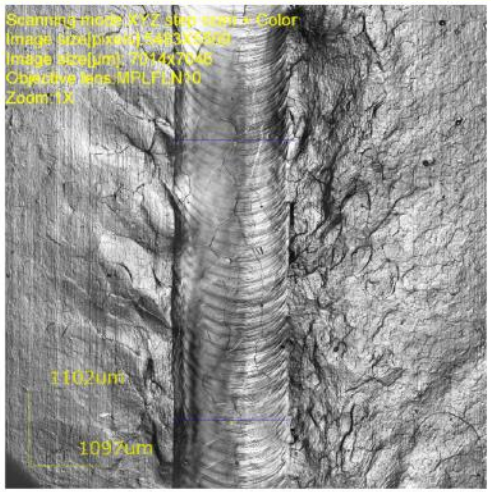
- Cavity internal surface measurement using a digital CCD camera with 10X-200X magnification.
- Tri-color LED for illumination
- Smallest measurable feature size : 10 microns



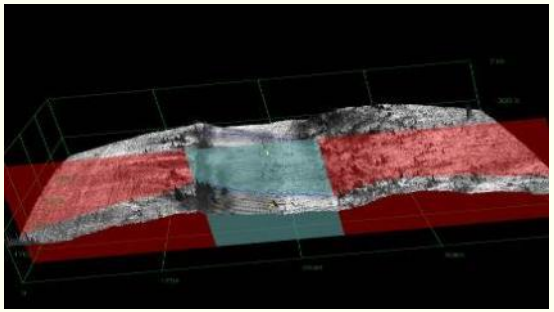
SCRF Cavity Inspection Facility

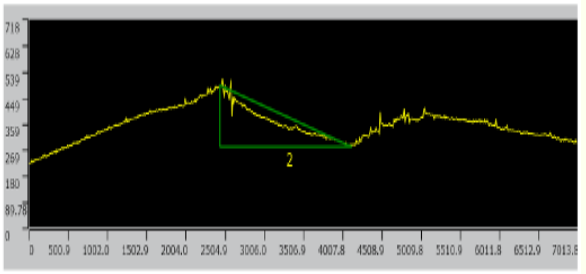
Laser Scanning Confocal Microscope

Imaging Method	3-D Laser Scanning Confocal system
Z - Resolution (Depth)	1 nm
Z - Measurement repeatability	12 nm
X-Y Resolution	0.12 µm



Confocal image of replica





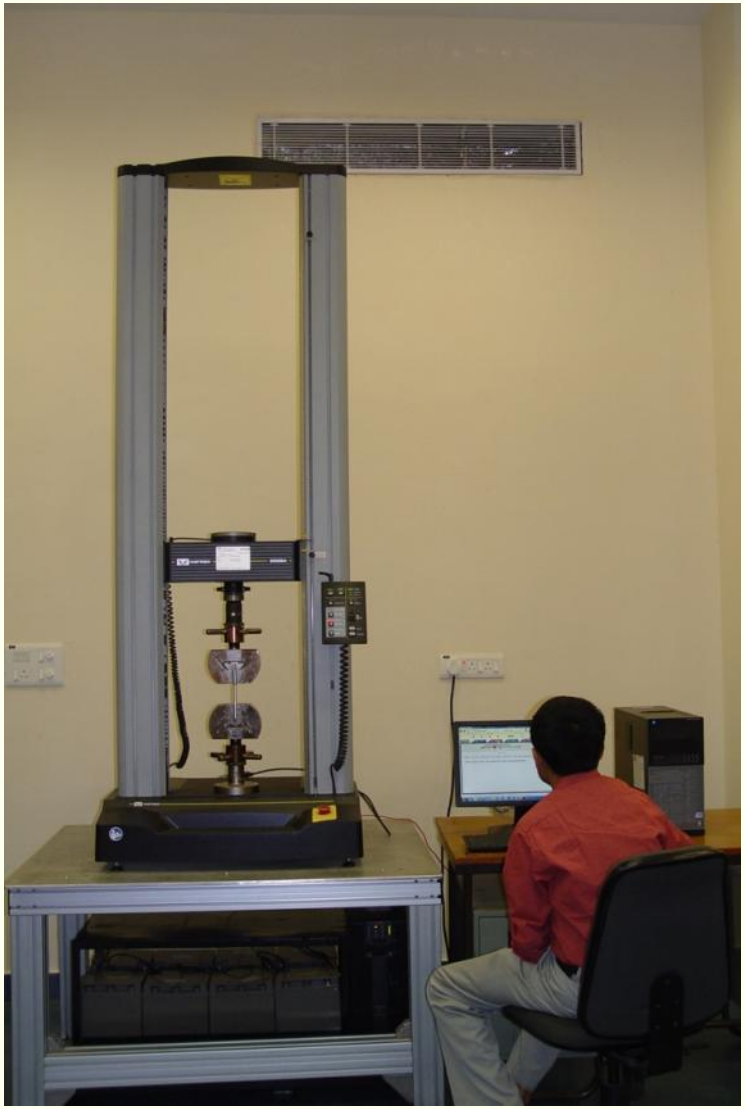
	No.	Result	Width[µm]	Height[µm]	Length[µm]
☑	1		1806.831	252.657	1824.410
☑	2		1689.145	212.954	1702.516

Measurement of bead profile

Universal testing machine

Instron UTM Model: 5569

- Load: ± 50 kN
- Testing speed: 0.001 – 500 mm/min
- Accuracy of Load: ± 0.5% for 0.5 – 50 kN
- Total cross head travel: 1500 mm



Measurements:

- Yield strength, ultimate tensile strength
- Elongation
- Plastic strain ratio, Strain hardening exponent.
- Cavity Stiffness measurement

Secondary Ion Mass Spectrometer (SIMS)

To develop understanding of impurity distribution near the top layer (~100 -200 nm) of niobium by 2-D, 3-D ion mapping of the impurities.

Quantification of the elemental impurity distribution using niobium standards.

Analysis Gun : Bi^+ at 30 kV
C_{60} at 20 kV

Sputter Gun : Cs^+ ; 0-2 kV
O_2^+ ; 0-2 kV
Xe^+ ; 0-2 kV
Ar^+ ; 0-2 kV

RRR Measurement Facility

* Calibration of the setup was carried by using reference samples from Fermilab & CERN

- **Facility for measurement of superconducting properties of niobium at cryogenic temperatures.**

Centrifugal Barrel Polishing (single Cell)

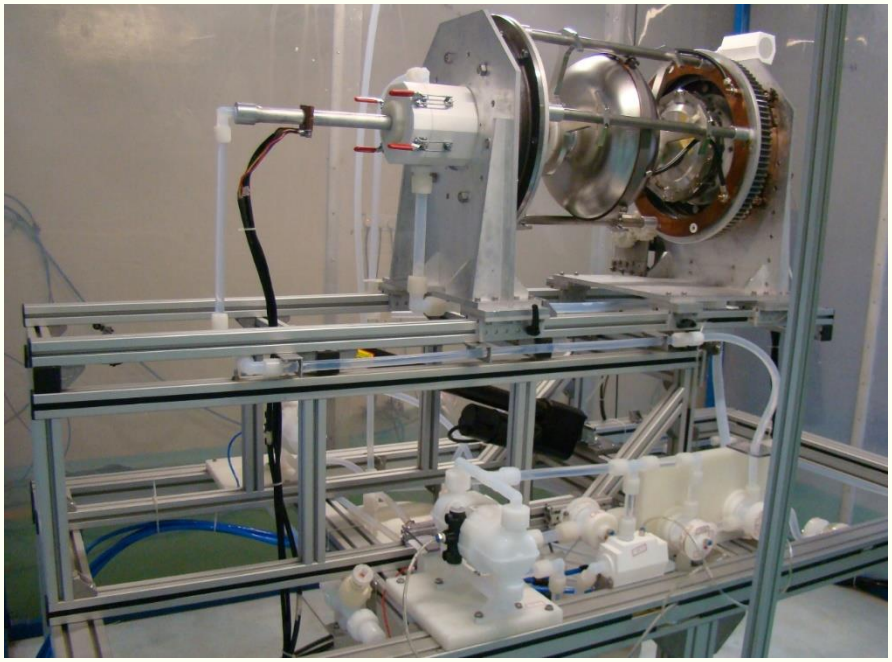
Main features of CBP machine

- Turret and Barrel rotate in opposite direction
- Turret speed – 0 – 200 rpm (variable)
- Barrel speed – 0 – 200 rpm (variable)
- Barrel size – 320 X 320 X 500 mm

Barrel Polishing Machine

Electropolishing setup for 1.3 GHz & 650 MHz Cavities

EP bench for 1.3 GHz Cavities



EP bench for 650 MHz Cavities

Ultrasonic cleaning facility

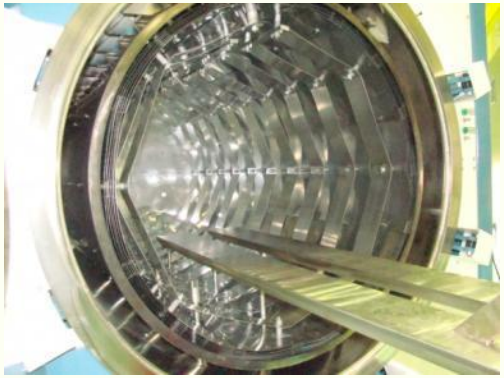
Ultrasonic cleaner for single cell cavity & small components

Cleaning of Single cell Niobium Cavity after EP

Ultrasonic cleaner for multi-cell cavities

Thermal Processing Facility

Specification of High Vacuum Furnace	
Orientation	**Horizontal**
Temperature range	**1400°C Max**
Working Vacuum	**<1 x 10^{-7} mbar (600°C -1000°C) <1 x 10^{-6} mbar (> 1000°C)**
Working Volume	**Diameter 825mm Depth 1500mm**



High Vacuum Annealing Furnace

Cavity Processing Facility

High Pressure Rinsing Setup

Ultra Pure Water Plant

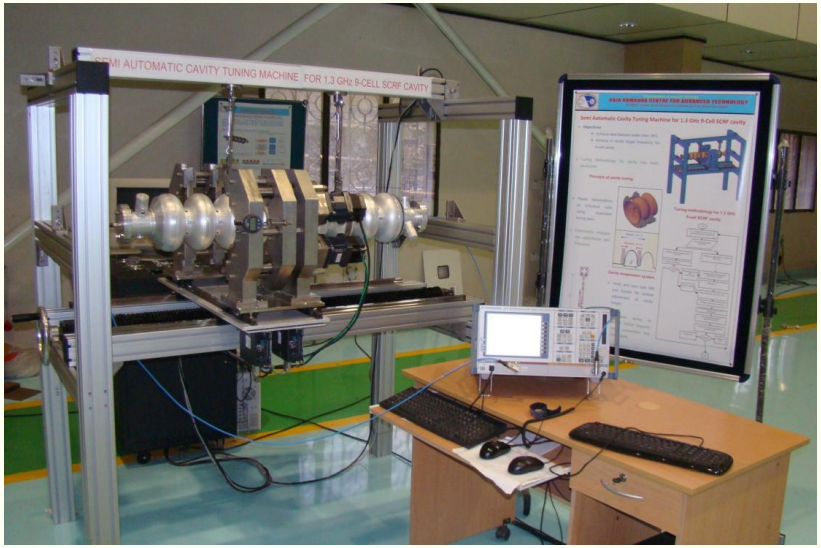
Low Temperature Baking & Pilot Cleanroom Facilities

Low temperature baking facility for 650 MHz

Pilot clean room facility

Tuning Setup of SCRF Cavity

- Manual tuners – Axial & radial (under development).
- Separate Semi-automatic tuning facility for 1.3 GHz and 650 MHz cavities (under development)



Semi-automatic tuning facility

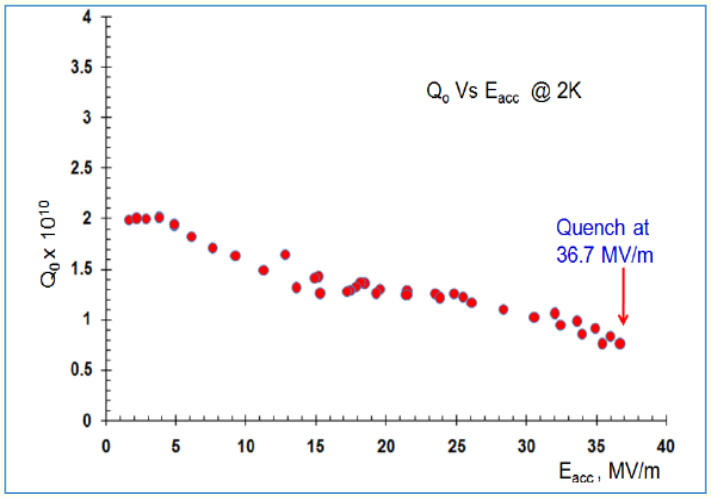
Manual Tuning of 1.3 GHz nine-cell cavity

2K Vertical Test Stand Facility

Cryostat & Cavity Insert Assembly

Transfer of liquid helium

RF testing in progress



The 2K cryostat & electronics was developed in collaboration with Fermilab under IIFC

Cryogenic facility

- ✓ One Helium liquefier with a liquefaction capacity of 50 l/h.
- ✓ One Helium liquefier with a liquefaction capacity of 145 l/h (under commissioning).

Cold Box: LR 280

Liquid Dewar 10,000 liters:

Cyclic Compressor

Cryogenic facility

Jumbo Cylinder cascades: Helium gas evaporated from 10,000 liters of liquid helium can be stored in these cylinder banks at 140 bar.

Cryogenic facility

Helium Gas Recovery Compressor, Capacity - 210 Nm3/hr. Suitable to recover helium generated cooling of 250 W at 2K

Capacity: 210 Nm^3/hr
Motor Power 100 kW

Suitable to recover helium generated cooling of 250 W at 2K

a) SRF Facility/Infrastructure development and commissioning at RRCAT

FACILITIES UNDER DEVELOPMENT

FACILITIES UNDER DEVELOPMENT :

- Upgradation of machining facility for trimming & machining of half-cells/ dumb-bells for HB 650.
- Nd-YAG laser beam welding facility for welding of 650 MHz five-cell cavity.
- Centrifugal barrel polishing machine for 650 MHz five-cell cavity. Polishing of four cavities simultaneously.
- Ultrasonic cleaner for 650 MHz five-cell cavities
- Upgradation of ultra pure water generation plant and high pressure pumps.

FACILITIES UNDER DEVELOPMENT :

- Low temperature baking oven for 650 MHz five-cell cavity.
- Semi-automatic tuning machine for 650 MHz cavities.
- Clean rooms up to Class 10.
- Setup for dressing of bare 650 MHz five-cell cavities - Tools and fixtures required for assembly of magnetic shield, helium vessel, end lever tuner etc (information required from Fermilab)

Status of VTS Facility:

b) How much VTS testing has been done, including qualification using 1-cell cavities FNAL sent. How many tests can be done in one month?

- Three 1.3 GHz single-cell cavity & one 650 MHz single-cell cavity have been tested in the VTS facility at RRCAT.
- It is planned to have two cool-downs per month. Two 650 MHz five-cell cavities can be tested in each cool down, which can give a yield testing of four cavities per month

THANK YOU