Dumbbell Fabrication and Tuning of the IHEP Large Grain 9-cell Cavity

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SRF09 Berlin·Dresden
14th International Conference on RF Superconductivity

THPPO067

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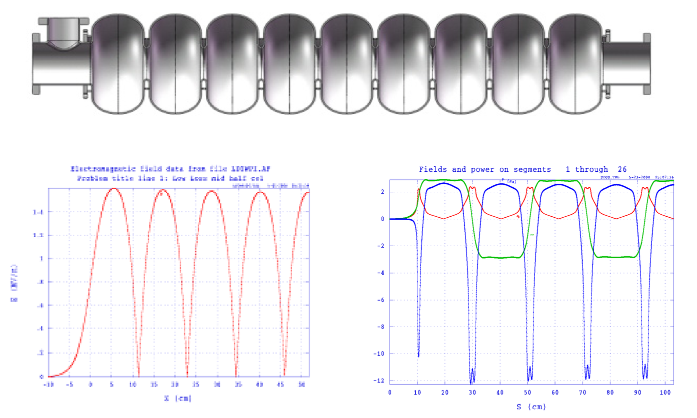
As the key component of the "IHEP 1.3 GHz SCRF Accelerating Unit and Horizontal Test Stand Project", a low-loss shape bare tube 9-cell cavity using Ningxia large grain niobium is being fabricated at IHEP. This paper presents the fabrication procedure and frequency tuning method of the dumbbells of this cavity. Due to the special properties of the large grain material, several mechanical and RF problems were found and successfully solved. After equator welding, this cavity will be surface treated late this year and tested early next year.

Low Loss Large Grain 9-cell Cavity

The combination of the low-loss shape and large grain niobium material is expected to be the possible way to achieve higher gradient and lower cost for ILC 9-cell cavities. The cost reduction of the large grain niobium cavities lies in eliminating electro-polishing process, and the newly developed multi-wire slicing technique on large grain niobium ingots at KEK.

A low-loss 9-cell cavity with full end groups is also under development. The end cell shape, the HOM couplers and the end plate will be optimized to damp higher order modes and reduce high field Lorentz force detuning according to ILC requirements. This cavity will be installed into the future short cryomodule (HTS) for the horizontal test at IHEP .

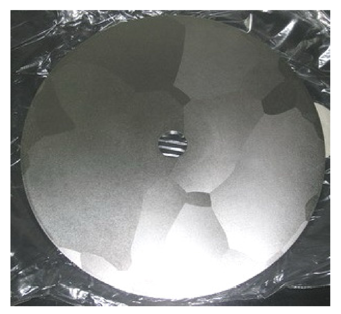


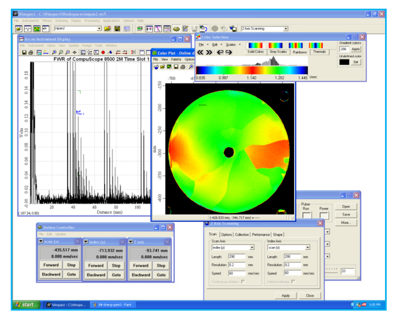
IHEP Low Loss Bare Tube Cavity Design Parameters

Active length	1.035 m
Cell to Cell coupling	1.54 %
Geometry factor	285 Ω
R/Q	1189 Ω
E_{peak}/E_{acc}	2.38
B_{peak}/E_{acc}	3.65 mT / (MV / m)

Niobium Inspection

Ultrasonic and eddy current scanning were both performed on some of the large grain niobium disks provided by OTIC, Ningxia. Some initial results of the ultrasonic scanning seemed to show no apparent defects of the material, while further investigation and improvement of the inspection methods are needed. The measured RRR value of the large grain niobium is 430.

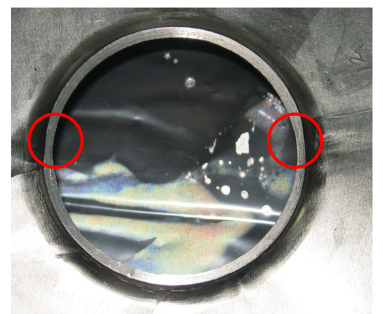


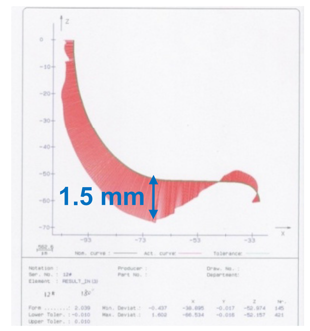


Half Cell Fabrication and Reshaping

Several problems were found during the fabrication of half cells from large grain material. Earrings and steps were found in the equator area, Large cracks and unsmooth were found between adjacent grains in the iris area. Iris wall thickness was not uniform after trimming (the largest thickness difference is nearly 1 mm). The spring back after deep drawing of the half cell was large according to 3D measurement and the equator became oval due to internal stress.

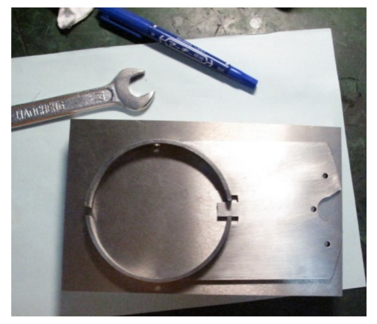
These problems were due to the different mechanical properties of the large grains with different crystal orientation. The steps and unsmooth area are supposed to be eliminated by CBP on the 9-cell cavity. For the oval shape, We adjusted the roundness of the half cells by reshaping the equator with a fixture. The final roundness was less than 0.2 mm.

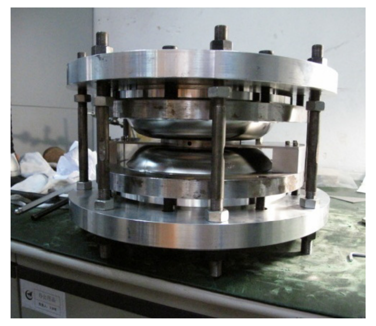




Dumbbell EBW

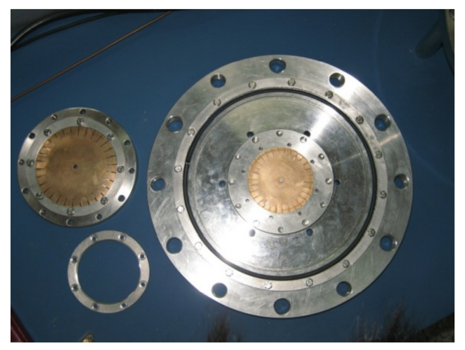
We chose two half cells with similar iris diameter to form a dumbbell. Inside and outside EBW were performed on the iris. The EBW of the iris did not meet big problems in spite of the large iris wall thickness difference. The shrinkage of the dumbbell length after iris and stiffening ring EBW is about 2 mm.





Dumbbell Frequency Measurement

The contact surface between the old dumbbell frequency measurement fixture and the equator surface was a 3 mm thick niobium plate. The Q values of the half cells and dumbbells were below 1000, and the frequency was not stable. The plain and hard contact need much more press and good equator surface flatness, thus a new fixture with radial slots on a thinner plate and elastic washers was fabricated for good RF contact. With the new fixture and about 10 kg press, the Q values of the half cells and dumbbells are above 5000, and the frequency is stable at kHz.



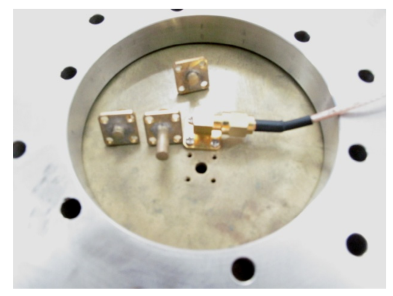
Dumbbell Reshaping and Tuning

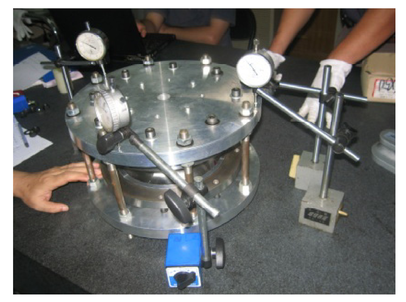
With a special jig, we reshaped the dumbbells to the target length and adjusted the parallelism to be less than 0.2 mm. The reshaping target length was the sum of the two half cells length before welding minus iris EBW shrinkage. With the perturbation method [1], we measured six frequencies to calculate the individual frequency of the half cells of a dumbbell. The perturbation amount was 50 kHz.

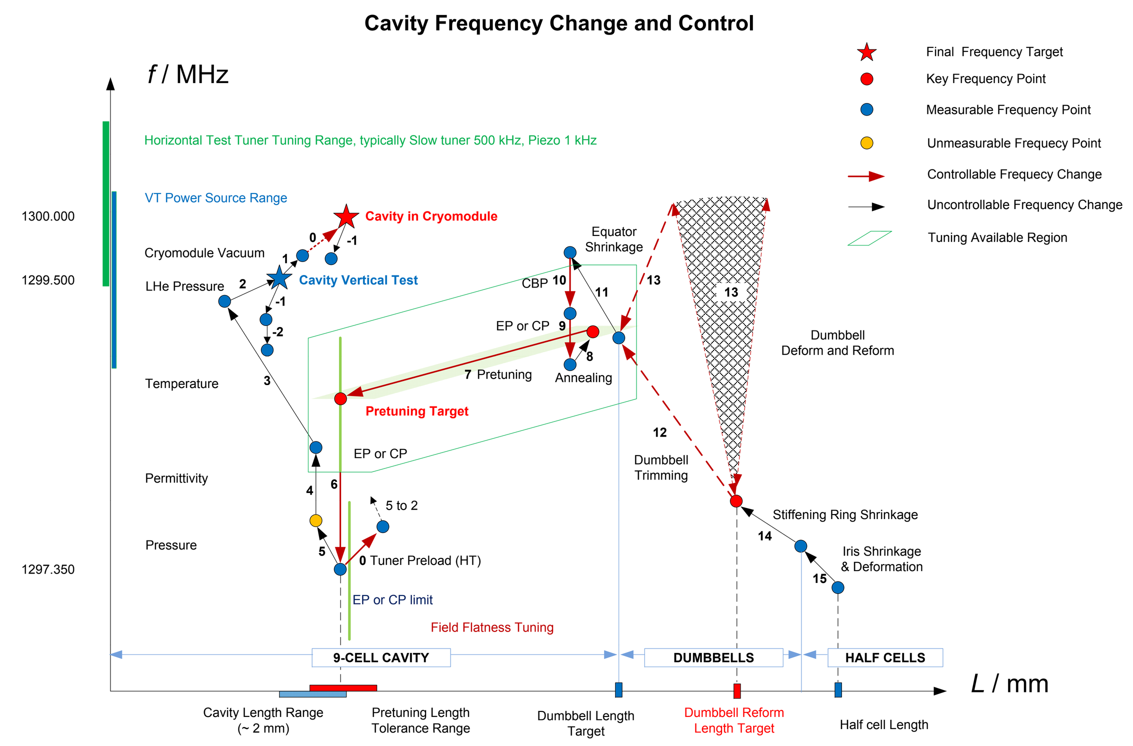
Then, according to the DESY cavity tuning method [2] and the estimated 9-cell cavity frequency and length evolution, we calculated the trimming length for each half cell of the dumbbell. The tuning target frequency of the dumbbell π mode was 1298.277 MHz, and the target length was 57.96 mm. Due to the relatively big scattering of the half cell length and frequency, we will make dumbbell matching for equator EBW according to both the equator diameter and the tuning requirement.

Dumbbell Tuning Example

Dumbbell #	Dumbbell Length / mm	Half cell #	Half cell frequency / MHz	Trimming length / mm	Pretuning Length / mm
#7-14	117.95	#7	1298.721	0.45	0.29
		#14	1298.072	0.88	0.41







Summary

Several problems have been solved during the fabrication, EBW and tuning of 13 dumbbells for the IHEP large grain low-loss shape 9-cell cavity. The whole cavity will be welded and treated in late 2009, and tested in KEK next spring.

Large grain niobium cavity fabrication has many special issues. Dimension and frequency control related to material mechanical properties is important and needs more investigation.

[1] A. Sun et al. A method to measure the frequencies of individual half cells in a dumbbell cavity. Review of Scientific Instruments, 79, 104701, 2008

[2] G. Kreps et al. Half-cell and dumbbell frequency testing for the correction of the TESLA cavity length. 9th workshop on RF superconductivity, Santa Fe, New Mexico, U.S.A, 1999

Acknowledgement

We would like to thank K. Yokoya and H. Hayano of KEK, B. Kephart and S. Mishra of Fermilab, and many thanks to K. Saito and F. Furuta of KEK for important suggestions on the 9-cell cavity fabrication, T. Khabiboulline of Fermilab for the information of the dumbbell frequency measurement fixture.