

R&D OF ICHIRO HIGH GRADIENT 9-CELL CAVITY FOR ILC

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Abstract

We are planning to construct Superconducting RF Test Facility (STF) at KEK for the R&D of ILC accelerator. In STF, four TESLA-like type 9-cell cavities and four Low-Loss (LL) type cavities will be installed into a cryomodule. We are aiming at the gradient of 51 MV/m with this LL-type cavity, and we named this cavity as ICHIRO after the back-number of famous base-ball player ICHIRO; 51. The four ICHIRO cavities were successfully fabricated and delivered to KEK. Two of them were already surface-treated and measured in vertical cryostat. In this article, the results of vertical tests by these two ICHIRO cavities would be reported.

INTRODUCTION

After the first ILC Workshop in KEK in November 2004, the Working-Group 5 (WG5) Asia made a plan to fabricate four 9-cell high-gradient cavities in LL-shape for Super-conductivity Test Facility (STF) at KEK. The details of the STF plan is found elsewhere [1]. The four LL-shape cavities were successfully fabricated and delivered to KEK on 4 July 2005. Two of them were surface-treated with the KEK recipe and measured in the cryostat.

DESIGN OF 9-CELL ICHIRO HIGH-GRADIENT CAVITY

The design of 9-cell high-gradient cavities started in collaboration with J. Sekutowicz from DESY. He originally designed so-called Low-Loss type cavity, where the H_p/E_{acc} ratio is lower than TESLA type cavity [2]. We modified this LL-type cavity so as to change the wall-angle of cell to zero degree, where each wall of cavity-cell is vertical as shown in Figure 1. Consequently, the H_p/E_{acc} ratio of 36 Oe/(MV/m) was obtained for our cavity, where the high-gradient of $E_{acc} \sim 51$ MV/m is expected in the best case. We named the cavity as ICHIRO after a famous Japanese baseball player, ICHIRO, whose back-number is 51.

As shown in Figure 1, both end-cells have slightly larger diameters at their equators and different shapes than the rest of seven central-cells. It is also shown that a beam-pipe of the cavity in the right-hand side has a Higher Order Mode (HOM) coupler and a port for input-

coupler. A beam-pipe in the left-hand side has a HOM coupler and a pickup port. The first 9-cell ICHIRO cavity was fabricated without HOM couplers and ports in order to finish fabrication as quickly as possible and to perform vertical test earlier. The rest of three ICHIRO cavities have two HOM couplers, an input-coupler port, and a pickup port as shown in Figure 1.

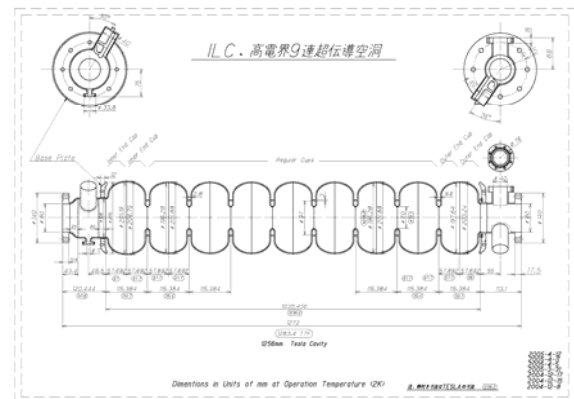


Figure 1: Draft of 9-cell ICHIRO high-gradient cavity.

FABRICATION OF 9-CELL ICHIRO HIGH-GRADIENT CAVITY

The fabrication of four 9-cell ICHIRO cavities started from the end of January 2005, when more than eighty sheets of niobium (Nb) with the RRR of 300 were delivered to KEK. The fifty six sheets were deep-drawn by a press-machine to form half-cell cups on 21st February 2005. The half-cups were trimmed at the iris and equator parts to have the design height with taking into account the EBW shrinkage. Then the iris part of two half-cell cups was welded by an Electron Beam Welding (EBW) machine to form so-called dumbbell-shape. A special jig was made to insert two stiffener half-rings into the iris part of a dumbbell and to align the position. The stiffener-rings were welded to thirty-two dumbbells by an EBW machine on 16th April. The equator parts of eight dumbbells per cavity were welded to make a 9-cell cavity-body. Two beam-pipes per cavity were assembled with main flanges, HOM couplers, input-coupler-port flange, pickup-port flange, end-plates for joint to liquid-helium jacket, and end half-cell cups by an EBW machine.

These assembled beam-pipes with flanges and end-cell were called “end-group”. Two end-groups per cavity were finally welded to a 9-cell cavity-body. The first 9-cell ICHIRO cavity was delivered to KEK on 5th May 2005, and the fourth 9-cell ICHIRO cavity was delivered to KEK on 4th July 2005.

Measurements and tuning of dumbbell-shape

We measured the height and 3-dimensional (3D) shape of dumbbells before the EBW of stiffener-ring. The measured results are shown in Figure 2. The average of dumbbell-height was 114.43 mm with the standard deviation of 0.16 mm. This average is shorter than the design value of 115.86 mm by 1.4 mm because the dumbbells were heat-deformed and shrank when the iris part was welded. A typical example of 3D measurement of dumbbell-cup is shown in the right-hand side of Figure 2. It is seen that deviation from the design curve is small around the equator part. But the deviation becomes larger around the iris part. This deformation is due to the heat of EBW at the iris part, and consequently, the height of dumbbell becomes shorter.

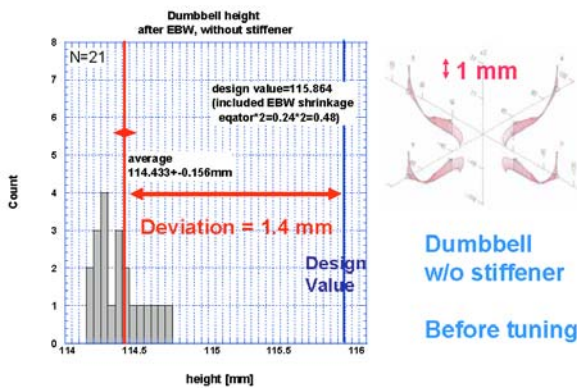


Figure 2: Dimensional measurements of dumbbells without stiffener-ring before tuning. Left-hand side: height measurement. Right-hand side: 3D measurement of dumbbell-cup. Black-curve is design shape and the red-lines denote the deviations from the design curve.

In order to force the dimension of dumbbells into the design shape, the stiffener-ring is very effective. However, the EBW of stiffener-ring changes the cup-shape in another way. We found the serious dimensional deviation after completion of 1st ICHIRO cavity fabrication and considered stiffener-ring is not enough to remove the total shape-deformation.

To remove the total deformation of dumbbell-shape, we pulled and extended the twenty four dumbbells by a special jig as shown in the left-hand side of Figure 3. Using this special jig, we tuned the height and shape of dumbbells for 2nd, 3rd, 4th ICHIRO cavities. After welding stiffener-ring and tuning of dumbbell-shape, we measured the height and 3D shape of twelve dumbbells. The measured results are shown in Figure 3. The average of dumbbell-height was 115.78 mm with the standard

deviation of 0.13 mm. This average is shorter than the design value of 115.86 mm by only 0.08 mm.

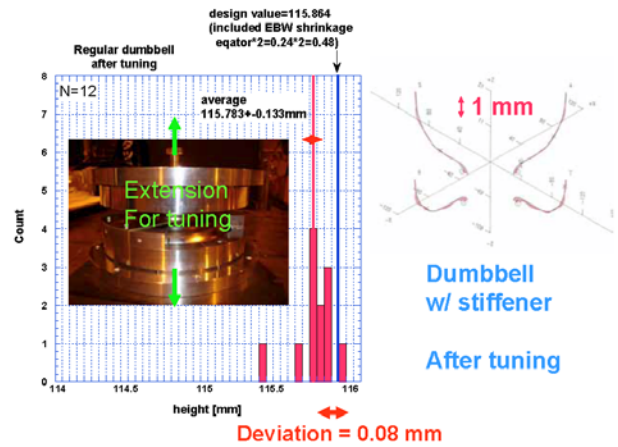


Figure 3: Dimensional measurements of dumbbells with stiffener-ring after tuning. Left-hand side: height measurement and height tuning by a special jig. Right-hand side: 3D measurement of dumbbell-cup. Black-curve is design shape and the red-lines denote the deviations from the design curve.

Dimensional measurements

Length measurement

After four ICHIRO cavities were fabricated and delivered to KEK, we measured the length of four cavities. The purpose of these measurements is to clarify the shrinkage and heat deformation of cells in the EBW process. Therefore, the length of only 9-cell part of cavity without beam-pipes was measured. The deviations from the design value of 1038.5 mm for 1st, 2nd, 3rd, 4th cavities were -10.0 mm, -0.7 mm, -0.1 mm, and -0.1 mm, respectively.

1st ICHIRO cavity has the largest deviation of 10.0 mm. However, after introducing the dumbbell-height tuning from the 2nd cavity as already mentioned, the deviations were significantly reduced.

Measurement of Shrinkage from EBW process

Table 2: Measured shrinkage from EBW process. (mm)

Part	Average	Standard deviation	N samples
Iris	0.148	0.044	32 (dumbbells)
Equator	0.424	0.125	27 (cells)

When half-cell cups were fabricated, a mark-off line was scratched at the constant distance of a few mm from each end of iris and equator edges. After each EBW process of iris and equator of half-cells, the distance between two mark-off lines across the EBW part was measured to estimate the shrinkage from the EBW process. The result of measurements is shown in Table 1. For 4th cavity, mark-off lines at the equator was not made and the data of equator is only from three cavities.

