IMPROVEMENT IN CAVITY FABRICATION TECHNOLOGY AND COST REDUCTION METHODS

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Abstract

Cavity fabrication method with new forming and laser welding technology are reported. 1.3 GHz 9-cell cavity with laser welding for stiffener and flange joint was achieved 29.5 MV/m at vertical test by KEK. 1.3 GHz 2-cell seamless dumbbell cavity is fabricated at MHI to verify the new fabrication method. These improvements are reported in detail. Some fabrication methods for cost reduction and stable quality are introduced.

INTRODUCTION

MHI has supplied 1.3 GHz superconducting RF cavity for STF project (STF is a project at KEK to build and operate a test linac with high-gradient superconducting cavities, as a prototype of the main linac systems for ILC.) and ERL project (Energy Recovery Linac) in several years [1][2]. To improve cavity performance, we have done several activities as shown Table 1 on STF cavity fabrication. Clean area was not used in cavity assembling at phase 1.0, but air top gun in clean area are used in cavity assembling at phase 2.0. The EBW conditions were always improved.

In recent vertical test at KEK, some STF cavities reached Eacc= 31.5 MV/m which is specification of ILC as shown figure.1. MHI-#12 cavity reached also over 40 MV/m. All these cavities (as shown figure.2) are governing high pressure gas safety law in Japan.

Table 1: Activities for improvement of cavity performance

Phase	1.0	1.5		2.0
Cavity No.	#1-4	#5-6 #7-9	#10-11	#12-22
Thickness of thinning	2.5 mm	2.0 mm	>	>
Bead condition	Bumpy	Smoother	Flatter	More stable
Shape of groove	Butt	>	Step	>
Frequency of *CP	Only after thinning	Each step (Just before EBW)	>	>
Management Of cleanness	Air duster	> Clean area	> >	Air top gun >

*CP: Chemical polishing

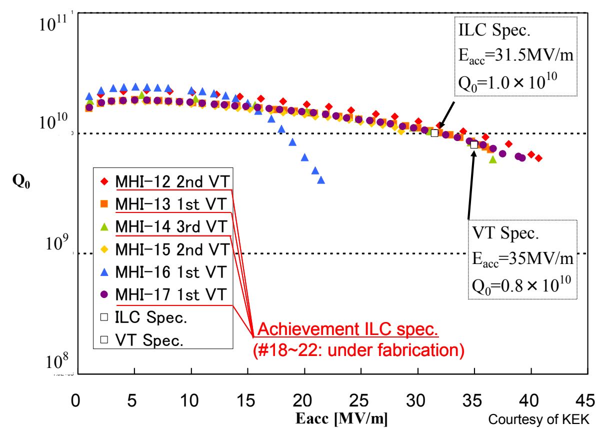

Figure 1: Q-E curve of recent vertical test for STF cavities.

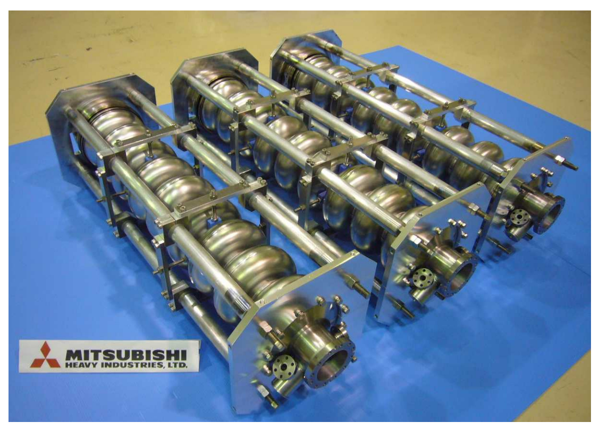

Figure 2: STF cavities governing high pressure gas safety law in Japan.

IMPROVEMENT FOR CAVITY FABRICATION METHOD

The principles for cost reduction in mass-production are reducing number of parts, automation or outsourcing, batch process and reducing process time (ex. Change of fabrication procedure, using special jig and machine or optimization of machine time and layout).

Since STF project was started, MHI has proposed some new fabricating methods based on these principles as shown below [3][4][5][6]. Some of them were applied to production or R&D cavities. Some of them are proposal for cost reduction. Improvements in R&D cavities for cost reduction are shown in detail.

Improvement Applied to Production Cavities

The items as following are applied to STF cavities.

- To simplify inner conductor of HOM (High Order Mode) coupler design
- Reduction of machining of HOM cup, beam tube and base-plate by using forming

Improvement Applied to R&D Cavities

The items as following are applied to R&D cavities.

- Automatic finishing by robot for cell's inner surface from human hand (applied to MHI-B cavity)
- Using LBW instead of EBW for stiffener and flanges (applied to MHI-A cavity)
- Seamless dumbbell (applied to MHI-B cavity)

Improvement Under Developing

The items as following are under developing.

- Change of flange's material NbTi to Ti or Nb alloy
- Brazing instead of EBW for stiffener and flanges

Proposal for Improvement

The items as following are our proposal.

- Combination of pick-up port and flanges
- Combination of base-plate and beam-tube

FABRICATION OF MHI-A CAVITY (R&D)

MHI-A cavity was manufactured to establish LBW for stiffener ring and flanges and to establish deep drawing for HOM cup. The vertical test of the cavity was carried out at KEK to inspect the influences to cavity performance by new techniques. The result of first vertical test is shown figure 3. MHI-A cavity achieved Eacc=29.5 MV/m without problem at LBW points and HOM coupler. Except for No.8 cell this cavity has capacity of good performance. So we found LBW and HOM cup can be available for production of future cavities.

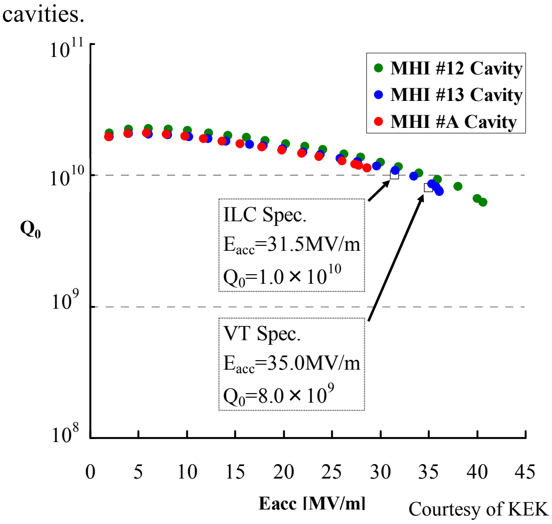

Figure 3: Q-E curve of first vertical test for MHI-A cavity at KEK.

Feature of MHI-A Cavity (shown figure 4)

- Using deep drawing of HOM cup
- No finishing for inner surface of HOM cup
- Using LBW for stiffener and flanges with argon gas atmosphere and oxygen content controlled
- Same design of STF cavity.

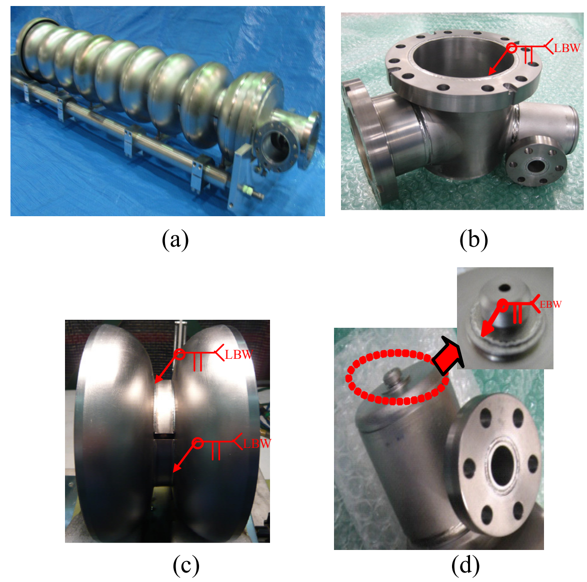

Figure 4: (a) Over view of MHI-A cavity, (b) Beam-tube, (c) Dumbbell, (d) HOM coupler.

FABRICATION OF MHI-B CAVITY (R&D)

MHI-B cavity is under fabrication to establish seamless dumbbell as shown figure 5. The vertical test of the cavity will be carried out to inspect the influences to cavity performance by seamless dumbbell with KEK and JLab this autumn.

Feature of MHI-B

- Number of cell is two.
- No welding seam on iris (seamless dumbbell).
- Finishing for inner surface of dumbbell is automatic buffing by robot.
- Cell's design is the same as STF cavity
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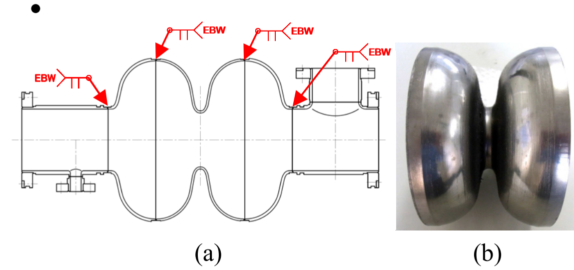


Figure 5: (a) Over view of MHI-B cavity, (b) Seamless dumbbell.

Seamless Dumbbell

Figure 6 shows the flow of forming for seamless dumbbell. The quality of inner surface of dumbbell depends on the condition of the seamless pipe. The seamless pipe was made by deep drawing.

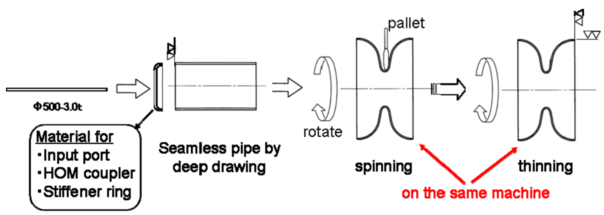


Figure 6: Flow of seamless dumbbell.

Automatic Finishing by Robot

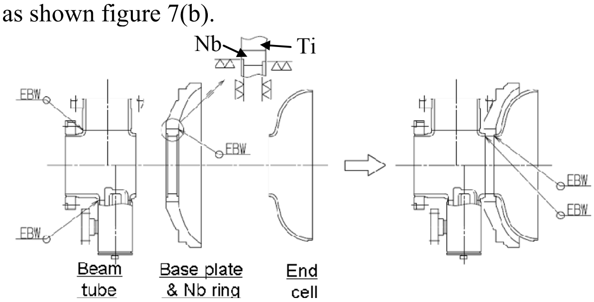
Inner surface of cell is needed to finish very smoothly by requirement of superconducting performance. It takes much time for finishing by human hand as shown figure 6-(a), so automatic robotic finisher was developed to reduce the time and carried out a basic test. This finisher was applied to seamless dumbbell for MHI-B cavity shown figure 6-(b) and (c).

(a) (b) (c)

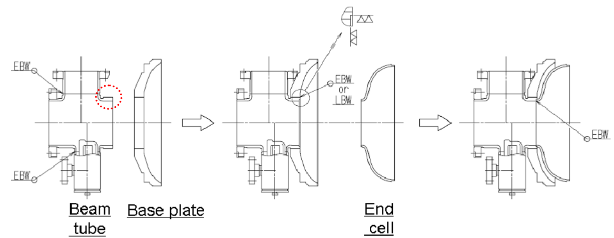
Figure 6: Finishing for inner surface of cell. (a) Present status (Finishing by human hand), (b) Seamless dumbbell before finishing, (c) Seamless dumbbell after finishing by robot

COMBINATION OF BASE-PLATE AND BEAM-TUBE (NEW PROPOSAL)

This proposal is to reduce a number of parts in end group for STF cavity. STF cavity has titanium base-plate and niobium base-plate ring and beam-tube. In case of present process it needs two pieces from end cell to beam-tube flange as shown figure 7(a). In case of this proposal it needs only one piece from end cell to beam-tube flange by combination of base-plate and beam-tube as shown figure 7(b).



(a)



(b)

Figure 7: Image of combination of base-plate and beam tube. (a) Present process, (b) Proposal shape

CONCLUSION

- We have supplied some 1.3GHz SRF cavities for STF and ERL projects at KEK for the last few years. The cavity performance is improving step by step.
- We have proposed some ideas for cost reduction and these methods were established step by step. We need to estimate in detail the effect of cost reduction.
- According to MHI-A cavity, we were sure that using LBW joints instead of EBW joints for the parts of little influence to cavity performance was available.
- MHI-B cavity with seamless dumbbell is under fabrication. This cavity is going to be finished on July 2011. After inspection and surface treatment, RF test is going to be carried out at JLab on this autumn.

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