FABRICATION OF SUPERCONDUCTING RF CAVITY AT MHI

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Abstract

We have supplied some 1.3 GHz superconducting RF cavities for STF project and cERL project for few years. Recently, we have manufactured STF phase 2.0 cavities (MHI-#12 to #22). Some of them achieved ILC specification in vertical test at KEK. We have also manufactured three sets of 2-cell cavities for injector linac modules of cERL and two sets of 9-cell cavities for main linac modules of cERL. These cavities were governed to high pressure gas safety law in Japan. We report recent activities of superconducting RF cavity at MHI in this paper.

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) for several years. Recently we have fabricated 2-types of cavity for cERL in KEK. One is 2cell cavity for injector linac, the other is 9-cell cavity for main linac as shown Figure 1.

Table 1 indicates the activities of improvement for cavity performance at MHI. We have done optimization of the design and the manufacture method for ERL cavity based on STF cavity.

We take care about cleanliness at cavity assembling, so we use clean area and air top gun. The EBW conditions were always improved. In recent vertical test at KEK, some ERL cavities show good performance [1] [2]. Furthermore STF cavities reached Eacc= 31.5 MV/m which is the required gradient of ILC. MHI-#12 cavity reached also over 40 MV/m [3]. All these cavities are governing the high-pressure gas safety law in Japan.

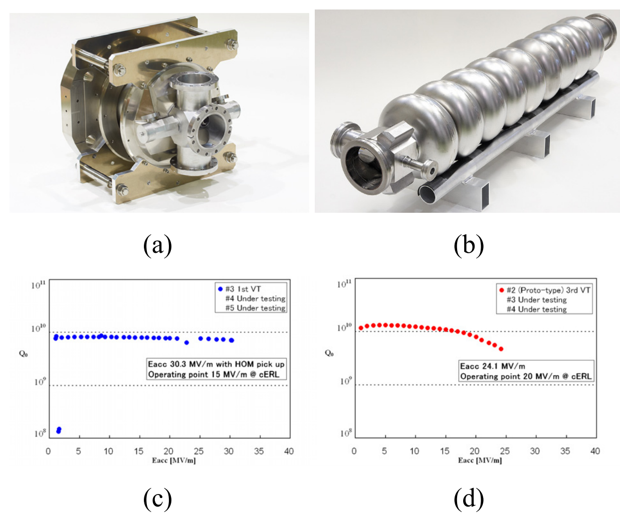

Figure 1: 1.3 GHz SRF Cavity for cERL. (a) Cavity for injector linac, (b) Cavity for main linac, (c) Q-E curve of recent vertical test of (a), (d) Q-E curve of recent vertical test of (b).

IMPROVEMENT FOR CAVITY FABRICATION METHOD (R&D AT MHI)

Since the STF project was started, MHI has proposed some new fabricating methods for superconducting cavity [4]. 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.

Table 1: Activities of Improvement for Cavity Performance

Project	Cavity	Thickness [mm]			Shape of groove	Fabrication procedure /Stiffener		Finishing of welding bead Iris/ Equator		High pressure gas safety law
	No.	Center -cell	End -cell	Equator						
Injector Linac	#1	2.8	2.8	2.0	Butt	Dumbbell	Yes	No	No	-
	#2	2.8	2.8	2.0	Butt	Dumbbell	Yes	No	No	-
	#3 to 5	3.5	5.0	2.0	Step	Dumbbell	Yes	No	No	Adapted
Main Linac	#1	2.8	2.8	2.5	Butt	Dram	No	Yes	Yes	-
	#2	2.8	3.5	2.0	Butt	Dumbbell	Yes	No	No	-
	#3 to 4	2.8	3.5	2.0	Step	Dumbbell	Yes	Yes	No	Adapted
STF	#12 to 22	2.8	3.5	2.0	Step	Dumbbell	Yes	No	No	Adapted

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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 follows are applied to R&D cavities.

- Automatic finishing by robot for cell's inner surface (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 follows are under development.

- 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 follows 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 the first vertical test is shown in Figure 2. MHI-A cavity achieved Eacc=29.5 MV/m without problems 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.

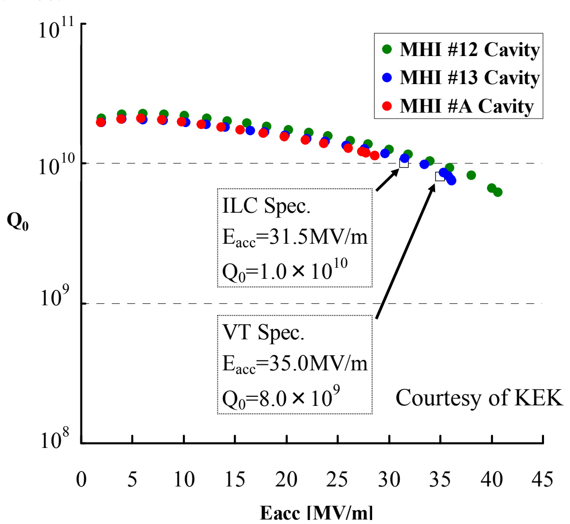


Figure 2: Q-E curve of first vertical test for MHI-A cavity at KEK.

Feature of MHI-A cavity (shown in Figure 3)

- 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.

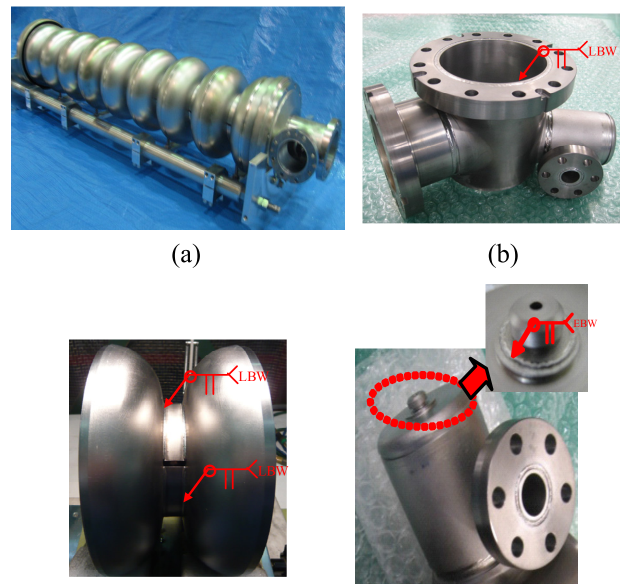


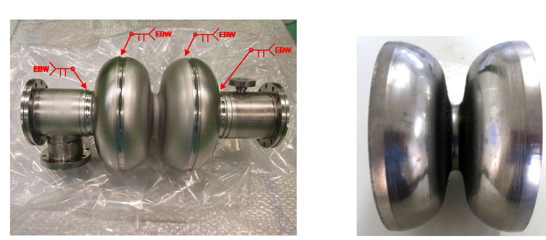
Figure 3: (a) Over view of MHI-A cavity, (b) Beam-tube, (c) Dumbbell, (d) HOM coupler.

FABRICATION OF MHI-B CAVITY (R&D)

MHI-B cavity is fabricated to establish a seamless dumbbell technique as shown in Figure 4. The vertical test of the cavity will be carried out to inspect the influences to cavity performance by seamless dumbbell with KEK and Jefferson laboratory. Now MHI-B is prepared for vertical test at J Lab.

Feature of MHI-B

- Number of cells 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



(a) (b)

Figure 4: (a) Over view of MHI-B cavity, (b) Seamless dumbbell.

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Seamless Dumbbell

Figure 5 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.

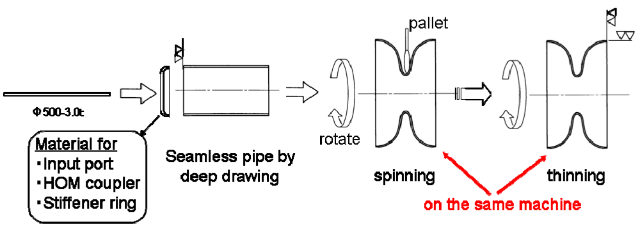


Figure 5: FlowD of seamless dumbbell.

THINNING FOR CELL BY USING NEW CHUCKING METHOD (NEW PROPOSAL)

We have developed a new cell thinning procedure by using vacuum chucking as shown in Figure 6. Conventionally, a cell was chucked by mould clamping (a cell was fixed at the inside and the outside points with metallic mould). So this method required replacement of the mould every time the thinning part was changed. And it required a long time to set up the mould due to many bolts being used. Furthermore, much attention was necessary in order not to damage the inner surface of the cell with the metallic mould.

On the other hand, if attachment by vacuum is utilized, it facilitates setting up the chucking jig. Also, as the jig is made of resin, it seldom damages the inner surface.

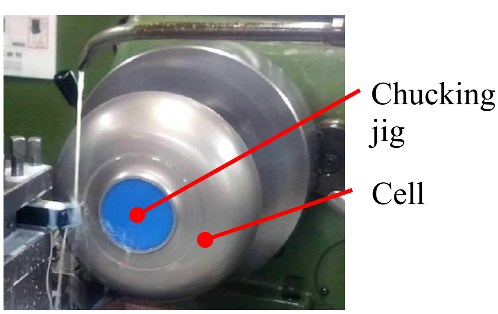


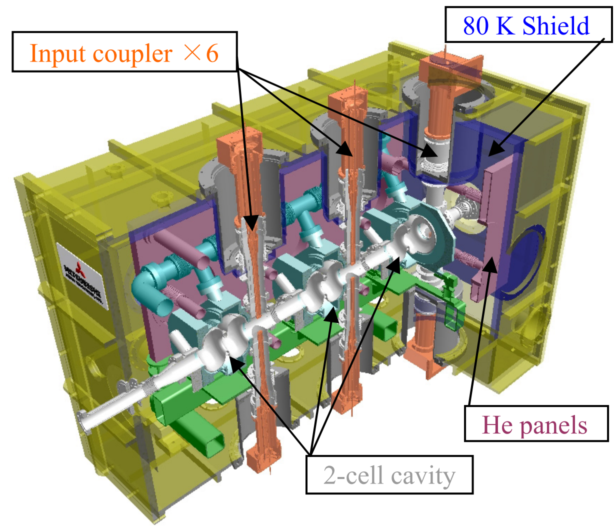
Figure 6: Image of new thinning process of cell.

RECENTLY STATUS OF COMPACT ERL PROJECT FOR KEK AT MHI

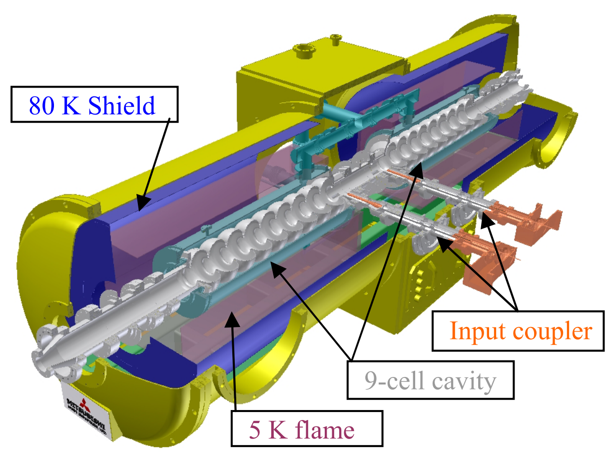
Now we are fabricating 2 types of cryomodule for cERL project at KEK. One is the Injector Module as shown Figure 7-(a). This module has square shape because input couplers are set from upper and lower side (double coupler system), and it has helium panels for 5 K thermal shield. This module has 3 sets of 2 cell cavities with LHe jacket and frequency tuner [5].

The other is the Main module which has 2 sets of 9 cell cavities with LHe jacket as shown in Figure 7-(b). Main components of this module are almost same as Injector module. The feature of this module is that some parts are supported in center of module [6].

Some of components need to be resisting pressure, so it is required to be granted permission on high pressure gas safety law in Japan for module operation.



(a)



(b)

Figure 7: Over view of cERL modules, (a) Injector module, (b) Main module.

CONCLUSION

- We have supplied some 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 improving productivity and these methods was established step by step.
- 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 fabricated. This cavity is going to be tested at JLab after this conference.

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- Now we are designing and fabricating 2 types of cryomodule for cERL at KEK. (Governed by the high pressure gas safety law in Japan)

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