STATUS OF SUPERCONDUCTING CAVITY DEVELOPMENT FOR ILC AT MHI

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Abstract

MHI has supplied 1.3GHz superconducting cavities for the Energy Recovery Linac (ERL) project and the International Linear Collider (ILC) R&D project (STF: Superconducting RF Test Facility in KEK) to KEK in Japan for several years. [1] We are improving the technology to design and fabricate the superconducting cavities for ILC R&D step by step. The status of superconducting cavity development for ILC at MHI is described in this paper.

INTRODUCTION

As shown in Table 1, we have manufactured a 1.3 GHz superconducting cavity and accumulated much technology and know-how about manufacturing cavities for several years.

As shown in Fig. 1, the vertical test of 5 superconducting cavities for the STF Phase 1.5(S1-Global) project was carried out. [2][3] The welding conditions were improved in order to improve the cavity's performance compared with the cavity for STF Phase 1.0. [4] In a recent vertical test, some cavities reached E_{acc}= 31.5MV/m, which are the specifications for ILC. Some efforts and preparations to improve their performance were done by KEK. [5][6]

So it was proved that MHI has technology to manufacture superconducting cavities.

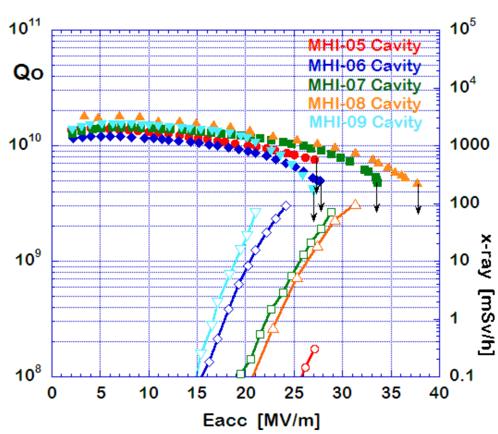


Figure 1: Q-E curve in the recent vertical test for STF 1.5 cavities (MHI #5- #9).

ACTIVITIES FOR ILC

Now we are manufacturing 11 cavities for the STF 2.0 project(which conform to high-pressure gas safety laws in Japan) and carrying out the R&D to improve the productivity of cavities while guaranteeing their performance for ILC. New techniques for improving productivity were considered and we tried to use them in the manufacturing cavity.

Table 1: Production List of the Superconducting Cavity by MHI

Project	Customer	Production year	Cell-number	Quantity	E_{acc} max at vertical test (MV/m)	Q_0 at operating (final) E_{acc}	Remarks
STF Phase1	KEK	2005	9	4	20.2 to 29.4	**2×10^{10}**	
ERL R&D		2006	1	2	31	**9×10^{9}**	
		2007	9	1	25	**2×10^{9}**	
		2007	2	1	43.7	**3.4×10^{9}**	w/o HOM pick up antenna
		2008	2	1	40.9	**3.3×10^{9}**	
		2009	9	1	before testing		
STF Phase1.5		2007	9	2	28.1	**5.4×10^{9}**	
		2008		3	37.7	**4.8×10^{9}**	
		2009		2	28.2	**4.9×10^{9}**	
STF Phase2		2010	9	11	under manufacturing		
ILC R&D	MHI	2009		1	before testing		

FABRICATING CAVITIES WITH NEW TECHNIQUES

We developed new techniques to improve the productivity and fabricated one cavity with them as a prototype (MHI-#A). The MHI-#A was completed at the end of March, 2010, and the performance measurement is carried out now.

Producing a cavity requires the use of two main techniques. One is a manufacturing method using deep drawing for an HOM coupler, and the other is a technique using laser beam welding (LBW) to produce a dumbbell and beam tube. Details of the new techniques are shown below.

Figure 2: 1.3GHz superconducting 9-cell cavity with new techniques. (MHI-#A).

Deep Drawing for HOM Coupler

The outer conductor of an HOM coupler was formed by deep drawing from a niobium sheet and bulge forming in place of machining as shown Fig. 3. A nipple to tune the notch frequency was fixed by electron beam welding (EBW) on the top of the outer conductor.

The smoothness of the inner surface after deep drawing was the same as the surface of the material. So finishing of the inner surface was not necessary.

(a) (b)

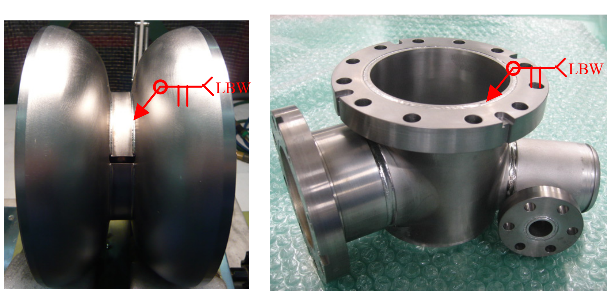
Figure 3: (a) Machining for outside after bulge forming and deep drawing, (b) Welding a nipple.

LBW for Dumbbells and Beam Tubes

Joints with flanges and beam tubes, and joints with a stiffener and half-cell used LBW in place of EBW as shown in Fig.4. LBW has the advantage of a shorter cooling time after welding in comparison with EBW and the equipment needed is cheaper.

Because the quality of the welding bead was equivalent to EBW and the inner surface of the cell was also polished by electro-polishing (EP), we assumed that LBW could be used in a product.

It will be necessary to verify the prototype cavity's performance in a vertical test.



(a) (b)

Figure 4: (a) Welding stiffener and dumbbell, (b) Welding beam tube and flange.

STATUS OF MHI-#A

The MHI-#A will be tested in 1st vertical test in KEK at the end of October, 2010. Now, the MHI-#A is under various processing before vertical test in KEK. The result of them are reported below.

Measurement of Welding Bead

To improve the smoothness of welding bead for cell compared with the STF's cavity, we adjusted a welding condition. To check the smoothness, we took a replica of inner bead and compared with conventional bead(MHI-#8). The measurement result is shown in Fig. 5. The height of MHI-#A's bead was about 0.15mm and became smoother than MHI-#8's bead.

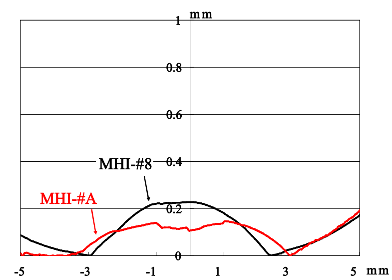
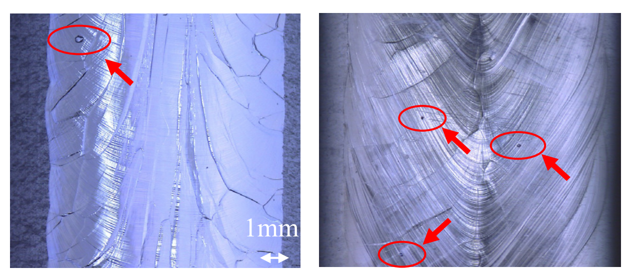


Figure 5: Result of measurement for inner welding bead.

Inside Inspection

The inside inspection before EP was finished. Result of that inspection, few pit-like thing was found on welding bead of cell. A typical thing is shown in Fig. 6. The diameter of pit-like thing is about 0.2mm or less. However, they may be removed by EP or may be not the pit. It is difficult to judge whether it is problem on this step, So the re-inspection will carry out after EP and check the status of pit-like thing.



(a) (b)

Figure 6: Result of inside inspection. (a) Equator of No.1 cell, (b) Iris between No.1 and 2 cell.

R&D OF NEW TECHNIQUES

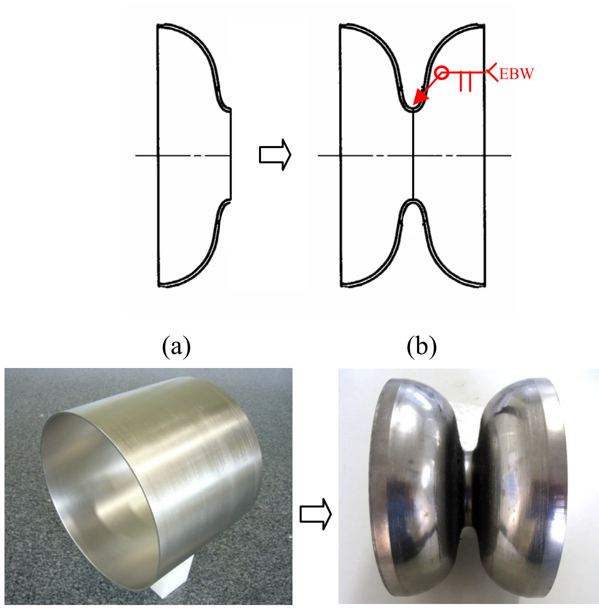
We are developing the other new techniques to improve a productivity for manufacturing cavity. Two typical new techniques are described below.

R&D for Manufacturing Dumbbells

Now the dumbbell is assembled from a joint with two cells which were formed in a bowl shape by pressing them from a niobium sheet (Fig. 7 (a) and (b)).

This time We tried to form a dumbbell using the technique of spinning fabrication from a seamless pipe (Fig. 7 (c) and (d)). The seamless pipe was obtained by deep drawing from a niobium sheet in place of spinning fabrication.

The quality of the inner surface became sufficient for the product to be usable with some slight finishing as shown in Fig. 8. So we are planning to adopt the seamless dumbbell for proto-type cavity.



(a) (b)

(c) (d)

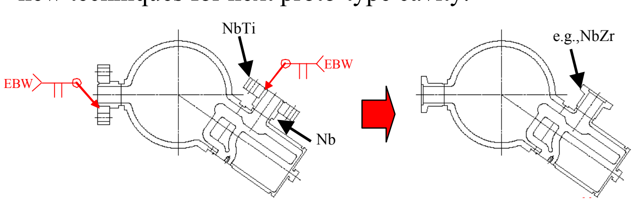
Figure 7: (a) Half-cell, (b) Dumbbell, (c) Seamless pipe, (d) Dumbbell made from pipe formed by spinning.

(a) (b)

Figure 8: Inner surface of seamless dumbbell (a) Made from seamless pipe formed by spinning [7] (b) Made from seamless pipe formed by deep drawing.

New Structure of Flanges

The idea to improve productivity for manufacturing the end group is considered. Unification of flange and port as shown Fig. 9 (b) has some advantage from present status. For example, it is able to decrease the number of parts and welding line. We plan to adopt these new techniques for next proto-type cavity.



(a) (b)

Figure 9: (a) present status, (b) new techniques (Unification of flanges and port).

CONCLUSION

- We have supplied some 1.3GHz superconducting cavities for STF projects at KEK for a number of years. We have improved the technology to design and fabricate superconducting cavities for ILC.
- 11 cavities for the STF Phase 2 project that conform to high-pressure gas safety laws in Japan are being manufactured.
- We used new techniques to manufacture a prototype cavity (MHI-#A) aiming to improve productivity. The MHI-#A was completed at the end of March, 2010. Now MHI-#A is under several processing before vertical test in KEK.
- We are developing some new techniques for ILC. For example, a seamless dumbbell by spinning fabrication and a structure of unification of flange and port.

ACKNOWLEDGMENT

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