

STATUS OF THE SUPERCONDUCTING CAVITY DEVELOPMENT FOR ILC

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Abstract

MHI activities for ILC are reported. MHI had developed several procedure and method of cavity production for stable quality and cost reduction. And we are producing cryomodules too. These activities are reported in detail.

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.) in several years [1]. 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, almost STF cavities reached $E_{acc} = 31.5$ MV/m which is specification of ILC as shown figure 1. MHI-#12 - #21 (as shown figure 2) are governing high pressure gas safety law in Japan. The average E_{acc} of these cavities is 37 MV/m, and the range of E_{acc} is from 35 MV/m to 40.7 MV/m.

Table 1: Activities for Improvement of Cavity Performance

Phase	1.0	1.5		2.0	2-a 2-b
Cavity No.	#1-4	#5-6 #7-9	#10-11	#12-22	#23-30
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	>	>	Air top gun	>

*CP: Chemical polishing

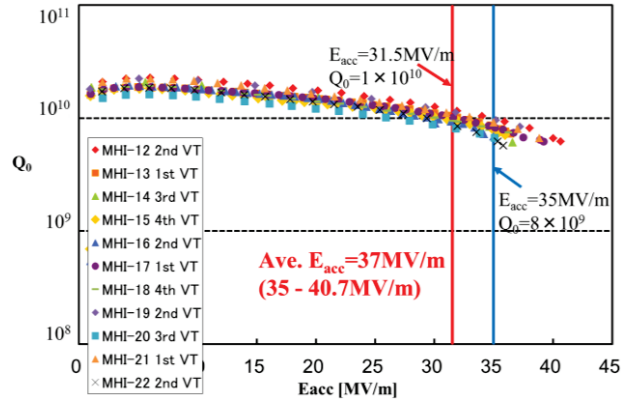


Figure 1: Q-E curve of recent vertical test for STF cavities.



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

IMPROVEMENT FOR CAVITY FABRICATION METHOD FOR COST REDUCTION

The principles for cost reduction in mass-production are reducing number of parts, automation or outsourcing, batch process and reducing process time (e.g. 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 [2-5]. 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, and Table 2 shows the summary of improvement for cavity fabrication method for cost reduction.

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
- Retainer flange for monitor port
- Welding 2 cavities in one batch

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)
- Welding all equator line of cavity in succession by vertical position without purge of vacuum chamber (applied to MHI-C cavity)
- LBW for baseplate consisted of Nb ring and Ti plate (applied to MHI-C cavity)

Improvement under Developing or Proposal

The items as following are under developing or our proposal.

- Welding 4 cavities in one batch
- Combination of pick-up port and flanges

Table 2: Summary of Improvement for Cavity Fabrication Method for Cost Reduction

Phase	Cavity No.	Assy direction	Stiffener welding	Baseplate welding	Cavity quantity at final welding in one batch	New procedure or new design
	MHI-A 9cell	Horizontal	LBW	EBW	1	
	MHI-B 2cell	Vertical	—	—	1	Seamless dumbbell
	MHI-C 9cell	↑	LBW	LBW	1	
STF 2-a		↑	↑	EBW	2	Retainer flange for monitor port
STF 2-b		↑	↑	LBW	4	

FABRICATION OF STF #23-26

STF #23-26 are under fabrication by new design and new procedure. These cavities have retainer flange for monitor port as shown figure 3. In previous design, we had to weld monitor port and flange after welding of HOM coupler and beam pipe, because the monitor port flange blocked the welding points. By new design, we could weld monitor port and flange separately from HOM coupler. New design will have an easy preparation of welding.

Also 2 cavities were welded at all equator lines in succession by vertical position without purge of vacuum chamber as shown figure 4. We could reduce the total EBW time and welding cost. New design and procedure will give an advantage for mass production.

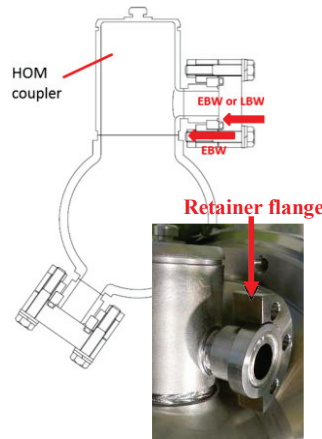


Figure 3: Retainer flange for monitor port.



Figure 4: Welding 2 cavities in one batch.

FABRICATION OF STF #27-30

MHI start to fabricate of STF #27-30 Cavities. The design of monitor port flange will be the same design as #23-26 cavities.

We will weld 4 cavities in one batch after verification. Fig. 5 and 6 show about the checking of cavity setting. This procedure will make still shorter welding time.

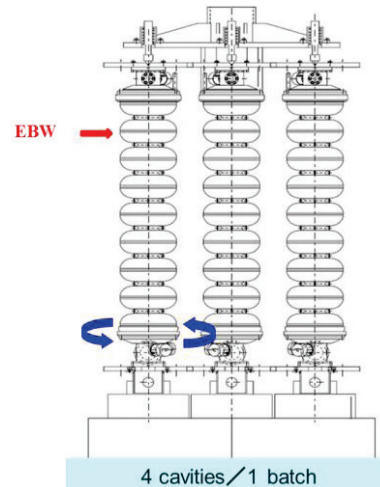


Figure 5: Welding 4 cavities in one batch.

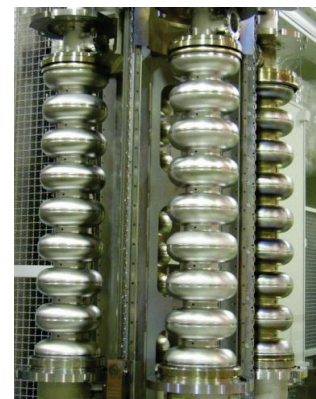


Figure 6: Setting of 4 cavities welding

IMPROVEMENT UNDER DEVELOPING AND PROPOSAL

We are developing some improvement and we have some proposals for cost reduction as below.

Combinaison of Pick-up Port and Flange

To reduce the number of parts for cost reduction, combination of pick up port and flange is under consideration as shown figure 7. In case of present status it needs 2 pieces and 2 welding line per a port. In case of this proposal it needs only 1 piece and welding line per a port. So it can reduce 3 parts per cavity and can reduce 3 welding line per cavity. We need to change port material for hardness (e.g. low RRR Nb) and need to test for the influence of EP.

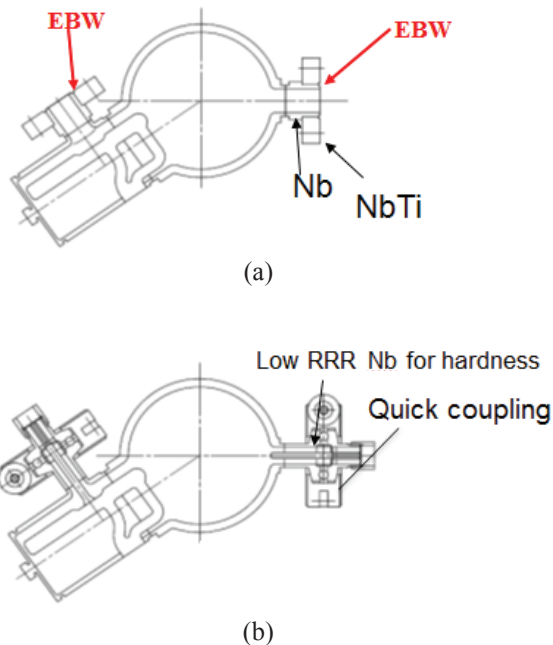


Figure 7: Combination of pick up port and flange (a) Present status, (b) Proposal.

ACTIVITIES OF CRYOMODULE

MHI produced some SRF cryomodules for superconducting RF cavities.

In recent production, we produced two kinds of cryomodules for c-ERL project at KEK. The cryostat of c-ERL injector (fig. 8) was installed three 2-cell cavities [6]. The cryostat of c-ERL main linac (fig. 9) was installed two 9-cell cavities and three HOM dampers in it. Driving temperature of these cryomodules is 2 K, and these cryomodules are governing high pressure safety law in japan.

The SRF cryomodule is under fabrication. Eight 9-cell cavities with jacket are installed at KEK. These experience will be turned to advantage for the fabrication and assembling of ILC cryomodules.



Figure 8: Cryomodule for c-ERL injector



Figure 9: Cryomodule for c-ERL main linac

CONCLUSION

- We have improved the quality of cavity step by step and almost achieved the ILC spec.
- We have reduced the cost and shorten the delivery time by changing the design and improving the productivity step by step.
- We keep to propose and verify various improvements steadily in according with general principle of cost reduction for realizing ILC as an industry.

AKNOWLEDGMENT

Special thanks to E. Kako, K. Watanabe, S. Noguchi, T. Shishido, Y. Yamamoto, T. Furuya at KEK for this paper.

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