SRF ACTIVITIES FOR ILC AT MHI

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Abstract

MHI has supplied 1.3 GHz superconducting cavities for the ERL (Energy Recovery Linac) project and the ILC R&D project (STF: Superconducting RF Test Facility in KEK) to KEK in Japan for a number of years. We are gradually improving the technology to design and fabricate the superconducting cavities for ILC R&D. We designed and fabricated nine STF-Baseline 9-cell cavities. We have improved the quality and productivity of the SRF activities for ILC. The status of superconducting cavity development for ILC at MHI is described in this paper.

INTRODUCTION

STF (Superconducting RF Test Facility) is under construction at KEK. MHI designed and fabricated nine superconducting RF cavities for STF. Four of these cavities have finished the cryomodule tests at KEK. [1] The five other cavities are undergoing surface treatment and vertical tests at KEK. [2] The recent three cavities fabricated at MHI are shown in fig.1.

Figure 1: The STF 1.5B-type cavities (#7-#9) fabricated at MHI in March 2009.

PRODUCTION LIST OF SUPERCONDUCTING CAVITY

We have fabricated various types of superconducting cavities since 1977 as shown in table 1. We have supplied 1.3 GHz superconducting cavities for the last few years, and we have obtained valuable technology and know-how.

Table 1: Production List of the Superconducting Cavities

Project	Customer	Production year	Frequency (MHz)	Cell-number	Quantity	Operating temperature (K)	E_{acc} max at vertical test (MV/m)	Q_0 at operating (final) E_{acc}
TRISTAN	KEK	1977-1989	508	5	36	4	6 to 12	2×10^9
L-band R&D	KEK	1991-1998	1300	9	1	2	12	3×10^9
	-			3	1		24.4	8.4×10^9
	KEK/-			1	4		12 to 30	4×10^9
	-			1	1		24.5	3×10^9
KEKB R&D	-	1993-1994	508	1	1	4	14.4	9×10^8
Crab	KEK	2004-2006	508	1	2	4	29.1 to 42 (E_{peak})	1.5×10^9
ADS R&D	JAEA	2002-2004	972	9	2	2	10.5 to 11.1	1.5×10^{10}
STF Phase1	KEK	2005	1300	9	4	2	20.2 to 29.4	2×10^{10}
ERL R&D	KEK	2006	1300	1	2	2	31	9×10^9
		2007		9	1		15 (under testing)	2×10^9
		2007		2	1		30.1	4.8×10^9
		2008		2	1		under testing	
STF Phase1.5	KEK	2007	1300	9	2	2	27 (under testing)	6×10^9
		2008			3		under testing	

FEATURE OF STF 1.0-TYPE CAVITY

Motivation

The motivation for developing the STF 1.0-type cavity was to establish a cavity package design with a jacket and frequency tuner that could decrease Lorentz detuning. [3]

Result

One cavity achieved Eacc=29MV/m and other three cavities achieved Eacc=20MV/m in the vertical tests at KEK. [4] The cavity packages confirmed the compensation for Lorentz detuning by rigid jacket and piezo tuner. [5] [6]

FEATURE OF STF 1.5A-TYPE CAVITY

Motivation

The motivation for developing the STF 1.5A-type cavity (for S1 Global) was to improve upon the cavity performance of the STF 1.0-Type cavity. To improve the cavity performance, we improved the cleanliness of the welding groove and the smoothness of the welding bead. [7]

Result

Cavity performance was enhanced at the first surface preparation and the vertical test, in comparison with the STF 1.0-Type cavity, as shown by the KEK vertical test in fig.2. These two cavities will be given additional surface treatment and vertical testing at KEK.

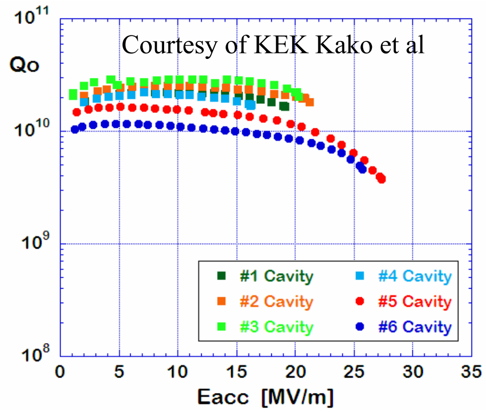

Figure 2: Q-E curve at the first vertical test of the STF 1.5A-type cavities (#5, #6) compared with STF 1.0-type cavities (#1-#4) by KEK.

FEATURE OF STF 1.5B-TYPE CAVITY

Motivation

The motivation for developing the STF 1.5B-type cavity (for S1 Global) was to improve upon the cavity performance of the STF 1.5A-Type cavity and improve the productivity of the end-group. To improve the cavity performance, we improved the welding condition at the junction of the equator. We chose a stable condition against the distribution of the niobium thickness. To improve the productivity of the end-group, we fabricated the outer conductor of the HOM coupler, beam tube and baseplate utilizing a forming technique.

Result

These cavities are visually inspected by CCD camera in preparation for the vertical test at KEK. [8] After the measurement, they will be dressed with a titanium jacket for the S1-Global horizontal test.

The end-groups of these cavities were fabricated as described below:

- <u>HOM coupler</u>: Inner conductor design of the HOM coupler was simplified as shown in Fig. 3. The stub thickness was changed along with the antenna. The outer conductor was formed by deep drawing from niobium sheet and bulge forming in place of machining as shown in Fig.4.

Figure 3: The inner conductor of the HOM coupler for STF1.5A (left) and STF1.5B (right).

Figure 4: The outer conductor of the HOM coupler for STF1.5A (left) and STF1.5B (right).

- <u>Beam tube</u>: The beam tube of more than 5mm thickness formed by deep drawing from a niobium sheet and bulge forming in place of machining as shown in Fig.5.

Figure 5: The beam tube for STF1.5A (left) and STF1.5B (right).

- <u>Input port</u>: The input port was formed by deep drawing from niobium sheet in place of machining with beam tube. The input port has to support the self-load of the input coupler so that the required thickness of the port is around 3 mm.
- <u>Baseplate</u>: The baseplate of more than 20mm thickness was formed by pressing from a titanium sheet in place of machining from forging material.
- NbTi Flange: An SRF cavity has six NbTi flanges. These flanges were changed at the joining point by the butt welding as shown in Fig.6. The newly designed flanges have the advantage of sealing chemicals during the electro-polishing, but have the disadvantage of lesser mechanical strength. The flanges must be welded more deeply, or else the back of the flanges must be welded as well as the front, or the thickness of the niobium beam tubes must be increased.

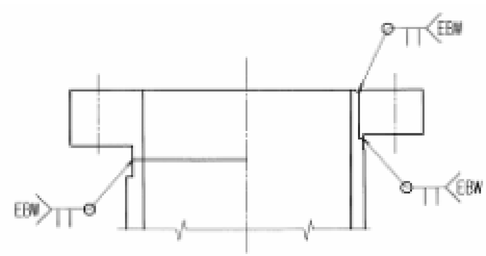

Figure 6: The NbTi flange for STF1.5A (left) and STF1.5B (right).

IMPROVEMENT FROM STF 1.5B-TYPE CAVITY TO STF 1.5C-TYPE CAVITY AND STF2.0-TYPE CAVITY

The next goal after achieving a stable cavity performance is to improve productivity and to fabricate cavities by conforming to the high pressure gas safety law in Japan for beam testing.

STF1.5C-Type Cavity (for S0 Program)

We are proposing to KEK a step welding groove shape like a European cavity based on our principal welding test to reduce assembling time before EBW. The chamfering inside at the equator is not needed because the welding condition against the distribution of the thickness is stable.

STF2.0-Type Cavity

The SRF cavity conforms to the high pressure gas safety law for beam operation in Japan. Now we are designing details and considering how to inspect the cavity quality in order to conform to the law.

SOME R&D FOR ILC

A lot of research and development is needed to realize the ILC project from the viewpoint of cavity productivity.

Welding

We should try to reduce the welding time described below for example:

- Flange joints and stiffener joints: We are developing joints with flanges and beam tubes and a joint with stiffener and a half-cell by using laser beam welding (LBW) rather than electron beam welding (EBW) as shown in Fig.7. We are advancing the basic welding tests for adapting to the stiffener and NbTi flange. The LBW has the advantage of a shorter cooling time after welding, in comparison with EBW and the cost of the equipments.

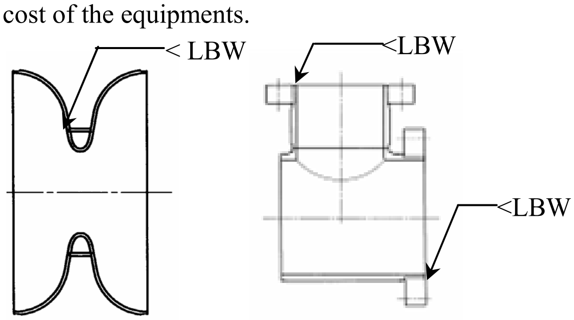

Figure 7: The procedure for joining the stiffener and half-cell by LBW for ILC proposal.

Inspection and Finishing

We should try to reduce the inspection time and the finishing time as described below:

- Inspection: We should decrease the inspection time while guaranteeing quality and safety. We should consider the items of the inspection, the frequency and the judgement standard.
- Finishing: It takes much time to finish the inner surface of the cell to remove small defects or pits. Finishing should be done automatically with a robotic finisher.

CONCLUSION

- We have supplied some 1.3GHz superconducting cavities for STF and ERL projects at KEK for a number of years. We are improving the technology to design and fabricate the superconducting cavities for ILC R&D.
- We could approximately establish the cavity package design with jacket and frequency tuner in order to decrease Lorentz detuning at STF1.0 project.
- We fabricated five STF 1.5-type cavities superior in performance to the STF 1.0-type cavities. The vertical tests for these cavities are being undertaken at KEK.
- Some ideas to improve productivity for ILC R&D were proposed. KEK is preparing some R&D and application for high pressure gas safety law.
- We have some ideas to improve productivity for ILC. We propose using LBW joints instead of EBW joints for those parts that have little influence on cavity performance.

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