DESIGN AND FABRICATION OF SUPERCONDUCTING CAVITIES FOR STF

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Abstract

We (MHI) designed and fabricated four STF-Baseline superconducting cavities with frequency tuners, helium jackets by the instruction of KEK . To decrease a cavity deformation due to Lorenz force, Jacket systems including tuner were designed rigid. By fabricating four cavities, some problems to the next step are cleared. The experience of the fabrication of STF cavities make us recognized the importance of improving technology to realize ILC.

INTRODUCTION

Construction of STF (Superconducting RF Test Facility) is being carried out at KEK. We MHI designed and fabricated four superconducting RF cavities for STF.

After the vertical test at KEK, the cavities were assembled the titanium jacket with bellows in our factory. Presently, assembling of the 6 m cryomodule including one of four STF-Baseline cavities had completed for the cooling test at KEK. Design and fabrication of the STF-Baseline cavity is described in this paper.

DESIGN OF STF BASELINE CAVITY

A STF baseline cavity system consists of a 9-cell niobium cavity, a titanium jacket, a frequency tuner and a magnetic shield. The main feature and dimension of the STF baseline cavity is shown fig.1.

Specificaion of STFBaseline cavity

The main specification of STF baseline cavity is as shown in table.1. To decrease Lorentz detuning, jacket systems including tuner were designed rigid. The jacket stiffness was designed about 25 times as large as the cavity stiffness.

To be rigid a jacket system, some modifications of TESLA cavity are summarised as follows: (shown in fig.2)

- Thick titanium baseplates.
- Thick beam tube by machining from the ingot.
- Thick bellows flange.
- Thick jacket body.
- Rigid frequency tuner system.

As a result of the improved jacket system, the stiffness is calculated at 72 kN/mm. Therefore, the Lorenz detuning is calculated at -550Hz in operation at 31.5 MV/m.

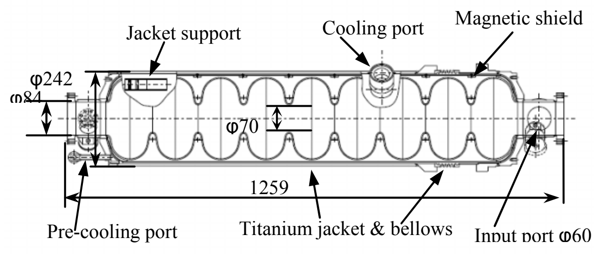

Figure 1: The STF baseline cavity with jacket.

Table 1: Specification and design value of the STF baseline cavity.

-	KEK Specification	Designed value or calculated value
Nb sheet thickness	Center-cell:2.8mm End-cell:3.5mm	-
Iris, equator thickness	-	2.5mm
Cavity stiffness	3,500N/mm	3,000N/mm
Jacket Stiffness with tuner	90 kN/mm	72 kN/mm
Lorentz Detuning at 31.5 MV/m	- 600 Hz	~- 550 Hz
Magnetic shield	Inside a jacket	-

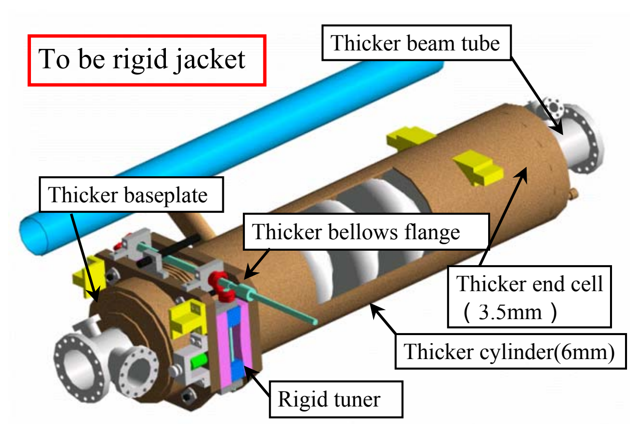

Figure 2: Design of the STF baseline cavity to be rigid jacket.

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Helium jacket stiffness

The stiffness of the jacket system refers to Lorentz detuning directly as shown Fig.3. The value is depend on the cavity shape and thickness.

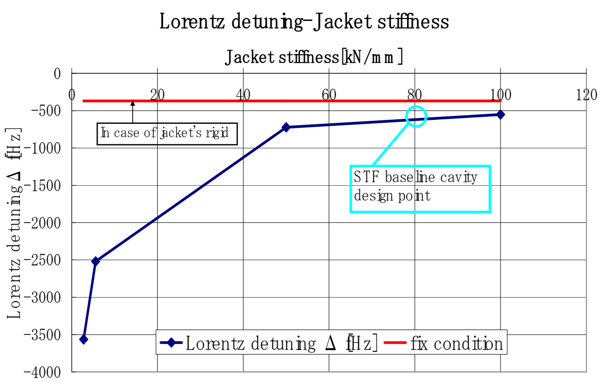

Figure 3: The relations between Lorentz detuning and jacket stiffness

Frequency Tuner

A slide-jack tuner system (see Fig.4) based on the concept from KEK was developed for the STF-Baseline cavities. A stepping motor outside of the vacuum vessel drive the tuner shaft. All parts are designed in oil-free condition by considering of the operation at 2K.

Figure 4: The frequency tuner with test stand

FABRICATION OF STF BASELINE CAVITY

Fabrication flow

Fabrication flow is as follows,

<u>Center-parts: as shown in fig.5 left</u>

- Center-cell pressing and trimming chemical polishing
- Stiffener pressing and machining
- Dumbbell electron beam welding
- Multi-dumbbell electron beam welding

<u>End-parts: as shown in fig.5 right</u>

- End-cell pressing, trimming and chemical polishing
- HOM coupler machining and electron beam welding
- Beam tube machining, electron beam welding flange and HOM coupler and chemical polishing
- Baseplate electron beam welding at KEK and machining and chemical polishing
- Assembling end-cell, magnetic shield cap, baseplate, beam tube

Figure 5: Center-parts (left) and End-parts (right) of the STF cavity

<u>Assembling:</u>

- Assembling center-parts and end-parts
- He leak test and dimension test

After the inspection in the factory, the cavity is transported to KEK with jig. Surfaces preparations at KEK are as follows, [1]:

- Barrel polishing
- Electron polishing 1
- Annealing
- Pre-tuning
- Electron polishing2
- Hot water rinsing
- High pressure rinsing
- Baking
- Vertical test

Dressing of the He Jacket

After the vertical tests, the four cavities were transported to our factory with filling Ar gas inside of the cavities from KEK. After covering the magnetic shield outside the cavities, the titanium jackets with bellows were dressed by TIG welding, as shown in Fig.6. The bellows are restricted by four shafts with ball bearings.

Figure 6: Before and after welding of a helium jacket. A magnetic shield (centre in left) was inside of a helium jacket.

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After dressing of the helium jacket, the four cavities were transported to KEK. And one of the four cavities was mounted frequency tuner and input coupler, as shown in Fig.7.

Figure 7: The STF cavity with jacket, tuner, input coupler at KEK

Dimension Inspection

Dimension inspections of four cavities were carried out as weld and after pre-tuning. The results are as shown in Fig.8. The No.1 cavity as weld shifts over 4mm as reference of the input-side baseplate. This caused from kinking in the welding at the input-side baseplate. The other cavities shift within 2mm both as weld and after pre-tuning.

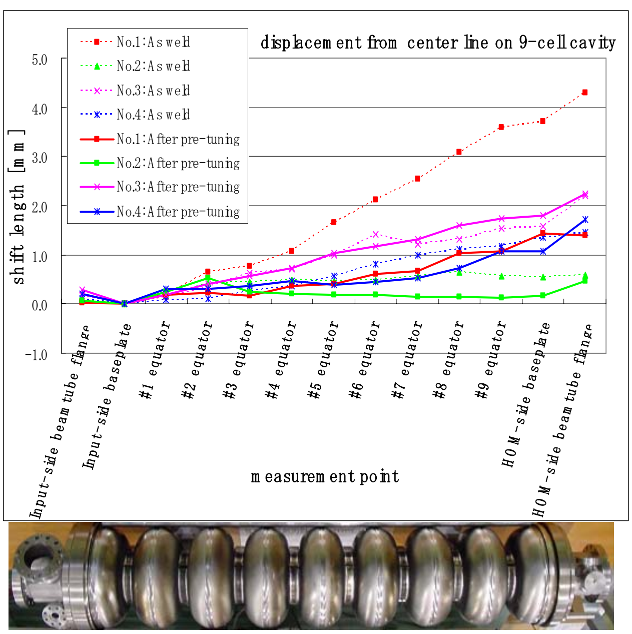

Figure 8: Dimension Inspection as weld and after pre-tuning.

Some problem at fabrication of STF cavity

There are some problems as following under the fabrication of STF cavity.

- Design ; Some parts (HOM coupler, beam tube) needed brushing up by hand.
- EBW ; Quality of inner welding beads are not smooth.
- Environment ; More clean area in assembling the cavity before EBW are needed.
- Cleanness ; The parts of the cavity were not frequently treated by chemical polish.

MASS PRODUCTION FOR ILC

We have to consider about Quality, Cost, Delivery time at the same time in mass production. We expect ILC to discuss QCD in the viewpoint of following as,

- Quality ; What ILC make us guaranteed, performance (Eacc, Q)?
- Cost ; ILC have to reduce the cost not only production but also surface treatment and vertical test.
- Delivery time ; ILC should realize the realistic delivery time of the material (Nb, Ti) and capacity of the production facility and the treatment and test facility.

We continue to consider about the following idea to improve QCD, how can we realize these methods.

- Decrease of welding line
- Other welding method
- Other material flange
- Decrease of pre-tuning
- No annealing
- No barrel polishing (European has already done)

CONCLUSION

- We designed and fabricated four STF baseline cavities. And all cavities have done vertical test at KEK. The performance of the cavities have reached to Eacc 20 ~ 29MV/m.
- We recognized what we should do the next step by fabricating four STF baseline cavities.
- In manufacturing fifty to one hundred cavities, we will catch up the quality of European cavity.
- We need to improve our technologies to realize ILC.

AKNOWLEDGEMENT

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REFERENCES

[1] E. Kako , et al., "CONSTRUCTION OF THE BASELINE SC CAVITY SYSTEM FOR STF AT KEK", PAC'07, Albuquerque, New Mexico, USA, (2007)

