DEVELOPMENT ON SUPERCONDUCTING CAVITIES AT SHI

Yuji.Matsubara Hajime.Saito Masaki.Hirose

H.Inoue M.Ono S.Noguchi* K. Saito* T.Shishido

Sumitomo Heavy Industries,ltd.(SHI)

2-1-1, YATO-CHO, TANASHI-CITY, TOKYO 188 JAPAN

** High Energy accelerator research organization (KEK)*

1-1, OHO, TSUKUBA-SHI, IBARAKI-KEN, 305 JAPAN

ABSTRACT

Developments on superconducting cavities have been started in 1997 under the collaboration with KEK, to learn many know-hows in this field . We fabricated a single cell L-band cavity, made surface treatment and tested. After several trials, the high gradient of over 30 MV/m is obtained on our cavity. In this paper we will report the results of the measurement on this cavity and activities at Sumitomo heavy industries, ltd .

1. Introduction

Our plan to establish the technology necessary for superconducting cavities is as follows.

First step : fabricating a single cell L-band cavity, making surface treatment and testing it to learn many know-hows in this field.

Second step: fabricating multi-cell cavities by own technics.

Third step: design and fabrication of the cryo-module .

The first step has been almost completed. Besides the general study, the special purpose in the present study was to see the change of the maximum accelerating gradient with increased surface removal by electropolishing. With the total removal of 150μ on the average in the cavity, the maximum gradient of 32MV/m was achieved.

2.Fabrication and surface treatment ,

The dimension of L-band cavities is shown in Fig.-1. The cavity is made by welding hydroformed half-cells from 2.5mm thick niobium sheet. It consists of two flanges, two half-cells and two beam tubes. The residual resistance ratio of each parts was 80, 180, 180 (supplied by Tokyo Denkai, ltd.) . As for the surface treatment of Nb cavities, an extensive study is being curried out in KEK, and the high gradient of over 30 MV/m is obtained repeatedly. It is found that the surface removal of about 100 μ on the average and the final treatment with E.P by about 30 μ are necessary to attain the high accelerating gradient over 30 MV/m in the cavities made from niobium of RRR=200.

So the following procedures are candidates of standard treatment in KEK.

Barrel polishing (***B.P***1:100) with light chemical polishing:

or heavy Chemical polishing (***CP)***

Electropolishing(***EP***2:30)

+Annealing(700800deg.)

High Pressure water Rinsing: ***HPR***3.

The choice of two possibility in the first step should be done by taking in to account costs, mass productivity, safety problem and so on.

The necessity of heavy removal of upper most surface and the dependence of the maximum accelerating gradients on an amount of removed thickness are studied by Dr. P. Kneisel using CP.

Although EP is not necessary for heavy removal of the first step, it is very interesting to repeat the above experiment by EP and to compare it with CP results.

Before EP, light CP of ~20was performed to prevent contamination of EP solution. Heat treatment might be not necessary in this experiment , but the cavity was heat treated at 760deg. for 5 hours (Fig.-2) to see how Q-disease by hydrogen absorption appears with increasing amount of EP. EP was performed with a step of 30and followed by HPR. Then the cavity was assembled with an input coupler and an momitor coupler in a class 10 clean room. The cavity was evacuated by turbo molecular pump and ion pump to 10^{9} torr with light baking(about 90deg.) for one to two days.

3. Measurement(vertical test)

In cold tests, we measured residual resistance (R_{res}) by fitting the temperature dependence of surface resistance (Rs) and Q dependence on Eacc at about 1.8 K. The results are shown in Fig.-3 (a),(b),(c) and summarized as follows.

.1st try:(total removed thickness : 50)

Chemistry:

CP(20)annealing(760 deg.hr)EP(30)HPR(75 kgf/cm^2).

X-ray was observed from about 3 MV/m. After 1st. measurement, we inspected inner surface of the cavity, and found out a lot of irregularities like pits (see Fig. 4). We think that chemical residue might be in these pits, resulting in such a heavy field emission.

.2nd try : (total removed thickness : 80)

After 1st. try , added EP(30)HPR

These pits did not vanish from the surface by 2nd. chemistry. The accelerating gradient was limited at 18.3 MV/m by thermal breakdown.

.3rd try : (total removed thickness : 110)

After 2nd. try , added EP(30)HPR

The pits still remained but the accelerating gradient of 22.3MV/m was achieved after RF processing. At the maximum gradient, the cavity showed self-pulsing .

. 4th. try : (total removed thickness : 140)

After 3rd. try, added EP(30)HPR

After EP, we found out the etched surface on our cavity due to bad EP condition. We were very interested in the cavity performance. But unfortunately we could not measured the cavity, because of vacuum leakage in liquid helium..

. 5th. try : (total removed thickness : 150)

After 4th. try , the cavity was exposed on air in a class 10 clean. Three months later ,the cavity was treated with EP(10) and HPR.

The surface was looked like extremely smooth. On the other hand, the pits on the surface became bigger and more than before (we did not expect good performance). The cavity showed the performance of high gradient over 30MV/m. X-ray was observed from 16 MV/m, same as 3rd try. From the plot of X-ray intensity vs. E_{peak} , it seems that it must be field emission.

5. Summary

We have learned a fabrication method and characterization method of niobium cavities . The cavity has many pits always in the experiments. However the maximum gradient of 32MV/m has been achieved by the surface removal of 150m on the average. The necessity of heavy removal has been demonstrated in the case of EP also (Fig.-3 (b)), and the superiority of EP has been confirmed. Although the cavity was not intentionally kept at dangerous temperature for hydrogen Q_deseas, seriously Q_deseas was not observed even after EP of 130 m(Fig_3 (c)).

Acknowledgment

The authors would like to thank Mr. H. Kitamura at Mitubish Electric Corporation, and Miss. T. Ota at Toshiba Corporation and Mr. M.Shiratake at Nomura Techno Research Co. Ltd. for this discussion and their support.

References

1 Tamawo Higuch, et. al, ;Proc. 22th Linear Accelerator Meeting in Japan, Tokyo, 1997, p.113-115.

2 Kenji SAITO, Yuzo KOJIMA, et. al,; Proc.4th Workshop on RF Superconductivity, 644-653.

3 K.SAITO, T.HIGUCHI, et. al,; Proc. 7th Workshop on RF Superconductivity

4 E.Mahner, P.Kneisel, N.Pupeter, G.Müller ; 7th Workshop on RF Superconductivity

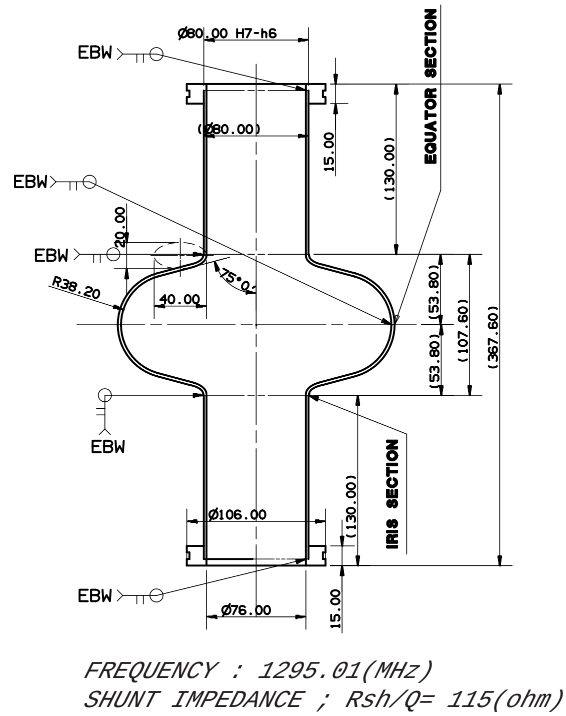

Fig-1.Dimension of L-band sing.

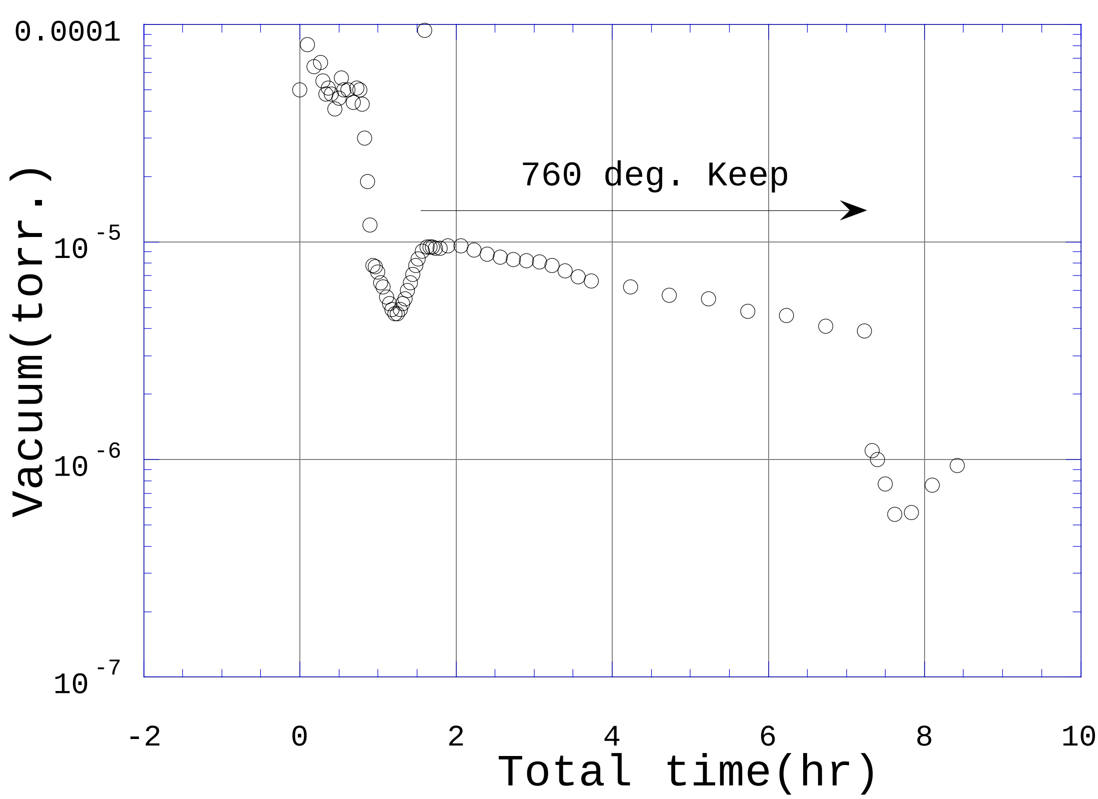

Fig. 2. Annealing condition of cavity.

a)
b)
c)

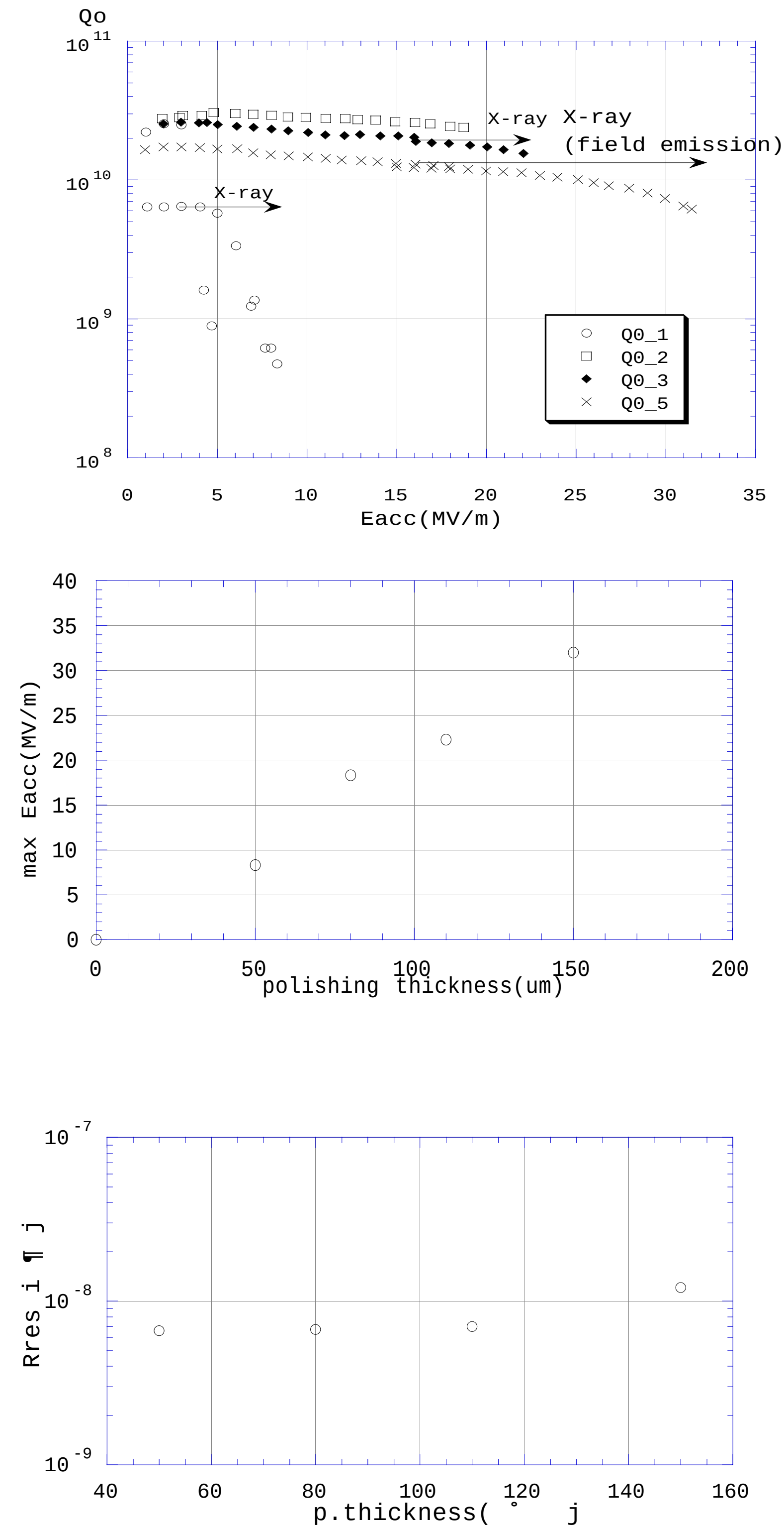

Fig.3 Measurement results

A) cavity performance Qo vs Eacc.
B) Maximum Eacc vs. Polishing thickness
C) Residual surface resistance vs.Polishing thickness

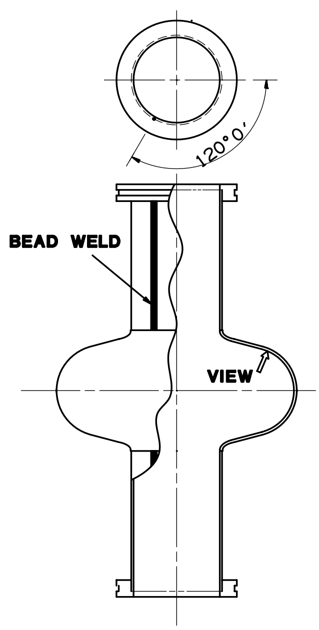

Fig 4 Inspection of pits of our cavity

This pit is most biggest comparde with others. The shape was ellipse and major dimension was about 600 μ m At first inspection.