# DEEP DRAWING EXPERIENCES OF NIOBIUM DISK FOR PEFP SRF CAVITY PROTOTYPE

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## 1. Introduction

A superconducting radio frequency (SRF) cavity with a geometrical beta of 0.42 has been designed to accelerate a proton beam after 100 MeV for an extension of Proton Engineering Frontier Project (PEFP). The designed cavity shape is an elliptical and the resonant frequency is 700 MHz. In order to confirm the RF and mechanical properties of the cavity, two prototypes of copper cavities have been fabricated and tested [1, 2]. Based on the experiences gained with the copper prototypes, two niobium prototypes have been designed. One is two-cell cavity and the other is five-cell cavity. The two-cell cavity is for finalizing the niobium cavity production procedure and testing the cavity RF properties at a low temperature and moderate power level. The five-cell cavity is for checking the production quality and testing vertical test system in the future. Both of them are under fabrication. Through the fabrication of the niobium prototype, several issues such as deep drawing, electron beam welding and surface treatment will be addressed.

The drawing of the PEPF SRF low beta cavity is shown in Fig. 1. Major parameters for the cavity are like following [3].

- Frequency: 700 MHz
- Operating mode: TM010 pi mode
- Cavity type: Elliptical
- Geometrical beta: 0.42
- Number of cells: 5 per cavity
- Accelerating gradient: 8 MV/m
- Epeak/Eacc: 3.71
- Bpeak/Eacc: 7.47 mT/(MV/m)
- R/Q: 102.3 ohm
- Epeak: 29.68 MV/m
- Field flatness: 1.56 %
- Cell to cell coupling: 1.41 %
- Geometrical factor: 121.68 ohm
- Cavity wall thickness: 4.3 mm
- Lorentz force detuning: 0.4 Hz/(MV/m)$^2$
- Stiffening structure: Double ring
- Effective length: 0.45 m
- External Q of FPC: 8.0E5 ±20 %
- HOM load: less than 2 W
- HOM Qext requirement: less than 3.0E5

At present, all the niobium disk and plates for cavity and NbTi flanges for beam pipe flange are prepared.

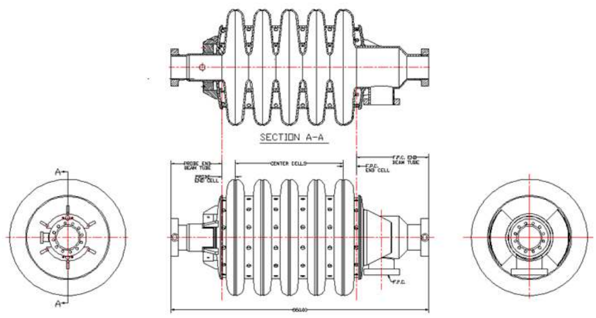


Figure 1. Drawing for PEFP SRF low beta cavity.

## 2. Deep Drawing Process

First we check the microstructure of the RRR grade niobium disk as shown in Fig. 2. The grain size is estimated about 75 um, which is not far from the optimum grain size of about 50 um for deep drawing [4]. We used 300 ton press machine for deep drawing and the dies used for fabricating the copper prototype are reused without modification. When we stamped the first half-cell, the raw half-cell was broken at iris part as shown in Fig. 3. This phenomenon was not observed during copper test and this means that the mechanical properties of the niobium are not the same as those of copper. A possible cause of this breaking is small size of the central hole. We increased the central hole size and obtained the ideal half-cell as shown in Fig. 4.

We also found same problem when we tried to press the beam-pipe transition part as shown in Fig. 5. We tested several copper specimens changing the central hole size and outer diameter and found that the outer diameter is critical factor as well as a central hole size.

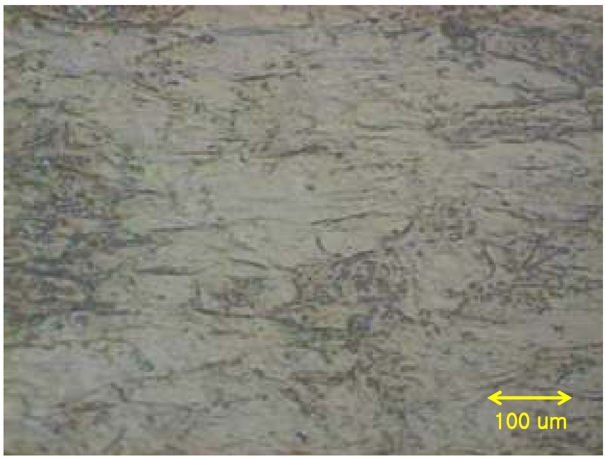


Figure 2. Microstructure of niobium raw material.

Figure 3. Broken part of half-cell during deep drawing.

Figure 4. Half-cell after deep drawing.

Figure 5. Broken part of beam-pipe transition.

In addition, we annealed the niobium disk following the recommendation provided by the niobium disk manufacturer. The annealing condition was 850 degree centigrade for two hours in high vacuum environment. We could obtain the beam-pipe transition part with a desired shape after taking those measures. Figure 6 shows the niobium transition part along with copper specimens. In Fig. 6, the different deformation patterns between the niobium and copper are clearly shown.

Figure 6. Beam-pipe transition part after deep drawing.

## 3. Conclusion and Future Work

We performed the deep drawing process using the niobium disk to make a half-cell and beam-pipe transition part. During the deep drawing process, we found that the mechanical properties are quite different from those of copper. The central hole size and outer diameter of the disk are important for successful deep drawing and the optimum values should be determined by testing the specimens. In addition, the annealing at 850 degree centigrade under vacuum condition can be effective way for deep drawing of the niobium disk.

After deep drawing, several steps should be taken such as iris trimming, surface cleaning and electron beam welding to make a dumbbell. The niobium prototype cavity will be assembled by electron beam welding after dumbbell tuning.

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