DTL FABRICATION STATUS OF PEFP LINAC*

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Abstract

The fabrication of the 20 MeV DTL tank1 is finished and the preparation for the vacuum test is proceed. A tank is divided into two sections and 50 DTs will be installed on first tank. We plated copper on inner surface of the carbon steel pipe using the PR plating method. All dimensions were compensated during the fabrication for the tank temperature. In this report, we will discuss the fabrication processes and problems.

INTRODUCTION

The PEFP (proton engineering frontier project) proton accelerator is under construction at KAERI (Korea Atomic Energy Research Institute) site for basic researches and industrial applications. In the 1st phase of the project we're plan to complete the system for acceleration to 20 MeV. The maximum beam current is 20 mA with maximum 24 % duty factor, for satisfying the various beam users. The accelerator consists of 50keV, 30 mA proton source, 3 MeV, 350 MHz RFQ and 20 MeV, 350 MHz Alvarez-type DTL [1]. Now we're beam testing the RFQ, and the construction the DTL tank 1 is in progress.

Table 1: PEFP DTL Parameters

Input /Output energy : 3.0 / 20.0 MeV
Beam current : 0 ~ 20 mA
RF frequency : 350 MHz
Peak RF power : 1 MW
Duty factor : Max. 24 %

TANK FABRICATION

The main DTL tank parameters are listed in table 2 which are the results of the Parmila code [2].

Table 2: Tank parameters

Tank	#1	#2	#3	#4
Energy (MeV)	7.18	11.5	15.8	20.0
Length (m)	4.43	4. 65	4.76	4.78
No. of cells	51	39	33	29
Tank dia.(cm)	54.4	54.4	54.4	54.4
RF power(kW)	225	225	224	221

Tank

We divided a DTL tank into two sections and bolted together with RF and vacuum seals for the manufacturing and installation conveniences. Tank must have the high electrical and thermal conductivity to reduce the power loss and to cool the cavity efficiently. Considered these we choose the forged seamless low carbon steel pipe (STPA21). This material has high mechanical strength and high resistance for corrosion.

In tank1, there're 50 stems, 17 post couplers, 5 pick ups, 8 slug tuners, 4 vacuum components and a RF coupler ports. We decided the joining method of these components to bolting to minimize the thermal distortions by welding.

The size and number of cooling channel are 30 mm x 5 mm and 20 ea to cool the tank against the thermal load about 0.8 W/cm^2. The main cooling line is divided into two legs and fed into each of tank sections. The coolant past through the tank wall is fed again for the drift tube and quadrupole magnet cooling.

All size - especially the intervals of stem holes and tank lengths - of the tank was modified to ambient temperature during the machining process to compensate the designed operating temperature, 40°C. We machined the tank in December so that we set the sizes in 10°C. The total length difference is about 750 micron per one section in this temperatureThe fabricated tank is mounted on support struts can move the tank 6 directions.

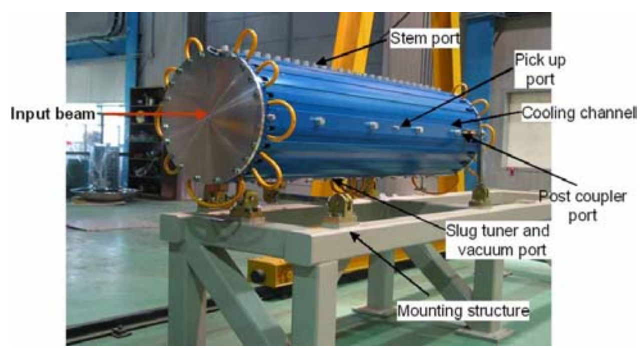

Figure 1: The fabricated DTL tank (1 section)

PR plating

DTL have to operate under UHV range about 10^{-7} mbar to minimize the beam loss. To satisfying this requirement, the tank inner surface – occupying the most system area – must has minimized outgassing rate. And to reduce the RF power loss, the surface passing through 350 MHz is required the finest surface roughness. The designed roughness is Ra 0.3 μm.

The PR (periodic reverse) method is well known copper plating skill satisfying these requirements. We made a plating sample on a pipe having inner diameter 150 mm and length 750 mm. And we got satisfactory results on vacuum outgassing rate about 2.74E-10 mbar L/sec cm^2 and RF quality factor from the sample [4].

Then we tried the PR plating on the DTL tank 1. The first plated tank had several problems (refer to figure 2). First, the plating thickness of every port such as stems and

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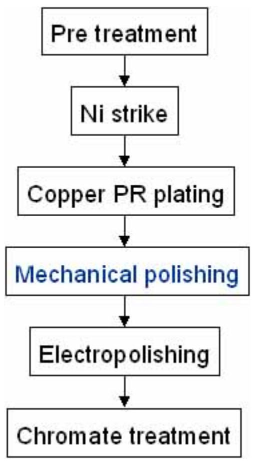
pick ups is only a few microns. In addition to this, the uniformity is also not satisfactory. That's cause to the insufficient plating solution flow on a bath. So we increased the blower capacity. Second, the final surface roughness is not come up to the requirement. And last, the copper bulk was produced in every port edges during the plating. Consider these point, we added the mechanical polishing process before electro-polishing. Accordingly the plating thickness is increased to 300 micron, and then copper surface is polished out about 100 micron. There's no problems on the mechanical polisher material residents on copper surface due to the electro-polishing.

Table 3: PR plating process



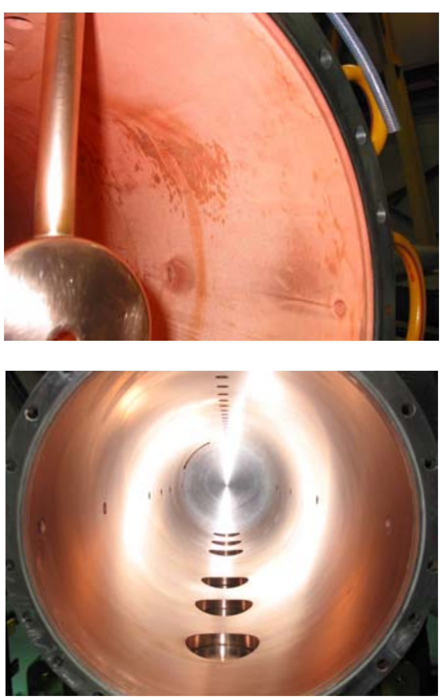


Figure 2: Copper Plated surface : before/after mechanical polishing

Drift tube

The PEFP DTL adopted the pool-type electromagnet as a focusing magnet. The length of the iron-core is 25 mm, so the length of the first drift tube is limited as 55.4 mm [5]. Four pieces of drift tube and the stem are welded together using E-beam. The material is OFHC copper. We designed the drift tube having all same nose cone geometry. The nose cone angle is 10 degree. We fabricated the test sample to test the DT machining and welding technique. The e-beam welding is reliable and the vacuum tightness is confirmed by measuring the He leak rate as under 1E-10 mbar L/sec. In figure 3, the sealing groove scheme of stem is showed.

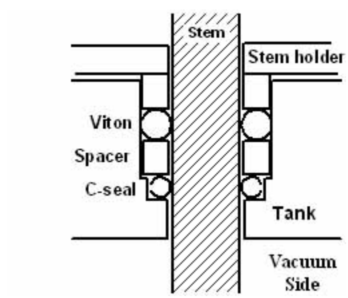


Figure 3: Stem seal groove geometry

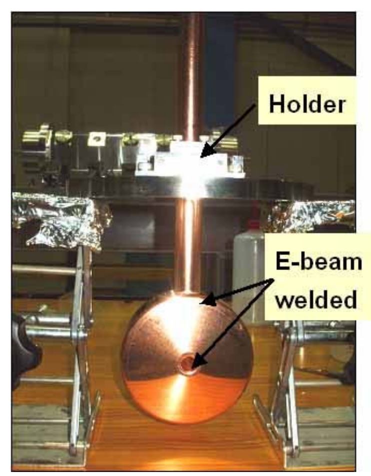


Figure 4: Drift tube sample

We changed the RF seal from canted coil type to Metal C-seal due to the high heat load on these points. The material is silver plated Inconel alloy 718. So that the adjusting the DT to alignment is get more difficult due to the rigidity of the C-seal.

The drift tube must arrayed with ±50 μm error range. The stem holder to adjusting the DTs precisely during the installation is fabricated. It divided into 3 parts, base plate, sustaining the DT part and holder fixing part. The M6 bolts installed to move the DTs in 3 directionally. We installed the DT with seals and confirmed the function of this holder. We could adjust required range and the maximum displacement was ±50 mm in each directions.

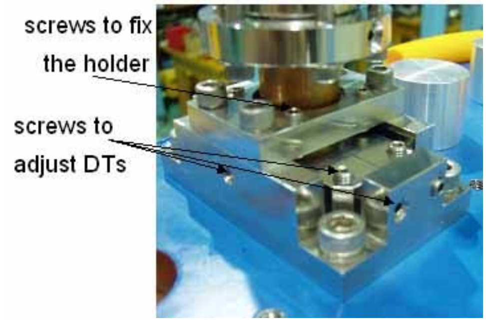


Figure 5: Stem mounting holder

Other components

We first designed to fabricate the vacuum grill adaptor into tank body directly. But this method is not suitable because of the difficult cooling channel machining. So we decided to make the independent grill adaptors and install to the tank. In order to tuning a tank in a range of ±1 MHz, 8 slug tuners of 150 mm diameter will be installed on one tank. The end wall is designed to compensate the half stem effect, and include the independent cooling channel and quadrupole magnet. Every component will be fabricated with OFHC copper and jointed to the tank with vacuum and RF seals.

CONCLUSION

The Physical and the engineering design of PEFP 20 MeV DTL cavity are completed. Now we're fabricating the DTL tank 1. One of the labouring is copper plating on tank surface. We made several test samples and changed the processes and then we get acceptable results. And also we made and tested the drift tube samples. Now we're preparing the installation of tank 1, and fabrication of 2nd, 3rd and 4th tanks. And also we're in progress in engineering design and fabrication of components for tuning such as slug tuner, end wall, post coupler and vacuum grill adaptor.

REFERENCES

[1] J. M. Han, et al., "Development of a low-energy proton accelerator system for the proton engineering frontier project (PEFP)", PAC03, Fortland, USA, May 2003

[2] Y. S. Cho, et al., "Technical Report for PEFP proton accelerator (Phase I : 20MeV) ", PE-x0000-DD-P00x, Sep. 2003

[3] H. Ino, et al., "Advanced copper lining for accelerator components", Proceedings of the XX international Linac conference, Monterey, 2000

[4] M. Y. Park, et al., "The first DTL tank fabrication and development", The 7th workshop on HPPA, Daejon, Korea, Oct. 2003

[5] Y. H. Kim, et al., "Design and pre-test of the quadrupole magnet for PEFP DTL", in this conference.