100 MEV DTL DEVELOPMENT FOR PEFP PROTON LINAC*

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Abstract

A 100 MeV DTL as a main accelerating section of the Proton Engineering Frontier Project (PEFP) proton linac is under development. The PEFP proton linac consists of a 50 keV proton injector based on a duoplasmatron ion source, 3 MeV four-vane RFQ, 20 MeV DTL and 100 MeV DTL. The 100 MeV DTL is composed of 7 tanks and each tank is an assembly of 3 sections. The tank is made of seamless carbon steel and inside surface is electroplated with copper. Each drift tube contains an electroquadrupole magnet (EQM) which is made of hollow conductor and iron yoke with epoxy molding. Following the fabrication of tanks and drift tubes, a precise alignment of drift tubes and field flatness tuning procedure are performed. Currently four DTL tanks out of seven are completed and the rest are under fabrication. The status of development and test results of the fabricated parts are reported in this paper.

INTRODUCTION

The PEFP Proton linac is 100 MeV accelerator which is composed of an injector, 3 MeV RFQ, 20 MeV DTL and 100 MeV DTL. An accelerating section up to 20 MeV is completed and installed in KAERI site [1-4]. The 20 MeV beam is available for the users. The 100 MeV parts are under development. Main parameters of 100 MeV DTL can be found in reference 5.

DTL TANK FABRICATION

Tank Fabrication and Assembly

Each DTL tank is about 6.8 m long and divided into 3 sections for easy machining and copper plating. Each section has four slug tuner ports and two vacuum ports. Copper is plated onto the inside surface of the machined seamless carbon steel pipe by using a periodic reverse method. Three sections are combined into one tank by using bolting method as shown in Fig. 1. Total weight of combined tank is about 5 tons. We used a C-seal and O-ring at the interface between the sections for RF sealing and vacuum sealing respectively.

Drift Tube and EQM Fabrication

Each tank contains drift tubes and an EQM is installed in every drift tube. The stem structure of the drift tube is tri-axial as shown in Fig. 2. Cooling water flows in through the space between the outer stem and middle stem and flows out through the space between the middle stem and inner stem. The space in the inner stem is available for the current lead of the EQM. Outer stem is made of OFHC and the others are made of stainless steel. Drift tube is assembled by using a brazing method and electron beam welding. EQM inside the drift tube is made of hollow copper conductor. We used 5.6 mm by 5.6 mm square conductor with coolant hole. The number of winding is 4.5-turn for each pole and windings are fixed by using epoxy molding. Power consumption of each EQM is estimated about 480 W at 450 A. To prevent the epoxy molded magnet from wetting, we wrapped the magnet with stainless steel casing as shown in Fig. 2.

Before installing the drift tube in the tank, we measured the field gradient of each EQM by using a rotating coil method [6]. A rotating coil measurement system is composed of a rotating coil, a speed adjustable motor to rotate the probe coil, a rotary encoder and data acquisition system. Measurement results for DTL102 are shown in Fig. 3 and Fig. 4. A field gradient deviation among the EQM was less than 1%.

Figure 1: Three-section combined into one tank assembly.

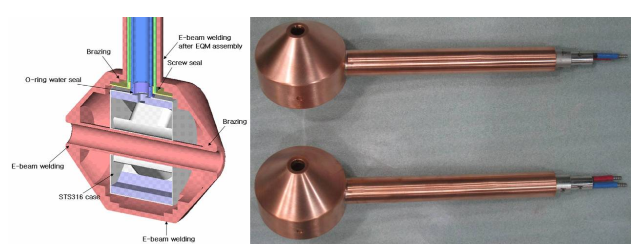

Figure 2: Structure of drift tube and fabricated drift tube.

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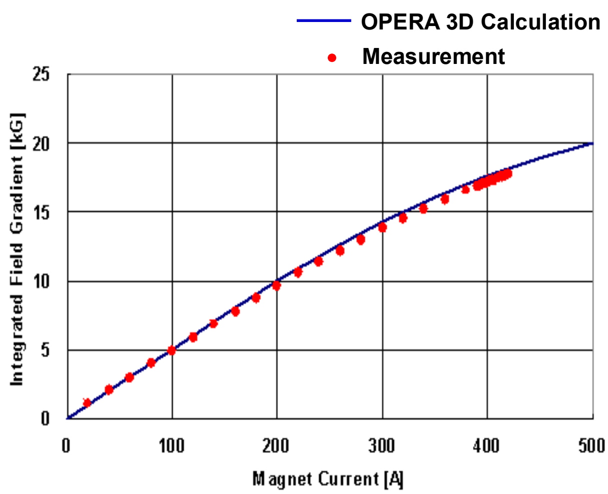

Figure 3: EQM excitation characteristics.

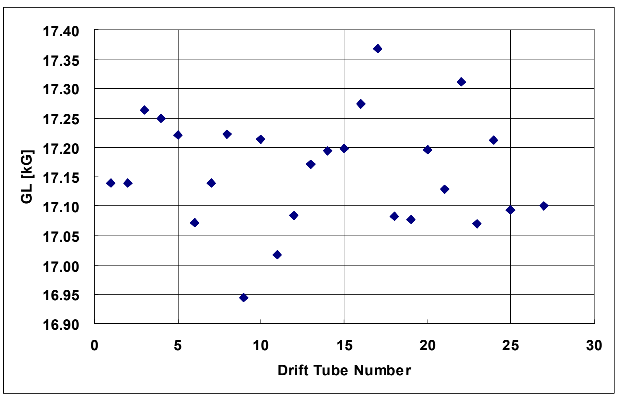

Figure 4: Measured field gradient of EQM for DTL102.

RF POWER COUPLER

For the RF power coupler for 100 MeV DTL, we considered an iris couplers with ridge-loaded waveguide of a quarter-wavelength as shown in Fig. 5. RF power couplers of a half-wavelength ridge-loaded waveguide with iris coupling were used in the 20 MeV DTL. For the 100 MeV DTL we reduced the length of the RF power coupler because of its small size and low multipacting probability in limited space. To check the design and characteristics, we fabricated a aluminium cold model and measured the dependence of the coupling coefficient on the hole size at the end of the iris.

We designed the ridge-loaded waveguide by using the SUPERFISH code to make the impedance of the ridge part same as that of a standard WR2300 rectangular waveguide. The fabricated cold model was mounted on the DTL102 tank to measure the RF properties as shown in Fig. 6. The RF power generated in the RF source is transferred through the waveguide and is coupled to the DTL tank by the iris. The coupling coefficient can be adjusted by changing the size of the coupling holes, which are located at both side of the coupling slot. The optimum beta of 100 MeV DTL tank is about 1.3 considering the beam loading effect and we found out that 16.6 mm diameter hole made required coupling.

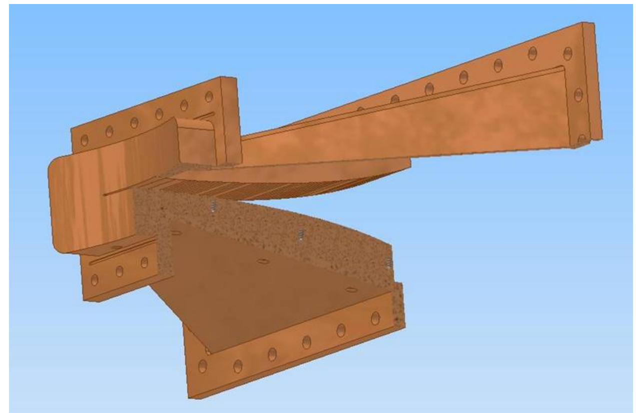

Figure 5: Iris coupler with ridge-loaded waveguide.

Figure 6: RF coupler cold model mounted on DTL.

DRIFT TUBE ALIGNMENT

We have performed the drift tube alignment by using two laser trackers. The alignment scheme is shown in Fig. 7. We mounted two reflectors; one is at the front end of the drift tube and the other is at the rear end of the drift tube. The slug tuner ports were used during installation. By using two laser trackers, the position of the drift tube can be monitored and adjusted in real time. Alignment tolerance is ±50 um in transverse direction and ±100 um in longitudinal direction at the center of EQM installed in the drift tube. The final alignment results for DTL102 are summarized in Fig. 8.

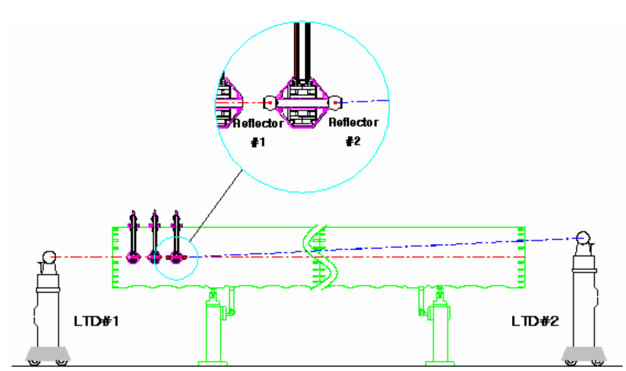

Figure 7: Alignment scheme by using two laser trackers.

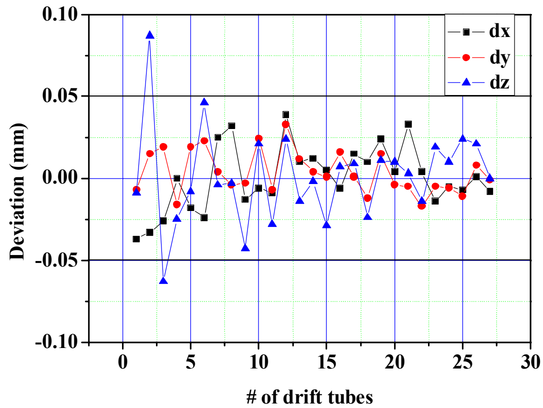

Figure 8: Alignment result for DTL102.

FIELD FLATNESS TUNING

After installing the drift tube in the tank, we have performed the field flatness tuning by using the slug tuners [7]. Each tank has 12 slug tuners and the tuning range is designed to be ±1 MHz. The field flatness requirement is ±2% considering the beam dynamics. To measure the field profile, we used a bead pull method. To minimize the temperature drift effect, the tuning was performed with constant temperature condition which was made by using SCR controlled heating cables around the tank and ambient temperature control. Tank temperature was maintained within ±0.2 ˚C. The field flatness tuning result is summarized in Fig. 9.

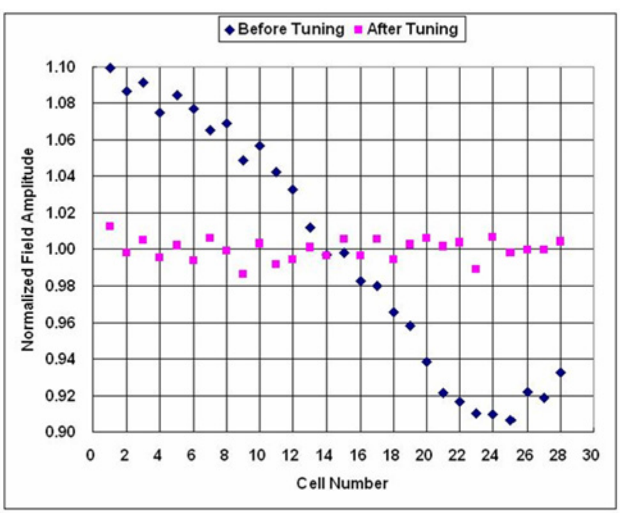

Figure 9: Field flatness tuning results for DTL102.

SUMMARY

Development of 100 MeV DTL is well undergoing. Currently four DTL tanks out of seven are completed and the rest are under fabrication. The electroquadrupoles in the drift tubes were measured by using a rotating coil method to check the field gradient. Drift tubes were aligned by using two laser trackers to meet the required alignment tolerance. Iris type RF power coupler with a quarter-wavelength ridge-loaded waveguide was newly developed and tested. Field flatness tuning was performed after DT installation and could be tuned to meet the field flatness requirements. The rest three tanks of 100 MeV DTL will be fabricated in near future.

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