INITIAL TEST OF THE PEFP 20 MeV DTL*

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Abstract

A conventional 20 MeV drift tube linac (DTL) for the Proton Engineering Frontier Project (PEFP) has been developed as a low energy section of 100 MeV accelerator. The machine consists of four tanks with 152 cells supplied with 900 kW RF power from 350 MHz klystron through the ridge-loaded waveguide coupler. We assembled the fabricated accelerator components and aligned each part with care. We have also prepared the subsystems for the test of the DTL such as RF power delivery system, high voltage DC power supply, vacuum system, cooling system, measurements and control system and so on. The detailed description of the initial test setup and preliminary test results will be given in this paper.

INTRODUCTION

The 100 MeV proton accelerator is under development for the Proton Engineering Frontier Project [1]. The low energy section of the accelerator consists of the ion source, LEBT, RFQ and DTL. The DTL accelerates the proton beam of 20 mA from 3 MeV to 20 MeV for the 1st phase of the project. The input beam for the DTL comes from the RFQ which produces the 3 MeV proton beam of 20 mA from the 50 keV beam of 23 mA.

The 20 MeV DTL is composed of four tanks and driven by single RF source, which causes unique problem with regard to the way of independent resonance control of phase and amplitude of each tank. The details of this problem are treated in another paper presented in this conference [2].

For the test of the DTL, many subsystems such as RF power delivery system, high voltage DC power supply system, vacuum pumping system, cooling system, measurements and control system and so on are required. The description of each subsystem and the current status of the DTL with future planning are included in the following sections.

SYSTEM DESCRIPTIONS

The general layout of the 20 MeV proton accelerator for PEFP is shown in figure 1, which includes the accelerating structures and the RF delivery systems.

DTL Structure

The DTL has been designed and fabricated to accelerate proton beam of 20 mA from 3 MeV to 20 MeV through 4 tanks and each tank is composed of 2 sections [3]. The tank is made of copper plated steel.

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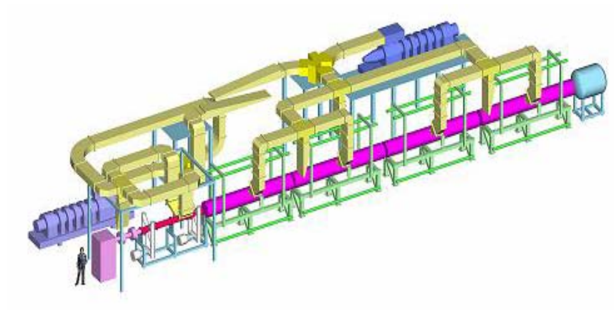

Figure 1: The layout of PEFP 20 MeV accelerator.

The lattice structure is FFDD where every drift tube includes water cooled quadrupole electromagnet. For frequency tuning and field stabilization, each tank has 8 slug tuners and one post coupler for every 3 drift tubes in tank1 and 2 drift tubes in tank 2, 3, 4. The main DTL parameters which are common for 4 tanks are given in table 1.

Table 1: DTL Parameters Common for 4 Tanks

Parameter	Value
Tank diameter [cm]	54.44
Drift tube diameter [cm]	13
Bore radius [cm]	0.7
Drift tube face angle [deg.]	10
Drift tube flat length [cm]	0.3
Corner radius [cm]	0.5
Inner nose radius [cm]	0.2
Outer nose radius [cm]	0.2
Stem diameter [cm]	2.6
Pos coupler diameter [cm]	2.6
Slug tuner diameter [cm]	15
Synchronous phase [deg.]	30
Effective Quad. Length [cm]	3.5
Quad. Gradient [kG/cm]	5.0
Average accelerating field [MV/m]	1.30

High Power RF System

The total required power for 20 MeV DTL is about 900 kW which can be covered with single 1 MW klystron [4]. The RF power from the one 1 MW klystron is split into 4 legs by magic tee to drive 4 DTL tanks simultaneously. Each leg has a phase shifter to adjust the phase of the RF

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field in each tank. From the viewpoint of the construction cost, single RF source for 4 tanks scheme The layout of the text on the page is illustrated in Fig. 1. The schematic of high power RF delivery system is shown in Figure 2 and the required RF power for each tank can be found in table 2.

Table 2: Required RF Power for 20 MeV DTL

Tank number	Copper power	Beam power
1	141.6	83.4
2	138.8	86.2
3	138.3	85.7
4	137.1	83.9
Total	555.8	339.2

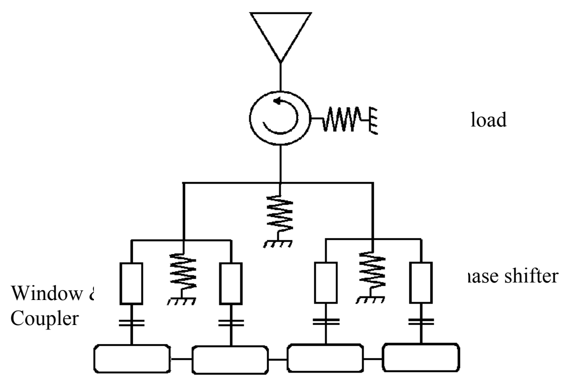

Figure 2: Schematic of RF power delivery system.

RF power is supplied by iris type coupler through ridge-loaded waveguide. Coupling can be adjusted by changing the coupling iris hole size. The coupler is made of copper plated steel for good mechanical stability and thermal conductivity. For checking the design and fabrication process, the aluminium cold model couplers were fabricated and then hot model couplers were fabricated. The fabricated cold model coupler was shown in figure 3.

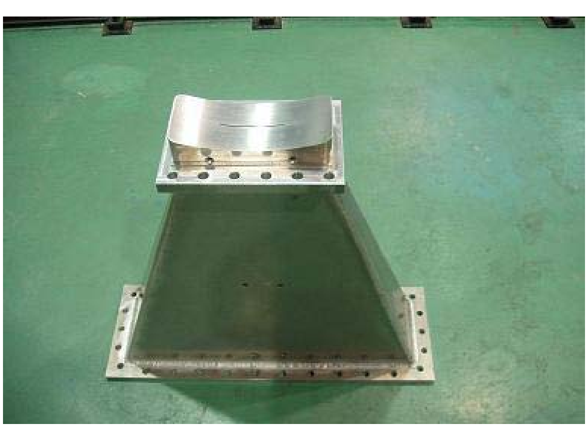

Figure 3: aluminium cold model iris coupler with ridge-loaded waveguide.

The mechanical analysis on the RF power coupler was performed and the results are shown in figure 4, which indicate that copper plated steel will work without problem.

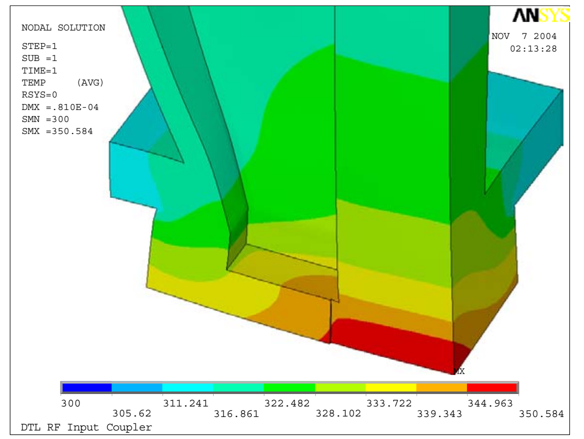

Figure 4a: Temperature distribution on the iris coupler.

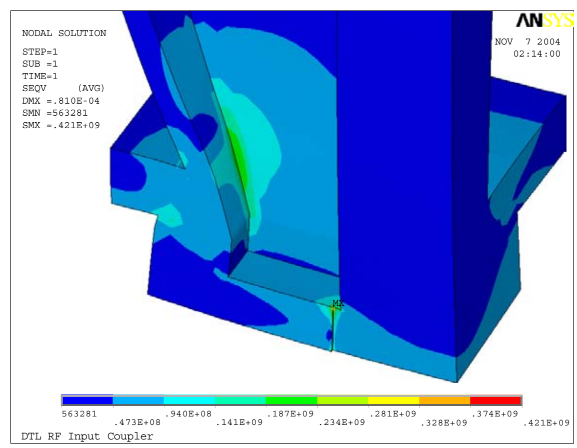

Figure 4b: Stress distribution on the iris coupler.

Vacuum System

The vacuum system configuration of tank is shown in figure 5. Two 300 L/sec turbo-molecular pumps with oil-free scroll pumps and two 300 L/sec sputter-ion pumps are installed in every DTL tank. The vacuum pressure requirement of DTL is under 3.0E-7 mbar and the total gas load of tank is estimated about 5.5E-5 mbar L/sec. The Non-evaporable getter pumps are adopted to evacuate the high power window region. The RF windows were manufactured by THALES Electron Devices. Before installing the RF window, we checked the vacuum leak with helium leak detector and the small leak found during the check was recovered with vacuum grade epoxy.

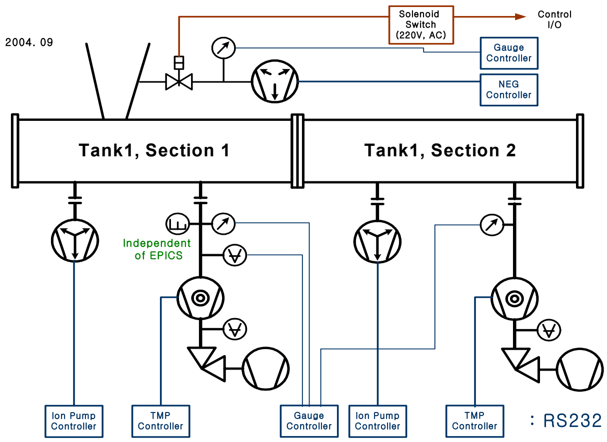

Figure 5: Vacuum System layout for PEFP DTL.

SYSTEM SETUP

Mechanical Installation

Most critical and time consuming process in the mechanical installation is drift tube alignment in the tank. The requirements of the alignment of drift tube are less than 50 um for translation and 1 degree for rotation. The laser tracker was used for precise alignment. The alignment setup with laser tracker and the aligned drift tube in the tank were shown in figure 6 and 7 respectively.


Figure 6: Drift tube alignment setup.


Figure 7: The aligned drift tube in the tank.

The spring suspension on the DTL stand was adopted for installation of the RF coupler to reduce the mechanical stress from the mechanical vibration and thermal expansion. The pipes for DTL cooling are also attached to the DTL stand.

DTL Tuning

Following the completion of the drift tube installation, the tuning of the DTL tank was performed [5]. The tuning goals for PEFP DTL are achieving ±5kHz of designed resonant frequency and ±2% of field profile flatness through the tank with the tilt sensitivity against the perturbation less than 2%/MHz. The field profile under properly tuned condition can be seen in the figure 8.

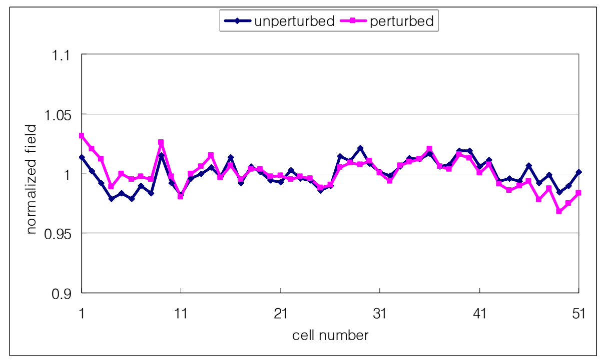

Figure 8: Tank1 field profile after tuning process.

STATUS AND PLANNING

The production of the 20 MeV DTL is well underway. 4 tanks are prepared and the drift tube alignment is almost finished. The tuning of the tank 1 is completed and tuning of the tank 2 is ongoing. High power RF system and high voltage power supply system also prepared and tested. The vacuum pumping system for all tanks is ready and successfully applied to tank 1 and tank 2. Following the completion of tank 2, the RF power will be delivered to the tank 1 and tank 2 for testing and conditioning prior to the beam based commissioning, which will be started after the completion of tank 3 and tank 4 tuning.

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