Resonant Frequency Adjustment Method of the 20-MeV Drift Tube Linac

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1. Introduction

Proton Engineering Frontier Project (PEFP) is developing a 100-MeV proton linear accelerator. As a front-end part, 20-MeV drift tube linac (DTL) has been developed and operated at Daejeon for five years [1]. The design temperature of the 20-MeV was 40°C. But the 20-MeV ~ 100-MeV DTL was designed to be operated at 27°C considering the utility and its low duty compared with the 20-MeV DTL. Therefore it needs to adjust the resonant conditions of the 20-MeV DTL to the 27°C operating conditions when it is re-installed and commissioned at Gyeongju. In this paper, the resonant frequency adjustment method of the PEFP 20-MeV DTL is described and its control margin is discussed.

2. 20-MeV DTL RF Properties

The PEFP 20-MeV DTL consists of four tanks which are designated as DTL21, DTL22, DTL23 and DTL24 from low energy side to high energy.

2.1 Operating Conditions at Daejeon Site

The PEFP 20-MeV DTL was operating for five years at Daejeon. There was no sufficient HVAC system in the experimental hall for 20-MeV DTL, the operating conditions should be adjusted at every operation time because it was difficult to maintain the environmental conditions to be constant. Therefore two methods were used to adjust the operating conditions of the 20-MeV DTL. The first method was to use the heater around the DTL wall to maintain the wall temperature to be constant. The second one was to use the cooling water temperature supplied to the drift tube. The resonant condition of each tank was adjusted by controlling the wall temperature by heater power. By doing this, the four independent tanks could be considered as one tank. The resonant frequency change depending on the environmental conditions was adjusted by the cooling water temperature supplied for the four tanks simultaneously. The operating conditions of the each DTL tanks at Daejeon site are shown in Table 1.

Table 1: 20-MeV DTL Operating Conditions

	Wall temp.	Water temp.
DTL21	26 °C	38 °C
DTL22	27 °C	38 °C
DTL23	35 °C	38 °C
DTL24	46 °C	38 °C

2.2 Frequency Sensitivity of Each Part

The frequency sensitivities of tank wall and drift tube were measured and calculated in 2005 when 20-MeV DTL tanks were developed. The values were slightly different from tank to tank, but we assumed representative values as shown in Table 2 [2].

Table 2: Frequency Sensitivity

Part	Sensitivity [kHz/°C]
Only tank wall	-1.2
Only drift tube	-4.2
Both tank wall and drift tube	-5.4

2.3 Slug Tuner Sensitivity

The resonant frequency of the DTL was adjusted by using slug tuners during tuning stage. There are total eight tuners in one tank of the 20-MeV DTL. The insertion depth of the slug tuners were 50mm in normal position. To increase the resonant frequency, the slug tuner should be inserted more deeply and vice versa. The tuner sensitivity measured during tuning stage was 20kHz/mm for all eight tuners moving simultaneously [2].

3. 20-MeV DTL Frequency Adjustment Method

3.1 Operating Conditions at Gyeongju Site

The PEFP 20-MeV DTL will be newly installed at Gyeongju site. The operating conditions at Gyeongju are such that the ambient temperature will be maintained at 27°C with 1°C deviation and the cooling water temperature of the DTL tank wall will be maintained at 27°C with 0.1°C deviation. The resonant frequency of each tank will be controlled by using the RCCS (Resonant frequency Control Cooling System) which supply the cooling water to the drift tube and quadrupole electromagnet.

3.2 Slug Tuner Length Adjustment

The target operating temperatures of the tank wall and drift tubes are both 27°C. To get resonant conditions at 27°C, the insertion depth of each slug tuner should be adjusted from the old values. The

adjustment lengths of slug tuners of each tank are summarized in Table 3. As shown in the Table, all the tuner length should be reduced to get 350MHz resonant frequency at 27°C. The reduction length ranges from 2.3mm to 3.5mm, which are less than 10% of the normal insertion depth of the slug tuner.

Table 3: Adjustment of the Tuner Length

	Tuner length change
DTL21	-2.3mm
DTL22	-2.3mm
DTL23	-2.8mm
DTL24	-3.5mm

3.3 Adjustment Margin

The RCCS will be used to control the resonant frequency of each tank. The operational range of the RCCS is from 21°C to 33°C, which is 6°C deviation centered at 27°C with 0.1°C control stability. When the target operating conditions of the tank wall temperature and drift tube temperature are both 27C, the tuner length should be adjusted according to Table 3. If it needs to minimize the tuner adjustment length, the operating temperature of the RCCS can be increased up to its maximum value, which is 33°C. In this case the tuner length change will be reduced as shown in Fig. 1. The 27°C cases are also compared in Fig. 1.

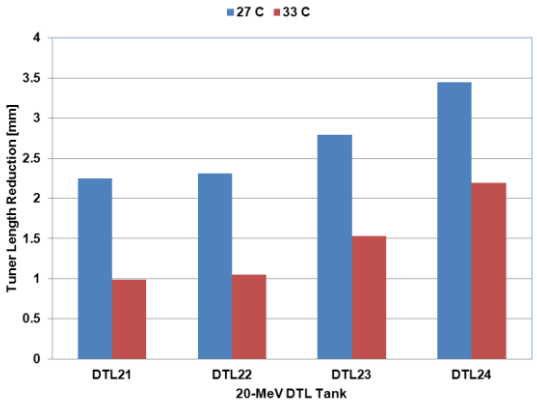

Fig. 1: Tuner length reduction at 27°C and 33°C operating conditions

3. Conclusions

The PEFP 20-MeV DTL needs to adjust its resonant conditions, when it is installed at Gyeongju site. If we are going to set the operating conditions at 27°C, it is enough to reduce the slug tuner length about 2.3mm ~ 3.5mm depending on each tank. Also the tuner adjustment length can be reduced by increasing the RCCS operating temperature to its maximum value.

Acknowledgement

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