OPERATION RESULTS OF 1MW RF SYSTEMS FOR THE PEFP 20MEV LINAC*

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Abstract

The PEFP (Proton Engineering Frontier Project) 20 MeV linear accelerator is composed of a 3 MeV RFQ and 20 MeV DTL. Two sets of 1 MW, 350 MHz RF systems drive the RFQ and DTL. The RF system can perform a 100 % duty operation. The TH2089F klystron is used as an RF source. During the test operation, only the driving RF signal of the klystron was operated in pulse mode, while the electron beam was maintained in DC mode. The klystron power supplies and cooling systems were also operated in 100 % duty mode. In this paper, we will discuss the operation results of 1 MW RF systems including klystron power supply and cooling system, and propose possible options to improve the operation conditions based on the results.

INTRODUCTION

The 100 MeV proton accelerator is under development for the Proton Engineering Frontier Project [1]. For the first phase of the project, the 20 MeV accelerator which consists of the ion source, LEBT, RFQ and DTL has been developed and installed at KAERI site [2].

The 20 MeV accelerator was designed for 24 % duty factor. Therefore high power RF system can support that high duty operation. Two sets of 1 MW average power RF system have been developed for 20 MeV accelerator, one for RFQ and the other for DTL. The TH2089F (THALES) CW klystron is used for the RF source. The high voltage power supply and cooling system for the klystron also have the capacity for 1 MW average RF power capacity. Recently, those RF systems are operated for 20 MeV accelerator test.

HIGH POWER RF SYSTEM

The HPRF system for 20 MeV Linac is summarized in Table 1.

Table 1: HPRF system summary for 20 MeV Linac.

Accelerating structure	RFQ	DTL
Frequency (MHz)	350	350
Energy range (MeV)	0.05~3	3~20
Beam current (mA)	20	20
Required RF power (kW)	460	895
No. of 1MW Klystron (ea.)	1	1
No. of coupler (ea.)	2	4 (1ea./tank)

The power from a klystron is divided into two ways to the RFQ because of the window power rating. The PEFP 20 MeV DTL has a unique feature that the four tanks are driven by single source. Therefore the RF power from a klystron is divided into four ways to drive each DTL tanks.

During low duty operation for initial, the RF systems are operated in pulse mode by pulsing only the input RF power and maintain all the other components such as high voltage power supplies and cooling system in 100 % duty mode.

The klystron for the RFQ was tested up to 600kW peak power and operated routinely to drive the RFQ and the klystron for the DTL was tested up to 800 kW [3]. All other high power components including Y-junction circulator (AFT), planar type RF window (THALES) and dummy load have been operated without any problems. The TH2089F klystron was used as an RF source. During the test operation, only the driving RF signal was operated in pulse mode, while the klystron power supply and cooling system were operated in 100% duty mode. .

HIGH VOLTAGE POWER SUPPLY

There are two types of high voltage DC power supplies for 20 MeV accelerator. The specifications of the power supply is 100 kV, 2 MW, and the ripple is less than 1 %. The high voltage DC power supply for the RFQ klystron has an IVR (Inductive Voltage Regulator) type voltage controller. Also it has a crowbar using ignitron switch for load arc limiting device. Three ignitrons are connected in series to perform the crowbar. The wire test showed that the crowbar could limit the load arc energy to be less than 20 J. The power supply for the DTL klystron has a phase controlled voltage regulator using thyristor switch. Also it has a unique feature to limit the load arc energy. In contrast to the crowbar used for RFQ klystron, it uses an opening switch to limit the load arc energy (Figure 1). The opening switch consists of stack of FET (Field Effect Transistor), and in addition to the arc energy limiting function, it can deliver a pulse power to the load as shown in Figure 2. From the wire test, the opening switch could limit the load arc energy to be less than 6 J. The modulating anode consists of a tetrode and two voltage dividing resistors. By adjusting the grid voltage of the tetrode, the modulating anode voltage could be controlled.

There were some power supply trips during the operation. For the RFQ klystron power supply, there were unidentified occasional crowbar trips and the reason was finally identified to the discharge between outer and inner conductor of CERN type connector. After cleaning the insulation parts, there was no unidentified crowbar trip.

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For the DTL klystron power supply, there were also unidentified opening switch trips during operation, and deep investigation showed that the interlock circuit for the electromagnet current for the klystron was very sensitive to external noise. Therefore we changed the interlock circuit and solved the problem.

Figure 1: Opening switch as arc energy limiter.

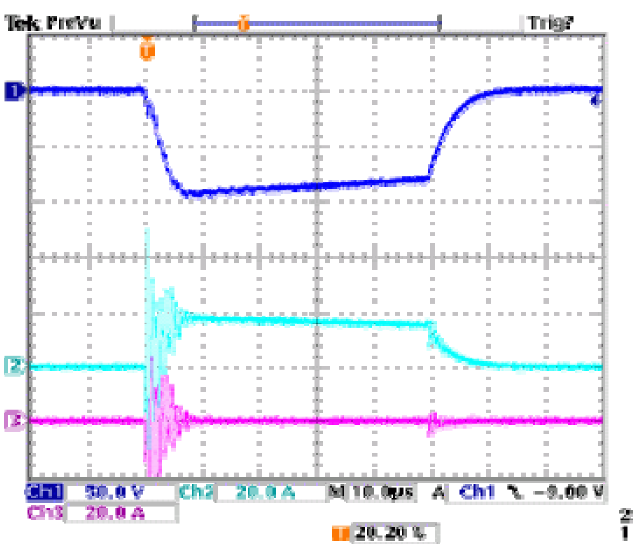

Figure 2: Pulse power using opening switch (horizontal : 10µs/div.).

COOLING SYSTEM

Two sets of cooling system have been operated for the RFQ and DTL. The cooling capacity, flow rate and pressure of each unit are 2 MW, 6000 l/min, 5 bar respectively. In PEFP 20 MeV accelerator test facility at KAERI site, the cooling system should supply the cooling water not only to the RF system but also to the accelerating cavity. That is the klystron cooling loop and cavity cooling loop are connected in parallel to the same cooling circuit. The characteristic of this configuration is that the thermal load to the secondary loop is always constant and independent of the operation duty factor. The cooling system has a cooling water temperature control mechanism using three-way valve as shown in Figure 3. The valve can control the flow rate that by pass the heat exchanger. Using this configuration, we can maintain relatively stable conditions irrespective of the accelerator duty factor with out any additional heater. The flow rate and water temperature were monitored during operation and the results are shown in Figure 4 and Figure 5 respectively. The operation temperature of the DTL is about 38 degree centigrade, therefore at start of the system, the cooling water temperature should be increased up to the operating temperature. During this stage, the klystron is used as a heating source. When it is reached to the operating temperature, the three-way valve is locked to the fixed temperature mode to maintain the cooling water temperature constant as shown in Figure 4.

Figure 3: DTL cooling system primary loop (Pump, three-way valve, heat exchanger).

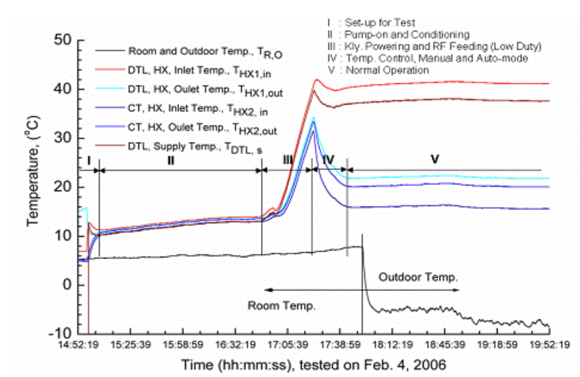

Figure 4: Cooling water temperature variation during operation (DTL cooling system).

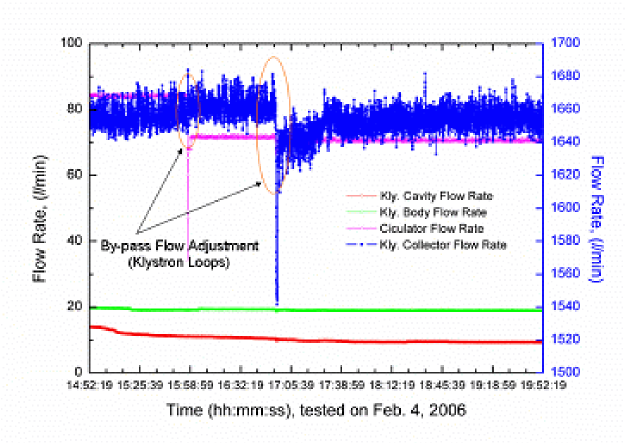

Figure 5: DTL klystron cooling water flow variation during operation.

SUMMARY

Two sets of 1 MW RF systems for PEFP 20 MeV linear accelerator have been operated. The klystron for the RFQ was tested up to 600 kW and the klystron for the DTL which consists of 4 tanks was tested up to 800 kW in pulse mode.

Recently, the HPRF system including high voltage power supply and cooling system has been operated routinely to drive the RFQ and DTL. We are now collecting the operating data of the HPRF components and improving the system successively.

REFERENCES

[1] B. H. Choi, et al, “Status of the Proton Engineering Frontier Project”, PAC05, Knoxville, USA, 2005
[2] Yong-Sub Cho, et al, “Development of PEFP 20 MeV Proton Accelerator”, presented in this conference
[3] K. T. Seol, et al., “Status and Test Results of HPRF System for PEFP”, PAC05, Knoxville, USA, 2005