COMMISSIONING OF A 6 MEV X-BAND SW ACCELERATING GUIDE

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Abstract

A 6 MeV, X-band on axis-coupled SW electron linear accelerating guide was developed in Accelerator Laboratory of Tsinghua University. It can be suitable for portable radiotherapy and radiography. The design, manufacture and high power test of the guide are given in this paper.

The length of the guide is 47cm long. It includes a 38cm long accelerating structure, a Pierce electron gun and a target. A 1.5MW pulsed magnetron at 9300MHz is served as its RF power source.

This paper presents the design performance characteristics of the guide and the results of the high-power tests.

INTRODUCTION

New generation portable electron linear accelerator requires small size, less weight and reliable. X-band electron linac can meet these requirements. In order to reduce side and weight of accelerator, in general, magnetron is adopted as microwave power source for X-band linac. The X-band accelerating structure has been studying by Tsinghua University since 1990. For developing X-band linac, we pushed Beijing Institute of Electron & Vacuum Technology to develop a 1MW, X-band magnetron. Using the magnetron, as RF power source a 2.5MeV X-band SW linac was made and successfully was applied to the large container inspection system produced by NUCTECH Company Limited in 1998. For the need of new radiotherapy techniques and radiography, a 6MeV, X-band on axis-coupled SW accelerating guide which operated in the $\pi/2$ mode has been developed by Accelerator Laboratory of Tsinghua University. Using a 1.5MW X-band magnetron was supplied by E2V Technologies Limited, England, the guide of the high-power test has been completed.

GENERAL DESCRIPTION

The geometry of the accelerating structure is a 38cm long, which consists of 49 cavities concluding 9 cavities of buncher. Main parameters of accelerating structure are as following the beam energy being 6MeV, while the pulse beam currents being 50mA.

The microwave power source is an X-band 1.5MW magnetron at 9.3GHz.

The accelerating structure can be used in two modes: electron and X-ray generation. To obtain small size and less weight of the structure, the phase-focusing technique was used without any external magnetic focusing device. As a result, the beam spot size of the accelerating structure is less than 1.5mm in diameters. The accelerating structure characteristics are listed in table 1[1].

Table 1: Accelerating Structure parameter Characteristics

Length	38cm
Beam Energy	6MeV
Beam Current Peak	50mA
Spot Size	<1.5mm
Frequency	9300MHz
RF Peak Power	1.5MW
Input Coupling	1.36
Shunt Impedance	143MΩ/m
Injection Voltage	~ 15KV
Q_0	9000
Q_L	6800
Coupling coefficient K	22%

Figure 1 shows a photograph of the 6MeV SW accelerating guide after brazing. Due to excellence brazing technology, it did not need further tuning after brazing.

Figure 1: The accelerating guide after brazing.

Figure 2: MG6005 magnetron.

Figure 2 shows the MG6005 1.5MW magnetron, which was supplied by E2V Technologies Limited, England.

HIGH-POWER TESTS

Commissioning of the guide was completed in Accelerator Laboratory of Tsinghua University under the full peak power. The test condition is listed in table 2.

Table 2: High-power test conditions

Parameter	Value
Operating frequency	9302.7MHz
Operating temperature	18℃
RF power at guide entrance	1.32MW
Pulsed width of magnetron current (at 50% power level)	3.3μs
RF power envelop width (at 50% power level)	3.3μs
Duty cycle	0.0264%
Vacuum pressure	3×10^{-8} torr

Figure 3 and Figure 4 show the current waveform of magnetron and reflected power waveform while the accelerating guide is under resonance respectively.

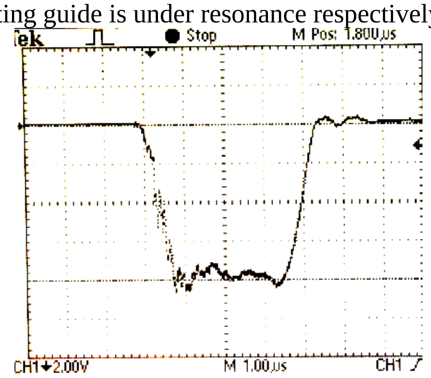

Figure 3: Waveform, Magnetron Current.

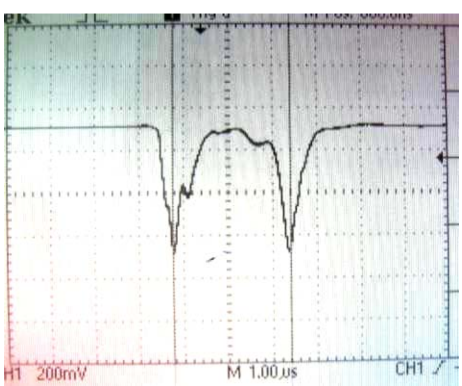

Figure 4: Waveform, reflected power at accelerator Guide resonance.

When an emission electron beam current from the electron gun is 90mA, and the injection voltage 15.4KV, the accelerated beam current and the X-ray radiation intensity was measured, which is 11.35μA, and 122.5R/min at meter respectively. At that time, in the accelerating guide entry, the peak power is 1.32MW.

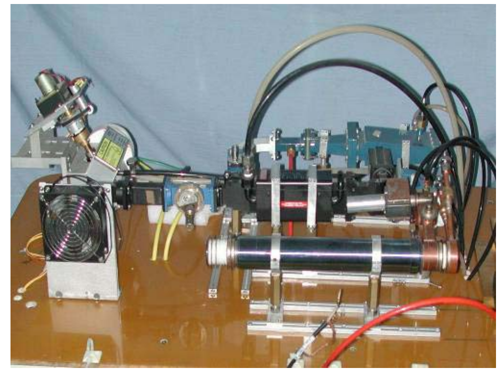

Figure 5: RF system facility.

The electron beam energy was measured with the penetrating range method. Figure 6 shows the measured curve.

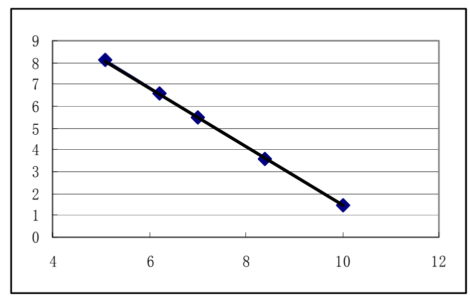

Figure 6: The penetrating range of electron beam.

With the curve, the electron energy we was calculated by the following formula:

$$W_e = W_{eo} + dW_e$$

Where $W_{eo} = \frac{(d\times\rho)+0.094}{0.526}$, d being penetrating range of electron, $\rho = 2.8$ being the density of alloy-aluminium, $dW_e = \frac{13\times W_{eo}{}^2}{(800-13W_{eo})}$ is a revised value of electron energy. From the experimental value of the penetrating range, the electron energy is equal to 6.09MeV.

The spot size is measured with a sandwich method. The magnitude of the spot size is less than 1.3mm in diameter.

CONCLUSION

The high-power tests of the accelerating guide have been completed. According to our experience and estimation, if the input power at accelerating guide entrance can reached a 1.5MW peak power, and a 1.1KW average power, X-ray dose rate should be more than 300R/min at 1 meter.

In the future, the follows works will be considered:

1. Further optimizations on accelerating structure.
2. Investigation and experiments under the condition of 1.8MW/1.1kW.
3. Less microwave power loss transmission system

4. Adopt triode electron gun for more easily controlling the injecting beam current.

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