DESIGN AND TESTS OF AN ACCELERATOR MODULE FOR LINEAR INDUCTION ACCELRATOR (LIA)

Cheng Nianan, Wang Huacen, Ding Bainan, Dai Guangshen, Liu Chengjun, Zhang Enguan, Wu Shengzong

Southwest Institute of Fluid Physics
P.O.Box 523, Chengdu, China

Abstract

An injector for LIA, composed of six accelerator modules, with cold cathode diode and voltage of 1.5MV is described briefly. The design information and preliminary test results of the accelerator module containing 14 ferrite toroids are presented.The plates of cavity voltage of 350 KV with 90 ns FWHM and prepulse voltage are given. The reset current and other factors affecting the cavity voltage are discussed. Futher improvement of the module is under way.

Introduction

The Linear Induction Accelerator, capable of accelerating indense beam to high energy, has extensively been used in many research fields [1], [2]. Interested in the unique characteristics of this kind of accelerators,we have designed an injector for LIA and built an accelerator module.

The injector with cold cathode diode, composed of six modules, has been designed to generate 3 KA electron beam with 60 ns FWHM at 1.5 MV. The preliminary tests on the accelerator module have been completed and a 350 KV cavity voltage with 90 ns FWHM was obtained.

Accelerator Module Design

Six accelerator modules mounted in tandem are used as the power of the injector to generate 1.5 MV voltage accross the diode, so each one must provide 250 KV when beam current there is. As well known, besides the ballast loads, the beam current and charging power (Blumlein), the cavity voltage is determined by the quantity of ferrite toroids loaded in the cavity. The design goal for the accelerator module is to generate a 360KV with 90ns FWHM and risetime less than 30ns whe absence of the beam current.

The module shown in Fig.1, contains 14 ferrite toroids with demension 254mm I.D, 580mm O.D,and 25mm thick.The specifications of those toroids are as follows: the saturation flux B_s is about 4000 Gauss with 10 Oersted drive,the remanent flux B_r is about 2900 Gauss

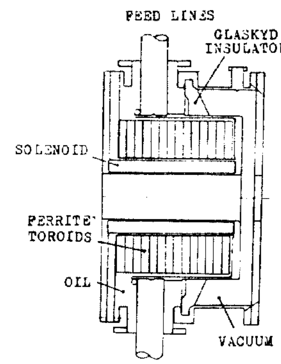

Fig.1 Accelerator Cavity

following a 10 Oersted drive and coercive force H_c is about 0.5 Oersted.The pulse tests of single and multiple ferrite toroids have demonstrated that the available flux change is closer to double the saturated flux [3], the flux change $\Delta\phi$ of each module,therefore,is 30 -36 mv sec, capable of supporting a 400 KV voltage for 90ns.For better high voltage standoff,the ferrite cores are immersed in transformer oil and seperated each other by a gap of 3mm.The accelerating gap width is 45 mm and a glaskyd insulator ring is used to seperate th oil-filled part from vacuum. The ballast loads made of the copper sulphate electrolytic columns can be adjusted between 15-25 Ohm. Water filled Blumlein with a characteristic impedance of 10.8 Ohm and electric length of 90ns, are charged by Marx generator, and its output is fed via two transmission lines to the induction cavity. They are long enough to provide a transit time insolation of 90ns drive pulse and each one's impedance is 21.6 Ohm. The ferrite toroids are reseted by charging current fraction of Blumlein inner line.

Preliminary Results

The accelerator module shown in Fig.2,has primarily been tested and some preliminary results has been obtained. The Blumlein output voltage U_B (t) and the accelerator cavity voltage U_a (t) shown in Fig. 3A and 3B, respectively are measured by resistive divider and capacitor probe. It can be seen from Fig.3 that the U_a (t) is 350KV and the rate of $U_a(t)/U_B(t)$ is about 1.3. The latter corresponds with voltage reflectance calculated from ballast resistance (20 Ohm), and characteristic impedance of Blumlein.

CH2387-9/87/0000-1783 $1.00 © IEEE

PAC 1987

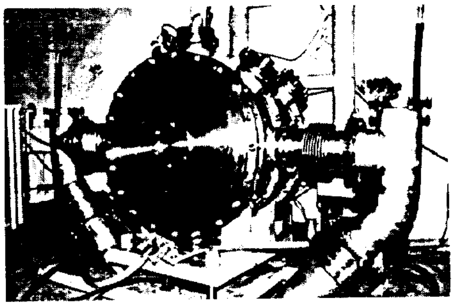

Fig.2 Accelerator Module Configuration

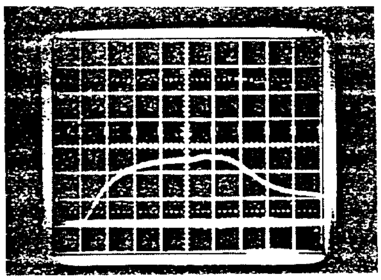

Fig.3A Blumlein Output Voltage
Measured with Resistor
Divider 105KV/div 20ns/div

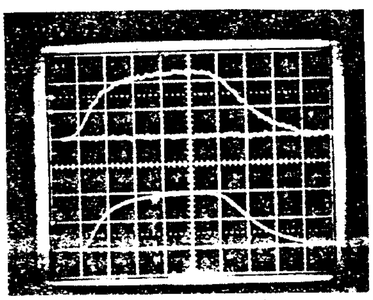

Fig.3B Accelerator Cavity Voltage
Upper: Measured with Capacitive
Probe 145KV/div 20ns/div
Lower: Measured with Resistor
Divider 175KV/div 20ns/div

The prepulse voltage $U_p(t)$ shown in Fig.4 is measured at the ballast resistance during Blumlein is being charged. The magnetic density of reset in ferrite cores calculated from

$$B=10^{8}\int_{0}^{t} Up(t)dt/S-B_r$$

where S is the total cross section of the cores, indicates that the ferrite core has saturated.

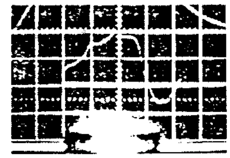

Fig.4 Prepulse Voltage
15KV/div 500ns/div

Meanwhile, the operating point of the ferrite core can be also estimated from its reset current $I_r(t)$ and exciting current $I_e(t)$ as following:

$$\vec{I}_r(t)=\vec{I}_c(t)-\vec{U}_p(t)/R_L$$
$$\vec{I}_e(t)=\vec{I}_B(t)-\vec{U}_a(t)/R_L$$

where $I_c(t)$ and $I_B(t)$ are respectively the charging current and discharging current of Blumlein before and after the switch triggered, R_L is ballast resistance. Both calculation and experiments have proven that the ferrite core has not completely saturated. It's possible to get a 400KV or even more accelerating voltage when the ferrite core saturated. Further tests are under way.

Acknowledgment

The authors wish to thank Dr. Tao Zucong and Dr. Zhang Shouyun for thier direction.

Reference

[1] B.Kulke, T.G.Innes, R.Kihara, Initial Performance Parameters on FXR UCRL 87306, Preprient, DE82 017554. LLNL, June, 11, 1982.

[2] T.J.Orzechowski, E.T.Scharlemann. et al.High-Gain Free Elector Laser Using Induction Linear Accelerator. IEEE Vol- OE-21 No. 7. July. 1985

[3] Liu Chengjun, Dai Guangsen, et al. Large Ferrite Core Tests Using A 50ns Pulse. Fifth Internation Conference on High-Power Particle Beams. P282, 1983