DESIGN AND PROGRESS OF THE AIRIX INDUCTION ACCELERATOR

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Abstract

A new electron accelerator is now being studied and designed for Flash Radiography Application. It consists of a pulsed injector (4 MeV-3,5 kA - 60 ns) and an Induction Accelerator increasing the energy of the electrons up to 20 MeV. We briefly describe the Injector built by PSI [1] and similar to the DARHT injector at LANL [2]. We present studies and experimental tests carried out in order to design and build new induction cells and high voltage generators suitable for this application.

Information is given on the PIVAIR milestone planned for a beforehand validation of the whole AIRIX machine.

I - INTRODUCTION

The main goal of the AIRIX [3] facility is the production of high quality powerful Radiographic Flashes. On that purpose the exclusive advantage of Induction Accelerator is its ability to accelerate high intensity (multi-kilo-ampère) electron beams and to focus them on a small point. The main physical parameter of the beam is its emittance at the output of the accelerator. In order to minimize it, a high brightness electron beam emission is needed with an energy high enough to prevent the beam emittance increase due to space charge effects. A 4 MeV electron beam accelerated up to 20 MeV by the means of induction cells is anticipated. The accelerator design, comprises 8 modules of 8 cells, each module being driven by 4 high voltage (250 kV) generators.

II - INJECTOR

The injector, now under fabrication, is the same type as the one used at Los Alamos on the ITS facility for the DARHT program. It comprises a prime power Transformer charging a glycol Blumlein through four laser triggered spark gaps and three output lines transforming the 1.8 MV pulse from the Blumlein to 4.0 MV on a 150 ohm vacuum tube load. The diode cavity is separated from the last output line by a segmented radial insulator interface with a water resistor allowing the resistance matching of the diode. The electron beam is generated by a 7.5 cm diameter velvet cathode. The injector designed performances have been summarized on Table 1.

Diode voltage	≥ 4 MV
Voltage flatness	≤ ± 1 %
Beam current	≥ 3,5 kA
Pulse width	≥ 60 nsec (flat top)
Voltage reproducibility	± 1 %
Jitter	≤ 1,5 nsec
Normalized emittance	≤ 1200 π mm. mrad
Shot Rate	One per minute

Table 1

Complementary studies are currently carried through at CESTA in order to improve the reliability and the performances of the machine. In a second step, a new Induction Injector could be a way of improving the overall performances of the AIRIX facility.

III- AIRIX INDUCTION CELLS

A Prototype Induction cell suited for the AIRIX Accelerator has been studied, designed and built, and is now being tested (figure 1). The FLUX-2D electrostatic code was extensively used in order to analyze the E field and voltage repartitions and determine the best gap geometry. It uses an alumina insulator brazed on the body of the cell to hold the 250 kV pulse applied to the gap and ensure vacuum insulation between the beam pipe and the oil-insulated ferrite cores. Elsewere Rexolite insulators are being considered as an alternative solution to the use of Alumina and cells without insulators (ferrite cores under vacuum) are being tested. The accelerating gap has been carefully shaped in order to minimize the beam coupling with the gap cavity and hence reduce the BBU instability. The prototype cell uses, as ferrite cores, 11 torroids from TDK (PE 11 B - 250 mm ID, 500 mm OD, 25 mm thick).

The device has been equipped with specific probes (Rogowski coils, current loops, resistive and capacitive probes) in order to understand the electrical behaviour of the cell and to adjust and compare the electrical diagnostics.

Other studies connected with beam - cell interaction are currently being carried out :

- Transverse Impedance measurements of a gap cavity mock-up (figure 2) have been undertaken and compared with results given by the PALAS electromagnetic code [4].

- Prototype solenoid magnets have been designed and built, and longitudinal B_z field uniformity is being characterized with and without homogenizer rings.

IV- HIGH VOLTAGE GENERATORS

A high voltage generator has been designed and built and is now being tested. It is able to feed 2 cells by the means of 4 (50 Ω) cables.

This high voltage generator, as it appears on the rough drawing of figure 3 can be divided into 4 main parts :

- a water blumlein, 2 m long, horizontaly placed for a more convenient handling in the future AIRIX building . It has a 12,5 Ω total impedance,

- a coaxial structure spark gap designed at CESTA with specific features including a V/3 polarization of the triggering electrodes and a 18 mm gap between the main electrodes which can be dismantled.

- a Blumlein charging device using a step-up transformer (1:11) and two EEV Cx 1722 thyratrons

- a two stage spark gap triggering circuit able to generate a triangular pulse with an amplitude over 160 kV and a rise time shorter than 15 ns.

This generator is now in operation, giving a pulse in the 300 kV range with a 70 nsec flat top, and is planned for coupling to the prototype cell in the near future.

V - PIVAIR MILESTONE

Next year, we shall have the injector in operation at CESTA. A first accelerating module (8 cells = 2 MeV) will be built and installed by that time, and then a second one in 1995. These two blocks of cells with the 8 associated generators, coupled to the injector, will make up the so called PIVAIR set up, giving rise to an 8 MeV electron beam. This facility is intended to allow a complete validation of AIRIX (cells and HV generators, technology, alignment, beam transport and focusing, X-ray generation).

VI - REFERENCES

[1] Pulse Science Inc. 600 Mc Cormick street - San Leandro CA 94577

[2] J. Downing et al. " Pulse Power Systems for the DARHT Accelerators " 8 th IEEE International Pulsed Power Conference, San Diego, CA, June 1991.

[3] AIRIX stands for " Accelerateur à Induction de Radiographie par Imagerie X "

[4] F. Delaurens, F. Charlet
Calcul par le code Palas des impédances de couplage d'une cavité résonnante
Internal Report 1991

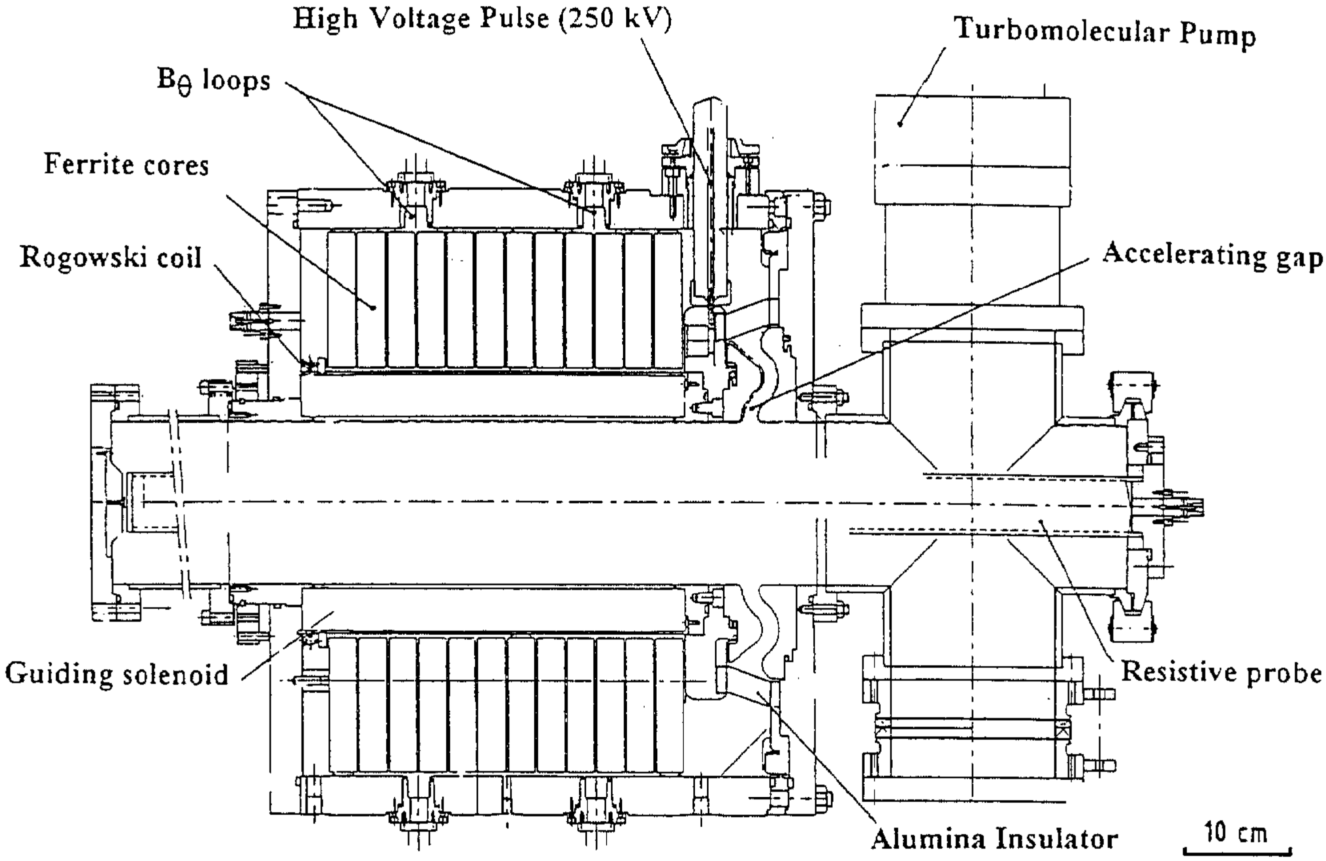

Figure 1 : AIRIX Prototype Induction Cell

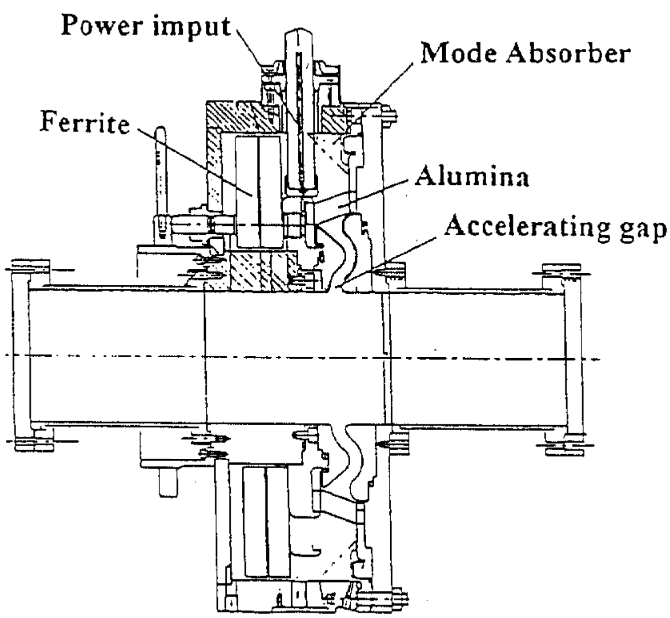

Figure 2 : Accelerating gap mock-up

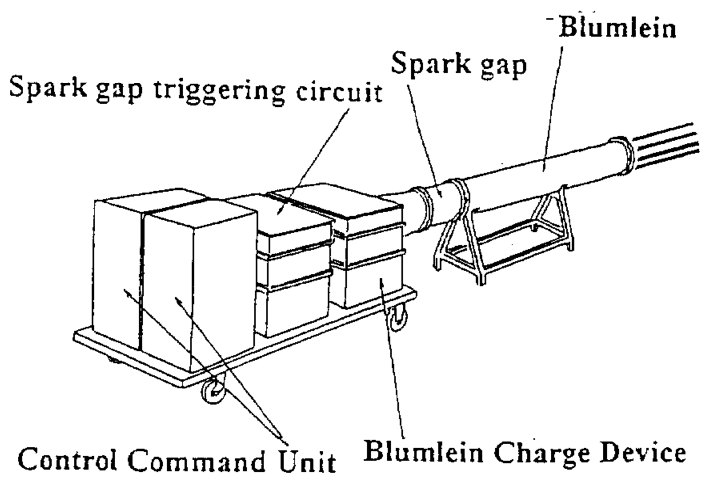

Figure 3 : High Voltage Generator
General view