Study on Induction Accelerator for Industrial Applications

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Abstract

The design of electron induction accelerator for industrial applications, for example sterilization, is presented. The injector, the accelerating column, the Blumlein circuit pulse power supply and the beam extraction system of movable (Compact and Light) electron induction accelerator with 5 MeV electron energy and 100 kW electron beam power are described.

I. INTRODUCTION

The electron induction accelerator can be industrially used for sterilization, deinsectization and sewage treatments. As to movability, it has strong-point since it requires less auxiliary equipments and can be operated by the commercial electric power.

Considering the electron beam applicability, the movability through compact and light equipment design, and at least one-year maintenance-free operation as well as low manufacturing costs, the specifications of designed industrial induction accelerator are presented as Table 1.

Table 1. Design parameters

Peak Energy	5 MeV
Peak Current	200 A
Pulse duration	1 μs
Pulse repetition rate	100 ppm
Average beam power	100 kW
Maintenance-free life shots	$> 10^9$
Weight	~15 t
Length	~12 m

II. INJECTOR

The injector consists of 4 induction cavities and electron gun and it has been designed to produce electron beams with 400 keV, 200 A, and 1 μs duration time. Considering life time and heating availability, the cathode material of electron gun has been adopted as LaB_6 with flat surface whose diameter is 50 mm. Induction cavities have aluminum electrodes and 0.1 V·sec core, whose material is 0.05 mm thick silicon steel. Polyamide film is used for intermediate layer insulation and cross-linked polystyrene for vacuum interface. The electron beam is focused by coils that is set both inside induction cavity and at anode. It can produce electron beams with 30 mm diameter along 500 Gauss guiding magnetic fields, which was calculated and verified by ETP (Electron Trajectory Program) Computer Code. The simulated electron trajectory in the injector is shown as Figure 1.

III. ACCELERATING COLUMN

Accelerating column is made up of induction cavities for 100 kV accelerating voltage and 1 μs pulse duration and the electron beam energy can be adjusted on the number of induction cavities. The materials of accelerating column are the same as those of induction cavities. Its bore radius is relatively small to 50 mm diameter. One of induction cavities is shown as Figure 2.

IV. POWER SUPPLY SYSTEM

The power supply system of induction cavities consists of high-voltage charging power supply, Blumlein circuit, pulse transformer and core reset

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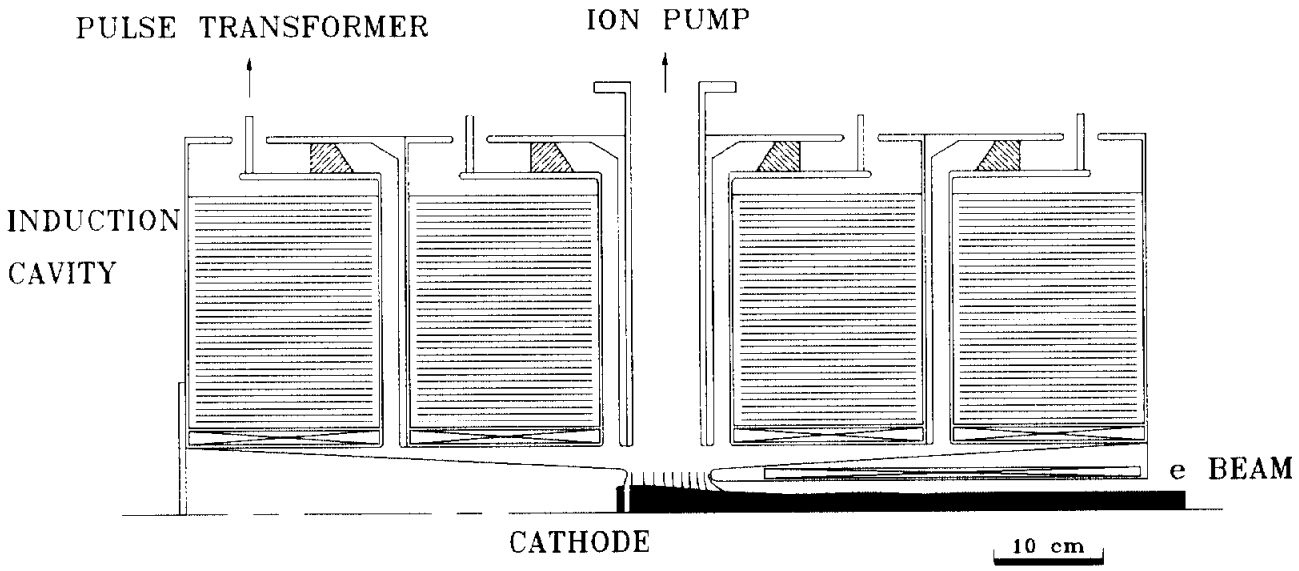

Figure 1. Injector

circuits. 20 kV charging voltage has been determined in that high efficiency solid-state switching power supplies are available as well as capacitors and thyratron switches which have 100 pps repetition rate and can be maintained over 10^9 shots.

For compact and light design, Blumlein circuits [1] are made up of capacitors and inductors, which can apply the full charging voltage to pulse transformer. The turn ratio of pulse transformer is 1:5 and the output voltage 100 kV. Since the pulse transformer like induction cavities is put in the same case and the 20 kV output pulse of Blumlein circuits enters induction cavity case, the power feeding can be facilitated. The core reset circuit supplies currents on the primary windings of pulse transformer. All the induction cavity cores can be reset on rotating switch connected to the same shaft. Figure 3 is the equivalent circuit diagram of all power supply components.

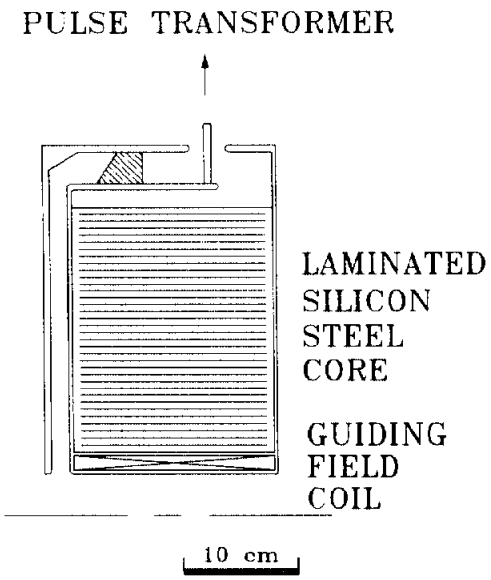

Figure 2. Induction Cavity

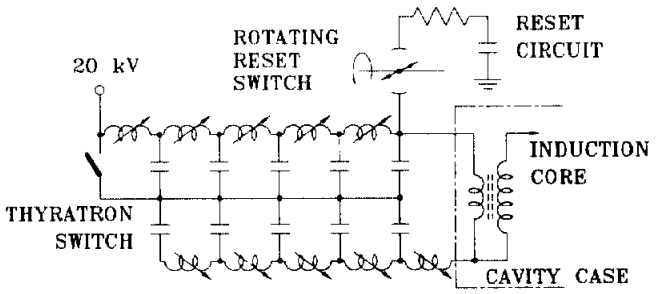

Figure 3. Power Supply System

V. BEAM EXTRACTION SYSTEM

The accelerated electron beams are extracted into the air through 20 μm thick Ti foil. For the extraction of pulse currents with 5 MeV, 200 A and 1 μs duration, the extraction window area requires over 10 cm^2 [2]. Multi-extraction methods with 10 windows are used, for its pulse repetition rate is 100 ppm. For high beam extraction efficiency, the

extraction window is spherically shaped. The extraction window can be air-cooled down by nozzles. The electron beam is guided to extraction window by solenoid focusing electromagnet and deflecting electromagnet. Figure 4 is the diagram of designed beam extraction window.

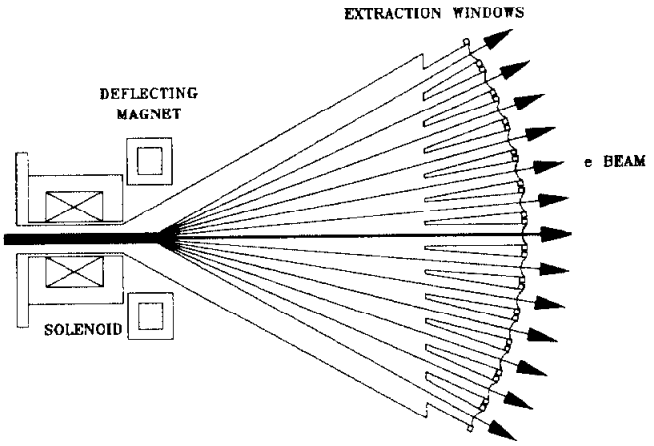

Figure 4. Beam Extraction System

VI. CONCLUSION

The electron induction accelerator for industrial applications has been designed with 5 MeV electron energy and 100 kW average beam power. The overall schematic of the designed electron induction accelerator is Figure 5. The movable accelerator will be useful for electron beam processings.

VII. REFERENCES

[1] G. N. Glasoe and J. V. Lebacqz, "Pulse Generators", McGraw-Hill Book Co., New York, 1948.

[2] E. A. Abramyan, "Industrial Electron Accelerators and Applications", Hemisphere Publishing Co., Washington, 1988.

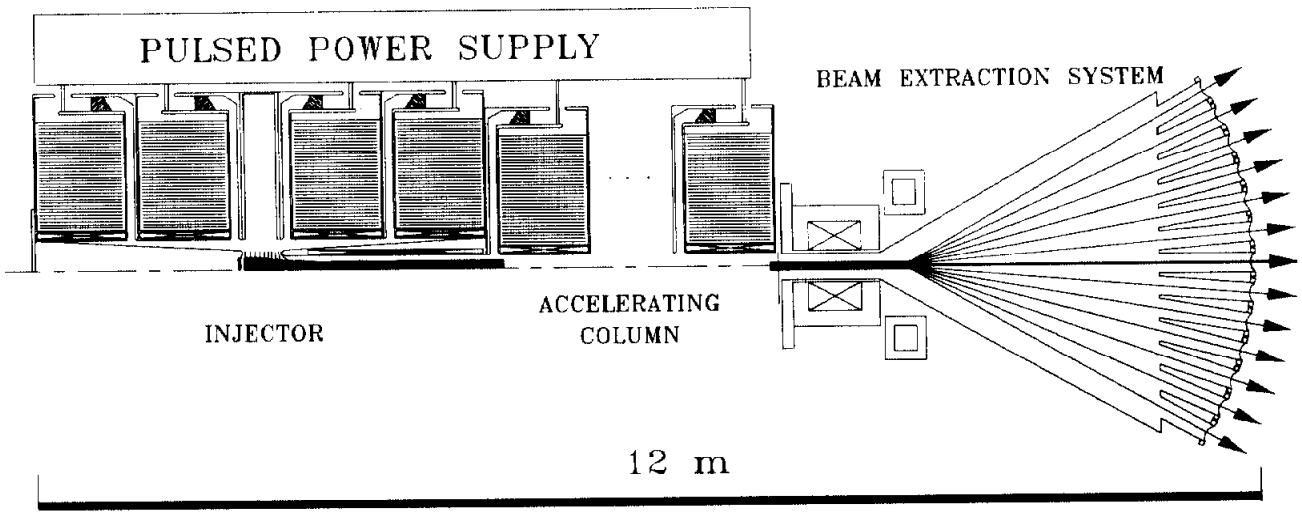

Figure 5. Total System