A PC-CONTROLLED BEAM SCANNING SYSTEM AT THE TECHNOLOGICAL ELECTRON LINAC

S.P. Karasyov, R.I. Pomatsalyuk, A.Eh. Tenishev, V.L. Uvarov, V.A. Shevchenko, I.N. Shlyakhov
NSC KIPT, Kharkov, Ukraine
E-mail: karasyov@kipt.kharkov.ua

The regulatory documents for a number of technological processes (sterilization and others) require that a continuous control and archiving of beam scanning regime should be provided. To meet these conditions at the radiation-technological facility with the electron linear accelerator LU-10 (10 MeV, 10 kW), an automated complex of scanner control was designed and put into operation. The complex is a CAMAC-based autonomous system controlled by a computer. It provides a programmed control of the beam scanning zone width proceeding from the assigned dimensions of the object under treatment, within 20 to 60 cm, with an automatic setting of the center of the zone in the middle of the object. The complex control also includes the possibility of correcting the position of the beam-scanning center in order to compensate the angle of beam entrance into the scanner electromagnet.

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1. INTRODUCTION

The radiation-technological facility based on the electron linac LU-10 [1] has been operating at the NSC KIPT R&D Prod. Est. "Accelerator" since 1987. The accelerator's radiator is located horizontally. At its exit, there is a scanner that provides the beam scanning in the vertical plane normally to the direction of motion of the container-(suspension)-shipping conveyor, where the products to be treated are placed. When fulfilling numerous orders for radiation sterilization of products, and when the products for treatment are delivered in boxes of different sizes, there arises the necessity of optimizing the treatment conditions, first of all, owing to quick correction of the scanning zone width. To provide this possibility as well as the possibilities to control the beam current density distribution along the scan zone, to control and to document the treatment conditions (the latter being the requirement of regulatory documents [2]), an automated beam scanning system was developed.

2. SYSTEM COMPONENTS

A computer with the CAMAC interface (Fig.1) controls the operation of the system, which includes:

- an externally controlled power supply of the scanner electromagnet,
- interlock system,
- PC PRO-200,
- DAC-002 (digital-to-analog converter),
- output register (R350),
- crate controller (CC),
- amplifier (DA).

2.1. THE DIGITAL-TO-ANALOG CONVERTER

The DAC-002 module is an originally designed block intended for generation of arbitrarily shaped voltage pulses with amplitudes ranging from –3V to +3V and an assigned pulse recurrence rate from hundreds to the tenths of Hz.

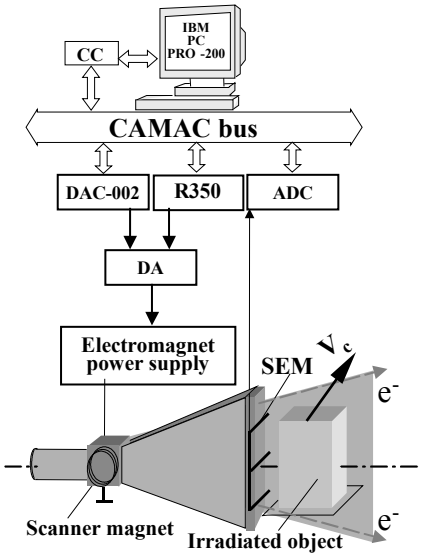

Fig.1. Block diagram of the radiation treatment control system

The block includes:

- two random-access memory (RAM) pages, 32 Kbit in volume;
- 14-digit digital-to-analog converter (DAC);
- DAC data reading system for the DAC with an adjustable memory scanning rate;
- controllable run/stop switch system arrangement with a smooth rise and drop in the output voltage (to suppress voltage surges at the input of the power source of the scanner electromagnet).

2.2. THE OUTPUT REGISTER 350

The standard block 350 (international classification) is used for switching the DAC output and the power source of the scanner.

2.3. THE AMPLIFIER

The device is intended for matching the DAC output voltage and the input voltage of the power unit of the scanner.

2.4. POWER UNIT OF THE SCANNER

The device presents the input voltage-controlled current generator, which is intended to supply the excitation current to the windings of the scanner electromagnet. The current amplitude is linearly dependent on the input voltage. Its maximum value makes ± 25 A at a scanning frequency of 3 Hz and an equivalent electromagnet impedance of ~ 2.8 Ohm (active and reactive components).

2.5. INTERLOCK SYSTEM

The system is intended to switch off the beam in the absence of the alternating-current component in the scanner electromagnet, or at the beam scan amplitude lower than the assigned minimum value. The interlock system includes both the electrical and software components.

2.6. THE SOFTWARE

The monitoring programs are written in the algorithmic language "Turbo Pascal" under the MS DOS operating system. The program package comprises the following modules:

- the exerciser of the operability of the equipment that forms a part of the system (DAC, module 350);
- program to check the permissibility of the data input for the scan mode. With a wrong data input (the monitoring signal amplitude is higher or lower than the admissible value), the scanner sets the "safe" scan amplitude; the beep noise and the text record point to the necessity of introducing the true value;
- program to generate the control voltage for the power unit of the scanner with a record of the voltage value in one of the memory pages;
- program for cyclic rewriting of control voltage parameters of the scanner in a free memory page with a simultaneous transfer of control to the page (this mode is necessary for eliminating a possibility of information distortion in the DAC due to electromagnetic noise);
- unit to correct the control voltage parameters (displacement of the center and variation in the amplitude of scanning, input of size of the object under irradiation).

3. CALIBRATION OF THE SYSTEM

3.1. For programmed control of the scanning zone width and the initial displacement of the beam, a corresponding calibration at the shipping container (suspension) was carried out with due regard for the height of the object to be irradiated. The calibration consisted in a sequential short-time exposure of a set of glasses, placed in the plane of the front wall of the object, to the beam. The electron energy corresponded to the rated value of 10 MeV. The position of the center of the beam at different excitation current values of the scanner electromagnet was determined by the method of photometering of irradiated glasses. On the basis of the data obtained and using the linearization method, we have obtained the amplitude and constant component of the scanner excitation current as functions of the height of the object under treatment with an aim to provide a uniform distribution of the beam current density along the scan on the near plane of the object at the minimum scan width value.

3.2. Figs.2 to 4 show the results of recalibration of the scanning system with programmed setting of its parameters against the given value of object height on the suspension.

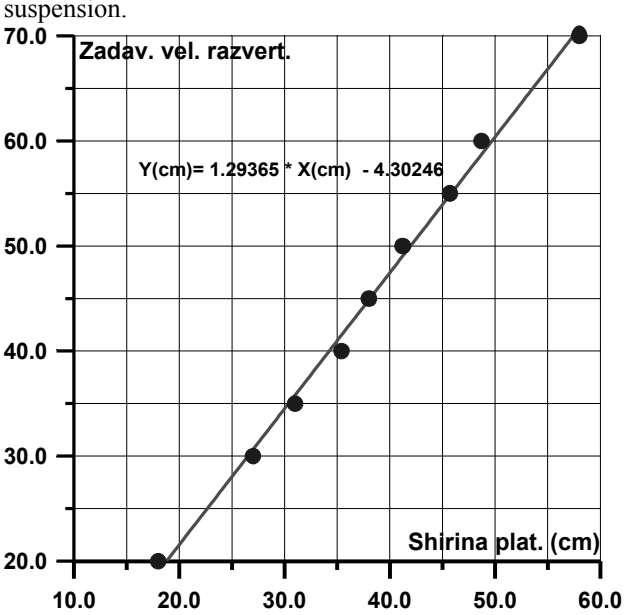

Fig.2. Program-assigned scan amplitude on the scanner versus size of irradiated object

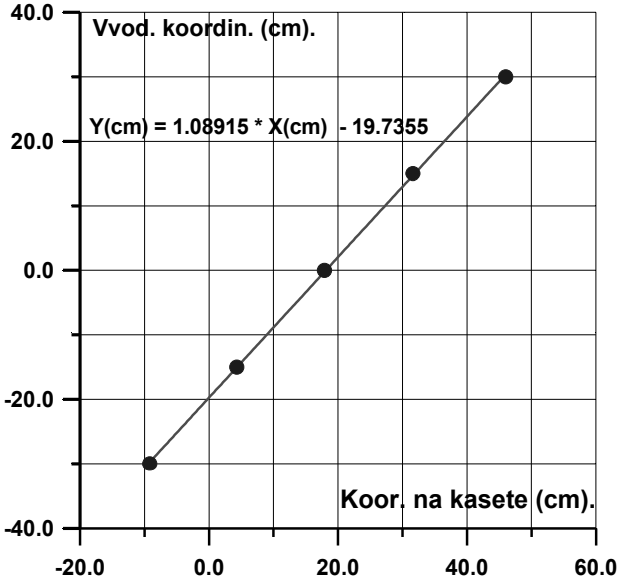

Fig.3. Constant bias applied to the scanner versus height of the scan center

As it is evident from Fig.2, the scan value is somewhat higher than the height of the object. This is necessary to compensate the decrease in the linear beam current density along the edges of scanning.

With a variation in the height of the object the program automatically corrects the position of the scan center by changing the constant component of current of the scanner electromagnet (Fig.3). In this case, the program provides both a constancy of the scan center height as the scan amplitude changes (Fig.4), and the possibility of additional correction of the center position with a change in the angle of beam entry into the scanner.

3.3. A continuous monitoring of the width and center position of the scanning zone is realized with the help of the measuring channel based on the secondary-emission monitor (SEM) arranged at the exit window of the accelerator [3].

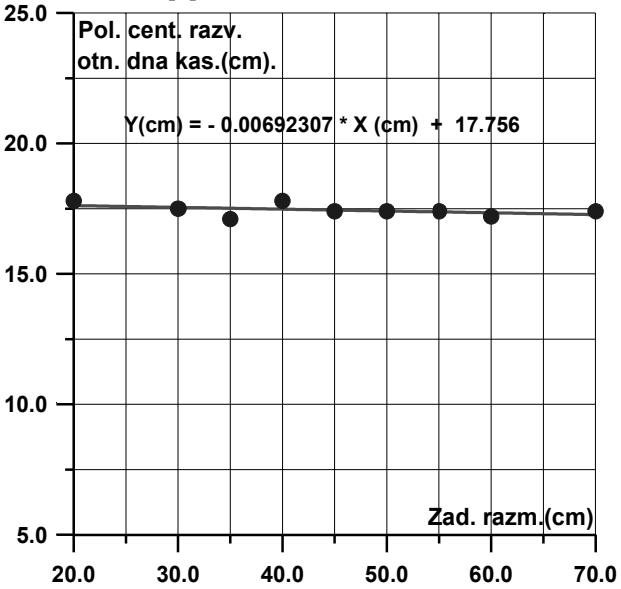

Fig.4. Center-of-scan position versus the scan amplitude

4. CONCLUSION

The scanner control system developed here for the technological electron linac provides a programmed formation of the scanning zone width within 20 to 60 cm, with a nonuniformity in the linear current density of no more than ± 5%, and with the possibility of varying the height of the beam scan center on the object within ± 20 cm.

The system provides a quick (≤ 10 s) adjustment of the irradiation zone at variations in the size of objects under treatment, and also the possibility of external correction of the zone position relative to the object under irradiation. A one-year exploitation of the system at the radiation-technological facility LU-10 with realization of different programs (sterilization of medical-purpose products and pharmaceutical raw materials, modification of polyethylene items and semiconductors) has demonstrated its high operational performance making it possible to improve the economic factors of radiation treatment.

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РС-УПРАВЛЯЕМАЯ СИСТЕМА СКАНИРОВАНИЯ ПУЧКА ТЕХНОЛОГИЧЕСКОГО ЛУЭ

С.П. Карасев, Р.И. Помацалюк, А.Э. Тенишев, В.Л. Уваров, В.А. Шевченко, И.Н. Шляхов

Нормативные документы на ряд технологических процессов (стерилизация и др.) требуют обеспечения непрерывного контроля и архивирования режима сканирования пучка. Для выполнения этих условий на радиационно-технологической установке с линейным ускорителем электронов ЛУ-10 (10 МэВ, 10 кВт) разработан и введен в эксплуатацию автоматизированный комплекс управления сканером. Комплекс является основанной на стандарте КАМАК автономной системой под управлением РС. Он обеспечивает программное управление шириной зоны сканирования пучка, исходя из заданных размеров обрабатываемого объекта, в пределах 20…60 см с автоматическим выставлением центра зоны в середине объекта. Управление комплексом включает также возможность корректировки положения центра развертки пучка для компенсации угла его входа в электромагнит сканера.

РС-КЕРОВАНА СИСТЕМА СКАНУВАННЯ ПУЧКА ТЕХНОЛОГІЧНОГО ЛПЕ

С.П. Карасьов, Р.І. Помацалюк, А.Е. Тєнишев, В.Л. Уваров, В.А. Шевченко, І.М. Шляхов

Нормативні документи на ряд технологічних процесів (стерилізація та ін.) вимагають забезпечення безперервного контролю й архивування режиму сканування пучка. Для виконання цих умов на радіаційно-технологічній установці з лінійним прискорювачем електронів ЛУ-10 (10 МеВ, 10 кВт) розроблений і введений в експлуатацію автоматизований комплекс управління сканером. Комплекс є заснованою на стандарті КАМАК автономною системою під керуванням РС. Він забезпечує програмне управління шириною зони сканування пучка, виходячи з заданих розмірів оброблюваного об'єкта, у межах 20...60 см з автоматичним виставленням центра зони в середині об'єкта. Керування комплексом включає також можливість коректування положення центра розгортки пучка для компенсації кута його входу в електромагніт сканера.