REAL-TIME SYSTEM FOR PROCESSING REGIME DIAGNOSTIC ON ACCELERATOR

L.V. Yeran, S.P. Karasyov, V.I. Nikiforov, R.I. Pomatsalyuk, A.Eh. Tenishev, V.L. Uvarov, V.A. Shevchenko, I.N. Shlyakhov
National Science Center "Kharkov Institute of Physics and Technology»
61108, Kharkov, Ukraine
E-mail: karasyov@kipt.kharkov.ua

A continuous mode of product transportation into the radiation zone of the electron accelerator with a scanned beam is attained by means of a remote loading of the conveyor. To keep an assigned distribution of the absorbed dose, it is necessary to provide a continuous monitoring of process parameters such as the beam current (average and pulse values), the electron energy, the linear density distribution of beam current, and also the conveyor speed. The automatic real-time system operating at the LU-10 linac and providing measurements of the mentioned parameters is described in the paper.

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1. INTRODUCTION

The radiation treatment, e.g., sterilization of products, at the electron accelerator with a scanned beam can be realized in a continuous mode by means of a remote loading of the transport conveyor. To keep an assigned distribution of the absorbed dose, it is necessary that the following parameters of the process should be monitored [1, 2]:

- beam current (average and pulse values),
- electron energy,
- linear density distribution of beam current on the object under treatment,
- conveyor speed.

These parameters should be monitored and entered into the archive throughout the irradiation run in the real-time regime. If any of the mentioned parameters goes beyond the assigned limits, the operator must be informed in order to take a decision on a further regime of products treatment.

We have developed the measuring information system (MIS) operating as a part of the radiation process facility on-line with the electron accelerator LU-10 [3]. The MIS is operated in the real-time mode and provides a continuous monitoring of the mentioned parameters.

2. PRIMARY SENSORS

2.1. A beam-induction monitor (BIM) has been used to measure the beam current (average and pulsed) [4]. A set of sensors to monitor the scan width and the current density distribution is arranged behind the objects of irradiation (Fig.1) and presents a group of Geiger counters operating in the current mode.

The choice of the Geiger counter as a primary converter was dictated by the following:

- the possibility of providing the small size of the monitor;
- a high sensitivity at registration of e- and γ-radiations;
- a high radiation resistance.

2.2. The use of Geiger counters makes it possible to measure the dose absorbed by the irradiated object, too. The measurement of electron flux upstream and downstream of the irradiated products can give this information. However, the registration of electrons by the counter is little efficient because of a substantial dependence of ionization losses on the electron energy. For photons, this dependence is not so essential. So, by measuring the flow of bremsstrahlung γ-quanta (electrons are converted ahead of the counter) we can measure the attenuation of the primary electron beam.

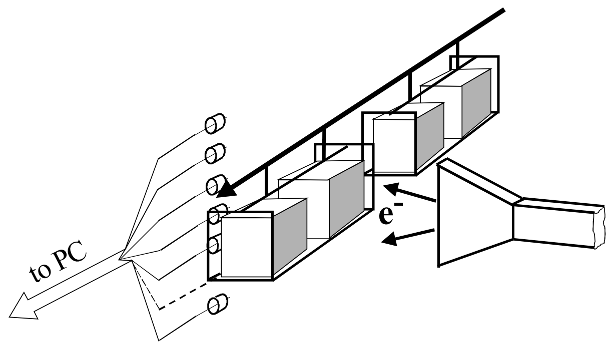

Fig. 1.

2.3. To verify this possibility and to choose the parameters of the converter, we have performed a numerical simulation with the use of the standard GEANT packet.

Figure 2 shows the spectra of bremsstrahlung γ-quantas for different surface density values of the object under irradiation, where ρ=0 corresponds to the direct electron beam, the average γ-quantum energy is ~1.3 MeV in all cases, i.e., the efficiency of photon registration by the counter for different densities of objects will be the same.

Figure 3 gives the relative yield of γ-quanta from the object under irradiation as a function of its surface density.

As it is seen from the plot, this function is linear up to a surface density of ~5 g/cm^2 (this corresponds to the real range of densities for the products being handled in our practice). So, by measuring the amplitude of the signal from the counter we can estimate the absorbed energy (dose) in the object under irradiation.

Relying on the results of computer analysis, Geiger counters were put into copper cylindrical screens having 5 mm thick walls. Each of 10 counters is arranged at ~15 cm behind the object under irradiation, at fixed points on the vertical relative to the bottom of the radiation container.

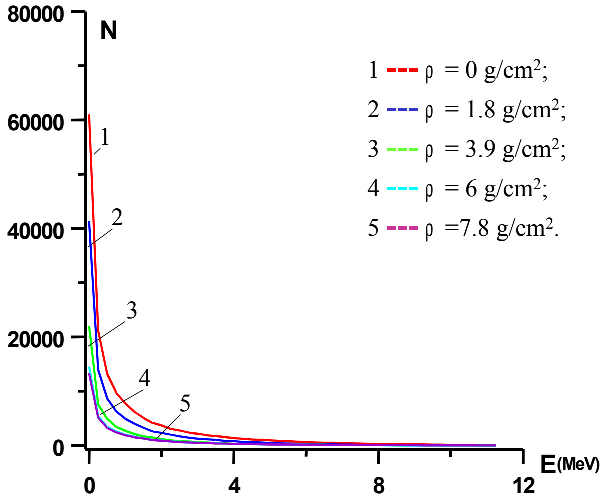

Fig. 2.

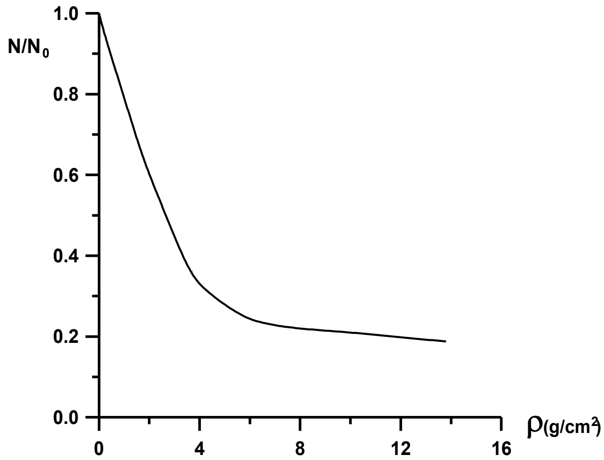

Fig. 3.

This permits us to measure the current density distribution of both the direct beam (in the spacing between the containers) and beam that has passed through the product under treatment.

3. THE MEASURING INFORMATION SYSTEM

3.1. The MIS devised on the basis of the above-described complex of monitors operates by the following algorithm:

- the average accelerator current and the energy taken up by the object are constantly monitored, archived and displayed on the screen in the form of plots;
- the current density distribution is measured at the moment when there is a spacing between radiation containers passing by the complex of monitors, and is graphically displayed on the screen; this moment is determined by the software;
- the conveyor speed is determined with the tachometer and mathematically from the time of radiation container passage, and is displayed on the screen;
- if any of the parameters monitored goes beyond the assigned limits, a prompt ADC channel is switched on to measure the pulse current of the accelerator. With a change in the current density distribution on the object under irradiation, the operator has a possibility to adjust this distribution with the help of the computer by varying the current pulse shape in the electromagnet excitation region of the scanning system.

3.2. The block diagram of the facility is shown in Fig.4.

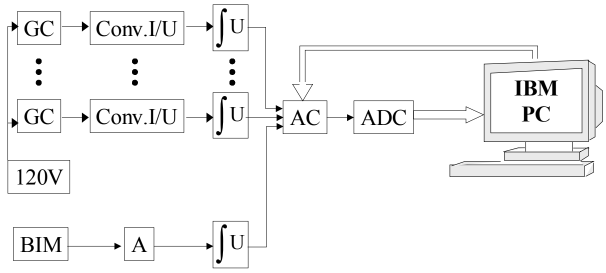

Fig. 4. Block diagram of the facility for monitoring and measuring the absorbed dose at the LU-10 accelerator

The counters (GC) are energized from the source U ~120 V (instability is less than 0.1%). The signal from the counter goes to the input of the current-voltage converter (Conv. I/V). The amplitude of voltage at the output of the converter is proportional to the input current. The conversion coefficient is equal to 5 μA/V. Then the signal is integrated. The integration time constant is ~2 s. The integrator ($\int U$) was applied to suppress the high-frequency noise and modulation due to electron beam scanning. The beam-current measuring channel includes the amplifier (A) and the integrator ($\int U$). The choice of the channel to be measured is provided by the software through the analog commutator (AC). Then the signal is supplied to the 12-digit analog-digital converter (ADC). The result of conversion comes to the computer (IBM/PC).

The communication with the computer is realized by means of the LPT port. The use of the LPT requires no additional interfaces and permits one to acquire the numerical stream at a level of 120 Kbod, this being sufficient for the systems with small and moderate information streams.

3.3. The subsystem for monitoring the accelerator beam scanning system is made as a separate unit which includes the digit-analog converter (DAC) and two memory pages. The information about the current pulse shape of scanning electromagnet, written in one of the memory pages, serves to control the DAC. In the special case that this information should be replaced, it is written in the second page and as soon as the current passes through zero, the unit checks the presence of record in the second page. If the record does exist, the unit deactivates the first page and jumps to the second page, and the next record may be made in the first page.

The unit of absorbed dose at control point was transferred by the use of detectors DRD 4/40. Before each run, the beam-current measuring channel is calibrated with the MIS converter.

4. CONCLUSIONS

The measuring information system has been developed to monitor the main parameters of electron radiation field of radiation process facilities. For the process of radiation sterilization, the system provides a continuous monitoring over a set of parameters responsible for the distribution of absorbed dose in the objects under irradiation. Provided that the measuring channels of the system are calibrated with the use of necessary working standards, the uncertainty as to the control of the absorbed dose distribution meets the requirements of standard documents [1,2].

REFERENCES

1. A.F. Booth. Sterilization Validation & Routine Operation Handbook // *Radiation. Technomic Publishing Company*, 2001, p.157.
2. ISO 11137, Sterilization of Health Care Products-Requirement for Validation and Routine Control – Radiation Sterilization, AAMI, Arlington VA, 1995.
3. K.I. Antipov, M.I. Aizatsky, Yu.I. Akchurin et al. Electron Linacs in NSC KIPT: R&D and Application // *Problems of Atomic Science and Technology. Series: Nuclear Physics Investigations.* 2001, № 1, p. 40-47.
4. V.L. Uvarov, V.N. Boriskin, V.A. Gurin, S.P. Karasyov, I.N. Shlyakhov et al. Calibration of Electron Beam Measuring Channels in Technological Linacs // *Proc. of the 7-th Intern. Conf. on Accelerator and Large Experimental Physics Control Systems ICALEPS'99,* 4-8 Oct. 1999, Trieste, Italy, p.220-222.

REAL–TIME СИСТЕМА ДИАГНОСТИКИ РЕЖИМА РАДИАЦИОННОЙ ОБРАБОТКИ НА УСКОРИТЕЛЕ ЭЛЕКТРОНОВ

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

На ускорителе электронов со сканируемым пучком для обработки продукции в непрерывном режиме применяют ее подачу в зону облучения с помощью дистанционно загружаемого конвейера. Для поддержания заданного распределения поглощенной дозы необходимо осуществлять непрерывный контроль таких параметров процесса, как ток пучка (среднее и импульсное значение), энергия электронов, распределение линейной плотности тока пучка, а также скорость конвейера. В работе описана автоматизированная система, работающая на ускорителе ЛУ-10 в режиме real-time и позволяющая проводить измерение указанных параметров.

REAL–TIME СИСТЕМА ДІАГНОСТИКИ РЕЖИМУ РАДІАЦІЙНОЇ ОБРОБКИ НА ПРИСКОРЮВАЧІ ЕЛЕКТРОНІВ

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

На прискорювачі електронів з пучком, що сканується, для обробки продукції в безупинному режимі застосовують її подачу в зону опромінення за допомогою конвеєра який завантажується дистанційно. Для підтримки заданого розподілу поглиненої дози необхідно здійснювати безупинний контроль таких параметрів процесу, як струм пучку (середнє й імпульсне значення), енергія електронів, розподіл лінійної щільності току пучка, а також швидкість конвеєра. У роботі описано автоматизовану систему, що працює на прискорювачі ЛУ-10 у режимі real-time і дозволяє проводити вимірювання зазначених параметрів.