MONITORING AND VISUALIZATION OF ELECTRONS BEAM PARAMETERS IN INDUSTRIAL LINACS

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Abstract

The questions of monitoring of technological pulse linacs beam in the atmosphere are discussed. The electron beams with energy up to 25 MeV and pulse currents up to 1 A at the exit of one- and two-structure linacs (KUT, LU-10, EPOS, KUT-20) have been investigated [1]. The beam current pulse width is up to 4 μs, linac operative frequency is variable from 50 to 300 Hz. The zone of the technological object irradiation by the accelerated electrons is created by the magnetic scanning system [2] or special magnetic lens [3]. Monitoring of beam energy, position and dimensions is done by wide-aperture magneto-induction position monitor [4] and secondary emission beam monitor. Signals from the monitors are used in the accelerator control system [5].

CONSTRUCTION OF THE SECONDARY EMISSION MONITOR

The beam profile monitor consists of four aluminium lames of width 80 mm and 0.15 mm thick(Fig.1). The lames are locked in cadre. The inner spacing between lames is dictated by size of irradiated sample.

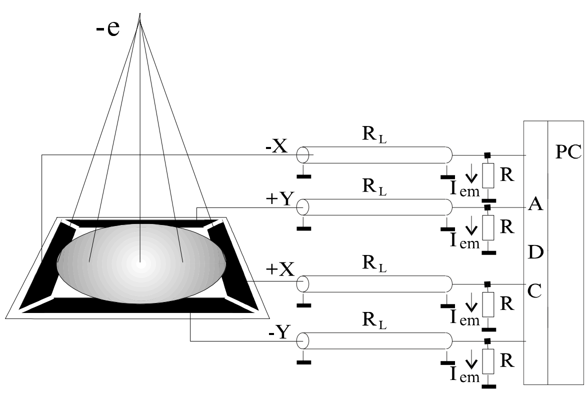

Figure 1: The monitor structure scheme.

R is matching resistance in the end of coaxial cable, R_L is resistance RK75 cable, PC is personal computer, ADC is the digitizer.

The inner monitor window of KUT-20 linac measures w=205 mm and h=93 mm. The lame planes are parallel to one another and perpendicular to optical axis of the accelerator. in high-energy electron passage through the lames, the positive signals come due to emission of secondary delta-electron. The monitor signal with amplitude no more 800 mV (fig.1) by RK75 cable 40 m in length is fed through electronic commutator to the ADC entry [5]. The simplicity of the monitor construction is conditioned by high level of induced activated radiation in the working zone. The employment of the traditional collector electrode with accelerating potential was not necessary for electron beams we used [6,7]. The monitor is installed in the air at 450 mm from the plane of accelerator exhaust foil. The center of inner monitor window is integrated with the optical axis of the accelerator by the use of the special screws.

In the work [7] we showed that at the energy range covered secondary emission current from aluminum lames is directly proportional to electron beam charge. The secondary emission coefficient is 3,1 %. The pulse signal train from monitor lames is given in Fig.2. The pulse area is directly proportional to total charge of electrons captured by monitor lames.

MONITORING OVER THE POSITION OF THE ELECTRON BEAM ON THE TARGET

The quadrupole lens forms the zone of irradiation for technological objects of KUT-20 accelerator exit. [3]. The beam electron section after lens is ellipse shaped in XY plane.

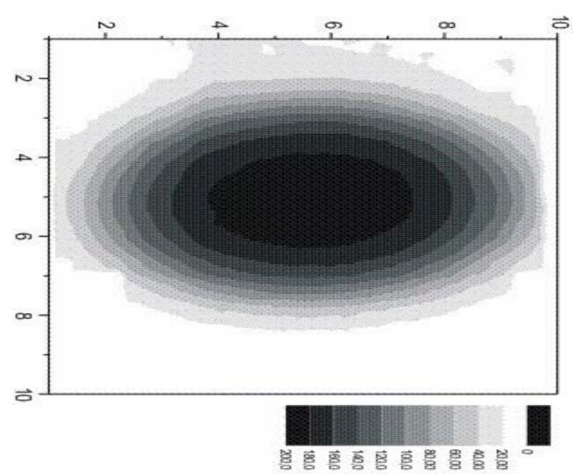

Figure 2: 2D- darkening density distribution on the glass by the action of electron pulse train of KUT-20 accelerator in a monitor plane (450 mm from exhaust foil).

To estimate section ellipse dimensions of beam in monitor plane we used the photometric method. The result of the photometric measurement of the beam electron distribution density is shown on the Fig. 2,3. The thickness of glass used for photometry was equal 3 mm.

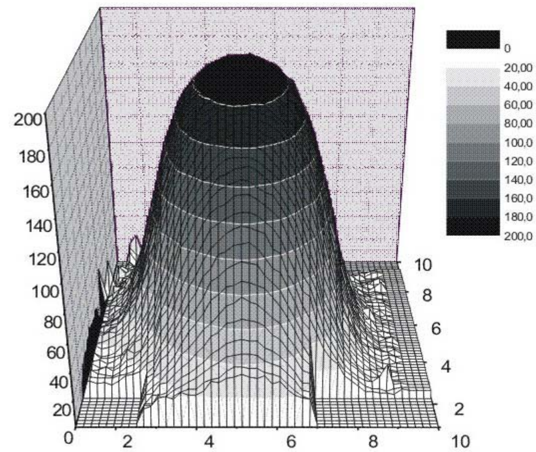

Figure 3: 3D- darkening density distribution on the glass by the action of electron pulse train of the KUT-2 accelerator in a monitor plane (450 mm from exhaust foil).

We customary suggest that glass darkening is linear with the beam electron quantity at short exposure. Results shown on the Fig. 2,3 were obtained at 0.6 A pulse current (pulse quantity was equaled 400). In deciding on distance L it is neccesary to allow for the following relationship :

$$(Dy - H) < W1,$$
$$(Dx - H) < W1.$$

The quantity L is equal to 450 mm for basic operating conditions of the KUT-20 accelerator. In Fig. 4 is seen that the beam centre was offseted top and right relative to accelerator axis. The accelerator control system [5] is accumulating in PC memory numerical values of a pulse series from the monitor lames with discreteness per 100 ns on accelerator operator command. The series of a pulse signals from the monitor lames are shown on the Fig. 4. After that average integrated values of signals are calculated. These values (-xP,+xP,-yP,+yP) multiplied by normality coefficients is displayed in graphical and numerical representations (Fig. 4).

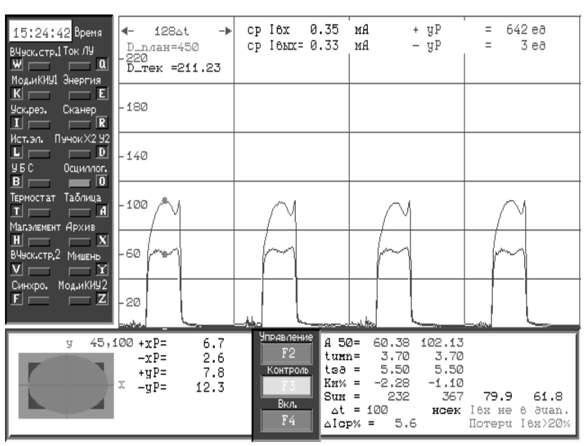

Figure 4: Videogram of the monitoring over the position of the electron beam on the target of the KUT-20 accelerator.

MONITORING OVER THE POSITION OF THE ELECTRON BEAM ON THE TARGET

The wide-aperture magneto-induction position transducers are worked for energy and position control of the sweeped electron beam on the EPOS and LU-10 linac exit [6].

One of the program modules provides the simultaneous signal measurement from the sensor winding and the scanning magnet excitation current (Fig. 5). By the results of the measurements of several scanning cycles maximum Y_{max} and minimum Y_{min} values of the electron beam center deviation are calculated and the value $2R = Y_{max} - Y_{min}$ is determined. It is shown in the works [4,7] that the scanning electromagnet equipped by beam position sensor may be used for the on-line control of the electron energy. For the small angles of the beam deflection ($\varphi \leq 20^{o}$) the practical formula for maximum probable average energy of the electron beam is used:

$$E_k = \sqrt{E_0^{\ 2} + \frac{k^2 I^2}{\sin^2 \varphi}} - E_{0,}$$

where k is the constant determined by bench testing of magnet. In this case $\varphi = arctg(R / h)$ where h is the distance from the magnet center to the plane of the beam position control. With inductive transduser value current R is evaluated, the amplitude of the electromagnet excitation current I is determined at the same time, and then the value E_k is calculated. with an error of about 5%. The videogram of the process of the electron beam energy control is shown in Fig. 5.

The evaluation of value R and the electron energy is performed without a denormalization of the accelerator operation regime and taken about 2 sec.

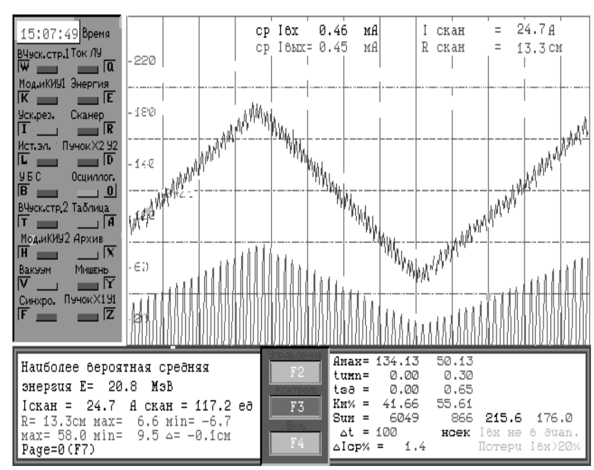

Figure 5: Videogram of the process of the electron beam energy control on the EPOS linac.

THE VISUALIZATION OF INFORMATION.

At the present time we connect linac control systems to the local network of our scientific research complex.. The values of the basic parameters of the linacs in operation have been gathered in the file-server of the local network (Fig. 6). In this way our scientists and engineers have a chance of observing of the linac operation.

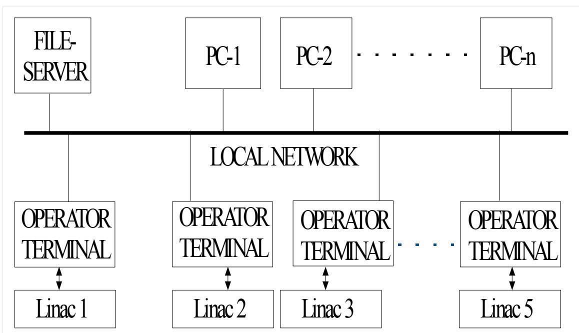

Figure 6:.The fragment of the functional diagram of the local network.

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