MONITORING POSITION OF THE ELECTRON BEAM IN THE AIR

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A possibility of operative control position of the electron beam with energy up to 30 MeV, pulse current up to 1 A with 3.5 pulse length and operate frequency from 50 to 300 Hz at the exit of two-structure linac has been investigated. The zone of technological objects irradiated by accelerated electrons is created with the magnet system. The irradiated samples are situated in the ambient air of the linac bunker. Special secondary-emission monitor is developed for the operative control of the beam position on the target. The monitor signals are used by the linac control system.

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1. CONSTRUCTION OF THE MONITOR

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

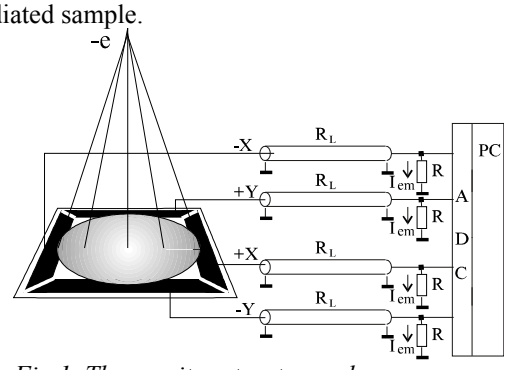

Fig 1. The monitor structure scheme. R is the matching resistance in the end of the coaxial cable, R_L is the resistance RK75 cable, PC is the personal computer, ADC is the digitizer

In our case the inner monitor window measures 205x93 mm. The lame planes are parallel to one another and perpendicular to the optical axis of the accelerator. In high-energy electron passage through the lames, the positive signal comes due to emission of secondary delta-electron. The monitor signal with an amplitude no more than 800 mV (Fig.1) by the RK75 cable 40 m in length is fed through commutator to the digitizer entry [3]. Simplicity of the monitor construction is conditioned by the 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 [4,5]. The monitor is installed in the air at a distance 450 mm from the plane of the accelerator exhaust foil.

The center of the inner monitor window is integrated with the optical axis of the accelerator by the use of the special screws.

In the air a relationship between a charge on the beam profile monitor lames and primary beam intensity may be not linear as a result of deposition of charge atmosphere particles and secondary electrons with low energy on the lames.

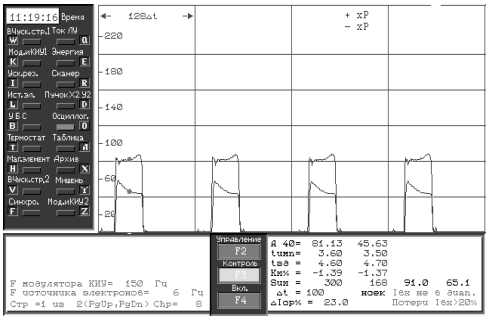

Fig.2. Videogram of the monitor signal measurement

However in our case these effects have insignificant impact. In the work [5] we showed that at the energy range covered the secondary emission current from aluminium lames is directly proportional to the electron beam charge. The secondary emission coefficient is 3.1%. The pulse signal train from the monitor lames is given in Fig.2. The pulse area is directly proportional to total charge of electrons captured by monitor lames

2. MONITORING OVER THE POSITION OF THE ELECTRON BEAM ON THE TARGET

The quadrupole lens forms the zone of irradiation for technological objects of the accelerator KUT-20 exit. [2]. The beam electron section after lens is ellipse shaped in the XY plane.

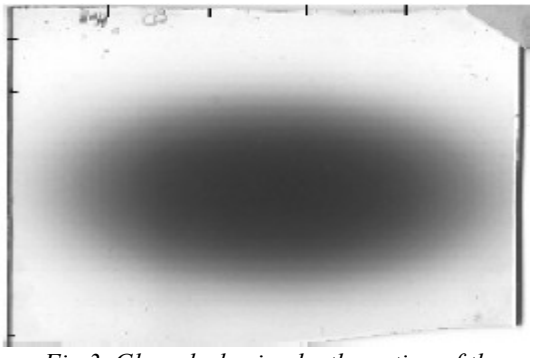

Fig.3. Glass darkening by the action of the electron pulse train of the accelerator "KUT-20". The glass is situated in the monitor plane (450 mm from exhaust foil)

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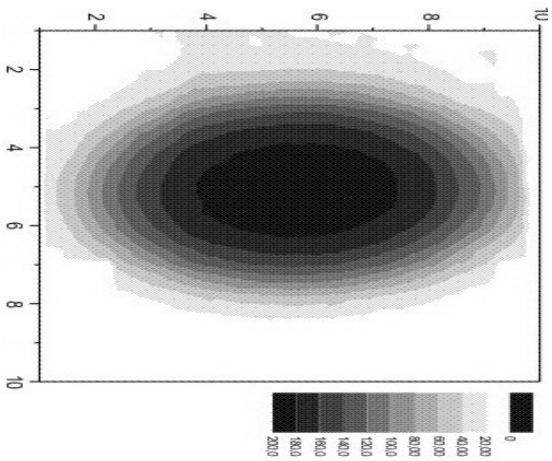

Fig.4. 2D- darkening density distribution on the glass by the action of the electron pulse train of the accelerator "KUT-20" in a monitor plane (450 mm from exhaust foil)

To estimate section ellipse dimensions of the beam in the monitor plane we used the photometric method. The result of the photometric measurement of the beam electron distribution density is shown in Fig.3-5. The thickness of the glass used for photometry was 3 mm. To perform the quantitative estimation of the beam electron distribution density the skanner EPSON 1660 is used.

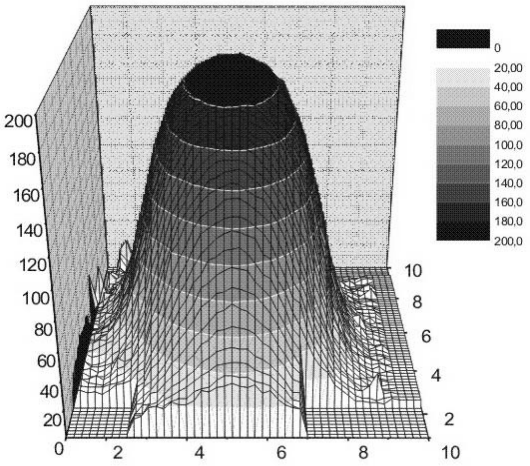

Fig.5. 3D- darkening density distribution on the glass by the action of the electron pulse train of the accelerator "KUT-20" in the monitor plane (450 mm from exhaust foil)

We customary suggest that glass darkening is linear with the beam electron quantity at short exposure. Results shown in Fig.3-5 were obtained at the 0.6 A pulse current (pulse quantity was equaled 400). In the solution with the 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.6 it is seen that the beam centre was offseted top and right relative to the accelerator axis. The accelerator control system [3] is accumulating in PC memory numerical values of a pulse series from the monitor lames with discreteness per 100 ns on the accelerator operator command. After that average integrated values of signals are calculated. This values multiplied by normalizing coefficients are demonstrated on the operator display in graphic and numerical forms.

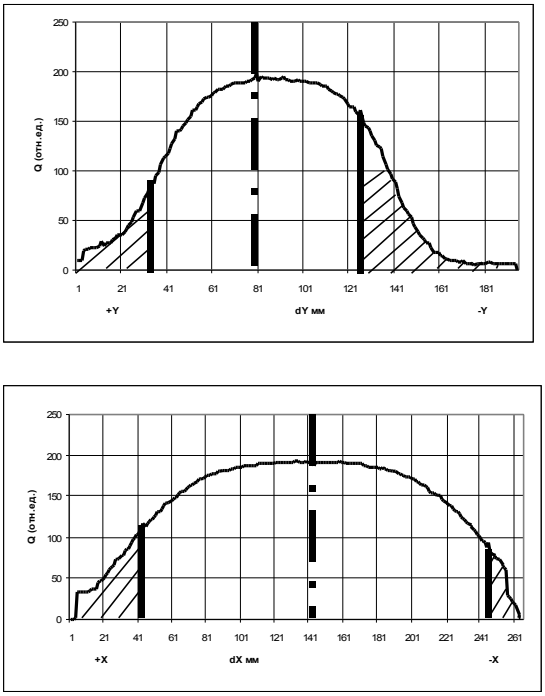

Fig.6. The distribution density (Q) of the glass darkening under the action of the electron pulse train of the accelerator "KUT-20". The top figure presents the cross-section in the YZ plane and the bottom figure presents the cross-section in the XZ plane. The disposition of the monitor lames is marked by hatching. The accelerator axis (Z) is shown by dot-dash lines

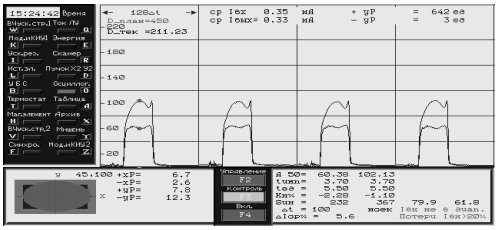

Fig.7. Videogram of the monitoring over the position of the electron beam on the target of the accelerator "KUT-20"

SUMMARY

On-the line channel of measuring the beam position has been in successful operation during many years as a part of the linac "KUT-20" control system. Authors are grateful to M.I. Ayzatsky, A.N. Dovbnya, V.A. Kushnir and V.L. Uvarov for the helpful discussion.

REFERENCE

1. M.I. Ayzatsky, V.N. Boriskin, A.M. Dovbnya et al. The NSC KIPT Electron Linacs –R&D // *Problems of Atomic Science and Technology. Series:*

"Nuclear Physics Investigations" (41). 2003, № 2, p. 19-24.

2. A.N.Dovbnya, N.A.Dovbnya, Z.M.Kolot et al. Formation of Uniform Electron Beams on Large-Area Targets // *Proc. of the 18th International Workshop on Charged Particle Accelerators, 2003.*
3. Yr.I. Akchurin, V.N. Boriskin, Yr.V. Borgkovsky, V.A. Gurin et al. Control system by the technological electron linac KUT-20 // *Problems of Atomic Science and Technology. Series: "Nuclear Physics Investigations" (38).* 2001, № 3, p.126-127.
4. V.A.Golshteyn, V.G.Vlasenko, S.V.Dementij et al. *Research of the secondary emission monitors on the LAE-2000 electron beam:* Preprint KIPT 72-14, Kharkov, 1972, p.27.
5. V.N. Boriskin, V.A. Gurin, V.A. Popenko et al. Monitoring channel of the technological linac beam cross-section // *Problems of Atomic Science and Technology. Series:" Nuclear Physics Investigations" (39).* 2001, № 5, p.147-149.

ОПЕРАТИВНЫЙ КОНТРОЛЬ ПОЛОЖЕНИЯ ПУЧКА ЭЛЕКТРОНОВ В АТМОСФЕРЕ

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Исследуется возможность оперативного контроля положения пучка электронов на выходе двухсекционного линейного ускорителя электронов (ЛУЭ) энергией до 30 МэВ, с импульсным током до 1 А длительностью 3,5 мкс и рабочей частотой 50...300 Гц. Создание зоны облучения технологических объектов ускоренными электронами осуществляется магнитной системой. Облучаемые объекты расположены в воздушной атмосфере в бункере ЛУЭ. Для оперативного контроля положения пучка на мишени разработан специальный монитор вторичной эмиссии. Сигналы с монитора используются в системе управления ускорителем.

ОПЕРАТИВНИЙ КОНТРОЛЬ ПОЛОЖЕННЯ ПУЧКА ЕЛЕКТРОНІВ В АТМОСФЕРІ

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Досліджується можливість оперативного контролю положення пучка електронів на виході двосекційного лінійного прискорювача електронів (ЛПЕ) енергією до 30 МеВ з імпульсним струмом до 1 А тривалості 3.5 мкс і робочою частотою 50...300 Гц. Створення зони опромінення технологічних об'єктів прискореними електронами здійснюється магнітною системою. Опромінюванні об'єкти розміщуються у воздушній атмосфері бункера ЛПЕ. Для оперативного контролю положення пучка на мішені розроблено спеціальний монітор вторинної емісії. Сигнали з монітора використовуються в системі управління прискорювачем.