VISUALIZATION OF ELECTRON BEAM IMAGE

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The system for visual monitoring of the electron beam was developed and implemented. The technique is based on registration of optical radiation, which is generated under object-beam interaction. The system comprises image transferring channel, remote-controlled digital photo-camera, connected with PC by USB-interface as well as proper software. The images obtained give information on the beam density distribution over the surface of the object being irradiated. 40 keV and 10 MeV electron beams were researched.

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VISUALIZATION OF ELECTRON BEAM WITH ENERGY OF 40 keV IN VACUUM

Tubelike electron beam was formed by magnetron gun with a secondary-emission 40 mm aluminium cathode [1] providing 40 kV and 50 A pulse of 40000 ns in width. The beam hit an eight-segment Faraday cup (Fig. 1).

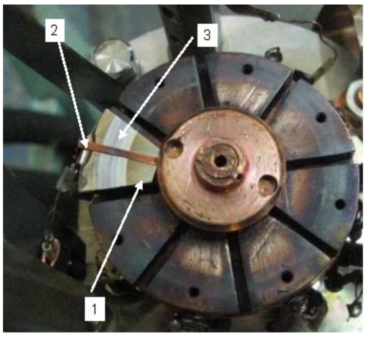

Fig. 1. Faraday cup with electron beam traces: 1 – target; 2 – calibration strip; 3 – beam image

One of its segments has a stainless steel cover with calibration strip. For visual control, electron beam image is taken out by system of mirrors and lenses (Fig. 2) and fixed with a digital camera controlled by PC.

Fig. 2. Electron beam image of magnetron gun with 40 keV electron energy at the target

Processing of images is provided using program Origin 7.5 (Fig. 3).

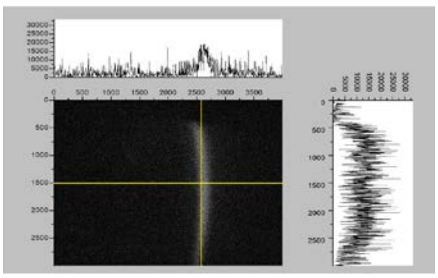

Fig. 3. Image of beam profile at the target

VISUALIZATION OF ELECTRON BEAM WITH ENERGY OF 10 MeV IN ATMOSPHERE

The system was created for visual monitoring of the objects being irradiated on LUE-10 LINAC (Fig. 4) as still as fixed and moved by transfer conveyor [2].

Fig. 4. LINAC LUE-10 with conveyor and supercritical water convection loop

Condition: average beam current – 0.8 mA; beam energy – 10 MeV; beam pulse rate – 250 Hz; beam scanning frequency – 3 Hz. Structural arrangement of electron beam visual monitoring system show at Fig. 5.

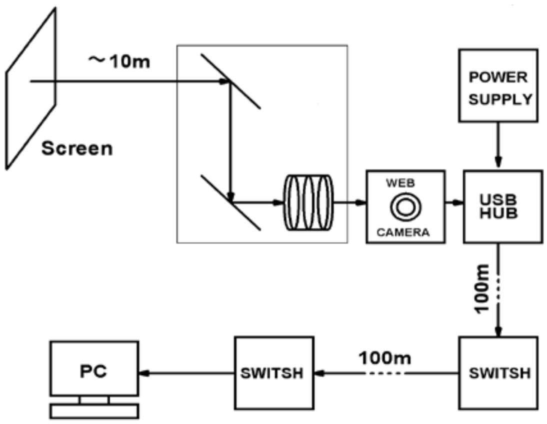

Fig. 5. Functional chart of the system for visual monitoring of electron beam at LINAC LUE-10

Electron beam image was observed with the use of such targets:

- carton (blue color of light, Fig. 6);
- plastic (white color of light, Fig. 7);
- aluminium screen coated with luminophor (yellow color of light).

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Fig. 6. Electron beam image on carton (distance between lines – 50 mm)

Fig. 7. Electron beam image on plastic (distance between lines – 50 mm)

Recovery of the beam density distribution is able by summarizing of beam images of irradiated plastic surface (Fig. 8).

Fig. 8. Picture of summarized electron beam images on plastic (distance between lines – 50 mm)

Electron beam density profile was processed in Origin 7.5 (Fig. 9).

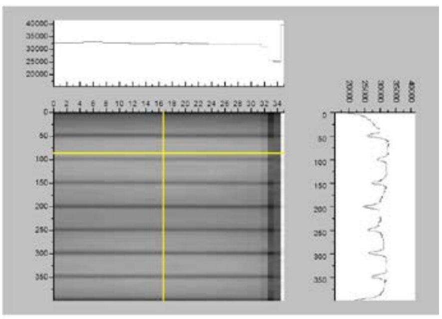

Fig. 9. Electron beam density profile on plastic (distance between lines – 50 mm)

The profiles obtained by proposed optical technique as well as by means of beam exposure of glass sheets and dosimetry film B3 are agreed satisfactory.

The pilot testing of the electron accelerator driven convection loop with water in supercritical state [3] was carried out during the summer 2012 (Fig. 10).

Fig. 10. Irradiated chamber with the loop and screen for electron beam monitoring

Implementation of on-line beam monitoring system was essential for its success. Patterns of constructional materials for next-generation reactors were exposed to radiation for 500 hours at pressure of 240 atm and temperature of about 400°C.

Electron beam on-line visual monitoring was enabled by aluminium screen coated with luminophor (Fig. 11).

Fig. 11. Summarized beam image on aluminium screen coated with luminophor (a shadow of the loop is visible)

CONCLUSIONS

1. The system developed enables on-line monitoring of electron beam profile.
2. The pictures of beam density profiles resulted using this procedure are similar to those, obtained by the conventional method on glass and film B3.
3. The described procedure enables to operate with electron beams of energy within trigger unit and lockout monitoring system are involved.

REFERENCES

1. N.I. Ayzatsky, A.N. Dovbnya, V.V. Zakutin, N.G. Reshetnyak, V.N. Boriskin, N.A. Dovbnya, V.P. Romas'ko, and I.A. Chertishchev. Investigations of Electron Beam Characteristics Using an Accelerator Based on a Magnetron Gun with a Secondary-Emission Cathode // *Physics of Particles and Nuclei Letters*. 2008, v. 5, № 7, p. 86-89.

2. K.I. Antipov, M.I. Ayzatsky, Yu.I. Akchurin, V.N. Boriskin, E.Z. Biller, N.V. Demidov, A.N. Dovbnya, L.S. Dovbush, V.A. Gurin, S.P. Karasyov, et al. Electron Linacs in NSC KIPT: R&D and Application // *PAST. Series «NPhI»*. 2001, №1, p. 40-47.
3. A.S. Bakai, V.N. Boriskin, A.N. Dovbnya, S.V. Dyuldya and D.A. Guzonas. Supercritical water convection loop (NSC KIPT) for materials assessment for the next generation reactors // *Proc. of 5-th Int. Sym. SCWR (ISSCWR-5)* Vancouver, Canada, March 13-16, 2011.

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ВИЗУАЛИЗАЦИЯ ОТПЕЧАТКА ПУЧКА ЭЛЕКТРОНОВ

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Разработана и изготовлена система для визуального on-line контроля параметров пучка электронов, основанная на регистрации излучения в оптическом диапазоне, возникающего при взаимодействии пучка с мишенью. Система включает оптический канал передачи изображения, дистанционно-управляемую цифровую фотокамеру, подключенную к PC через USB-интерфейс, а также программное обеспечение. Система позволяет вести контроль распределения плотности пучка на поверхности облучаемого объекта. Исследования проводились на пучках электронов с энергией 40 кэВ и 10 МэВ.

ВІЗУАЛІЗАЦІЯ ВІДБИТКУ ПУЧКА ЕЛЕКТРОНІВ

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Розроблена та виготовлена система для візуального on-line контролю параметрів пучка електронів, заснована на реєстрації випромінювання в оптичному діапазоні, яке виникає при взаємодії пучка з мішенню. Система має оптичний канал передачі зображення, дистанційно-керовану цифрову фотокамеру, підключену до PC через USB-інтерфейс, а також програмне забезпечення. Система дозволяє контролювати розподілення густини пучка на поверхні об’єкта, що опромінюється. Досліди проводилися на пучках електронів з енергією 40 кеВ та 10 МеВ.