ELECTRON BEAM IMAGE VISUAL MONITORING

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Abstract

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.

VISUAL MONITORING 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 (see Fig. 1).

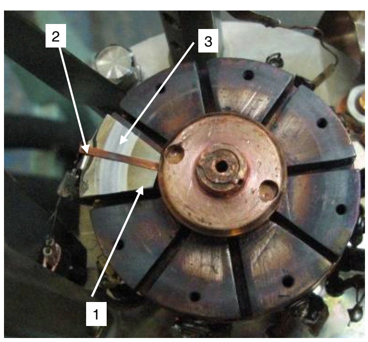

Figure 1: Faraday cup with electron beam traces. 1- target, 2- calibration strip, 3- beam image.

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 (see Fig. 2) and fixed with a digital camera controlled by PC.

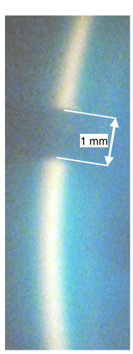

Figure 2: Electron beam image of magnetron gun with 40 keV electron energy at the target.

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Processing of images is provided using program Origin7.5 (see Fig. 3).

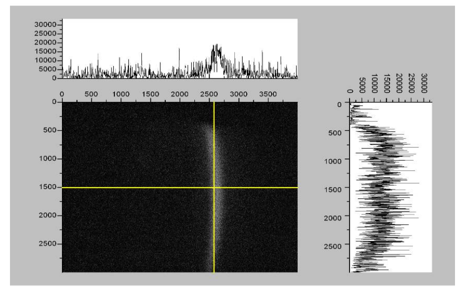

Figure 3: Image of beam profile at the target.

VISUAL MONITORING 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 (see Fig. 4) as still as fixed and moved by transfer conveyor[2].

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

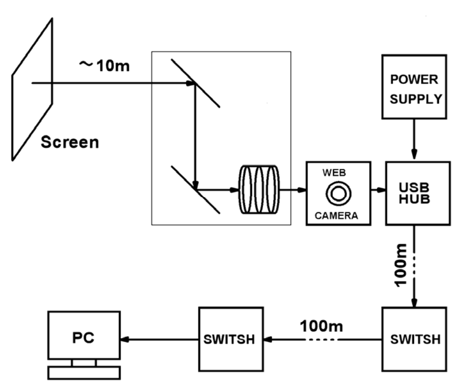

Fig. 5. Functional chart of the system for visual monitoring of electron beam at LINAC LUE-10.

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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.

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

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

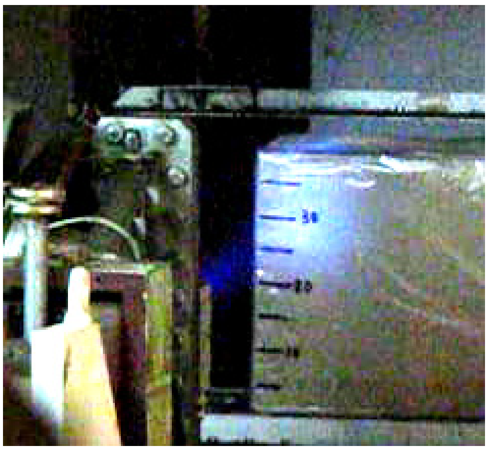

Figure 6: Electron beam image on carton (distance between lines – 50 mm).

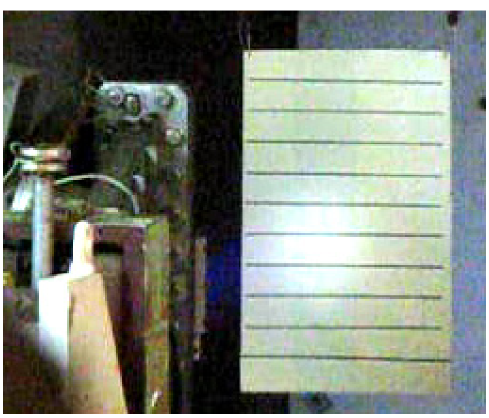

Figure 7: Electron beam image on plastic (distance between lines – 50 mm).

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

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

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 (see Fig.10).

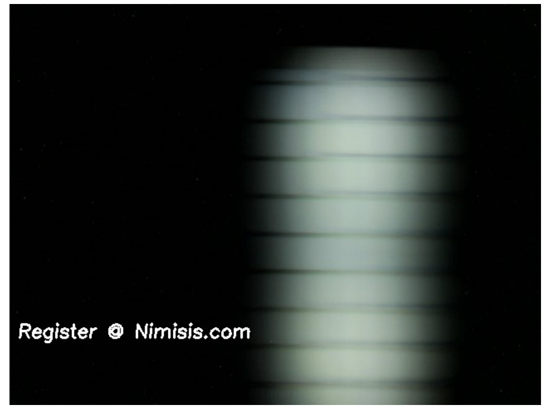

Figure 8: Picture of summarized electron beam images on plastic (distance between lines – 50 mm).

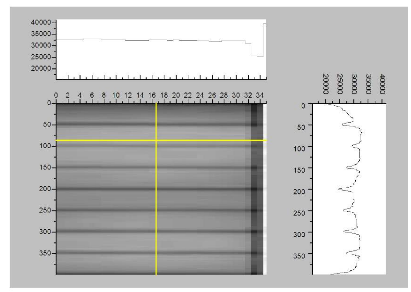

Figure 9: Electron beam density profile on plastic (distance between lines – 50 mm).

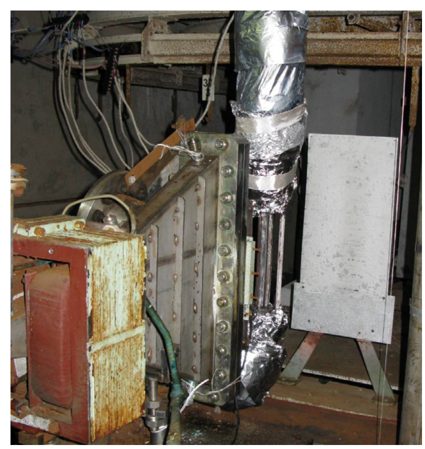

Figure 10: Irradiated chamber with the loop and screen for electron beam monitoring.

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 (see Fig. 11).

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

CONCLUSION

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 the range from tens of keV up to tens of MeV.

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