ELECTRON BEAM TREATMENT LINE WITH ILU-6 MACHINE FOR MEDICINAL RAW DECONTAMINATION

V. L. Auslender, V.V. Bezuglov, A.A. Bryazgin, M.V. Korobeynikov, A.V. Sidorov, E.A. Shtarklev
BINP SB RAS, Novosibirsk, Russia.

Abstract

A new irradiation line based on ILU-6 electron accelerator is put into work in September 2007. The line is purposed for decontamination of medicinal raw and sterilization of the medical goods.

The medicinal raw is treated in hermetically sealed polymer packs. The products are transported to the irradiation zone and back from it by the loop conveyor driven by chain. The nominal electron energy is 2.5 MeV, conveyor velocity – up to 10 cm/s, production rate – up to 400 kg/hour.

The installation is housed in specially designed 2-storeyed building. The biological shield is made of concrete.

The report describes ILU type industrial electron accelerators. It describes their main parameters, design, principle of action, electron beam extraction devices, wide set of auxiliary equipment for various technological processes and ways of their usage.

BRIEF INFORMATION ABOUT ILU-6

The ILU-6 pulse RF electron accelerators are produced by Budker Institute of Nuclera Physics for more than 40 years. These reliable and rather simple RF machines are working for decades in the research and industrial radiation-technological installations.

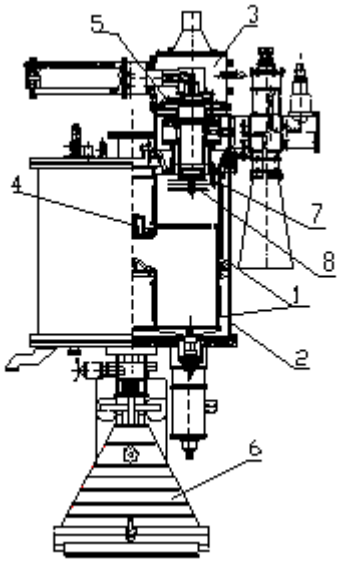

Figure 1: ILU-6 accelerator.

1 – copper toroidal cavity, 2 – vacuum tank, 3 – RF generator, 4 – electron injector, 5 – triode, 6 – beam extraction device with linear scanning, 7 – coupling loop support, 8 – vacuum capacitor.

The ILU-6 [1-3] is the most widely used accelerator in the ILU family. Its energy range is 1.7-2.5 MeV, beam power is up to 20 kW. This accelerator has rather good parameters at modest dimensions and is used for wide spectrum of technological processes. The design of the ILU-6 machine is given in Fig. 1. The height of the machine is 2.5 meters (with RF generator installed directly on the tank). The high voltage (up to 2.5 MV) exists only in the resonator, so the accelerator does not need the high pressure vessel with insulating gas.

The ILU-6 machines for years were mainly used for cable treatment. But in the end of 80-s the single use plastic medical devices appeared on the market – first syringes, then blood exchange systems, etc. The industry demanded new sterilization facilities for these devices. First they were sterilized by ethylene oxide and in cobalt sources, then the time for accelerators came.

The facilities with accelerators have high production rate and are expensive, so to be efficient they ought to be loaded by work.

In 1989 the ILU-6 machine was put in operation in Kiev. This machine was used for researches and also rendered the contact irradiation services, and it was used for syringes sterilization.

The first specialized sterilization facility with ILU-6 accelerator was put in operation in Russia in 1996 in Izhevsk. Fig. 2 shows the ILU-6 accelerators installed in Izhevsk. The line with ILU-6 working at energy of 2.5 MeV was used for sterilization of the 5 ml and 10 ml single use syringes packed in the consumer packs.

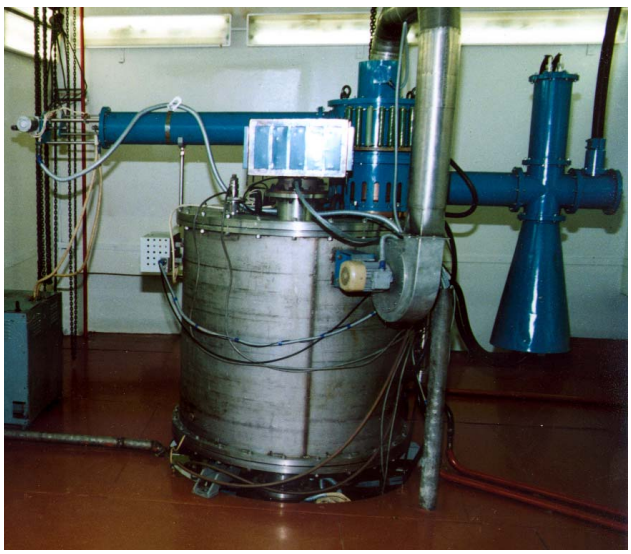

Figure 2: ILU-6 accelerator in Izhevsk.

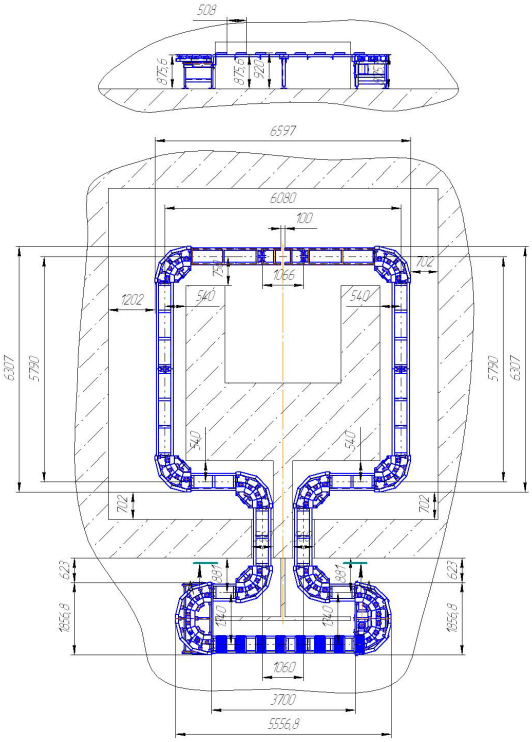

Figure 3: Conveyor system.

NEW FACILITY IN ALTAY REGION

The new electron beam treatment line with ILU-6 machine was put into operation in September 2007 in Altay region. The facility was designed for decontamination of medicinal raw and sterilization of the medical goods. The ILU-6 accelerator was chosen because it is able to treat the medicinal raw in packs.

The computer simulation and experimental measurements for single side irradiation give the following dependence for the penetration depth R (in cm) on energy (in MeV) for organic (and plastic) products having density of 1 g/cm^3 :

$$R = 0{,}405*E - 0{,}161$$

So for the working energy of 2.5 MeV the penetration depth is of 0.8 cm. For double sided irradiation the maximum admissible product thickness is to be multiplied in 2.5 times thus giving the value of 2 cm. The medicinal raw is packed so that the thickness vary from 0.85 cm to 1.3 cm so the 2-sided irradiation is used.

The design of the conveyor system and the radiation shield is given in Fig. 3. The conveyor consists of 73 pallets driven by the chain. The dimensions of the pallets are 268 mm * 448 mm, the maximum load is 1.2 kg. The conveyor speed can vary from 0 to 10 cm/second.

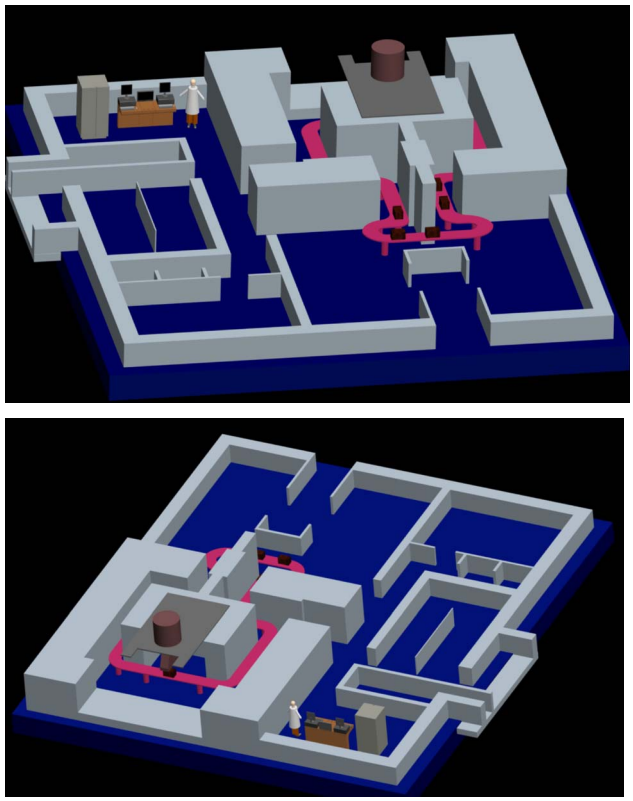

Figure 4: View of the building.

The facility is placed in the separate especially fuilt building. The sketchy view of the building where the facility is placed is shown in Fig. 4. The concrete radiation bunker is the core of this 2-storeyd building.

Main parameters of the installation are given lower:

- Energy – 2.5MeV;
- Beam current – up to 8 mA;
- Beam power – up to 20 kW;
- Pulse repetition frequency – up to 50 Hz;
- Conveyor velocity – up to 10 cm/second,
- Irradiation zone width – 600 mm;
- Standard dose for products – 20 kGy;
- Surface dose inhomogeneity – less than ±10%.

Main parameters of the ILU-6 resonator are given below:

- Specific frequency – 115.435 MHz;
- Shunt resistance – 2.5 MOhm;
- Q-factor – 14.4*10^3;
- Accelerating gap – 30 cm.

The facility is fully automated. It is controlled by the main computer that controls the accelerator and gives the signals to the conveyor system. The conveyor has its own control system based on the microcontroller. The second computer is used for processing the signals from the interlock systems, including the radiation level sensors. The third computer is used for recording the video signals from the cameras that are installed in the loading-unloading zone and in the control room. The images from these cameras are displayed on the monitor in the control

room so the operator can see the process of the loading-unloading.

The facility was successfully tested in round-the-clock mode of work. The production rate of the facility is up to 300 kg/hour, but such rate is still not required now. The facility is working 2 shifts per day with production rate of 56 kg/hour. Nevertheless sometimes the rate is higher when there are many products to be treated.

The loading of this facility by the products to be treated is constantly growing , the load doubled in 1 year.

CONCLUSION

The industrial accelerators are demanded by industry and research institutions, and this demand in Russia is growing, and we are ready to meet the market needs.

The Budker Institute of Nuclear Physics is not restricting the activity only by supplying the accelerators. The important directions of work are researches connected with medical, biological and pharmacological applications of our accelerators. The medicinal raw for Altay region that are treated by this new facility were for years treated by ILU-6 machine that is working in the Institute. The sterilization technologies were also elaborated in the Institute.

The electron beam sterilization technology for disposal medical products is well studied and widely used in our country and abroad. This technology is good alternative to the gamma irradiators (Co and Cs isotopes sources).

REFERENCES

[1] V.L. Auslender. “ILU-type electron accelerator for industrial technologies”, Nuclear Instruments and Methods in Physical research, B 89 (1984) p. 46-48.

[2] V.L.Auslender, R.A. Salimov, “Electron accelerators of INP SB AS USSR for national economy”, Atomnaja energija, v.44, issue 5, 1978. – p. 403–408.

[3] V.L. Auslender et al, “Electron Accelerator for Energy up to 5.0 MeV and Beam Power up to 50 kW with X-ray Converter”, Problems of Atomic Science and Technology, 2004, №1, p.21-23.