ILU - ELECTRON ACCELERATORS FOR INDUSTRY

V.L. Auslender
Budker Institute of Nuclear Physics
Russian Academy of Sciences of Siberian Division
Ac. Lavrentyev pr., 11, Novosibirsk 630090, Russia

1 INTRODUCTION

The Electron Beam (EB) treatment of the different types of materials gains the steady positions in the various fields of industrial production. The successes of this technology are firstly based on its economical efficiency, technological flexibility and ecological safety. These advantages of the EB processing are clearly seen in comparison with the competitive technologies although in some cases it is the only possible technology.

More than 500 accelerators are functioning now in the industry and in the R& D centers all over the world, and about 100 machines from this park are manufactured in the Institute of Nuclear Physics implying more than 30 accelerators type ILU.

The description of the ILU type accelerators' design was given on the previous EPAC [1].

The present report describes the new results in the improvement of accelerators' parameters and some new technological applications.

2 PROGRESS IN DESIGN OF ILU ACCELERATORS

The ILU-10 accelerator with the accelerating gap width 26 cm and shunt resistance of 9 MOhm was produced and tested on the testing facility in the Institute. The shunt resistance increase was reached mainly due to increase of cavity's height (approximately on 0.5 m) and increase of accelerating gap with respect to ILU-6. It has reached the energy up to 4 MeV and power 30 kW in the energy range 2–4 MeV with single generator. The main application field for this accelerator is the sterilization of medical goods, drugs and irradiation of polyethylene tubes with thick walls and high voltage cables (up to 30 kV). The next step which is now in the stage of preparation for testing is the work with two generators with correspondent increase of output energy and power.

The universal installation in local shielding was created on the basis of ILU-8 accelerator. This installation can treat the polyethylene tubes with diameter from 1 to 20 mm with wall thickness up to 1.5 mm or films with width up to 800 mm. The equipment's set implies three compatible underbeam devices for irradiation of different kinds of products. The time for replacement of any device is about one or two hours.

3 DEVELOPING AND PERSPECTIVE TECHNOLOGIES

The Electron Processing System's (EPS) application is now widening in the agricultural and food products treatment for the stocking term prolongation. The WHO established the recommendations on the irradiation treatment of these products, and many countries adopted the laws, regulated such treatment.

The abrupt rise in the single-use medical devices (made from the polymers) production and consumption pose the problem of the large-scale sterilization processes without heating. The polymer single-use medical devices practically can be sterilized only by the two technologies—by the gas (ethylene oxide) or irradiation treatment.

The main problems of ethylene oxide sterilization are:

- processing safety (danger for the working staff);
- residual ethylene oxide in polymer goods (danger for the patients);
- environmental pollution.

The enriching variety of the radiation resistant composed polymers effectively solved one of the most crucial problems of radiation technology - the possible radiation degradation.

The EB treatment gives the guarantee of sterility in some orders of magnitude higher than the ethylene oxide process. The high productive rate is the most distinguishable feature of the EB process (for example the accelerator with the beam power about 20 kW provides sterilization of more than 100,000 syringes per hour).

Some of the pharmaceutical raw and medicaments are sensitive to heating and incompatible with the ethylene oxide. The EB treatment is the only possible way of the sterilization of such products. Besides this, optimal dose choice for the minimal biological load is also attractive.

The EB treatment has become used for immobilization of ferments, and this application can be also enlarged.

In the last years the usage of accelerators starts in the field of Radiation Thermal (RT) proceeding. The realization of such processes can be done by electron beam extracted into atmosphere through the foil with the power density up to 400 W per cm^2. In this case beam can be extracted on the big square ($200 - 400$ cm^2).

The specific features of the beam thermal action are the energy input in the whole electron penetration volume and high obtainable power concentrations. The direct energy

N	Parameter/Accelerator	ILU-8	ILU-6	ILU-6M	ILU-10	ILU-10M
1	Beam energy range, MeV	0.5 – 1.0	1.2 – 2.5	1.0 – 2.0	2.5 – 4.0	2.5 – 4.0
2	Maximal beam power, kW	20	40	20	50	20
3	Maximal beam current, mA	20	25	20	15	8
4	Irradiation velocity, kg/h	400	850	450	1000	450
	dose 10 Mrad, maximal power					
5	Mains, V*)	$3 \cdot 380$	$3 \cdot 380$	$3 \cdot 380$	$3 \cdot 380$	$3 \cdot 380$
6	Total consumption, kW	100	120	120	200	120
7	Local protection weight, t	76	—	—	—	—

*) May be changed according the customer's demands.

transfer to the volume of the treated material excludes practically inevitable in any other process thermal inertia and realizes direct correlation between thermal conditions and irradiation parameters. The simplicity of irradiation parameters control permits to realize practically any desired heating regime needed, for example, in the special ceramics synthesis or other processes and guarantees the high preciseness and reproducibility.

The thermal activation effects during the solid state inorganical systems EB irradiation are additionally growing by the radiation. This results in sufficient reaction speed growth and the decrease of the necessary reaction temperature.

So in the RT processes the electron beam can be regarded as the non-traditional heat source from one side and as the radiation activator of the chemical transfers from the other side.

Up now this technology finds the application in the ferrum catalyst (for ammonium synthesis) manufacturing, the high temperature glasses and ceramics production, high quality ferrite materials production.

The subject of a great interest is also the EB usage for the passive components of the Hybrid Integrated Circuits (HIC) production.

The firing of the thick-film elements by EB heating provides the following:

- improve the quality of thick-film components;
- increase the density of thick-film elements;
- decrease the quantity of defective multilayer plates;
- use base-metal paste instead of a noble- or rare-metal system;
- use the metal plates instead of ceramic plates with the higher insulation properties;
- make the screen-and-fire process fabrication system highly automatic.

The EB thick-film technology permits also to produce the gas sensors and form the structure of high temperature supraconductor on the ceramic plates.

4 ARRANGEMENT OF EPS WITH DIFFERENT TECHNOLOGIES

One of the modern trends in EPS development is the single device beam power increase. This permits to create the EPS with the high productive rate and in some cases not to pay much attention to the electron beam usage efficiency.

Powerful EPS are applied in large-scale industrial production lines. Great powers are of much importance in the ecological applications.

This trend results in situation when accelerator's size and price are dependent mainly on the electron beam energy and slightly on the beam power, so their usage in relatively small enterprises causes some problems.

In many cases (for example, for the disposal medical goods and medicines sterilization, HICs, etc.) the beam power range 20 – 50 kW is more than enough. Because of that the second trend is forming now—the creation of compact electron accelerators with medium beam power (20 – 50 kW) capable to operate in the wide range of the electron energies with the constant average beam power. Such accelerators are good for the treatment of wide production variety. More over, the creation of the very compact self-shielded EPS is possible at the energy range up to 1 MeV.

The extraction system and the underbeam equipment are the very important parts of the EPS. The properly elaborated extraction device ought to be fitted with the technological process, providing the electron beam power effective use. So even in the most simple case of the flat goods (bands, sheets, etc.) EB treatment with one-side irradiation maximal reaching beam power efficiency is 60% and the two-side irradiation increases this efficiency up to 80% and the penetration depth increases in 2.5 times.

The most interesting is the construction of the relatively cheap compact accelerators with the beam energy range of 2 – 5 MeV and beam power up to 20 kW. Such accelerators undoubtedly will find the wide application in the sterilization of the disposable medical goods.

The high frequency accelerators are most fitted for the second case when the technological requirements are not high in respect of energy and power.

5 REFERENCES

[1] V.L. Auslender et al., "High-frequency powerful electron accelerators type ILU for industrial applications". Proceedings of the EPAC 92, pp.182–184, Berlin, March 1992.