HIGH VOLTAGE ELV ACCELERATORS FOR INDUSTRIAL APPLICATION (FAMILY OF ACCELERATORS AND TENDENCY OF DEVELOPMENT)

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Abstract

Budker Institute of Nuclear Physics Siberian Branch of Russian Academy of Science (SB RAS) continue its activity in the development and manufacturing of electron accelerators of the ELV-type for their use in the industrial and research radiation-technological installations. The ELV-type accelerators were designed with use of the unified systems and units enabling thus to adapt them to the specific requirements of the customer by the main parameters such as the energy range, beam power, length of extraction window, etc.. INP proposes a series of electron accelerators of the ELV-type covering the energy range from 0.3 to 2.5 MeV with a beam of accelerated electrons of up to 400 mA and maximum power of up to 400 kW. The design and schematic solutions provide the long term and round-the -clock operation of accelerators under the conditions of industrial production processes. The ELV accelerators are especially popular accelerators not only in Russia, but in China, Korea, and etc.

INTRODUCTION

Radiochemical technologies with the use of electron accelerators as ionizing radiation sources were generally developed in the early sixties. By recent, they had strongly consolidated in world industrial production and, thereby, confirmed their efficiency as well as their uniqueness. The technological processes with the use of electron beams for polymer radiation modification, stimulation or initiation of chemical reactions, smoke purification, waste waters treatment, grain disinfection, etc., are widely used in modern industry. A lot of accelerators are installed and operated in different science and research centers and applied-research laboratories. That leads to growth of radiation-modified goods production and development of new matters and technologies, where electron beams are used to obtain new and, sometimes, unique properties.

Budker Institute of Nuclear Physics (BINP) of Siberian Branch of Russian Academy of Sciences is one of the world leaders in the development, design, manufacture and application of electron accelerators of different series (such as DC accelerators of continuous action based on high-voltage rectifier, high-frequency accelerators, pulsed accelerators), the accelerated electron energy and power of which are much more. ELV-series accelerators are some of them. Their compact size and high functional quality allowed BINP to stand as a leading institution at industrial accelerators market as in Russia and abroad.

DESIGN OF ACCELERATOR

ELV high voltage power source is cascade generator with parallel inductive coupling. The rectifier column is installed inside the primary winding. The primary winding is supplied with frequency converter on IGBT transistors. The operation frequency is near 400 Hz. The coil of secondary winding has maximum induced voltage

Figure 1. ELV-8 accelerator.

on its ends 20 kV. This voltage is rectified with the voltage doubling circuit. Thus, the output voltage of the rectifying section is 40 kV. The rectifying sections are connected either in series. The rectifier section column is terminated with the high voltage electrode inside of which there is the injector control unit. The accelerating tube are located inside the column of high voltage rectifier.

All these elements are installed inside of pressure tank filled with SF6. Due to these circumstances ELV-accelerators are the most compact among the devices of this class. Accelerator is equipped with gas system that allow to recovery SF6 during service and maintenance. The vacuum system components and extraction device are fixed to the bottom of the tank. Electrons emitted by the cathode, placed on the upper end of the accelerating tube, have the total energy eU0 on the output of the

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accelerating tube. Passing through the vacuum system they reach the extraction device where they are homogeneously distributed along the foil by the scanning electromagnets and then extracted into air. The beam is scanned in 2 directions along and across the foil window. The irradiated material is transported under the frame of the extraction window. Due to special electronics device the beam raster position on extraction window is monitored by oscilloscope.

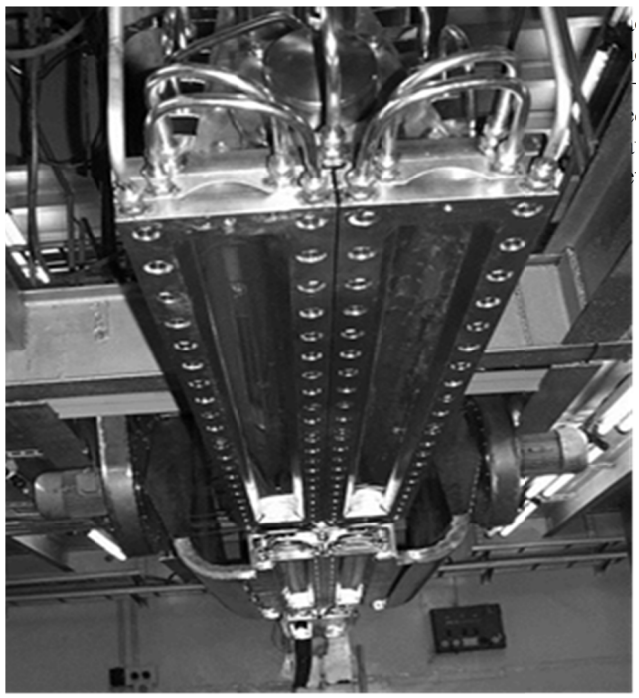

Figure 2. Double window extraction device of ELV-12 accelerator.

CURRENT STATUS

Market conditions and growing demands for modified materials forms the industrial manufacturers needs in more powerful and effective electron accelerators enabling to increase the volume of production without compound and expensive inputs for change all equipment. Table 1 and 2 shows accelerator parameters of last 38 contracts.

Table 1			
Energy, MeV	1 or less	1,5	2,5
Amount	14	14	10

Table 2				
Power, kW	100	70	50	20 (mobile)
amount	14	1	1	2

As it is shown in Tables 1, 2 the needed accelerators are distributed enough evenly starting from 1 MeV by energy in accordance with maximum energy. Most of them are of 100 kW power. That is why, at present, the development of ELV model range goes towards increase of accelerators power within the range of 1.0…1.5 MeV. Earlier, we can obtain 100 kW at 1.0 MeV with maximal current 100 mA and 2.0 MeV with maximal current 50 mA. There was redesigned ELV-4 accelerator and appeared 3 new models with maximal energy 1.0, 1.2, 1,5 MeV and maximal current 100, 83 and 67 mA accordingly. Those accelerators designed in new dimension type extend power and energy range of earliest models enabling the following:

− production of more powerful electron beams, which accurately satisfy existing production needs, taking into account present and new industrial technologies;

− modification and/or replacement of accelerator equipment without changing the existing technological auxiliaries such as rewinding lines, take up &payoff units, etc.

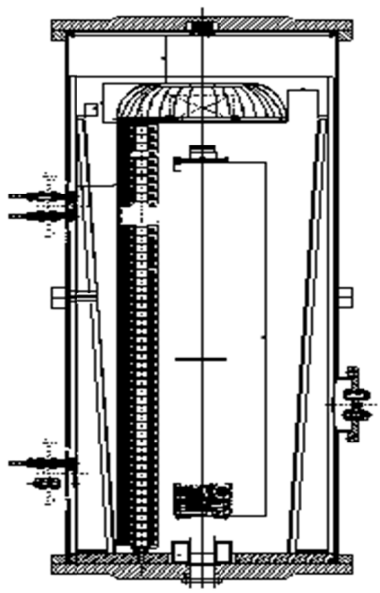

Figure 3: Structure and dimensions of ELV4-1,2 accelerators.

Another important direction in development of accelerators is adaptation of accelerator complexes to present technological equipment and their integration with industrial technologies. So, to increase production efficiency in accordance with the customers' needs, the scanning and beam extraction systems were modified. The length of extraction window was increased from 1600 mm up to 2000 mm (see Figure 5). This enabled to irradiate two and more types of products.

Figure 4. Modification of extraction window.

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Other examples of integration allowing improvements in productive efficiency are information-measuring complex on visualization of accelerator current parameters and technological irradiation process (Fig.6) and under-beam transportation system developed in BINP.

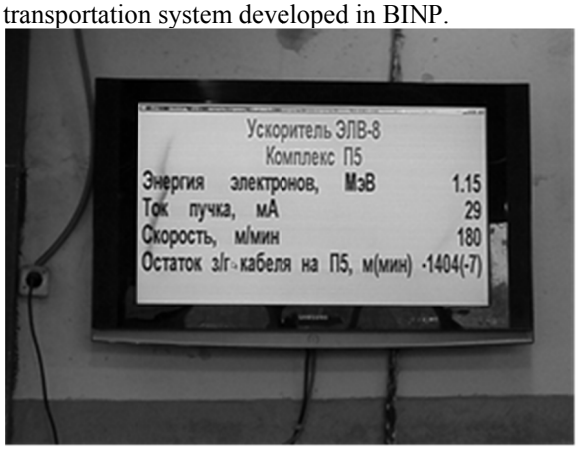

Figure 5. Parameters of accelerator ELV operation.

Concerning the high power ELV-12 400 kW accelerator for environmental application: it continues operation and proves advantage of EB technologies but during 5 years we have no orders for such accelerators.

Figure 6. Irradiation hall of 400 kW accelerator.

There was developed movable accelerator. This project was made together with our collaborator from South Korea EB-TECH. Accelerator together with radiation shielding was installed inside trailer. Main reason of this installation is demonstration of EB treatment. Extraction device is adapted for treatment the flow of gas or liquid substances. EB-TECH already replaced this accelerator in Saudi Arabia and made demonstration experiments.

ELV accelerators are used practically in all technologies where electron beam is needed. 140 accelerators were delivered in 12 countries. The most of them are under operation until now. The oldest operating accelerator has age 32 years.

Figure 7. Movable accelerators.

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