HIGH POWER ELV ACCELERATORS FOR INDUSTRIES APPLICATION

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Abstract

Beginning from 1971, the Budker Institute of Nuclear Physics Siberian Branch of Russian Academy of Science (SB RAS) started 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 The cross-linking technologies are applied very widely in industries. While the improved maximum operating temperature was one of the initial attractions of cross-linking, there are other important product advantages as a results of cross-linking of the polymers, such as: reduced deformation under load, improved chemical resistance, increased abrasion resistance, improved impact properties, memory characteristics. At present the electron-beam technologies are extensively used in a cable industry for cross-linking of insulation made on the basis of polymer compositions. The use of these technologies enabled to develop the manufacture of a wide range of wires, cables and heat-shrinking goods for different markets (power plant, telecommunications, electronics, oil industry, nuclear power plant, submarine and aircraft, etc). All of them are of high reliability, when being mounted and during operation as under standard and extreme operating conditions.

INTRODUCTION

The use of electron-beam technologies gave an opportunity to develop the production of wide range of wires, cables, heat-shrinking products (heating cables, power and ship cables, airborne wires and cables, as well as atomic power plant (A-plant) wires). All of them are of improved reliability at assembly and operation as in regular service and in extreme conditions. The quality of radiation treatment depends on accelerator itself as well as on under-beam equipment. Thus, the accelerators should provide stability of electron beam parameters, such as energy, beam current and width of irradiation area. In order to enhance absorbed dose azimuthal homogeneity they should be provided by 4-side irradiation system.

The main specification of the system of cable transportation through radiation zone is transportation rate of speed, which should be proportional to beam current rate. Proportionality coefficient called “specific rate” depends on the type of irradiated product and accelerator parameters. Taking into account the information mentioned above, there was developed the high-automated systems for electron-beam treatment of cable isolation. Practically, there is no necessity in permanent presence of accelerator control panel operator. Effective visualization of irradiation process (energy, beam current, cable transportation speed) allows the operators of transportation line to control and set the treatment conditions directly at working place close by pay-off and take up machines.

ACCELERATORS

The main features of ELV-accelerators are as follows:

1. High power of electron beam in wide energy range, it means high productivity of EB processing;

Fig.1 Accelerator ELV-8

2. High efficiency of conversation of electricity power to electron beam power. The efficiency is limited by frequency converter and in case of transistors frequency converter efficiency is increased up to 80-92%;

3. Simple procedure of accelerator control by operator due to control system based on computer. It allows operating accelerator in on-line mode.
4. Accelerator control system comprises a set of software and hardware covering all the accelerator units required an operative control and diagnostics.
5. Accelerator itself has simple design and high reliability. If some troubles appear our customers repair accelerator by themselves with our consulting by phone, as a rule.
6. After warranty service. It means we delivery spare parts or parts with limited lifetime or make any accelerator service after warranty period by separate contracts with the low price.
7. A set of additional equipment (such as transportation line, ring or double side irradiation system, 4-side irradiation system) increases the accelerator possibility.
8. ELV accelerators are stable in operation. The energy and beam current instabilities practically do not exceed +/-2%.

By now, over 120 accelerators had been delivered inside Russia and abroad and the total operation time exceeds 800 accelerator-years**. .**

4-SUIDE IRRADIATION SYSTEM

In due time the laboratory proposed to develop the system of 4-side irradiation, which allowed us to enhance dramatically the quality of cable products treatment. Fig. 2 shows the extraction device with 4-side irradiation system. Together with enhancement of absorbed dose azimuthal homogeneity this method enables to decrease accelerated electrons energy that considerably expands the range of accelerator applications in the area of irradiation of big diameter cables. New system of irradiation exchanged the traditional early applied systems of 2-side irradiation and enhanced the quality of manufactured products and raised labor productivity. The cables are laid out under the beam in such a way that at each turn (lap) the upper and lower surfaces of a cable swap their places. If beam trajectories are crossed 90^0 angularly, than, taking into account the exchange of surfaces, 4-side irradiation is achieved (Fig. 3 and Fig. 4). It is important that the cable passes the irradiation zone few times.

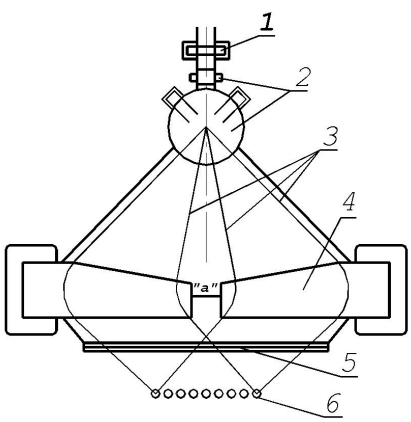

Fig.2 4-side irradiation system

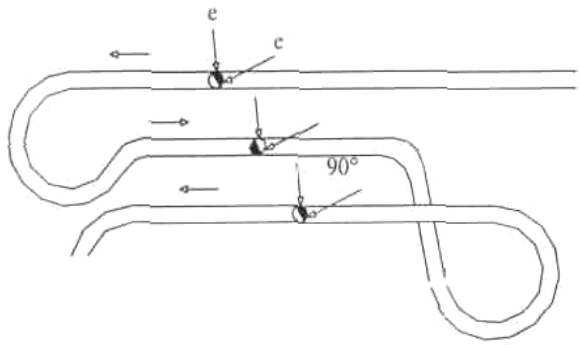

Fig.3

UNDER-BEAM TRANSPORTATION SYSTEM

Universal under-beam transportation system (UBTS) was developed in our laboratory. Its design is shown in Fig. 5. UBTS consists of 2 drums, one of which is driving and another one is guided. That reduces the risk of stretching of treated product and prevents the decrease of cable cord diameter.

Fig.4

Big diameters of the drums (900 mm) allow treatment of monoconductor cable with 36 mm^2 section (Fig. 5) and exchange tape guide rollers enable to treat multiconductor cables with the diameter up to 42 mm. Minimum pitch diameter of treated wire for this facility is 1 mm, but during the experiment we successfully irradiated cable of 0.12 mm^2 Irradiated chamber with UBTS, extraction device and 4-side irradiation system delivered to “Rosskat Ltd.” is shown in Figure 6. In UBTS we use the asynchronous motor (induction motor) with frequency drive. The rotation frequency is set by accelerator control system. The operation drive has a wide dynamic range, that is proportionality between transportation speed and beam current is saved within wide speed range. That enables to realize a smooth start of the technology and to refuse movable target. Irregularity of absorbed dose at UBTS acceleration from 0 right up to 250 m/min does not exceed 5%.

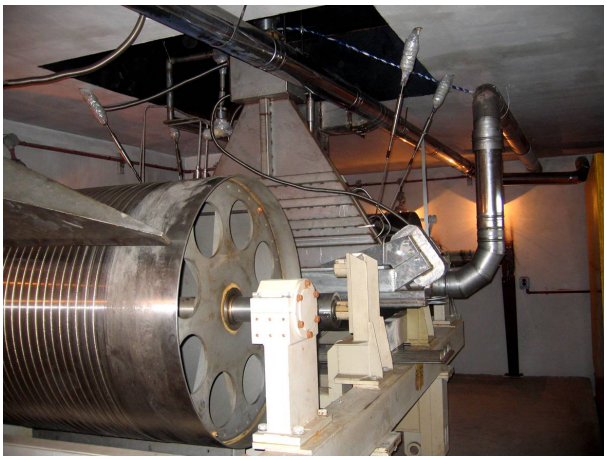

Fig.5. Cable irradiation

DATA-COMPUTING SYSTEM

The information of processing is shown on illuminated indicator board. It's dimensions allow to read information from any point of operation hall. The following parameters are continuously displayed: energy, beam current, speed of line, remainder of cable on bobbin, time to finish of bobbin (Fig. 7). The perfect quality of treatment is proved by reliable operation of cables in extreme conditions of oil industry.

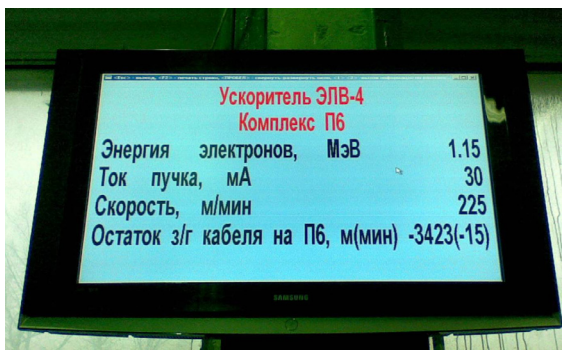

Fig.6

ACCELERATORS FOR ENVIRONMENTAL APPLICATIONS

ELV-12 accelerator with power 400 kW is used for ecological purpose. The installation for electron-beam waste water treatment was put in operation in Korea.

Simultaneously with manufacturing of high power accelerators we developed movable accelerators. Accelerator together with radiation shielding is arranged inside of trailer. Main purpose of these accelerators is to eliminate small local contamination.

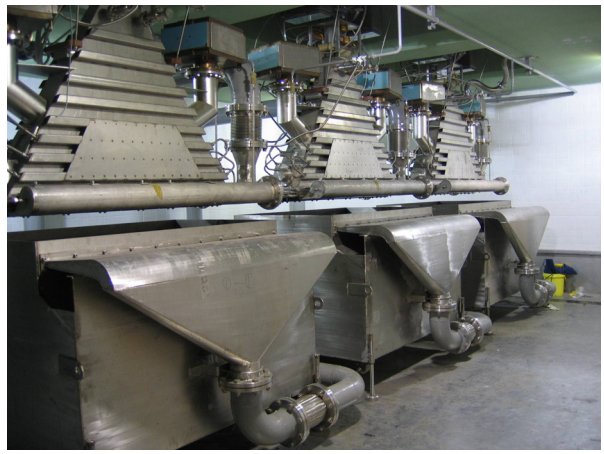

Fig.7. Irradiation hall for waste water treatment with ELV-12 accelerator

Fig.8. Movable accelerator

BINP continuously improves design and increases parameters of accelerators. The set of additional equipment (such as transportation line, ring or double side irradiation system, 4-side irradiation system, focused beam extraction device) increases the accelerator possibility. Due to this circumstances and improving of economics after crisis amount of orders for accelerators extremely increased.