EXPERIENCE ON OPERATING HIGH-VOLTAGE ACCELERATORS DESIGNED IN NIIEFA ON INDUSTRIAL FACILITIES INTENDED FOR POLYMER MATERIALS' MODIFICATION

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Abstract

High-voltage accelerators "Aurora-5" and "Electron-10" designed and manufactured in the D.V. Efremov Institute have been operated at the plastic-production plant in Izhevsk and the joint-stock company "Terma", St. Petersburg on facilities intended for production of polymer materials with specific properties due to radiation processing. The results of accelerators' operation are considered in the paper. The annual operating time of each facility is 5-7 thousand hours, which meets the requirements for industrial equipment.

At present, electron accelerators find more and more wide industrial applications: to modify physical and chemical properties of different materials and products, to eliminate bacterial and other types of pollution as well as for other purposes. From the data given in the IAEA review, nowadays more than 1400 high-power electron accelerators are commercially used throughout the world, and the cost of the products manufactured using these machines is more than 85 billions $ per year [1].

From the diagram shown below (see Fig. 1), it can seen that a significant part of the modern industrial electron accelerators is involved in the production of articles on the basis of polymer materials, such as wires and cables, heat-shrinkage pipes, sheets, tapes and gaskets.

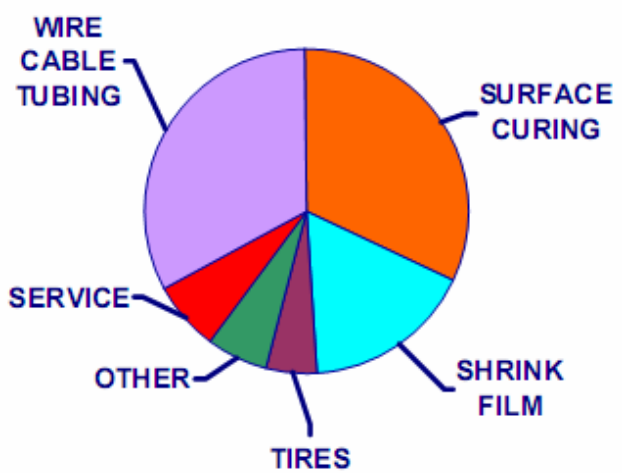

Figure 1: Industrial applications of electron accelerators

For many years, the development and manufacturing of high-voltage electron accelerators for radiation processing have been one of the traditional directions of activities in the D.V. Efremov Institute, NIIEFA. To date, more than fifty similar machines have been manufactured and delivered to different sites in Russia and abroad including eleven machines intended to operate in industrial processing lines for radiation curing of products made of polymers. Accelerators with an energy below 1 MeV are provided with a local radiation shielding and can be installed in conventional industrial buildings.

In 1985 the "Aurora-5" accelerator with the 400-600 keV electron energy, the beam current of 50 mA and the irradiation field width of up to 2 m was delivered to the Izhevsk Plastic-Production Plant to be used in the line producing sheets of foamed polyethylene using the manufacturing technique developed by the Japanese firm Sekisui Chemical (see Fig.2). The accelerator consisted of a separately located high-voltage generator and an irradiator with the local radiation shielding interconnected with a high-voltage cable. By using a special device, a component of the line, the material of up to 2 mm thickness was irradiated consequently from one and the other side; and the absorbed dose distribution was sufficiently uniform. The admixtures doped into the material resulted it its foaming under heating; the density decreased by 5-30 times and the heat conductance decreased as a result.

Figure 2: The "Aurora-5" accelerator in the line producing foamed polyethylene at the Izhevsk Plastic-Production Plant

The production rate of the line involving the "Aurora-5" accelerator was about one thousand tons of

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foamed polyethylene per year, which did not satisfy the demand for this material. In this connection, the second line involving the "Electron-10" accelerator was installed at the Izhevsk Plastic-Production Plant, which allowed the material to be processed from both sides for one passage through the irradiation chamber (see Fig.3).

The schematic view of the "Electron-10" accelerator is shown in Fig.4. In contrast to the "Aurora-5"machine, its irradiator is in the horizontal position. The beam is extracted from the vacuum chamber of the accelerator in two opposite directions by using two electromagnets [3].

In 2002, the "Electron-10" accelerator was also delivered to the "IPM" Ltd, St. Petersburg to be used in the line producing double-layer heat-shrinkage coatings for underground pipelines (see Fig. 5). In 2003, the machine was put into commercial operation. Somewhat later, one more such an accelerator was installed there.

Figure 3: The "Electron-10"accelerator at the Izhevsk Plastic-Production Plant

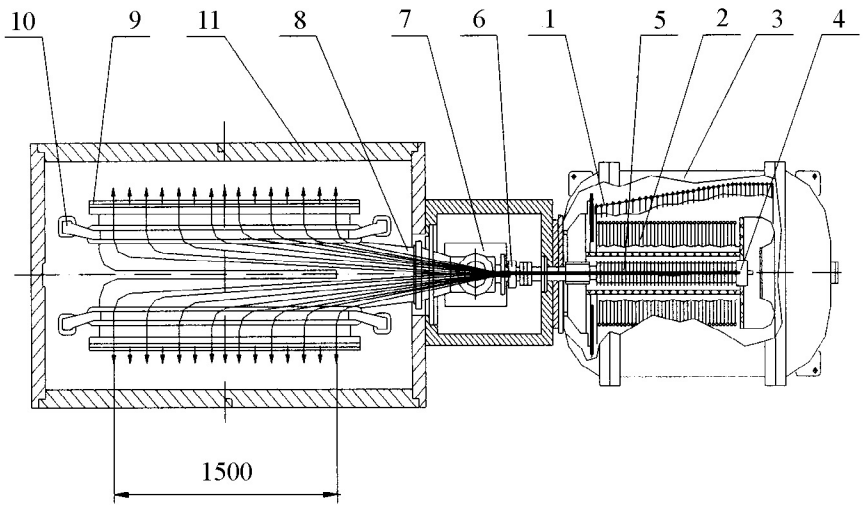

Figure 4: Schematic view of the "Electron-10" accelerator:1-primary winding, 2-secondary winding sections, 3-pressure vessel, 4-electron source, 5-accelerating tube, 6-scanning device, 7- vacuum pump, 8-vacuum chamber, 9- extraction window, 10- electromagnet,11- local radiation shielding

Figure 5: The "Electron-10" accelerator in the line for production of heat-shrinkage anti-corrosion coatings at the "IPM" Ltd, St. Petersburg

The experience gained in the process of operation of the "Aurora-5" and "Electron-10" accelerators proves their high reliability. At the Izhevsk Plastic-Production Plant in 2008 and 2009 these machines provided the fulfillment of the plan for the foamed polyethylene production; the running hours were respectively: 6170 and 3236 in 2008; 3036 and 5040 in 2009. The lifetime of the electron source cathode was 3000 hours, on average, on both the accelerators; the lifetime of the extraction window foil was 3000-4500 hours. Replacement of the cathode took 18-36 hours and of the foil -36-48 hours.

At the "IPM" Ltd, St. Petersburg since 2005 the "Electron-10" accelerator has been continuously operating in the three-shift mode with shut-downs necessary for replacement of the cathode, foil and high-vacuum pumps as well as for cleaning the filter of the water cooling system. Depending on the thickness of a material processed and the velocity of its transport, the accelerating voltage was varied from 510 up to 750 kV

and the beam current – from 30 up to 60 mA. The total running time of the accelerators for 5 years was 38 740 hours. During this period of time, the electron source cathode was replaced eleven times and the extraction window foils were changed twelve times. To ensure more stable operation of the accelerator and for protection of its units against corrosion, in the process of operation a system for automatic maintaining of the temperature was used, which maintained the temperature of the water cooling the extraction window and other units at a level somewhat higher than the temperature in the building. This measure reduced a possibility of corrosion of the accelerator components located in the irradiation area.

Further it seems reasonable to consider also the replacement of high-vacuum NMD pumps used in these accelerators for turbomolecular pumps or application of turbomolecular pumps at the initial stage of evacuating the accelerator vacuum chamber after the cathode/ foil replacement, which will allow the time needed for these operations to be reduced substantially.

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