Four-Side Irradiation Systems with a Window for Cables and Pipes

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At present, electron-beam technologies are widely applied in the cable industry for the radiation modification of the polymer-based insulation with the use of the high cost equipment. Therefore, the most important problem is the improvement of its usage efficiency. One of the ways to improve the EBM equipment efficiency is the use of a multi-side irradiation.

The four-side irradiation system is the optimal for treating the cable and pipe-like products of the outer diameter up several tens of millimeters. In the case of the use of the four-side irradiation system, at the same thickness of the insulation, the required penetration depth of electrons is two times lower than that for two-side irradiation systems. This leads to a 2–4 times reduction of the electron beam energy required thus facilitating much the design and thereby reducing the total cost of the electron accelerator. In some firms, in order to provide a four-side irradiation of products two accelerators are used whose beams are intersected at an angle of 90°.

At our Institute, two new universal systems of irradiation are developed. The systems enable one to realize both the standard (one-side) and four-side irradiation at the same installation equipped with one electron accelerator. The device was preliminary developed for the use of the ELV-type accelerator but it can also be used with any industrial accelerator of electrons. The under-the-beam positioning of the cable is performed in such a way that at each turn the lower and upper surfaces are interchanged and the beams are intersected at an angle of 90 degrees.

The first of these suggested devices is shown in Fig. 1. Electromagnets 2 are scanning the beam along the foil similarly to that as in the standard extraction device. At outputs of bending electromagnets 4, all the electron trajectories have an angle of ±45° with respect to the vertical axis independently of input angles into the magnet constant field. The magnetic field configuration is determined by the shape of electromagnet poles. An additional reswitching electromagnet 1, which is synchronized with electromagnetic scanning, enables the fast pass of the area «a», where it is impossible to form the constant magnetic field of the configuration required. Because of the presence of the electromagnet 1 the fraction of electrons with angles different from 45° does not exceed 4%.

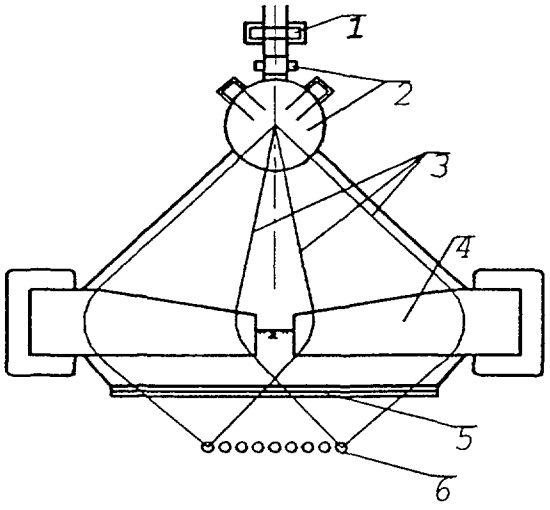

Fig.1 First Version of a 4-Side Irradiation Device

1 - reswitching magnet;
2 - scanning electromagnets;
3 - trajectories of electrons;
4 - bending magnet;
5 - extraction widow;
6 - irradiated product.

By optimizing the shape and dimensions of poles of electromagnets together with the focal length of the magnetic lens of the ELV-accelerator the edge focusing effect is reduced to its minimum, therefore the inhomogeneity of the raster width of the electron beam extracted from the extraction device is minimized. An ultimate value of the extracted beam current is comparable with the values of the standard extraction devices, which are 70-100 mA/m of titanium foil of a 50 μm thick and 70 mm width.

Another system of a 4-side irradiation is based on a two-widow extraction device. Schematic diagram of the device is shown in Fig.2. As is seen, an electron beam is scanned along two parallel titanium foils of the extraction device. The beam is reswitched from one widow to another is performed with the electromagnet. However, in this device, the magnetic system of bending electromagnets, which consists of two coils and three poles, is located under the extraction device. The magnetic field formed by the system is of the opposite direction under different widows of the extraction device. Because of this, the irradiated product is treated from one side when passing the first foil and when passing the second foil it is treated from its opposite side.

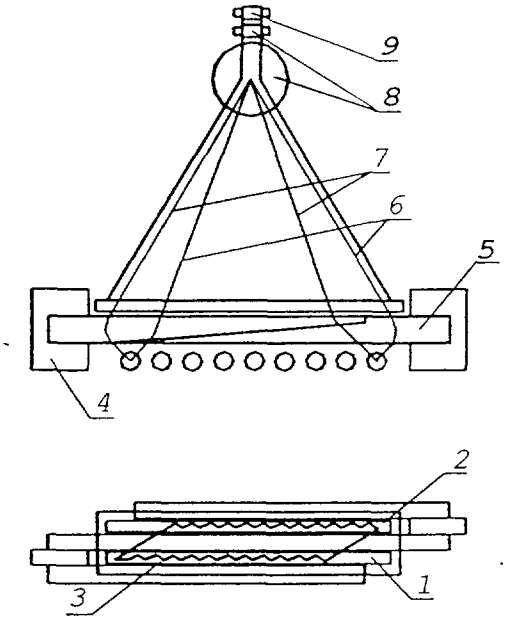

Fig. 2 Second Version of a 4-Side Irradiation Device

1 – first window;
2 – second window;
3 - beam trace;
4 - magnet winding;
5 - bending magnet;
6 - trajectory of an electron beam passing through the second window;
7 - trajectory of an electron beam passing through the first window;
8 - scanning electromagnets;
9 - reswitching magnet

In order to reduce the influence of the twist-effect on the homogeneity of irradiation the scanning frequency along the foil of the extraction widow was selected to be high (50-90 Hz) thus enabling the treatment of the product per one pass of the irradiation zone even at a driving speed of 200-400 m/min.

As is seen from Figs. 1 and 2, these extraction devices are slightly different from the standard device dimensions and they could easily be installed instead of them. When the bending and reswitching electromagnets are switched off in the first case, and bending electromagnets are switched off in the second case, the beam extraction system starts its operation in the regime of the standard linear scanning. This provides the universal character of the devices and enables the treatment of a wider range of products.

The main advantages of the 4-side irradiation systems are the following:

- low cost and simplicity of the design (the cost of the version with one accelerator is much less than the cost of the version with two accelerators);
- the larger size of the irradiation zone enables the reduction of the dose power thus allowing to improve the quality of irradiated products;
- a decrease in the ozone yield because of shorter distance between the irradiated product and the extraction device;
- a substantially lower scattering angle of output electron beams.

The developed systems of 4-side irradiation enable one to improve substantially the quality of the product without essential changes of the design and the cost of the device for radiation treatment. Such systems can be used not only with the ELV-type accelerator but also with any industrial electron accelerators both of the continuous and pulse action. This enables to use them not only with the newly developed devices but also with the old ones upgraded to improve their quality and efficiency.