Abstract

The results of test bench simulation and magnetic measurements were used to develop and manufacture “di-pole magnet”-type units with a constant field of intensity up to 1.8 kOe in the working gap, 3 to 3.5 cm in height. The operating experience at the technological accelerators has shown that these devices are convenient in service, are easy-to-transport and can be used for solving the various problems in electron beam formation and steering at the exit of the accelerator.

Extension of the class of radiation works on the external electron beam from the accelerator KUT-20 [1] has given rise to a problem of searching new devices for beam extraction and irradiation field formation. For the long-term treatment of large-scale objects one uses successfully electromagnetic scanners we have developed [2], but for the work with converters one needs an extracted electron beam of a maximum density (power) and, respectively, of a minimum cross-section that, as a rule, leads to failure in the foil of the exit window. Therefore, besides development of special exit windows of a small area in the course of time, a demand arose to have a device of “fast technology”. For example, a scanned electron beam in air is contracted again and is concentrated into required sizes. It is advisable that this device be independent, movable, not requiring power supplies and evacuation and its assembling and disassembling should take a few minutes of the accelerator time.

A search has shown that a similar device can be realized on the base of metal-laminated series BA magnets the properties and features of which are described sufficiently e.g. in [3].

In the course of selecting and designing the device construction, barium anisotropy plates 2BA (typical size is 180x80x16 mm³) were used in different combinations - from single to composite units by thickness and lengths. The criteria were: electron energy 15 ÷ 25 MeV, working gap of 3 cm in height, maximally possible values of the strength of a magnetic field and its integral length along the beam path.

At first from available single magnets the plates selected were by a maximum residual magnetization and by their identity: in five points (on angles and on center) on top side and on lower side, without substrate of steel and with substrate. It has been established, that in the case with steel the strength on the surface increases by ~30% and as “flattens out” throughout the surface being on average 550 Oe.

To study experimentally the magnetic field distribution in the assumed working gap and on its edges we have assembled a dummy including four plates and a standard C-core from the magneto-discharge- type vacuum pump with poles each of which comprising two plates fastened together and a gap of 3 cm in height. Fig. 1 gives the results of measurements allowing to conclude that the value of the strength inside the gap, uniformity and behaviour of field decrease at the edge are in conformity with requirements to the “classic” C-core magnet (electromagnet) that provided the basis for development of the design of the whole device.

Figure 1: Magnetic field distribution in the median plane of the dummy

The design of the device is based on two identical magnets, spaced 3 cm apart. The field directions in the magnets are opposite (anti parallel), and the resulting field smoothly decreases towards the central region, passing through the zero value (Fig. 2a, b).

Each of poles of a single magnet is a composite bar of three magnetic laminas. Around the side perimeter the bar is rigidly tightened with a stainless-steel strip. The C-core of the magnetic circuit is made from soft iron laminas (St.3); it bears some important functions: frame, core of the reverse magnetic flux and “amplifier” of lamina magnetization. The poles in the assembly are fastened by point welding to the upper lamina and lower lamina of the core. Both magnets are rigidly joined together with the
use of two other nonmagnetic laminas. These laminas, as well as the main steel walls have longitudinal slots for bolts that provides adjustment and positioning of working magnet gaps.

In Fig.3 the scheme of the experiment on determining the efficiency of the device developed is shown. The accelerator produced electron beam of an energy \( \approx 25 \text{ MeV} \) and a pulsed current \( \approx 0.5 \text{ A} \) was scanned by a scanner electromagnet (2) onto an exit window foil (3) as a band (4) having a length of about 9 cm, and then in air the beam failed into the gap of a double magnet (5).

In the course of adjustment and alignment of the exit window with a minor diameter, when the scanner electromagnet (fig.3, pos.2) did not turned on and then did not been at all, there appeared an urgent necessity of operative determining the energy of extracted not scanned electron beam. In this case, the above described anti parallel magnet was transformed (by 180° “inversion” of one half and by joining together both parts) into an one-piece planoparallel dipole magnet having the following characteristics: \( O_0 \approx 1.75 \text{ kOe}, D_0 \approx 3 \text{ cm}, \) width of good field region \( \approx 11 \text{ cm}, \) effective length of field along the beam trajectory \( \approx 17 \text{ cm}. \) In this performance the device was applied as a portable quasi-spectrometer of the electron beam in air directly behind the exit window by the methods of [4]. Thanks to this feature we have checked out during a short time the accelerator KUT-20 operation conditions by the beam current and electron energy, that allowed to put the accelerator into standard operation for different programs.

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