REFERENCES

1. Альтернативные источники энергии // Электрик Инфо [The electronic recource]. – 2014. – Access mode: http://electrik.info/main/news/614-alternativnye-istochniki-energii.html. – Date of access: 29.12.2014.
2. Энергетические ресурсы мира / под ред. П.С. Непорожнего, В.И. Попкова. – М. : Энергоатомиздат, 1995.
3. Нетрадиционные источники энергии. – М. : Знание, 1982.
4. Информация об энергосбережении и повышении энергетической эффективности: проблемы, пути решения, передовой опыт // Энергосбережение и водоподготовка, 2010. – № 1(63).
5. Кириллин, В.А. Энергетика. Главные проблемы: в вопросах и ответах / В.А. Кириллин. – М. : Знание, 1990.
6. Биоэнергия // Альтернативные источники энергии [The electronic resource]. – 2014. – Access mode: http://www.energy-source.ru. – Date of access: 29.12.2014.
7. Новости энергетики // Энергосбережение и водоподготовка [The electronic resource]. – 2014. – Access mode: http://www.energija.ru. – Date of access: 29.12.2014.

UDC 537.291

COMPUTER SIMULATION OF STATIC ELECTRON BEAM ENERGY ANALYZER USING IBSIMU PACKAGE

DMITRY OKUNEV
Polotsk State University, Belarus

The possibility of computer simulation systems of electron and ion optics by means of the open source computer code IBsimu was considered. The results were get and their analysis was carried out within the applied task of restoring the values of the initial energy of beam electrons.

There are many simulation packages that allow the solution of problems of electron optics and, in particular, to carry out the simulation of processes of extraction and transportation of electron and ion beams from plasma sources. Possibilities and methods of these packages differ markedly. Many packages are developed in academic institutions, while others are only available on a commercial basis. All of them can be divided into three groups [1] :

a) A computer code includes simulation of appearance and disappearance of charged particles in plasma;

b) a computer code that allows to calculate the trajectories of charged particles (i.e., provides an exceptional opportunity to solve the problem of electron optics);

c) a computer code with a simplified model of plasma, which gives the opportunity to solve the problem of of extraction of electron and ion beam from plasma source and the problem of its further transportation, focus, etc.

Plasma simulation packages often use methods of continuous media (hydrodynamic), or the so-called method of "particle in cell" (particle in cell (PIC), integration methods of Monte Carlo or hybrid methods. The development of plasma models is very time consuming and calculations take a lot of computer time.

Packages that build trajectories of charged particles, providing a solution to problems of electron and ion optics, often work within the formalism of transfer matrix method. Moreover, the packages are able to solve the problem of associated arbitrary electric and magnetic fields calculation. The most well-known examples of this group of packages include the following: SimIon, Cobham Vector Fields and Integrated Engineering Software Lorentz. These packages have broad opportunities, but are spread only on commercial bases.

The third group, i.e. packages allowing to extract beams of plasma sources with restrictions are PbGuns and IGun (work in two-dimensional and cylindrically symmetric geometry, allowing to simulate plasma sources of positive and negative ions), Kobra-INP (works with three-dimensional geometry and extraction from plasma positive ions). The disadvantages of these packages also include their commercial nature. Package IBsimu, which belongs to the same group, but which is distributed freely, was used in this research.

IBSimu – Ion Beam Simulator package was developed at the University of Jyvaskyla, Finland, Kalvasom T. (T. Kalvas) and posted on the Internet for public access [2] under the GNU General Public License (GPL). This package is a library of classes and methods, which is written in the programming language C++ and is available for use under the operating systems Linux and Windows.

The main feature of this package is to calculate the electrostatic field and potential distribution determination by solving the Poisson equation (1) by means of finite element method. One-, two- and completely three-dimensional tasks are available. The description of the distribution of space charge of the beam particles in

position vectors and velocity space, taking into account independent magnetic field is considered by solving the Vlasov equation (2).

$$\nabla^2\varphi = -\frac{\rho}{\varepsilon_0}, \tag{1}$$

$$\vec{v}\cdot\nabla f - \frac{q}{m}\left(\vec{E}+\vec{v}\times\vec{B}\right)\cdot\frac{\partial f}{\partial \vec{v}} = 0. \tag{2}$$

A simple electrostatic energy analyzer for electron beam extracted from the plasma source was simulated in this research by means of IBSimu package. Despite the simplicity of such a device, its manual calculation is nevertheless difficult even for classical geometry of planar capacitor. Boundary effects are complex, their role can be reduced by increasing the length of the electrodes and reducing the distance between them [3]. In case if the shape of electrodes is different from flat surfaces, and an electrostatic field between them is not uniform, analytical calculation becomes generally impossible, and the task requires a numerical solution.

The simulation was performed in a two-dimensional geometry of two cases - an electrostatic field which was close to homogeneous (planar capacitor) and an inhomogeneous electrostatic field generated by the electrode with a tip. The length of the simulation volume was chosen similar to the volume of the beam extraction camera in a real setting. Feynman and Dirichlet's boundary conditions were used and the numerical tasks decomposition grid parameters were chosen on the basis of two factors: special considerations of the task and at the same time the use of little computer calculation time.

The results of the simulation of electron beam separation by the electrostatic field between two flat surfaces are shown in Figures 1 and 2.

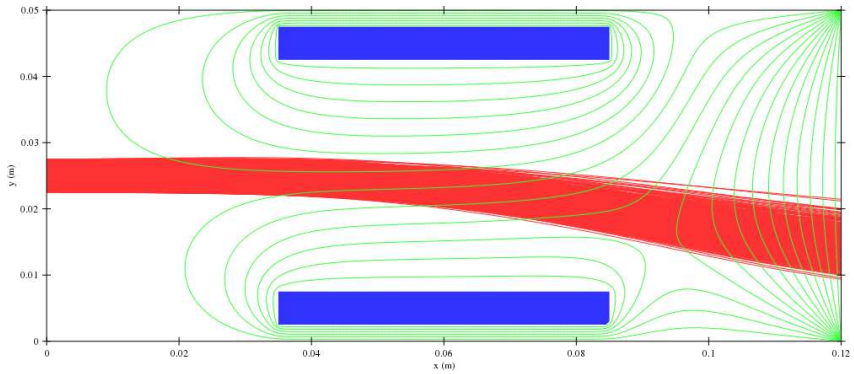

Fig. 1. Passing of electron beam through the deflection potential difference of 100 V. 10,000 particles with average energy of 400 eV and beam current density of 0.05 A / m2. The beam is red, the electrodes of the deflection system are blue, equipotential lines of the electrostatic field are green

The simulation results of the electron beam separation inhomogeneous electrostatic field are shown in Figures 3 and 4.

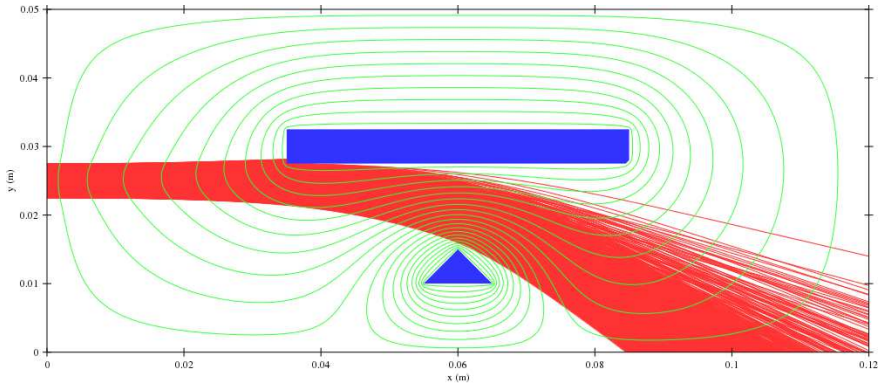

Fig. 3. The passage of an electron beam through a nonuniform deflecting electrostatic field. The potential difference between the electrodes is 200 V 10,000 particles with an average energy of 400 eV and beam current density of 0.05 A / m2. Beam is shown in red, the electrodes of the deflection system – blue, equipotential lines of the electrostatic field – green

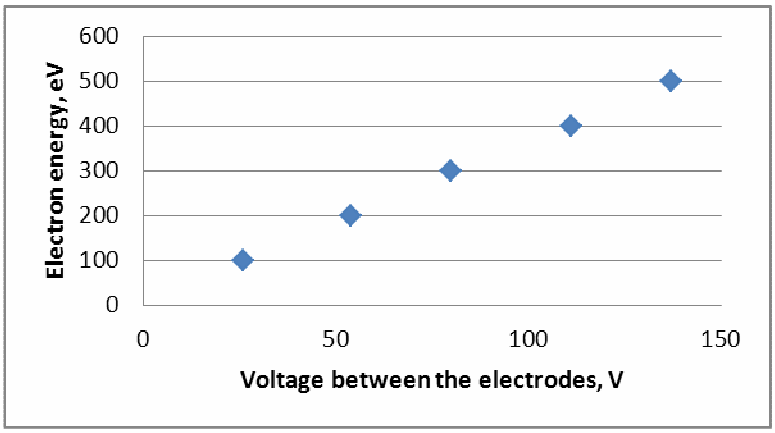

Fig. 4. The dependence of the electron energy on electrodes potential difference for selection in the aperture of Faraday cup

Computer simulation IBSimu package is a powerful and available tool for solving problems of electrophysics, connected with transportation of charged particle beams. In this research the simulation of electrostatic analyzer with two different electrodes was carried out. The shape and position of the electrodes can be randomly chosen, so that the solution of this problem may be optimized depending on the real conditions available in the electron gun.

REFERENCES

1. Kalvas, T. Development and use of computational tools for modelling negative hydrogen ion source extraction systems / T. Kalvas // Research Report No. 10/2013. – Department of Physics, University of Jyväskylä.
2. http://ibsimu.sourceforge.net/index.html.
3. Готт, Ю.В. Корпускулярная диагностика лабораторной и космической плазмы : учеб. пособие / Ю.В. Готт, В.А. Курнаев, О.Л. Вайсберг; под ред. В.А. Курнаева. – М. : МИФИ, 2008. – 144 с.

UDC 658.264 = 111

THE METHODS OF FUNCTIONAL COATINGS APPLICATION ONTO FLAT SEALING SURFACES OF THE STOP VALVES PARTS

ALEXEI PIROGOV, VICTOR DANILOV
Polotsk State University, Belarus

The actuality and effectiveness of the stop valves worn-part reclamation are presented. The results of the comparative analysis of the known techniques of protective finishing onto the sealing surface for valves service properties restoration are given. The classification of anti-abrasion coating application methods are given depending on their properties and characteristics. Factors and conditions influencing the abrasion resistance of the coating material and its adhesion with the detail base material are defined. The usage of the freezing out coating process onto the flat sealing surfaces of the stop valves parts are shown.

In practice the service life of the stop valves parts is frequently less than the standard one, what is predetermined by many reasons, namely, by stiffening of operation conditions: the increase of temperature and working medium (water, steam, drilling and bore-hole fluids, natural gas, hydrocarbon oils), its corrosive power. Due to the high rate of the working medium vibro-impulsive loads, cavitation and flowing section elements erosion of valves emerge, against this background of high temperatures such damaging factors as abrasive erosion and mechanochemical wear intensify.

The current concern lies in the issue of increasing the durability of the stop valves used in pipeline transportation systems (oil-and-gas, heat-and-power), since their insufficient endurance capability can be the reason for the environment pollution, increases the scope of repair-and-renewal operations, parts repair stock.

Special importance is paid to the matter of pipeline valves parts service life improvement in the respect of the used materials and know-how. This can be exemplified by prefabrication of parts with sealing surfaces from