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COMPARATIVE ANALYSIS OF SOFTWARE FOR SIMULATION OF ELECTRONIC - OPTICAL SYSTEMS

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A number of existing packages of applied programs for computer modeling of electron-optical systems of sources of charged particles built on the basis of analytical synthesis models and numerical methods of analysis are considered. The analysis of the main advantages and disadvantages of the packages MAGIC, MAFIA, CEM, KARAT, POISSON, TAU, ERA, BEAMCAD and their functionality is carried out.

Electron beam technologies occupy an essential place among modern highly efficient methods of metalworking and obtaining materials with new properties. Expanding the field of application of this kind of technologies in industry is necessary both to improve the quality and reliability of products and to increase their competitiveness, since the use of modern technologies, including electron beam technologies, meets the requirements of European and international quality standards. A wide range of technological capabilities of electron beam heat treatment has determined the use of electron beams in many technological processes. [1], including for cutting, melting, welding and heat treatment - hardening, hardening and surface modification. In this case, for the formation of beams of charged particles, different classes of devices are used according to the principle of operation, one of the most promising are sources of charged particles, the principle of operation of which is based on the emission of charged particles from the plasma of a gas discharge [2]. The basis of any electron-beam device is an electron-optical system (EOS), which is used to form an electron beam with certain parameters. The variety of factors affecting the parameters of the generated beams, their interrelation and mutual influence, require a large amount of experimental work to obtain electron beams with the required characteristics in the development of new EOS designs, which makes it expedient to use computer simulation technologies to reduce financial and time costs at the design and construction stage. similar devices.

The purpose of this work is some analysis of the functional capabilities of a number of existing software for modeling electro-optical systems of sources of charged particles.

Material and methods. The material for the study was software for mathematical modeling of electro-optical systems. During the research, generally recognized methods of scientific knowledge were used.

Result and its discussion.

Software for modeling electron-optical systems can be divided into three groups depending on the intensity of the simulated beam of charged particles: for calculating low-current electron beams (taking into account only the effect of their own space charge), for calculating high-current electron beams, and for calculating high-current electron beams in complex gas-dynamic conditions.

Each of the programs has its own sources of errors, since they are based on analysis methods or synthesis methods. In methods of analysis, errors, as a rule, arise due to the discretization of the flow of charged particles and the computational domain, in addition, errors arise associated with numerical methods for solving differential and integral equations of problems of mathematical physics. In synthesis methods, errors proceed from the approximate nature of the solution of both the internal and external problems in the approximation of asymptotic expansions.

To simulate processes in low-temperature plasma, there are a large number of software systems. One of the examples of such complexes is COMSOL MULTIPHYSICS [3], in which there is a module that allows simulating plasma physics without taking into account kinetic effects. For modeling processes in low-temperature plasma, there is software that allows you to build mathematical models of these processes. Also, MAGIC (USA) [4], MAFIA (Germany, USA) [5], CEM (USA) [6], KARAT (Russia, USA) [7], POISSON (Novosibirsk, USA) can be used as examples of software systems. [8], TAU (St. Petersburg) [9], ERA (Novosibirsk) [10], BEAMCAD (Moscow) [11].

All the aforementioned application packages (APPs) use Newton's equations as methods for calculating the motion of charged particles. The first four programs use a large particle model to discretize the flow of charged particles, POISSON and BEAMCAD use a non-deformable stream tube model, and TAU can use both methods. The mobility of the EOS boundaries allows modeling only the ERA, in all other RFPs it is considered that the boundaries are immovable.

None of the above PPPs take into account secondary emission processes. Ionization processes can be simulated only by ERA and BEAMCAD, they take into account the ion flux by the method of non-deformable current tubes, the effect of paired electrons is neglected.

All programs from the list simulate an EOS with a solid-state cathode, POISSON, in addition, simulates bipolar fluxes, and ERA, in turn, allows simulating a plasma anode.

Conclusion. To date, a number of applied software packages have been developed to simulate the processes of formation of beams of charged particles, mainly in systems using emission from solid-state emitters. Such SPPs are not applicable for systems based on a plasma emitter, which have a number of physical features in comparison with systems based on solid-state emitters. In the presently existing SPP for modeling the EOS of plasma emitters, there are many unsolved problems. Namely, the shape of the emitter is not taken into account (the possibility of analyzing the shape and the possibility of changing it are not considered), secondary electron-electron and ion-electron emission are not taken into account, and the compensating charge for electron beams provided from the outside is not taken into account. In addition, the existing software does not take into account the magnetic field, which can affect the formation of the beams. Taking into account the promising application in mechanical engineering and instrument making of beam devices based on plasma emitters [12], the task of creating a software package for modeling the physical processes of the electron-optical properties of systems of sources of charged particles based on plasma emitters, taking into account the features of such EOS, is urgent.

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