THE CAD CONCEPT FOR STELLARATOR-TYPE MAGNETIC SYSTEMS

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The paper describes the computer-aided design (CAD) concept for stellarator-type magnetic systems. Consideration is given to the main peculiarities, principles, and dialog organization and design stages of the CAD. The practical realization of the concept is illustrated by specific examples.

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Long-standing investigations in the area of plasma physics and problems of controlled thermonuclear fusion have shown the toroidal magnetic systems to be the most promising means on the way of creating a power plant. Among these systems are the magnetic traps with a rotational transform of magnetic field lines, i.e., the stellarators [1]. Creation of a stellarator facility is a complicated and labour intensive process that involves much of manual labour and takes a great deal of time. The present-day aids of computing machinery, new ways of data representation and processing, based on the principles of artificial intellect, the development of new numerical methods for the solution of engineering problems and optimization make it possible to develop the CAD for complicated technical systems and facilities.

The creation of a new stellarator-type magnetic system includes the following design stages:

– conceptual description of a new system;

– optimization calculation of magnetic configuration characteristics;

– development of the requirement specification;

– development of the design solutions;

– release of design documentation;

– manufacture of the plant and tests.

The all-round automation of work at all design stages provides:

– improvement in the accuracy of calculations;

– optimization calculations of the magnetic configuration of the system to carry out at a qualitatively new level and in the shortest possible time [1];

– desciption of the geometry of basic components and units of the future plant [2,3];

– creation of a computer model of the stellarator, including the three-dimensional model [4];

– elaboration of the design documentation with the use of modern graphical packages.

In the development of the magnetic-system CAD it is necessary to take into account the following factors:

– a great diversity of stellarator systems;

– special features in the geometry of basic components and units;

– magnetic-configuration computational procedures;

– capabilities of technological equipment;

– existent software products, the usage of which provides a high-level solution of the problems posed, etc.

At the same time, the following basic features peculiar to any of the mentioned systems can be distinguished.

1. A unified procedure for calculation of stellarator-trap magnetic configurations in the absence of plasma. It is reduced to the calculation of the following five characteristics, which have a determining effect on plasma confinement at a given value of the main magnetic field:

– the size of the outermost closed magnetic surface, i.e., proficiency in the use of useful magnetic volume;

– the angle of rotational transform;

– rate of variation in the rotational transform along the radius (shear);

– rate in the decrease of the specific magnetic volume across the magnetic surfaces (depth of the magnetic well);

– modulation of the magnetic field intensity along the field line.

The search for optimum combination of these parameters in a magnetic trap is the main task in the investigation of versions of stellarator-type systems. The problem is solved with the help of the mathematical apparatus and software developed at NSC KIPT; they provide a multi-criterion optimization of magnetic configuration characteristics in the interactive mode with a computer [2].

2. The presence of structural elements with a complicated spatial shape [5]. Their configuration is either toroidal, or "is laid" on the torus surface in accordance with a special law (law of winding). These elements are a helical winding, a vacuum chamber, twisted coils, separatrix.

3. Large overall dimensions. The dimensions of modern plants (meters in the major diameter of the torus and tens of centimeters in the meridional section) are such that the manufacture of structural elements by traditional methods appears impossible. Instead, new nonconventional methods must be used [3,6].

To create the CAD, mathematical models were developed to optimize the calculations of a magnetic configuration of the future plant in the absence of plasma, and to analytically represent the geometry of components and units constituting the facility, algorithms of their construction were also developed.

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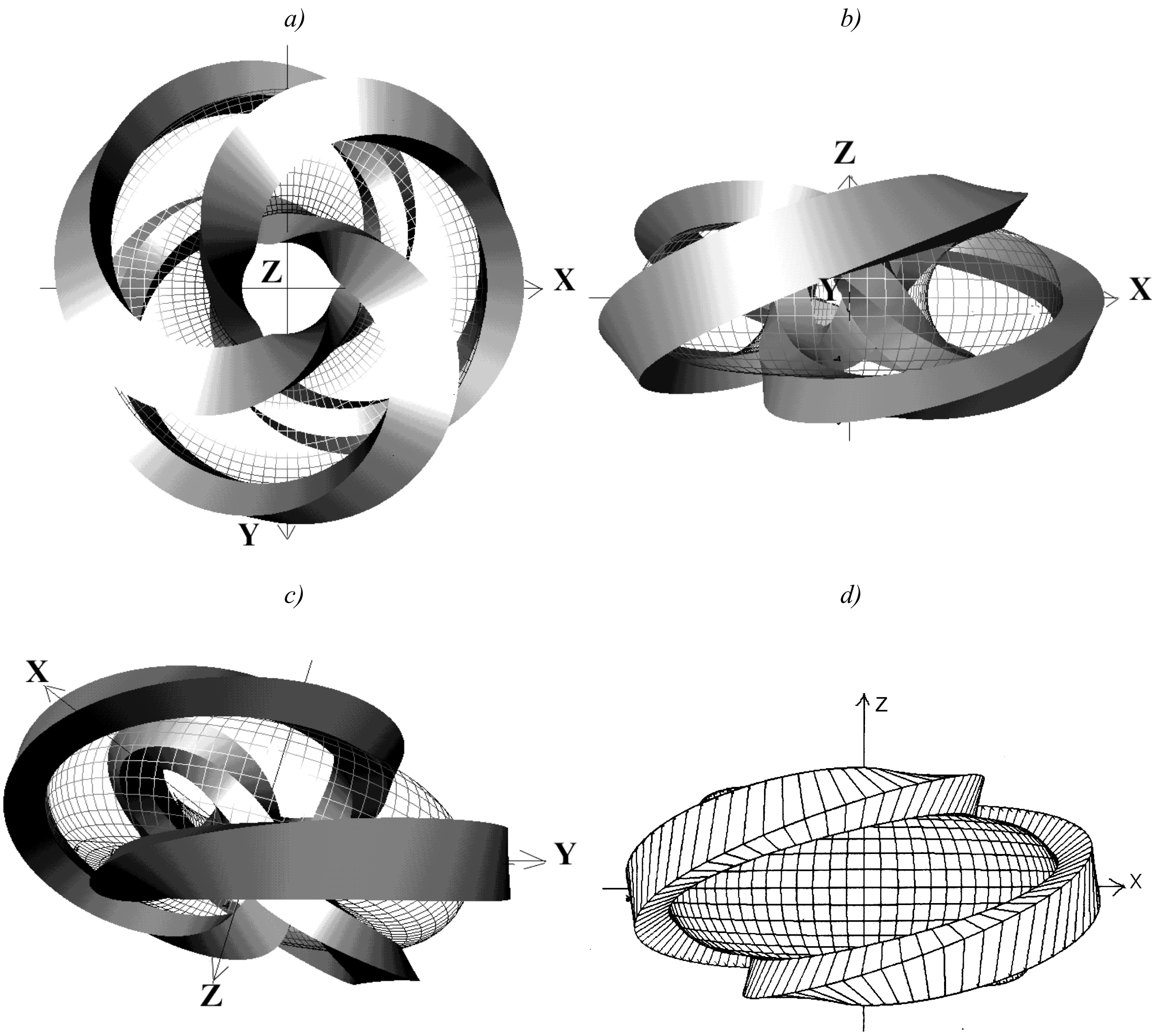

Helical winding of the l=3 stellarator with a trapezoidal pole (three-dimensional simulatio): a) top view; b) front view; c) arbitrary direction of view; d) raster graphics representation

Computer programs for simulating and imaginging the experimental model of the future plant on the display screen were written, providing the possibility of editing the model by means of graphics systems of the computer. To exemplify, a helical winding of the *l=3* magnetic trap with a pole, trapezoidal in shape, is presented. The image was obtained from different observation points.

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