System of Computer Simulation Modelling of Operations, Geometric Characteristics and Methods of Pulsed Optical Tomography of Nuclear Fuel Micro-Objects

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The system of computer simulation and research of fast processes of geometric industrial command setpoint testing control of micro-objects (MO) quality of nuclear fuel (drops of fluid, core samples, core samples with coating, micro fuel rods) is under consideration.

The paper refers to the area of morphological processing of projected images and its goal is to design some computer simulation models of basic operations, methods and characteristics of pulsed optical tomography:

- the approximation (image) model of three-dimensional MO and the spatial geometric characteristics of its size and shape;

- the models of operations for obtaining (generation) of pulsed discrete projected images of MO and operations of determining their number and optimal camera angles;

- the models of procedures for the numerical determination of the optimal basic features on each projected discrete image of the MO;

- the models of procedures (methods) for dynamic reconstruction of spatial geometric characteristics of MO, taking into account the basic feathers of discrete images;

- the models of defining the metrological characteristics of reconstruction methods of MO in terms of performance, accuracy and reliability.

The modeling system is organized as a hardware and software complex, built on the principle of multifunctionality, modularity, unification and openness. It consists of five subsystems: obtaining reference data; obtaining experimental data; methods of geometric control; research programs; control. The system uses C++, OpenGL and MATLAB languages.

On the base of the proposed computer models, a high-speed precision laser method of geometric contactless differential opto-electronic industrial and quality control of real-time MO flow of nuclear fuel was developed and experimentally tested. The method is based on the dynamical, few view, spatial-temporal, statistical reconstruction of size and shape of each MO and take into account the maximum and minimum overall dimensions of outlines of three mutually orthogonal two-dimensional pulsed discrete projected images of the MO.

While describing the size of each MO, the spatial geometric characteristics of MO are its overall dimensions and the average projected diameter (D) of its approximating ellipsoid of general form. Moreover, when describing the MO shape, its spatial geometric characteristic is represented as a non-sphericity coefficient (K) defined as the ratio of the maximum to minimum overall dimensions (axes) of the approximating ellipsoid.

The performance of this method is not less than 100 MO/s in the diameter range of 400 – 1500 mkm. The relative error of MO diameter control is no more than 0.25% (at the reliability of PD = 0.7 and K = 1,3 relative units), and the relative error of the non-sphericity coefficient control lie in the range of 2.3% (PK = 0.7 and K = 1.3 relative units) to 0.6% (with PK = 0.96 and K = 1.05 relative units).