APPLICATION OF CELLULAR AUTOMATa IN CONTROL SYSTEM OF TOKAMAK-REACTOR.

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Currently, active research continues on the development and creation of plasma control systems (PCS) in reactor scale machines, primarily in ITER [1]. Distinctive features of such reactors are, firstly, the substantial excess of the energy stored in the plasma over the energy of active systems that can be used to control the plasma discharge and, secondly, a smaller set of available diagnostic systems, which is resulted both with the possibility to use only diagnostics that are resistant to neutron fluxes in the reactor, and with a decrease in the number of sensors after transition from research facilities to industrial prototypes.

The report considers the possibility of applying the theory of cellular automata to the control of systems with insufficient instantaneous control power. A cellular automaton is a set of cells that form a lattice with certain transition laws that determine the state of the cell at the next time point through the state of the cells at the current and previous time points. For simplicity, without loss of generality, a two-dimensional lattice is considered, in the nodes of which cells with the installation and control system parameters are located. The rows of the lattice correspond to successive points in time. In each row, there are three types of cells: (1) - store the current status of actuators (parameters of magnetic and vacuum systems, gas fuelling, injection, additional heating, etc.); (2) - store the current data of the involved diagnostics; (3) - calculated parameters required for control, determined from the data in the cells of the previous row. It should be noted that for the cells of the second type, it is not necessary to specify the laws of state change during the transition to the next time point, their state is determined by experimental diagnostics data. The cells of the third type must include calculations of the necessary parameters for the current time, but also predicted values, for example, the probability of plasma disruption after a given time.

When forming the transition laws, it is necessary to minimize the numerical calculations of the systems of equations and to strive for the possibility of parallelization of calculations. This feature is provided by replacing PID controllers with controllers using fuzzy logic or neural networks, as well as computational methods using support vector machines or symbolic regression. In this case, the resource-intensive numerical solution of the equations is replaced by simpler calculations in the operation of the control system, because the long time learning of the control system is performed a priori.

As the stored energy in the plasma increases, the requirements for predicting the evolution of the discharge increase as well. In the case when the power of an actuator during its preemptive turn-on is sufficient to return the plasma to an acceptable state, there is a chance to prevent plasma disruption. Otherwise, the only option for control will be the immediate start of energy extraction from the plasma, since the power of modern active systems for discharge quenching significantly exceeds the power of additional heating and plasma control.

References

1. J.A. Snipes et al., Nucl. Fusion, 2017, **57,** 125001