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Disruption mitigation in tokamak by Fast Gas and Macroparticles Injection

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Safe termination of the plasma discharge using injection of intense gas flows and macroparticles (pellets) is considered as the main system for preventing development of the runaway electron beams in tokamak-reactor (ITER) [1]. One of the main limitations in the use of these systems in large-scale tokamaks is the weak penetration of injected gas and particles into the central zones of the high temperature plasma discharge. This reduces reliability of the disruption stabilization and leads to the need to develop additional methods for safe discharge termination.
To minimize consequences of the plasma disruptions in tokamak, "alternative"methods of gas flow injection are considered, including initiation of fast chemical combustion reactions, the injection of neutral particles from targets when a potential is applied, injection of impurities sprayed using powerful microwave waves-target interaction, and superheated liquid bubbling. Present report represents analysis of the experiments carried out with "alternative"methods at the laboratory stand and in T-10 tokamak (target voltage U°=°0°-°450°V, battery capacity C°=°0.4°F, maximum energy reserve W°˜°40°kJ, microwave power up to 1°MW) [2]. Analysis indicated that "alternative"methods could provide effective penetration of fast gas and macroparticles flows into the central zones of the plasma and demonstrated the possibility of quickly stopping a plasma discharge with current decay rate of up to 35°-°40°MA/sec and control system response time less than 0.1°ms. Preliminary analysis considers possibility of using "alternative"methods in tokamak reactor for generation of directed gas and macroparticles flows, including fast chemical combustion reactions with initiating substances [3] (increased radiation resistance to fast neutron flows, E°>°1°MeV, F°˜°7.5°e12°neutron/cm2/sec, temperature stability T°˜°280-300C, and stability under high vacuum conditions).
One of the key issues of the disruption mitigation is trigger condition of the control system. Experiments in the T 10 tokamak with all-metal (tungsten, lithium) in-vessel elements indicated that transition from quasi-stationary discharge to a fast phase of disruption can be associated with development of arc plasma discharges at the plasma-facing components [4]. In-vessel movable electric and magnetic probes installed in the T-10 tokamak allows monitoring of the arc discharges and could provide reliable trigger parameters for disruption stabilization systems and/or for safe discharge termination.

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