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ANALYSIS OF RUNAWAY ELECTRON BEAM GENERATION AT THE INITIAL STAGE OF TOKAMAK T-10 AND T-15MD DISCHARGE *)

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Optimizing the conditions of the initial stage of the discharge is an important task in modern experiments on tokamaks. The formation of a plasma column with homogeneous ionized plasma is hampered by the formation of runaway electron beams that appear already at the initial stage of gas breakdown. The acceleration of electrons in tokamaks with an iron core inductor is usually associated with a high voltage on the torus bypass (tens of volts), which is formed due to the high flux linkage of the inductor and the plasma coil. Thus, in experiments on the T-10 tokamak it was shown that in induced loop electric fields up to 4 V/m, accelerated electrons with energies up to 0.5-1 MeV arise within 5-9 ms after the onset of breakdown. Controlled gas injection in feedback mode and control of the magnetic flux in the inductor, as well as careful preliminary preparation of the vacuum chamber and the first wall, prevent the formation of accelerated electrons.

In tokamaks with an air inductor, with a limited loop voltage of several volts, using only the vortex field for gas breakdown is difficult. Under these conditions, additional methods of plasma formation using ECR waves, injection of plasma jets and the formation of additional current channels are used.

The report analyzes the generation of runaway electron beams at the initial stage of the discharge of tokamaks T-10 and T-15MD, both during ohmic breakdown of the gas and with the help of additional input of ECR waves. Tokamak T-10 and T-15MD have similar parameters in terms of breakdown conditions, including comparable lengths of the magnetic line and electric field strengths required for breakdown. Experiments performed earlier on the T-10 tokamak showed the possibility of using microwave breakdown of gas for the subsequent formation of a stable plasma column [1]. In this case, in some discharges, an increased intensity of hard X-ray radiation is observed when microwave power is applied.

The T-15MD tokamak has an air inductor, so at the moment the main breakdown method is considered to be microwave breakdown [2]. Experiments conducted during the power start-up of the T-15MD tokamak using a gyrotron with a frequency of 82 GHz (power up to 1 MW) showed the appearance of high-intensity hard X-ray radiation at the stage of preliminary ionization. The analysis showed that hard X-rays may be due to accelerated electrons generated in intense electromagnetic fields. The report presents the results of studies of runaway electrons in the T-15MD tokamak at the stage of preliminary ionization during microwave breakdown and with the combined input of microwave waves simultaneously with inductive vortex electric fields up to 0.2-0.4 V/m. Various possible ways to minimize the effect of the formation of runaay electron beams during microwave breakdown are considered to optimize the initial stage of the discharge in experiments on the T-15MD tokamak.

References

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