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Thermal Equilibrium and Density Limit in Tokamak-Reactor

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The problem of thermal equilibrium and density limit in contemporary tokamaks has been discussed by many authors. As it is well known a part of disruptions is related to the radiation collapse [1,2]. However, the influence of the fusion energy production has not yet been investigated. The problem for a tokamak-reactor is analyzed in the present paper. The empirical Greenwald criterion n_cˆI [3] determining the critical plasma density may be exceeded in tokamaks with an auxiliary heating. Here I is the total toroidal current. An auxiliary heating increases the value of n_c by factor 1.5 and more [1, 4-6]. One may expect that the fusion power also can increase the critical plasma density. The thermal balance in tokamaks plasmas is discussed in the present paper. The critical density is defined by the equality of the heating power (auxiliary plus fusion) and the radiation losses at the edge. The influence of the fusion power input as well as the auxiliary heating on the critical density is studied. The simplified analytic model and the numerical one are presented both. The analytic model is based on some simplifying assumptions. The auxiliary heating as well as the fusion one is assumed to be localized at the center of the plasma column. It is shown that the fusion input for D-T mixture increases the critical density in comparison with the critical density in pure deuterium plasmas. The reason is following. The fusion reaction rate is proportional to the value of nˆ2. Also, it rises together with the temperature. Hence, the critical density rises up increasing the fusion output drastically. Numerical results confirm the analytical ones qualitatively.

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