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D-D Neutron Emission Measurement in the Compact Tokamak TUMAN-3M

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Recent experiments on the TUMAN-3M compact tokamak were aimed at study of fast ion (FI) capture and confinement in co-current NBI heating scheme. Target plasma parameters in the experiments were as follows: $R_0 = 0.53$ m, $a_l = 0.22$ m, $BT \leq 1$ T, $I_p \leq 180$ kA, $n_e \leq 4 \cdot 10^{19}$ m⁻³, $T_e(0) \leq 0.7$ keV, $T_i \leq 0.2$ keV. Maximum output power of deuterium neutral beam $P_{inj} = 700$ kW. Measurement of 2.45 MeV DD neutron flux was used to study of FI behavior. The experiments allowed establishing of parametric dependencies of neutron rate and concluding absence of significant losses of FI during slowing down. Use of powerful ion source in second set of experiments allowed beam current by a factor of two higher than that with old one. This arrangement provided a possibility to alter output beam power at given beam energy.

Losses of FI during slowing down were estimated using measurements of neutron rate decay time τ_n after NBI switch-off. Experimental R_n and τ_n measured at $E_b = 21.5$ keV indicate equal portions of FI power transferred to target electrons and ions during slowing down and small if any influence of anomalous losses on R_n magnitude. Numerical modeling of neutron rate in NBI experiment was performed using ASTRA transport code. Modeling of the influence of n_{av} , E_b , BT and I_p on R_n in assumption of classical slowing down has shown good agreement with the experiment. Database of neutron rate measurements obtained with beam energy range of 14-20 keV was utilized to establish dependence of R_n on n_{av} , BT , I_p and E_b : $R_n = 6 \cdot 10^5 n_{av}^{0.36} BT^{1.29} I_p^{1.34} E_b^{4.69}$. The scaling doesn't contain dependence of R_n on input power since the NBI module is unable to provide independent variation of E_b and P_{inj} . Replacement of ion source opened possibility to get another dataset in the same energy range but with approximately doubled power. Contrary to expectations increased input power does not result in an increase in the neutron rate. The deficit could be understood assuming significant dilution of target plasma in conditions of increased input power. Another option is substantial reduction of input beam intensity due to its attenuation in the input port. Further experiments are planned to clarify the reason of R_n deficit in conditions of increased input power.

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