Analysis on DT Fuel Ratio in Power Plant Plasmas Using Integrated Equilibrium and Transport Simulation Code TOTAL

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Deuterium (D) / Tritium (T) fuel ratio is a key parameter to determine the output power of nuclear fusion energy reactor. Several fueling methods in fusion reactors, such as pellet injection, compact torus injection, neutral beam injection or gas puffing, have been proposed to control the D/T fuel ratio.

In order to analyze the relationship among fueling methods, D/T fuel ratio, and output reactor power numerically, we apply the TOTAL (toroidal transport analysis linkage) simulation code for the modeling of fuel supply in D-T burning plasmas [1]. The 2-dimentional or 3-dimentional equilibrium calculation using APOLLO or VMEC code and 1-dimention transport simulation model are combined in the TOTAL code. The neutral gas shielding model with mass relocation model is included in the code to calculate the profile of pellet penetration. As preliminary results, in the case of ITER like tokamak reactor with the reversed magnetic shear and the internal transport barrier, the simulation with scanning the D/T ratio in a pellet has revealed that the operational region of temperature and density varies with the D/T ratio. Figure 1 shows required frequency of pellet injection (f_{pel}) and tritium consumption per unit time (N_T) in the steady self-burning state of the tokamak reactor as a function of the tritium ratio in the pellet. As the D/T ratio becomes far from 50 : 50, temperature decreases and higher density is required. Therefore, as shown in Fig. 1, the frequency of pellet injection increases in cases with such asymmetric D/T ratio to sustain high density plasmas. Tritium consumption per unit time obtained by multiplying the frequency of pellet injection with the ratio of tritium in a pellet has a minimum value in the case with the D/T ratio of 70 : 30. It suggests that there is a possibility to reduce the tritium consumption in the reactor by applying appropriate D/T ratio in the pellet and corresponding operational regime of density and temperature [2].

Based on these simulation results, we proceed further analysis on the D/T fuel ratio in tokamak and helical fusion reactors. Then, the possibility of controlling the fusion output power through the controlling the D/T fuel ratio will be also discussed.

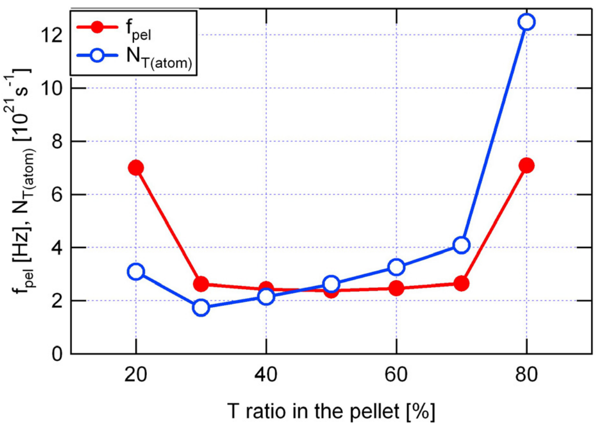

Fig. 1. Required frequency of pellet injection (f_{pel}) and tritium consumption per unit time (N_T) in the steady self-burning state of the tokamak reactor analyzed in the present study plotted against the tritium ratio in the pellet. The tritium consumption has a minimum value in the case that tritium ratio in the pellet is 30 %.

[1] K. Yamazaki and T. Amano, Nuclear Fusion **32** (1992) 633.
[2] T. Oishi *et al.*, *to be published in* J. Plasma and Fusion Res. SERIES.