A CONTROL METHOD OF DIVERTOR PLASMA START-UP ASSISTED BY TRITIUM-RATIO CONTROL FOR DEMO-CREST

R.Hiwatari[1], K.Okano[1], K.Maeki[2], M.Ishida[2], A.Hatayama[2], Y.Ogawa[3], M.Nakamura[3]

[1] *Central Research Institute of Electric Power Industry, Komae, Tokyo 201-8511, Japan.*
[2] *Faculty of Science and Technology Keio University, Yokohama, Kanagawa 223-8522, Japan.*
[3]*Graduate School of Frontier Sciences, The University of Tokyo, Kashiwa, Chiba 277-8561, Japan.*

Corresponding author: hiwatari@criepi.denken.or.jp

The control of the divertor plasma is one of the critical issues for DEMO, because of the large gap of the heat-handling condition between ITER and DEMO. Furthermore, DEMO is the first device to demonstrate such huge heat-handling in the divertor-SOL region. Hence, DEMO is required to develop a control method of the divertor plasma start-up, where the fusion power and the total heating power entering the SOL-divertor region have to be increased step by step under the condition of the limited heat flux onto the divertor plate.

In this paper, we propose a control method of the divertor plasma start-up assisted by T-ratio (the ratio of the tritium density to the total fuel density) control for a steady state tokamak DEMO concept Demo-CREST, which has the major radius 7.25m, the aspect ratio 3.4, the plasma current 15.6MA, and the normalized beta value(β_N) from 1.8 to 3.4[1]. Analytically, a control of T-ratio enables to change the fusion power with a plasma density kept constant. This property is applied to the divertor plasma start-up to keep a high density to reduce the heat flux on the divertor plate. First, the analysis on the core plasma operational space was carried out by the MHD/current drive code, ERATE[2] and DRIVER88[3]. Fig. 1 shows the operational space on the total heating power vs. the electron density together with T-ratio(fn_T). Without T-ratio control(fn_T=0.5), the density for the total heating power 300MW (corresponding to the fusion power 1.0GW) is small around $0.4\times10^{20}m^{-3}$, where the divertor condition is severe in comparison with the ITER steady state operation(ITER-SS). With T-ratio control, we can keep higher density(~$0.6\times10^{20}m^{-3}$) and lower heating power(~200MW). Moreover, reduction of plasma current from 15.6MA to 12.4MA enables to keep a higher density around 0.8×10^{20} m^{-3} than that of ITER-SS. This operation point can be considered as the initial operation point of the operation route for the divertor plasma start-up with T-ratio control. The critical issue on this operation route is that operation points with T-ratio(fn_T) less than 0.1 requires a high confinement HH~1.57 similar to ITER-SS, while the normalized beta value(~2.5) and the ratio to Greenwald density limit(~0.85) are moderate.

Next, the divetor plasma transport for operational points of Fig.1 is also analyzed by SOLPS5.0[4]. The result on the heating power 200MW showed the good prospect of the peak divertor heat load less than $10MW/m^2$ by neon puff(1.0×10^{22}/s). The effective charge is kept less than 2.1 in the core plasma region. This initial operation point of the proposed start-up method is shown to be operational. In the presentation, applicability of this operation method to the ITER steady-state operation is also discussed.

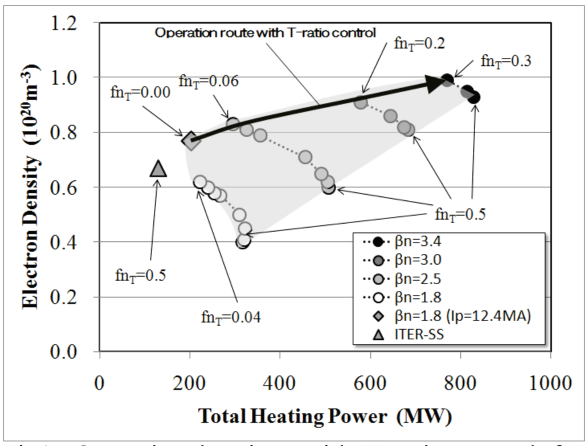

Fig1. Operational points with T-ratio control for Demo-CREST and ITER-SS. Operational space and Operation route with T-ratio control are also delineated.

[1]R.Hiwatari et al., Nucl.Fusion 45(2005)96.
[2]Gruber et al., Comput. Phys. Comm. 21(1981)323
[3]K.Okano et al., Plas. Phys.Cont.Fusion 32(1990)225
[4]R.Schneider, et al., Contrib. Plasma Phys. 46 (2006) 3-191.