High-density, low temperature ignited operations in FFHR

O. Mitarai, A. Sagara[(a)], R.Sakamoto[(a)], N. Ohyabu[(a)], A. Komori[(a)], and O. Motojima[(a)]

Liberal Arts Education Center, Kumamoto Campus, Tokai University, 9-1-1 Toroku, Kumamoto 862-8652, Japan

(a) National Institute for Fusion Science, 322-6 Oroshi-cho, Toki, 509-5292, Japan

e-mail address: omitarai@ktmail.tokai-u.jp

Achievement of the superdense core (SDC) plasmas in LHD experiments [1][2] stimulates the study on the stabilization method of the thermal instability in a fusion reactor. Recently, new, simple and comprehensive control method of the unstable operating point is invented for the high-density and low temperature ignited operation for the FFHR helical reactor (R=14 m, a=1.73 m, B=6 T, P_f=1.9 GW and γ_{ISS}=1.6) [3]. PID feedback control of the fueling using the error of the fusion power with an opposite sign of $e'_{DT}(P_f)= -(P_{fo}-P_f)$ can stabilize the unstable operating point and the desired fusion power is obtained at the same time [3]. Here P_f is the measured fusion power and P_{fo} is its set value. Using this control algorithm with the box type density profile, the operating point can reach the high-density and low temperature steady state condition ($n(0)\sim 1\times10^{21}$ m^{-3}, T(0)~6.4 keV, and $<\beta>\sim$ 2.5 %) from the initial very low temperature and density regime. Although this control was demonstrated by the zero-dimensional analysis, it can be also applied to one-dimensional simulation code and implemented in a reactor because linearization is not necessary in equations

As the high-density and low temperature ignited operation is inherently unstable, it is skeptical whether the steady state can be maintained or not when plasma parameters are disturbed, for example, by pellet injections. Contrary to this skepticism, we show in this study that this control is robust to the pellet injections, the change in the confinement factor and impurity fraction to some extent. Although feedback control was not used for the external heating power so far [3][4], we report that feedback control of the external heating power is possible from ignited to sub-ignited regimes, expanding the operational regime.

[1] N. Ohyabu, T. Morisaki, S. Masuzaki, et al., Phy. Rev. Lett., **97** (2006) 055002-1.

[2] R. Sakamoto et al., in 21th IAEA conference (Geneva, Switzerland, Oct 13, 2008) EX/8-1Ra.

[3] O. Mitarai, A. Sagara, N. Ohyabu, R. Sakamoto, A. Komori and O. Motojima, Plasma and Fusion Research, Rapid Communication, Vol.2 (2007) 021-1-3

[4] O. Mitarai, A. Sagara, N. Ashikawa, R. Sakamoto, M. Yoshinuma, M. Goto, T. Morisaki, et al., in 21th IAEA conference (Geneva, Switzerland, Oct 13, 2008) FT/P3-19