Plasma start-up and steady-state operation control of the LHD-type helical reactor FFHR

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Helical systems with a net-current-free plasma have an advantage in a steady-state operation: no disruptive events caused by the plasma current, low recirculation power. Recently it was found that helical systems have another advantage comes from the characteristics of the net-current free plasma: easiness in the plasma operation control. In this presentation, plasma operation control scenario of the LHD-type helical reactor FFHR was examined using the integrated 1D physics analysis tool developed by coupling a simple 1D calculation model based on the LHD experimental observations with the integrated transport analysis code TASK3D. As a result, a smooth change and steady-state sustainment of the fusion power with an acceptably small perturbation (several percent) was attained for both self-ignition and sub-ignition operations and consistency with MHD equilibrium and neo-classical transport was confirmed [1]. This stable control of the fusion power can be realized by feedback control of the pellet fuelling and a simple staged variation of the external heating power with a small number of simple diagnostics: line-averaged electron density, edge density and fusion power. Among them, measurement of the line-averaged electron density is a key component because it requires high reliability and high resolution (an order of 10^{17} m^{-3} and less than 10 ms) to determine the adequate pellet fuelling rate. This requirement can be satisfied by a diagnostic system with the combination of a dispersion interferometer, which was already tested and installed on LHD, and a polarimeter [2]. Consequently, stable operation control of the FFHR can be achieved as long as the target value of line-averaged electron density is adequately set.

[1] T. Goto et al., Proc. of 25th IAEA FEC, Oct. 2014, St. Petersburg, Russia, FIP/P7-16.

[2] T. Akiyama et al., Proc. of 25th IAEA FEC, Oct. 2014, St. Petersburg, Russia, FIP/P8-31.