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Integrated operation of steady-state long pulse H-mode in EAST

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Recent EAST experiment has successfully demonstrated long-pulse steady-state scenario with a good plasma performance through the integrated operation since the last IAEA in 2016. A discharge with a duration over 100s has been obtained with multi-RF power heating and current drive. Plasma parameters are as follows, plasma current Ip=0.4 MA, poloidal βP ~1.2, toroidal magnetic field BT=2.5 T, elongation κ=1.6, the safety factor at the 95% normalized poloidal flux surface q95 ~6.6. The zero-loop voltage and pulse length (~ 250 times the current relaxation time) indicate the really steady state condition. Small ELMs were obtained in this long pulse H-mode discharge which facilitates the RF power coupling in the H-mode phase. In the operation, the optimization of X-point, plasma shape, the outer gap and local gas puffing near LHW antenna were investigated to maintain RF power coupling and particle exhaust and to avoid formation of hot spot on the 4.6 GHz LHW antenna. Global parameters of BT and line averaged electron density were optimized for higher current drive efficiency of LHW and on-axis deposition of ECH. A peaked electron temperature profile was observed with a weak ITB at rho ~0.4. No obvious MHD instabilities were found in the whole discharge. The maximum tungsten divertor temperature monitored by the IR camera shows the temperature raises quickly in several seconds and reaches a stable value, ~500 oC. As a key element, wall conditioning was addressed before long pulse plasma operation. Several difficulties are reported in the development of this 100s long pulse discharge. To achieve the next goal (≥400s long-pulse H-mode operations with ~50% bootstrap current fraction), 0-D predictions have been carried out. The modelling suggests that steady-state high performance will require not only increased injected power, but also significantly improved energy confinement quality. The recent long pulse H-mode has demonstrated several key elements and will increase a confidence in achieving high performance, steady state discharges with more key elements in integrated control on EAST.

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