Exploration of Advanced Tokamak Operation and Its Control in KSTAR

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We report the status and prospect of advanced scenario development in KSTAR. Experimental results of two types of advanced scenarios with NBI heating power of about 4 MW are presented; high poloidal beta (β_P) scenarios for steady-state operation and hybrid scenarios for advanced inductive operation. For the high poloidal beta scenarios, fully non-inductive current drive has been achieved with a plasma current of 400 kA and a toroidal field of 2.0 T (q_{95} ~ 8.5) which has β_p ~ 3.5, β_N ~ 3.0, H_{89} ~ 2.2, and H_{98} ~ 1.7. The fully non-inductive phase has been achieved transiently due to the engineering limit of the plasma radial position feedback control in present KSTAR experiment. For the hybrid scenarios, high performance with $\beta_N > 2.0$ and H_{89} ~ 2.0 has been obtained in stationary phases without sawtooth activities at a range of plasma currents from 400 to 600 kA and a magnetic field from 1.6 to 2.0 T with constant q_{95} ~ 5.5. β_N up to 3.0, H_{89} up to 2.7, and H_{98} up to 1.4 have been achieved in transient phases due to the limit of the radial position control then saturated to the values of plasma parameters in the stationary phase. The plasma current overshoot scheme has been applied to establish a q-profile with higher magnetic shear at the edge where β_N above 2.4 has been sustained for about 1 s but decayed afterwards to 2.0 mainly due to evolving q-profiles as a result of current diffusion. Predictive modelling is performed for hybrid scenarios with upgraded heating and current drive planned in KSTAR. Feedback control of the q-profile is simulated for this hybrid scenario by employing a newly developed control algrorithm. The effect of electron temperature profile control is discussed in improving the performance and stability of the q-profile control.