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High Beta Steady State Research with Integrated Modeling in JT-60U

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Improved performance and its long sustainment were obtained by a magnetic material of ferritic steel tiles in JT-60U, which are recently installed inside the vacuum vessel to reduce the fast ion loss by the decrease of the toroidal field ripple. Temperature of the pedestal region explicitly increases by ~20% and the H-mode confinement clearly improved. The improvement is implied to be caused by the change of the radial electric field and the co- rotation near the plasma edge attributed to decrease the fast ion loss. Higher beta (β_N >3) than the no-wall beta limit was obtained by the increase of the net heating power due to the reduction of the fast ion loss and by the close conducting wall. The growth time of the RWM becomes shorter and the achieved beta becomes lower by the decrease of the co- or counter rotation. Performance of long-pulse ELMy H-mode plasma was extended by the integration of the improvement of the confinement and the stability in addition to the suppression of NTM and a real time profile control. High β_N >2.3 simultaneously with H_{98} ~1 was sustained for 23.1s (~12 times of the current diffusion time) at q_{95} ~3.2, which exceed the ITER reference scenario of β_N H_{98} ~1.8. The electron density has been successfully controlled by the active divertor pumping in long-pulse high-density ELMy H-mode plasmas where the wall pumping is not effective and even outgas from the divertor tiles appears. In order to realize a steady-state tokamak fusion reactor, an integrated control of high performance is a critical issue. Based on the analysis of experiments of JT-60U, an integrated model of pedestal/ELM/SOL of the transport code TOPICS and the stability code MARG2D and an integrated model of divertor/neutral/impurity of the edge transport code SONIC are produced as an effective means for the evaluation and the simulation of complex burning plasmas.