Effect of toroidal field ripple and toroidal rotation on H-mode performance and ELM characteristics in JET/JT-60U similarity experiments

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In the past similarity experiments using matched shape plasmas between JET and JT-60U, pedestal parameters in JT-60U could not be scaled to that in JET [1]. Since the analysis shows that MHD stability of both tokamaks is similar and probably cannot explain the observed difference in ELMy H-mode performance [2], the toroidal field (TF) ripple and consequent difference in the toroidal rotation (V_T) profile have been pointed out as major differences between two devices. Therefore, new similarity experiments in terms of TF ripple and V_T profile have been performed in both devices.

In JT-60U, the pedestal performance and ELM characteristics with reduced ripple using Ferritic Steel Tiles (FSTs) are compared with previous experiments without FSTs. Although the reduction of fast ion losses and consequent reduced counter plasma rotation were achieved by reducing the ripple amplitude from ~1.3% to ~0.6% at the outer separatrix, no significant improvement of pedestal performance has been observed. On the other hand, ELM size (ΔW_{ELM}) clearly increased from ~20kJ to 30-50kJ. The effect of local ripple well region was also investigated, because the ASCOT simulation including an effect of ripple induced thermal ion losses indicates that a ripple near the x-point (X_p) might have a significant impact on the thermal ion confinement [3]. The comparison of plasma profiles between high and low X_p configuration revealed that the effect of the local ripple well near X_p on the pedestal performance seemed to be small at least in cases without gas puffing.

In JET experiments with enhanced ripple, where a different current flows in the 2 “odd” and “even” coils creating TF ripple of 0.08-1%, dedicated density and NB power scans were performed. One of the remarkable responses of the plasma to the increased TF ripple was a density pump-out effect, where achievable pedestal and core density with the same level of gas puffing were reduced by ~15%. But, by increasing gas puffing rate, the same level of the density can be recovered with keeping pedestal pressure in contrast to the case in JT-60U, where additional gas puffing degrades pedestal pressure. Normalized ELM frequency to the loss power through the separatrix increased (instead ΔW_{ELM} decreased) together with reduced co-toroidal rotation, as ripple amplitude increased without gas puffing.

These results from dedicated ripple experiments in two devices will reveal important parameters and physics to determine the pedestal performance and ELM characteristics.

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