ELMy H-mode Helium plasma at JET-ILW

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Access to type I ELMy H-mode operation regime in non-nuclear phase (Helium or He/H mixture) is seen as a risk mitigation for ITER as it could be used for commissioning ELM mitigation techniques prior to operations with D-T plasmas. For that purpose, a helium experimental campaign has been conducted at JET. One of the main goals was to assess the possibility of H-mode operations with large type-I ELMs in the ITER-like wall conditions.
A series of H-mode plasmas in Helium and He/H mixtures have been achieved at 1.3MA/1.3T and 1.4MA/1.7T. Plasmas with NBI power ramps were performed in both pure He and H/He mixtures at 1.3MA/1.3T at several plasma density values to investigate the L-H transition. At the same plasma density, the H/He mixture with hydrogen fraction up to 45% was found to have higher H-mode power threshold (P_{LH}) than their pure Helium counterpart.
Transitions from a lower confinement/high ELM frequency regime to higher confinement with large ELMs or transiently ELM-free regimes have been observed, which could be associated with type-I H-mode access. The loss-power required to achieve the transition at 1.3MA/1.3T was around P_{loss}~10MW which is much larger than the power requirement for otherwise similar Deuterium plasmas. The power required to achieve a type-I ELMing H-mode in pure Helium was estimated to be at least 2.5 times higher than P_{LH}. That result is not consistent with previous observations made in JET with carbon wall [1]. In most cases, the transition to the type-I regime has led to heavy impurity accumulation, increase of core radiation and subsequent back transition to type III due to the reduction in P_{sep}.
The transition to type-I H-mode has also been observed in H/He mixture at 1.3MA/1.3T, at similar values of the heating power (10 MW). The H/He plasma was found to be less prone to impurity accumulation due to the lower sputtering yield of Hydrogen. At 1.4MA/1.7T a stationary type-I ELMy H-mode was not achieved in either pure Helium or in H/He mixture. The available NBI heating power in helium was ~13MW, which is larger than type-III – type-I power threshold in the reference pure Hydrogen plasmas found in previous studies [2]
The outcome of this experiment is that in these particular conditions of JET with metal wall and helium pumped in the divertor by means of Ar-frosting (i.e. in conditions approaching those of ITER), there is no clear benefit of pure Helium plasmas over He/H mixture or even pure Hydrogen plasmas to access to type I ELMs regime.

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