The effect of helium on plasma performance at ASDEX Upgrade and JET


While it is well known that confinement in helium plasmas is lower than in deuterium plasmas [1, 2], helium is suspected to degrade confinement even when present at low concentrations in deuterium plasmas [3, 4]. This effect is demonstrated for reactor relevant helium concentrations (<10%) in dedicated experiments in ASDEX Upgrade and JET and is investigated in detail in search of the physics reason behind the confinement degradation.

At ASDEX Upgrade (AUG), feed-forward helium puffs were injected in good confinement plasmas with and without nitrogen seeding, leading to helium concentrations of up to 12%. A clear reduction of the plasma stored energy was observed in both cases, attributed partially to dilution and partially to a change in the pedestal profiles observed when helium is injected. However, this reduction is not clearly correlated with the absolute helium concentration.

At JET, the helium concentration in baseline scenario plasmas with only NBI heating was scanned up to 10% from pulse to pulse by means of real time control on the helium puff. A linear reduction of the plasma stored energy was observed, 12% at a helium concentration of 5%, with an even stronger reduction of the measured neutrons. Dilution due to helium explains only a small part of this reduction and the loss in confinement cannot be connected to a reduced pedestal top pressure, as this remains roughly constant (with increasing density and decreasing temperature). The changes in the plasma profiles, however, have a significant impact on the NBI penetration and absorption. The effect on the confinement can be offset by applying combined NBI and ICRH heating and, furthermore, a reduced deuterium gas puff.

Transport analyses of the AUG and JET experiments allow for the separation of core and edge confinement, as well as the investigation of the reappearance of the High Field Side High Density [5] (in the case of AUG) and the behaviour of the ELMs in response to an additional helium puff. The effect of the helium puff itself on the plasma, in contrast to that of the helium concentration, is also discussed. As the dominant effects causing the degraded performance are different between AUG and JET, the underlying mechanisms are examined, putting emphasis on the comparison between the observations in the two machines.


*See H. Meyer et al., Nuclear Fusion FEC 2016 Special Issue (2017). *See the author list of “Overview of the JET results in support to ITER” by X. Litaudon et al. to be published in Nuclear Fusion Special issue: overview and summary reports from the 26th Fusion Energy Conference (Kyoto, Japan, 17-22 October 2016)