Effect of fuelling location on pedestal and ELMs in JET

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Since the introduction of the Tungsten (W) divertor in JET we find that low fuelling with associated infrequent large ELMs can cause W sputtering and entrain W into the plasma, lowering pedestal temperatures and eventually cooling the plasma core. To avoid core W accumulation, typically large fuelling is used, producing high ELM frequencies and smaller ELMs. As seen in Carbon \cite{1}, large fuelling or low pumping have a detrimental effect on confinement: $H_{98} \sim 0.8$ has been typical in heavily fuelled 2 MA baseline plasmas.

We studied the effect of poloidal fuelling location on plasma pedestal and W screening in a database of comparable ILW plasmas with 2 MA, 2.3 T, $n_e/n_{e,Greenwald} \sim 0.65$, 12-14 MW of NBI heating. We found that if sufficient fuelling is applied to reach $f_{ELM} > 30-40$ Hz, then the plasma can recover from transient W events and a healthy steady state can be reached.

In a well pumped configuration (outer strike at divertor pump duct entrance) the fuelling required to just reach 30-40 Hz is sufficiently low that confinement is recovered: $H_{98} \sim 0.9$ for all fuelling locations. There is an effect of fuelling location: to reach that minimum $f_{ELM}$, higher fuelling is required from the divertor as opposed to remote locations (plasma top and/or midplane). This higher fuelling from the divertor is associated with lower pedestal temperature ($T_{e,ped}$ drops from 1 keV to 800 eV), higher pedestal density, and marginally lower confinement, and has a greater tendency to display "negative ELMs" \cite{2} in inboard $D_n$. This is a sign of recombination: a cold plasma cloud is present in inboard SOL and/or X-point \cite{3}. Hotter pedestals in steady plasmas with top fuelling display positive spikes of $D_n$ after ELMs, possibly indicating a hotter X-point.

In a configuration with reduced pumping (with outer strike away from divertor pump duct) there is no apparent effect of puffing location: considerably colder pedestals and low confinement, $H_{98} \sim 0.8$ are observed, together with evidence of recombination after ELMs, even when the ELM frequencies are sufficient to control W.

\cite{1} G. Saibene et al., JNM Vol.241–243, 476–482 (1997) \cite{2} A. Loarte et al 1998 Nucl. Fusion 38 331 \cite{3} G.M. McCracken et al 1998 Nucl. Fusion 38 619

*See the Appendix of F. Romanelli et al, Proc. of 24th IAEA Fusion Energy Conference 2012, San Diego, USA