Development of a hybrid plasma scenario for D-T experiments in JET-ILW

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One of the main scenarios exploited in the recent JET-ILW DTE2 campaign is based on the so called 'hybrid' plasma regime [1]. Its main characteristics are high poloidal beta (with high toroidal magnetic field and moderate plasma current, B_0=3.45T / I_P=2.3MA), low core collisionality (T_{i0}>T_{e0}>=8keV) and relatively flat q-profile with q_0>=1. To achieve high performance for t=5s, a detailed optimization of the different plasma phases was carried out in Deuterium and Tritium, to be ultimately translated into the final D-T plasma target: (i) In the current ramp-up (ohmic) phase, the q-profile evolution was carefully tailored using a plasma current overshoot associated with a fine control of the plasma density and appropriate timing for the high power switch-on; (ii) For the H-mode entry phase (the first second after the application of high external power), edge impurity screening was explored by using a transitory phase of high pedestal ion temperature (low fuelling) followed by a smooth transition to a type I ELMy regime (high gas injection puff); (iii) For the steady H-mode phase of the plasma, ELM frequency control using appropriate (real-time controlled) gas injection was key to help mitigating the net impurity influx typically observed in W divertor machines, and central H minority ICRF heating (4-5MW) was used to provide additional impurity screening in the plasma core. For the latter phase, a compromise between high performance, impurity control and mitigation of deleterious MHD was important and inevitably restricted the exploitable domain of the main engineering actuators available for optimizing the discharge (NBI and ICRH power, gas injection, plasma shape, etc.). The ultimate 50:50 D:T plasmas exceeded 10MW of fusion power transiently and achieved 8.3MW averaged over 5s (E_{fus}=46MJ), with ~33MW of injected NBI+ICRH power, T_{i0}>10keV, and relatively low bulk plasma radiation (typically <50% of the heating power) with moderate impurity accumulation. By avoiding too high q_0 values at the start of the heating phase, large/detrimental neoclassical tearing modes (NTM's) were absent in most discharges despite the high β_N values achieved, but (1,1) MHD activity was usually present in the second half of the pulse. The different steps carried-out for the scenario optimization in D, T and D-T plasmas will be described and examples of the final D-T discharges performed in the recent JET DTE2 campaign will be presented.

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