**Coupled Core/SOL Modelling of Fuelling Requirements During the Current ramp-up of ITER L-mode plasmas**

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**Introduction**

Is it possible for the plasma to reach minimum density during the current ramp up for the NBI to be switched on and avoid shine through with just gas puff alone?

A series of simulations with increasing gas injection rates has been carried out with the integrated Core/SOL suite of codes JINTRAC [1].

- The currents used for this study were: 5 MA, 10 MA and 15 MA, with Electron Cyclotron Heating (ECRH) of 5 MW, 10 MW and 20 MW respectively.

If it is not enough than what changes are needed to satisfy the NBI shine through criteria:

- Increase the input power, 20 and 40 MW of ECRH power for 10 MA plasma current
- Decrease the heat and the particle diffusivities within the SOL for the 10 MA plasma current

**JINTRAC Simulations settings for 5, 10 and 15 MA**

- The grid for 5 and 10 MA were adapted from the 15 MA.
- At the SOL, optimized EDGE2D/EIRENE code settings obtained by a dedicated benchmark between SOLPS and EDGE2D were used.
- In the core, JETTO simulations were set by previous ITER simulations in L-mode plasma with 25% of the Greenwald limit.
- The gas rate limit was set when the plasma was fully detached
  - At fully detached plasma the, $T_e < 1eV$ for a region of $r_{sep} > 50$ cm.
  - Incrementing the gas beyond detachment the density goes out of control.
- The simulations have been continued until steady state was reached for a given input power and main gas inlet rate. Steady state conditions correspond to a steady core density during at least one energy confinement time, which for L-mode ITER plasmas is around 3s. In average the simulations took 10 s of plasma time to reach steady state.

**10 MA power scan**

- Time traces with 1.3e22 gas rate and different input power of ECRH:
  - 10 MW, 40 MW
- The density increases start at the edge and propagates to the plasma core.
- The density increases with input power because the density in the main SOL and mainly in the divertor increases.
- The minimum line average density for the NBI shine through was achieved with 40 MW of ECRH

**10 MA SOL transport coefficients scan**

- Tanh decay to the far scrape off layer to:
  - $\chi_e \times 1.0 m/s$ and $D_e \times 0.3 m/s$
- Different transport outside the last closed flux surface with constant transport coefficients:
  - $\chi_e \times 1.0 m/s$ and $D_e \times 0.3 m/s$
  - $\chi_e \times 0.5 m/s$ and $D_e \times 0.15 m/s$
  - $\chi_e \times 0.25 m/s$ and $D_e \times 0.07 m/s$
- The average core density decreases and the average core temperature increases with the transport in the SOL.
- The density increase is mainly due to the density at the separatrix and not to the neutral flux.
- The divertor conditions changed with the SOL transport. The density and power width at the divertor targets decreased with the transport at the SOL.

Simulations for the JET in L-mode plasmas at high recycling regime with different edge codes reached similar of transport coefficients, $\chi_e \times 0.5 m/s$ and $D_e \times 0.15 m/s$, in order to match the density and temperature profiles at the outer mid plane separatrix and at the outer divertor target.

**Conclusions**

- During the current ramp up not only the input power has to increase but also the gas fuelling rate.
- For a given input power the density increases with the gas inlet rate until an optimum density.
  - Further increase of the gas decreases the temperature in the divertor but the density does not increase at the separatrix.
  - The input power increases the density for a given deuterium puff because the density in the main SOL and mainly in the divertor increases.
  - The plasma also can be fed by the neutrals but on the cost that the divertor becomes unstable and very cold.
  - The plasma density is dependent on the assumption of the plasma transport not only in the plasma core but also in the SOL.


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