Pellet injection experiments on Tokamaks in ASIPP, China

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Pellet injection has been proved to be an effective method for deep fueling of fusion devices. Improvements of both the particle confinement and the energy confinement were observed in many experiments. In HT-6M and HT-7 tokamaks, single and multi-pellet experiments are tried, and attractive results are obtained.

For HT-6M(R=0.65m, a=0.2m) and HT-7(R=1.22m, a=0.28m), with the bulk plasma electron density of around 1×10^{13} cm^{-3} and electron temperature of 500 eV for HT-6M and 1 keV for HT-7, pellets with the size of around $\Phi0.6\times0.8$ for the former and $\Phi1.0\times2$ for the latter (Fig.1) are acceptable according to Parks model:

$$\tau_{PB}=3.47\times10^{7}n_{e0}^{-1/3}T_{e0}^{-1.65}r_{p0}^{5/3}.$$

One multi-shot 'in-situ' pellet injector is constructed. By careful control of the freezing temperature, filling pressure, and freezing time, pellets with the size from $\phi0.6\times0.8$ to $\phi1.5\times2$ are obtained reliably. Propelled by high-pressure gas He, the pellets reach a velocity of around 0.9 km/s.

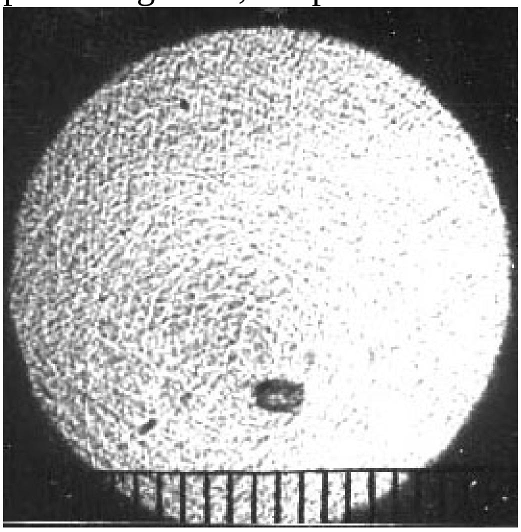

Figure 1, Picture of pellet for HT-7 (ruler is placed beneath the trajectory, 1mm between 2 grids)

During the experiment, typical phenomena are observed: sudden rise of the electron density and loop voltage, the decrease of Zeff, etc. Deep fueling can be seen obviously from the multi-channel Hα array signal. The life time of pellets ranges from several hundred micro-second to several milli-second. The result of Abel inversion of Hα signal corresponds well with the deposition depth presumed by Parks' model.

With multi-pellet injection during ohmic discharge, electron density is raised approaching to the Greenwald limit. Because of the profile effect, deep fueling by pellet injection results in considerably higher line averaged densities than what is obtained by other methods with the same boundary conditions. Since the density limit is more sensitive to the density at the edge than in the center, disruptions due to density limit could be avoided by carefully handling the edge plasma parameters. The result may be extrapolated to reactor plasmas and makes the future fusion reactor more economical.

Some interesting phenomena are observed too. The suppression of the fluctuation in the edge plasma by pellet injection is observed from the edge probe signal. However, pellet injection could cause m=2 MHD oscillation, which is intercepted by the peaking of the density. The connection between pellet fueling and MHD activities is further examined in the paper.

Though it is generally acknowledged that, the power loss in the center exceeding the local input power can cause a flattering of the electron temperature, and even lead to a radiation collapse, recent investigation shows that the impurity accumulation can lead to the peaking of the resisivity profile, then flatten the current density. The reversed shear-like mode are realized on HT-7 by the injection of a pellet during the Ip ramp-up stage to get a hallow j(r) profile. The related mechanisms could be that: the suddenly increasing plasma current constrains itself from diffusing to the center immediately, on the other hand, the flattening of electron temperature and peaking of density cools down the central plasma. As a result, the resistivity peaks.

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