ADVANCES ON THE HIGH SPEED IGNITOR PELLET INJECTOR (IPI)

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The control of the density profile during the initial plasma current rise is a critical issue to optimize ohmic and fusion heating rates of the plasmas to be produced by Ignitor. Simulations performed with the NGS ablation model, for the reference ignition plasma parameters ($n_{e0} \cong n_{i0} \cong 10^{21}$ m^{-3}, $T_{e0} \cong T_{i0} \cong 11$ keV), indicate that deuterium pellets of a few mm (≤ 4 mm) in size injected at 3-4 km/s from the low field side should achieve sufficient penetration and ensure adequate deep fuelling. Therefore a high-speed pellet injector has been included always in the Ignitor design..

ENEA and Oak Ridge National Laboratory are collaborating on the development of a four barrel, two-stage pneumatic injector for the Ignitor experiment, featuring two innovative concepts: (i) the proper shaping of the propellant pressure pulse to improve pellet acceleration, and (ii) the use of fast closing (< 10 ms) valves to drastically reduce the expansion volumes of the propellant gas removal system. Two independent sub-systems have been built. The ENEA equipment, including four independent two-stage guns (TSG) and pulse shaping valves, the gas removal system, and the associated controls and diagnostics, has been built and thoroughly tested at CRIOTEC, prior to being shipped to ORNL. In particular, the pressure rise in the downstream expansion volume could be completely cut-off by reducing the delay (relative to the pressure pulse time) with which the valve closes. The ORNL apparatus consists of the cryostat and pellet diagnostics, with related control and data acquisition system. New light gate and microwave cavity mass detector have been developed specifically for this application. A single, toroidally shaped, microwave cavity monitors simultaneously all four of the guide tubes.

Integration of the two subsystems (except for the gas removal system which will follow as the last step) has been readily achieved. Preliminary tests, carried out with the four TSG's fitted to the cryostat in their final configuration, demonstrated that the two systems match properly, while their respective control systems interface correctly and perform outstandingly. A first attempt to demonstrate reliable operation of the injector at relatively high speed (in the 2 to 3 km/s range) was pursued during a short joint experimental campaign (July 20-31, 2009). Launching sequences with all four barrels were successfully performed, with pellets accelerated at speeds up to 2.2 km/s. The analysis of these first results indicate that the IPI has the potential of achieving higher speed performance, as compared with those previously achieved by the Single Pellet Injector (SPIN) installed on the Frascati Tokamak Upgrade (FTU) in the early 90's. However, during these tests, it was more difficult than expected to accelerate intact pellets at speeds above 2 km/s, indicating that pellets trajectories were exhibiting a too wide dispersion, most likely due to the oscillation of the thin walled barrels, as a consequence of the propellant shockwave propagating along them. To avoid this problem, the barrels have been replaced with thicker ones, which can be more firmly held along their length to grant better alignment and stability. The results of high speed testing of the injector in this improved configuration, planned for April 2010, will be reported.