ORNL MOCK-UP TESTS OF INSIDE LAUNCH PELLET INJECTION ON JET AND LHD*

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In experiments on ASDEX-Upgrade and DIII-D tokamaks, the injection of deuterium pellets from the magnetic high-field side (HFS) of the plasma resulted in deeper pellet penetration and improved fueling efficiency. Based on those successful experiments, fusion researchers at the Joint European Torus (JET) and the Large Helical Device (LHD) decided to implement inside launch pellet injection. These injection schemes require the use of curved guide tubes to route the pellets from the acceleration devices to the inside launch locations, and the pellets are subjected to stresses from centrifugal and impact forces in traversing the tubes. Before the installations on the large experimental fusion devices, mock-ups of the guide tubes were constructed and tested at the Oak Ridge National Laboratory (ORNL) to determine the pellet speed limit for reliable operation without pellet fracturing.

A versatile ORNL pipe gun facility was used to make and accelerate pellets to speeds in the range of 100 to 1000 m/s. For the JET mock-up, 4-mm-diam deuterium pellets were shot through a 8.7-m-long by 10-mm-inside diameter (ID) curved guide tube; for the LHD mock-up, 3-mm-diam hydrogen pellets were shot through a 19-m-long by 8-mm-ID curved guide tube. For both tests, stainless steel tubes were used. Because of the long length of the LHD tube run, multiple tubes were required, and a special union that was previously developed at ORNL was used to connect four tube sections. The main objective of the mock-up tests was to determine the speed limit at which intact pellets could be delivered reliably to the plasma for the JET and LHD configurations. Data from ≈300 test shots were collected in this study, including speed measurements and in-flight photographs at the gun muzzle and the guide tube outlet. For the JET mock-up, it was found that the speed of the 4-mm deuterium pellets had to be maintained below ≈160 m/s to ensure delivery of intact pellets through the guide tube. Subsequently, the initial HFS pellet experiments were carried out on JET in late 1999 (with a centrifuge pellet injector), and the data were in good agreement with the ORNL speed limit. For the LHD mock-up, the speeds of the 3-mm hydrogen pellets had to be maintained below ≈300 m/s for reliable pellet delivery. The initial inside launch pellet experiments on LHD are scheduled for late 2000 and will mark the first inside launch of pellets into a helical device. While LHD will only operate with hydrogen pellets, an additional set of data was taken with the LHD mock-up and deuterium pellets to examine the effect of the pellet material on the speed limit; only a small difference was observed in the mock-up tests. Estimates from the photography information and downstream pressure measurements suggested ≈20% maximum mass loss through the curved tubes. Also, upstream and downstream pellet speed measurements indicated that pellets slow down in the curved guide tubes at most by ≈5–10%. In this paper, the test equipment and operations will be described, along with the experimental data and results.

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