§14. Particle Transport Diagnostic Method with Double-Layer Pellet

Sudo, S, Itoh, H*, and Khlopenkov, K.**
*Nippon Sanso Corp., Kawasaki-city
** Soken-dai and on leave from SPTU

An innovative device for producing a double-layer pellet is designed, constructed and operated to demonstrate its proof-of-principle. The objective of the development of the double-layer pellet is to establish an accurate transport diagnostic system to measure particle transport both parallel and perpendicular to the magnetic field lines of magnetic confinement devices. The essential point of the diagnostic is based upon a tracer particle source which is poloidally and toroidally localized within a limited small volume of the plasma on the order of 1 cm^3. The tracer particles are deposited by a double-layer pellet which consists of a small core of the tracer light atom, such as carbon or lithium, and the major outer layer of hydrogen isotope which is the same species as the bulk plasma ions. The key issue of the technology is accurate positioning of the core pellet under a low temperature condition. For the technical demonstration of a device producing a double layer pellet with a size adequate for the Large Helical Device (LHD) which is under construction at National Institute for Fusion Science, we chose the cylindrical form of the pellet: the typical outer diameter of 3 mmϕ with length of 3 mmL, and an inner core with diameter of 240 mmϕ in the form of a sphere. To realize the conceptual design of the production method of the double-layer pellet, the device is designed and constructed. The cryohead made of OFC (Oxygen Free Copper) is supported with three invar rods, and two stepping motor systems with liner scale position sensors are used for driving the pellet carrier disks and also supplying the core pellet inside the outer layer of the pellet with a high accuracy on the order of 5 μm. Thermal contraction of the driving systems by cooling the cryostat with liquid helium can be compensated with bellows. The locations of the pellet production and the core supplier which change position during the cooling also can be adjusted by monitoring the new position of electric contact switches which are set up in both directions. The thermal contraction of the OFC disk with a length of 153 mm is 450 - 600 μm depending on the temperature profile of the disk. For the precise set-up of the cryohead, a special brazing method in vacuum has been used. The whole device has been successfully assembled, and it has been shown that the stepping motor systems can drive the pellet carriers smoothly in spite of a small clearance of several tens μm. For producing a cryogenic pellet, hydrogen isotope gas is first introduced for the partial pellet with thickness of 1.6 mm. Then, the carbon core with diameter of 240 μmϕ is fed through by a tungsten wire with diameter of 230 μmϕ. This pellet is then transferred, and the hydrogen isotope gas is introduced again. Here, the additional pellet with thickness of 1.4 mm is put in order to cover with hydrogen isotope that part of the core which remains exposed. Then, the whole pellet is completed, and it is transferred to the place, where the pellet is accelerated through the barrel by high pressure gas. The ejected pellet is photographed by fast flash lamps (typical pulse width of 100 ns) during its flight. The photograph of the pellet in flight with a velocity of 500 - 600 m/s has been taken simultaneously in the two directions, that is, vertically and horizontally. The photographs have proved the cylindrical disk shape of the pellet. The double-layer pellet having a carbon core is clearly shown in Fig. 1 for the first time world wide in the image.

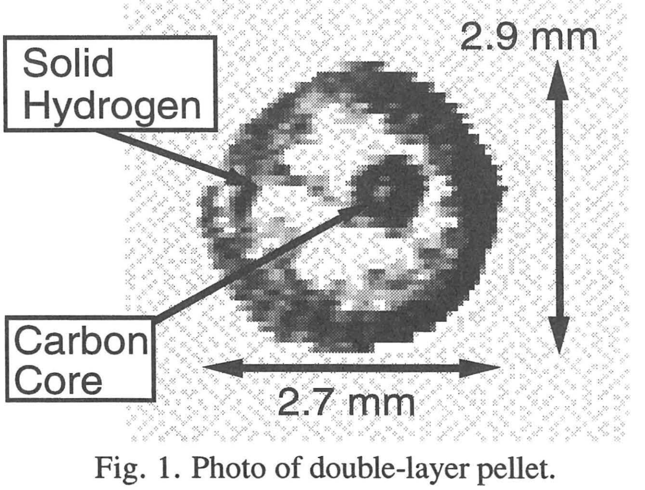

Fig. 1. Photo of double-layer pellet.