Developing the Basis for Target Injection and Tracking in Inertial Fusion Energy Power Plants*

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Fueling of a commercial Inertial Fusion Energy (IFE) power plant consists of supplying about 500,000 fusion targets each day. The most challenging target in this regard is for laser-driven, direct drive IFE. It consists of a 4 mm diameter spherical polymer capsule with a cryogenic DT layer that must be positioned at the center of a reaction chamber operating at temperatures as high as 1500°C and possibly containing as much as 0.5 torr of xenon fill gas. The DT layer must remain highly symmetric, have a smooth inner ice surface finish, and reach the chamber center at a temperature of about 18.5 K. This target must be positioned at the center of the chamber with a placement accuracy of ± 5 mm. The accuracy of alignment of the laser driver beams and the target in its final position must be within ± 20 µm. All this must be repeated six times per second. The method proposed to meet these requirements is injecting the targets into the reaction chamber at high speed (~400 m/s), tracking them, and hitting them on the fly with steerable driver beams.

These requirements lead to several critical issues for target injection and tracking: (a) the ability of the DT ice to withstand the required accelerations, (b) heating of the target by thermal radiation and by gasses in the reaction chamber, (c) stress generation in the DT ice due to temperature changes and thermal gradients during injections, (d) mechanical wear and reliability of injection systems operating at ~6 Hz, and (e) ability to detect and track the targets to the required accuracy.

These challenging scientific and technological issues are being addressed through a combination of analyses, modeling, materials property measurements, and injection demonstration equipment. Measurements of relevant DT properties are planned at Los Alamos National Laboratory. An experimental target injection and tracking system is now being designed to support the development of survivable targets and demonstrate successful injection scenarios. Analyses of target heating is underway. Calculations have shown that the direct drive target must have a highly reflective outer surface to prevent excess heating by thermal radiation. In addition, heating by hot chamber fill gas during injection far outweighs the thermal radiation. Thus, the dry-wall, gas-filled reaction chambers (like the SOMBRERO design) must have gas pressures less than previously assumed. These conclusions have prompted the IFE community to begin a re-evaluation of the dry-wall chamber design, including the possibility of reductions in the gas fill pressure. The evaluations are scheduled to begin this summer.

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TOPIC: #2