Thermal Loading of a Direct-Drive Target in Rarefied Gas

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In an inertial fusion energy (IFE) power plant, each fusion micro-explosion (~10 Hz) causes radiation and pressure shock waves that impose extreme loads on the IFE reactor wall and driver optics. This deposition of energy in the reactor wall over a short time could result in the sputtering of wall material, high stresses, and fatigue. The loading on the wall must remain sufficiently low to ensure that economic and safety constraints are met.

One proposed method for decreasing the intensity of the wall loading is to fill the reactor chamber with a gas, such as Xe, at low density. The gas will absorb much of the radiation and ion energy from the fusion event, and then slowly release it to the chamber wall. Unfortunately the protective gas introduces major heat loads on the direct-drive target. The thermal loading of a target, during injection, largely determines the viability of that target upon reaching chamber center (CC).

The objective of this work is to quantify and characterize the heat flux resulting from the interaction of the target and the protective gas. For the range of expected protective gas densities (3e19 m^{-3} to 3e21 m^{-3}), the energy exchange takes place in the molecular or transition regime. The high Knudsen number flow (Kn ~ 1-100) around the target is modeled using DS2V (a DSMC program). Using DS2V, this work explores the affect of the protective gas density, temperature, sticking (condensation) and accommodation coefficients on the heat flux to the target.

As expected the heat flux is extremely sensitive to the density of the protective gas (increasing as the gas density increases). It is also found that the sticking and accommodation coefficients significantly influence the heat load on the target. Unfortunately the sticking and accommodation coefficients are unavailable for the temperatures expected in the reaction chamber; thus, an experimental determination of these coefficients is necessary.