Modeling DT Vaporization and Melting in a Direct-Drive Target

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During injection, inertial fusion energy (IFE) direct-drive targets are subjected to heating from energy exchange with the background gas and radiation from the wall. This thermal loading could cause phase change (vaporization and/or melting) of the deuterium-tritium (DT). In the past, it was assumed that any phase change would result in a violation of the stringent smoothness and symmetry requirements imposed on the target. The objectives of this work are to demonstrate the advantages, and determine the effect on target symmetry of allowing phase change under different assumed scenarios.

This work summarizes the results from a one-dimensional finite difference model that was created to simulate the coupled thermal and mechanical response of a direct-drive target to an imposed heat flux. The model utilizes a simple method, known as the apparent c_p method, to account for the effect of melting on the heat conduction in the target. The model also accounts for the change in density, and hence deflection of the polymer shell and DT solid, attendant with DT vaporization and melting.

It is found that as the amount of melting and vaporization increases, the ultimate strength of the DT solid and/or polymer shell can be exceeded. The amount of liquid and vapor is given for several heat fluxes as a function of time. Insight is gained as to the fertility, in relation to vapor bubble nucleation and growth, of the target environment by calculating the maximum superheat in the liquid DT. It is also shown that under certain circumstances preexisting vapor can be minimized or eliminated by allowing melting. The results of this preliminary study suggest that some phase change may be allowable. To gain a better understanding of the consequences of phase change it is proposed that a new 2-dimensional model be created and coupled with experiments.