Convective Heating of the LIFE Engine Target During Injection

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Laser Inertial Fusion Energy (LIFE):
- A rep rate of 10-20 Hz is required for adequate power generation
- Chamber gas can be considered viscous (CFD ok), but density is low enough a direct simulation Monte Carlo (DSMC) solution is tractable on a PC platform

Design Requirement:
- Melting of either the DT ice or laser entrance hole (LEH) window constitutes target failure and no burn

Target Evolution has been Investigated:

Target flight conditions (TFC):

Heat flux along hohlraum bodies:
- Heat transfer along hohlraum’s body predicted well by ANSYS and DS2V with following correlations:
  - From Bird (1994):
    - Overall Knudsen number can be misleading
    - Suggests using a ‘local Knudsen number,’ Kn*, where the characteristic length is the scale length of macroscopic gradients (such as density):
      \[
      Kn^* = \frac{d}{\lambda_L} \left( \frac{d}{\rho} \right) \frac{d}\{\frac{d}{\rho} d\}
      \]
    - Errors in Navier-Stokes result for Kn* above 0.1 and is hardly usable for Kn* above 0.2
    - A maximum Kn* of 0.17 was found, suggesting the continuum models are beginning to break down
- Inclusion of baffles has shown to reduce the heat transfer to the LEH windows as much as 8-10x for the original target flight conditions
- Inclusion of baffles will dramatically decrease heat transfer to LEH windows
- Internal helium acts as a heat sink to cool the LEH windows and heat fuel capsule
- Testing is warranted once final conditions have been set

Conclusions and Recommendations:

Internal Transient Heating Analysis:
- Adiabatic heating using lumped capacitance method shows the 0.5 µm thick LEH window has very little thermal resistance
- The combination of target spinning and heating through the LEH windows induce buoyancy driven swirling effects, cooling the window and heating the capsule
- The temperature of the LEH windows steadily increased as a function of heat transfer coefficient, h, over windows
- Helium near the capsule rises less than 1 K for h less than 27 W/m²-K

DS2V velocity comparison with (top) and without (bottom) baffles

Temperature along Stagnation Line

Velocity along Stagnation Line

Pressure along Stagnation Line

Density along Stagnation Line

Note: P2 shields, tent and fuel capsule have been omitted from schematic