Objective:
Explore plasma-jet magnetized-target fusion (MTF) burn dynamics in the reactor regime.

Abstract
Magnetized-target fusion (MTF) constitutes one form of pulsed power. MTF relies on the magnetic field of the target to reduce thermal conduction and an incoming liner’s inertia to provide transient plasma stability and confinement. The attractiveness of MTF as an electric power-plant option stems from its position intermediate in plasma density and energy between magnetic fusion energy (MFE) and inertial fusion energy (IFE). That position potentially leads to lower costs for MTF than for MFE and IFE, in large part because MFE magnets are eliminated and the required driver energy compared to IFE drops significantly [1]. Almost all of the research on magnetized-target fusion has focused on solid or liquid liners. This poster gives preliminary results of burn-dynamics exploration in the reactor regime of the recently invented concept of using plasma jets to form the liner [2]. The investigations use the University of Wisconsin’s 1-D radiation hydrodynamics code, BUCKY, described below.


Features of the University of Wisconsin’s 1-D Radiation Hydrodynamics Code, BUCKY

- Lagrangian approach
- Simulates plasmas in planar, cylindrical, or spherical (used here) geometries
- Single-fluid equations of motion with pressure contributions from electrons, ions, radiation, and fast charged particles
- Plasma energy transfer treated using either a one-temperature (T_e=T_i) or two-temperature model.
- Electrons and ions assumed to have Maxwellian distributions
- Thermal conduction for each species presently treated using either specified or Spitzer constant conductivities, with flux-limited electron conduction
- PdV work
- Fast-ion (beam or target debris) energy deposition
- Heating due to fast charged particles and neutrons during the burn
- D-T, D-D, and D-He reactions
- Charged particle reaction products transported and slowed using time-dependent particle tracking
- Neutrons deposited in the target using an escape probability model
- Fast ions from an ion beam and target microexplosion debris tracked using a time-, energy-, and species-dependent stopping power model
- Stopping powers computed using a Lindhard model at low projectile energies and a Bethe model at high energies

Typical MTF Reactor Parameters

- Electrons and ions assumed to have Maxwellian distributions
- Thermal conduction for each species presently treated using either specified or Spitzer constant conductivities, with flux-limited electron conduction
- PdV work
- Fast-ion (beam or target debris) energy deposition
- Heating due to fast charged particles and neutrons during the burn
- D-T, D-D, and D-He reactions
- Charged particle reaction products transported and slowed using time-dependent particle tracking
- Neutrons deposited in the target using an escape probability model

Initial parameters for target and jet regions

<table>
<thead>
<tr>
<th></th>
<th>Target</th>
<th>Jets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of zones used by BUCKY calculation</td>
<td>zones</td>
<td>25</td>
</tr>
<tr>
<td>Zone mass-change factor</td>
<td>0.05</td>
<td>0.0315417</td>
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<tr>
<td>Region thickness</td>
<td>Δz(0-0M)</td>
<td>0.05</td>
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<tr>
<td>Region outer radius</td>
<td>r(0)</td>
<td>0.05</td>
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<tr>
<td>Total mass</td>
<td>mg</td>
<td>0.00847892</td>
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<tr>
<td>Density</td>
<td>n/cm³</td>
<td>2x10¹³</td>
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<td>Electron temperature</td>
<td>T_e(kv)</td>
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<tr>
<td>Velocity</td>
<td>v_e(kv)</td>
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<td>Confinement time</td>
<td>t_ψ</td>
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<tr>
<td>Ion-acoustic velocity</td>
<td>v_ia(kv)</td>
<td>4.41712</td>
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<tr>
<td>Kinetic energy</td>
<td>KE(MJ)</td>
<td>1.56628</td>
</tr>
</tbody>
</table>

Plasma-Jet MTF for Space Propulsion

- Space propulsion constitutes an interesting potential application of MTF.
- Research performed at NASA Marshall Space Flight Center.
- Figure at right, from Francis Thio, shows the basic concept of direct thrust by reflecting the expanding MTF plasma off a magnetic nozzle.
- Predicted space-propulsion performance shown at right (see references above).

Future Work

- More sophisticated B-field models and the dependence of thermal conductivity on the B-field must be implemented in BUCKY.
- Use BUCKY to investigate the details of plasma-jet burn dynamics.
- Use SNL’s Scars code to model g transport across equilibrium and stochastic magnetic fields.
- Optimize the performance of plasma-jet MTF plasmas in the concept-exploration, proof-of-principle, and reactor regimes.