The X2 Nested Channel Hall Effect Thruster: an Inner Channel Simulation

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Background

- Hall Effect Thrusters (HETs) have a rich history of over 60 years [1]
- Nested channel HETs were first developed at the University of Michigan in the Plasmadynamics and Electric Propulsion Laboratory (PEPL):
  - 2 channel, 10kW class X2 by Liang [1]
  - 3 channel, 100kW class X3 by Florenz [2]

Motivation

- Performance gains were observed in multiple channel operation [1]
  
<table>
<thead>
<tr>
<th>Channel</th>
<th>Thrust (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X2</td>
<td>255±10</td>
</tr>
<tr>
<td>X3</td>
<td>750±20</td>
</tr>
</tbody>
</table>

- Full characterization of the thruster channels
- Hard to measure quantities inside channel
- Investigation of channel interaction
- Future input for a plume simulation
- Design feedback

Simulation Setup

- Parameters:
  - Xe propellant
  - total number of neutrals: 113,300
  - total number of ions: 568,800
  - time step: 50 ns
  - simulation time: 4 ms
  - propellant flow rate: 7 mg/s
  - discharge voltage: 200 V
  - wall temperature: 812 K
  - computation time: 18 hrs

- The 2D axisymmetric hybrid-PIC code HPhall [3] is used in the current study.

Results

- Axial ion velocity
- Centerline neutral number density comparison
- Electron temperature
- Double ion number density
- Single ion number density
- Electron number density

Thrust Values (kN)

<table>
<thead>
<tr>
<th>Source</th>
<th>Measured</th>
<th>Simulation in vacuum</th>
<th>Simulation with 1.5 x 10⁻¹⁷ Torr</th>
</tr>
</thead>
<tbody>
<tr>
<td>X2</td>
<td>255±10</td>
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</table>

Conclusions

- Facility backpressure does not influence the inner channel
- Thrust values are in good agreement with measurement
- Electron temperature values confirm ionization assumption (no triples)

Future Work

- Near term:
  - Obtain raw data for electron temperature and plasma potential measurements, and error bars
  - Obtain B field map from measurements and compare to MagNet output
  - Obtain B field from Infolytica MagNet for other thruster operating conditions
- Medium term:
  - Update code:
    - Mesh reading routine
    - Electron model
  - Prepare dual channel simulation
- Long term:
  - Move on to X3 simulations
  - Provide design feedback

References


Acknowledgments

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