MAMBA-3D Development & VERA Integration

Benjamin Collins
Physics Integration
Oak Ridge National Laboratory

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Overview of Coupling Method

- Previous work in FY15-FY16 developed coupling between MPACT, CTF, and MAMBA1D
- This capability was used to simulate the CIPS experienced in Cycle 7 of Watts Bar Unit 1
Watts Bar Cycle 7 with MAMBA1D

- Axial Offset [%]
- Cycle Exposure [GWD/MT]

- without MAMBA1D
- with MAMBA1D
- Measured
- Outages/Downpowers
Watts Bar Cycle 7 with MAMBA1D

- Two coefficients were calibrated which controls threshold in which boron precipitates and the thickness of boron which can be precipitated.
Strategy to Improve Reliability of CIPS Predictions

- Improve and integrate MAMBA3D
  - MAMBA1D is missing the detailed chemistry kinetics models in MAMBA3D
  - Create a API for MAMBA3D similar to MAMBA1D
  - Improve computational efficiency of MAMBA3D
  - Improve testing of MAMBA3D

- CTF Hi2Lo Reconstruction
  - Use CFD results to improve CTF wall temperature resolution

- Implement Source term model (Wirth)
  - Next talk
Refactoring of MAMBA3D

• Goal
  – Refactor MAMBA to allow for easier coupling with CASL codes
  – Improve code quality by encapsulating data and increased local testing
  – Improve performance to reduce run time

• Refactor defines the interfaces that need to be called
  – Similar interfaces as MAMBA1D for ease of integration
  – Major difference is entire pin has one input instead of every surface
  – Several input parameters in MAMBA3D are moved into the code as defaults
    • These parameters can be overridden but does not require user to define

Significant effort to improve MAMBA
Updated MAMBA Code Layout

- Implemented Class data structures to better encapsulate data and allow for unit testing
- Three main classes based on physics and previous
  - Node class – contains dominant physics
    - Surface growth
    - Interior kinetics
    - Boiling rate
    - Calculating thermal coefficients
  - Radial class – contains mechanics to grow crud mesh, handles radial integration
  - Pin class – contains container for azimuthal and axial mesh, Location where 3D conduction solve would occur (current only 1D conduction)
Current Status and Timeline

• All major physics components have been refactored into the new infrastructure (except 3D conduction)
• API for input and output is mostly in place, still testing

• Next steps
  – Implement MAMBA3D API into CTF
  – Evaluate new MAMBA3D against experiments, calibrate as needed
  – Evaluate performance of VERA with MAMBA3D for core analysis
  – Evaluate accuracy of VERA with MAMBA3D for WB1C6-8
CFD Informed CTF to Provide Local Information

Wall Temperature (K) Around a Fuel Pin

- CFD
- 24 Azimuthal CTF Axial
- 12 Azimuthal CTF Axial
- CTF Mesh
Conclusion

• Previous work with MAMBA1D successfully demonstrated that modeling CIPS is feasible but requires tuning of MAMBA1D

• Current developments focus on improving
  – MAMBA3D
  – CTF boundary conditions provided to MAMBA
  – System mass balance for CRUD

• DOE Reportable Milestone - Complete and demonstrate improved VERA CRUD Induced Power Shift (CIPS) capabilities (8/17/2017)
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clarnokt@ornl.gov