Update on the Passive Moderator Cooling Concept for Advanced CANDU Reactors

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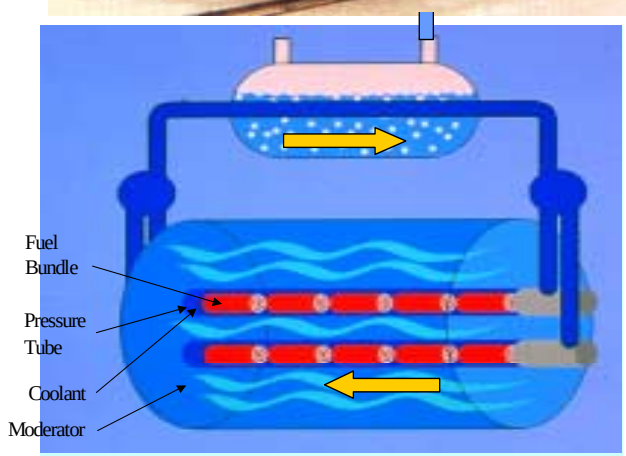
Outline

- Introduction (CANDU reactors)
- Passive Moderator Cooling System
- Status
- Future Plans

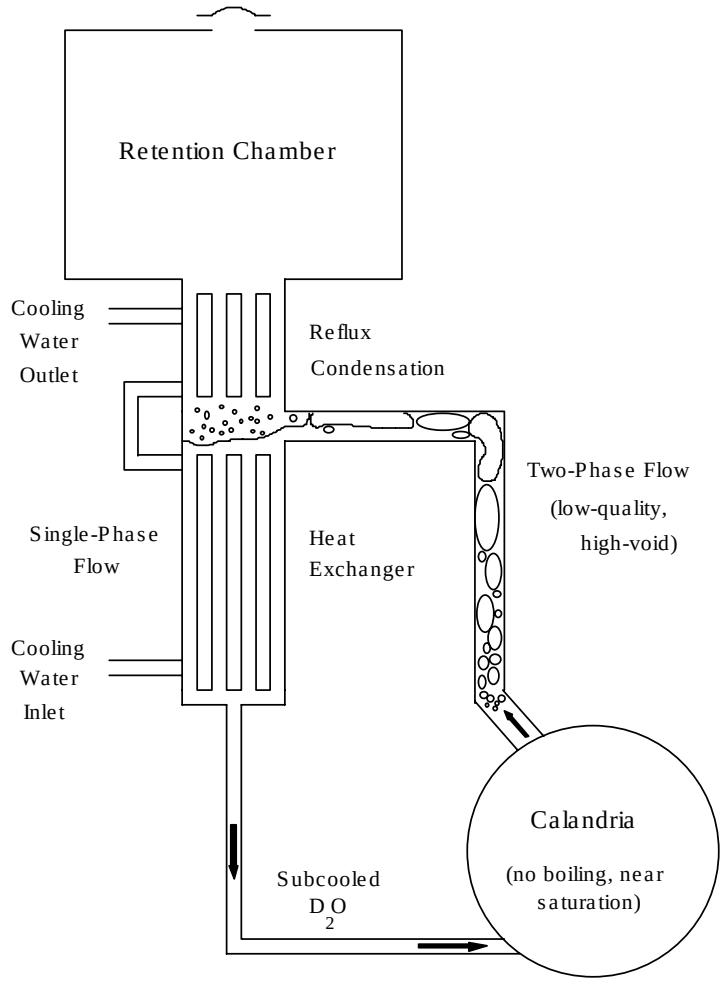
CANDU Reactors

- High-pressure coolant
- Low-pressure moderator
- Moderator is also a backup heat sink
- Heat is deposited in moderator during normal operation (~5% of thermal power, comparable to decay heat)
- Moderator heat is rejected in operating CANDUs using a pumped loop.
- A passive moderator loop is under development.



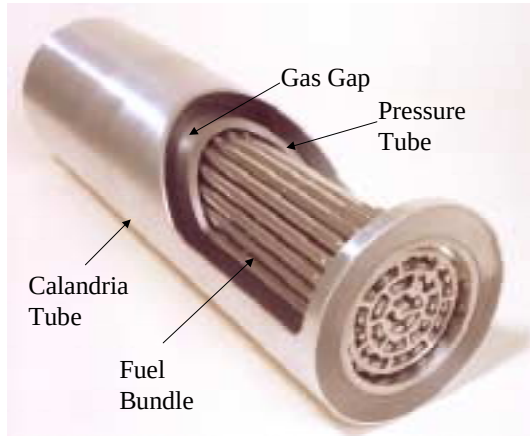
Passive Moderator Cooling

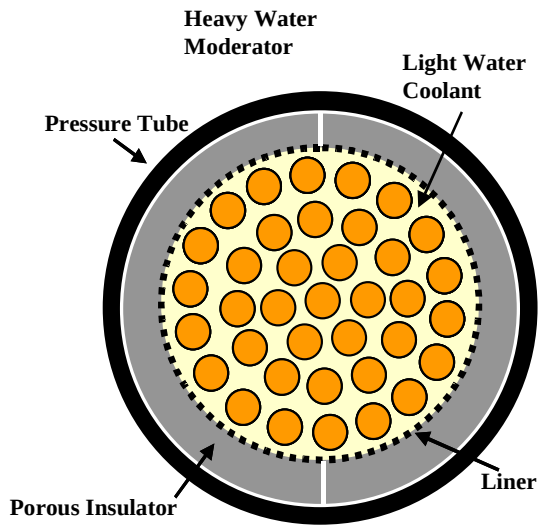
- Two-phase in hot leg generated by flashing (need single-phase moderator in core)
- Moderator operates close to saturation (slightly subcooled at exit)
- Can be designed for normal and emergency operation
  - Need a different fuel channel design
  - Under development as part of GenIV SCWR R&D



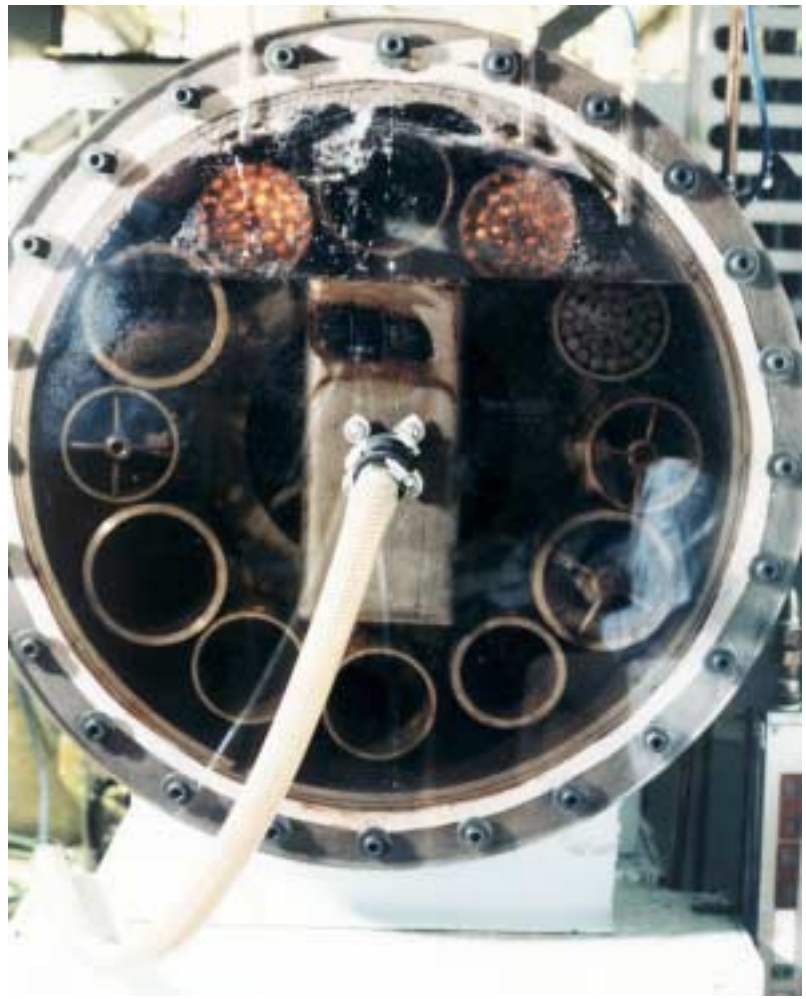
Advanced Fuel Channel

- **Current fuel channel design**
  - **Pressure tube/Calandria tube design**
  - **Gap provides thermal insulation**
  - **Fuel bundles (usually 12, 0.5m long each) slide inside pressure tube**
- **Advanced fuel channel**
  - **Internal insulation (eliminates CT and annulus gas system)**
  - **Provide controlled conductance to facilitate heat removal following postulated accidents**



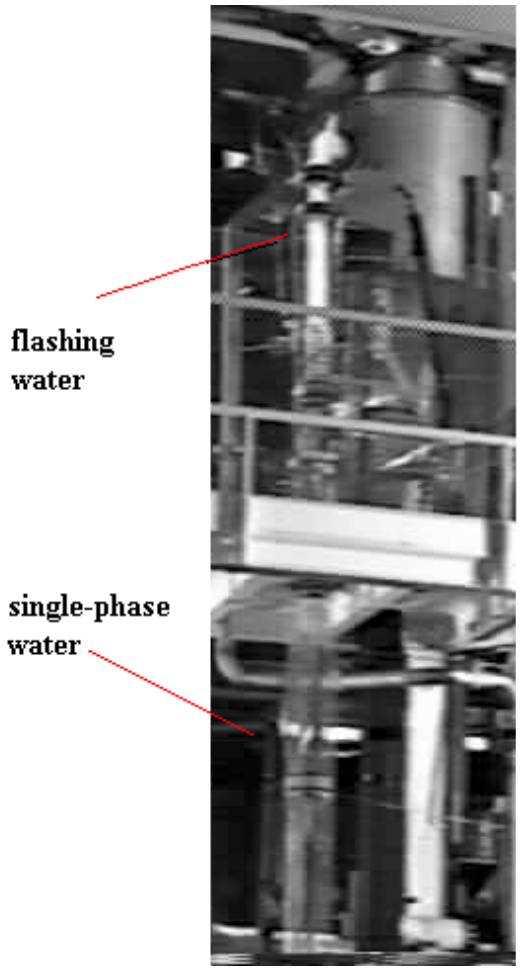


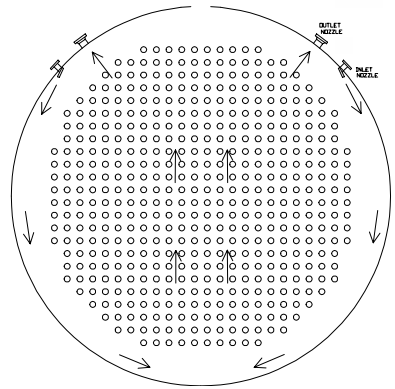
- The insulator thermal resistance can be optimized to achieve
  - negligible heat loss to the moderator during normal operation (compared to heat deposition in the moderator by radiation)
  - Removal of decay heat via the moderator during accidents
  - The goal is to eliminate or significantly reduce the possibility of severe core damage if emergency cooling fails

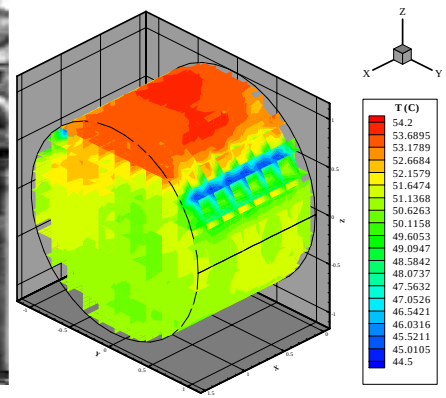


Status

- **Preliminary tests and analysis showed passive moderator concept was feasible**
  - **Scaled loop (full-height, reduced volume)**
  - **CATHENA simulations**
  - **Calandria not representative**
- **Separate-effects tests**
  - **Behaviour in hot-leg**
  - **Calandria circulation patterns**
- **New loop with a representative calandria has been commissioned**
  - **Combines features from separate-effects test loops**

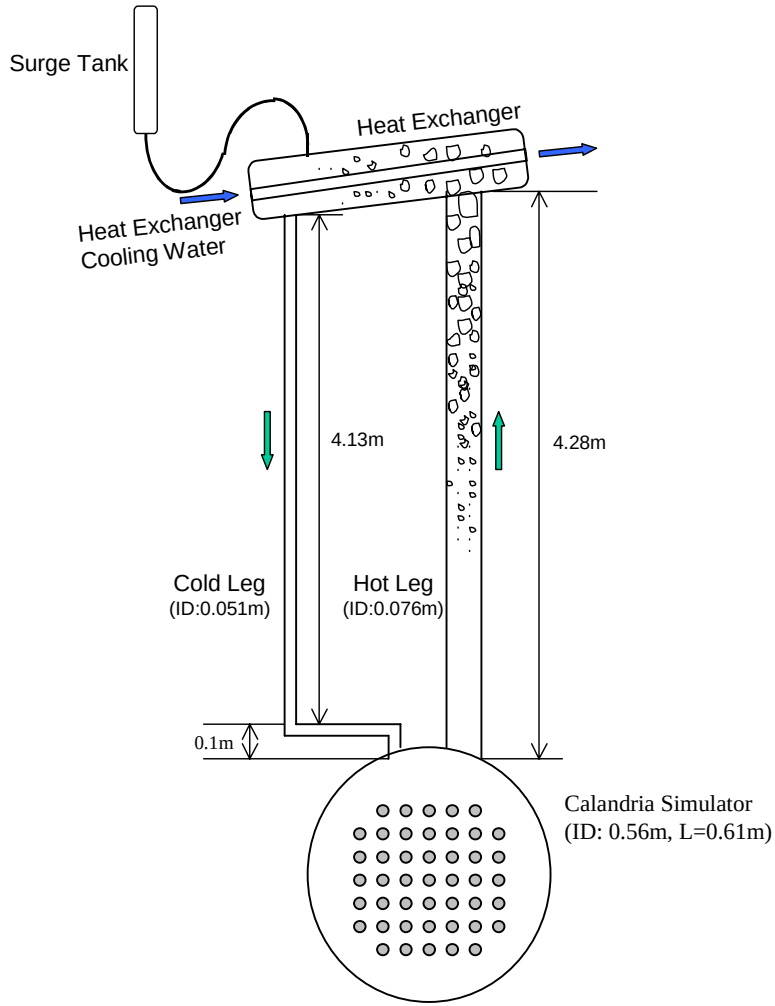






Status, cont.

- Preliminary and separate-effects tests presented last year
- New loop was under commissioning
- Preliminary results and comparison to previous tests will be presented next
- Main improvements in new loop
  - Better calandria circulation
  - Inclined heat exchanger
  - Provisions for secondary natural circulation circuit



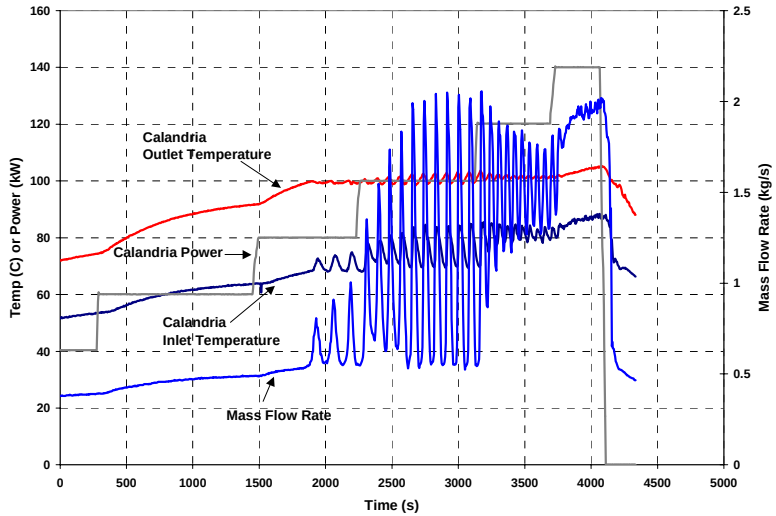
Initial Test Results

- Several commissioning tests were completed
  - Explore limits and modes of operation
- The results show behaviour consistent with expectations (based on results of separate effects tests and pre-test simulations)
- The test results are being used to improve certain models in CATHENA (e.g., heat exchanger parameters, flashing initiation, etc)

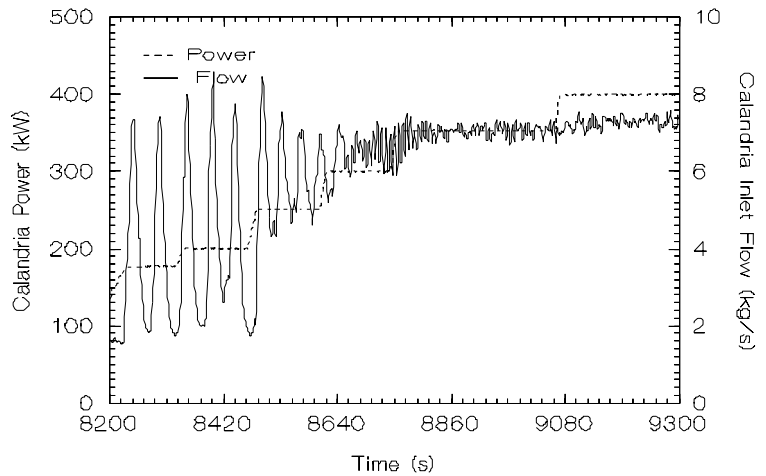
Initial Test Results, cont.

- Flow oscillations at low powers (expected)
- Oscillations at low powers much milder due to better calandria circulation
- Flow stabilizes when flashing can be sustained (similar to previous findings)
- CATHENA simulations ongoing
  - Heat exchanger model needs improvement
  - Will be used to plan more experiments

New loop results



Old loop results



Next Steps

- Complete CATHENA simulations
- Collect more data
  - Validation
  - Improved models
- Modify loop and study interaction with secondary loop
- Repeat with ¼-scale calandria simulator (current loop is 1/10 scale)
- Data from larger loop will help study and understand scaling effects
- Above is part of GenIV work on the CANDU-SCWR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