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Westinghouse Update August 2021

August 2021

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Changing the World's Energy Future

Idaho National Laboratory

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Sockeye

Westinghouse Update

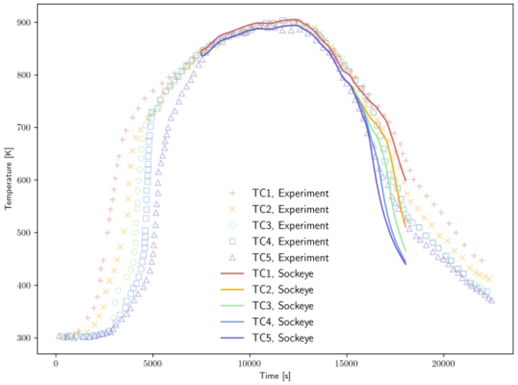
August 2021

Sockeye Activities Since Last Update

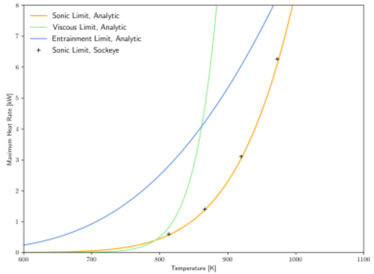
- **Conference paper submitted**
  - Introduced new conduction model based on controls
  - Modeled SAFE-30 experiment with new conduction model
  - Repeated SAFE-30 experiment with flow model improvements
  - Repeated sonic limit assessment with correct reference temperature
  - Repeated some previously shown results
- **Summer intern performed some validation work**
  - SPHERE (in progress)
  - UMich NEUP experiments (in progress)
- **Wetting dynamics (now testing)**

Improvements Shown in Paper

- **SAFE-30 flow model:**
  - Temperature-dependent contact angle
  - Minor robustness improvements
  - Now gets to 18000 s instead of 9575 s:



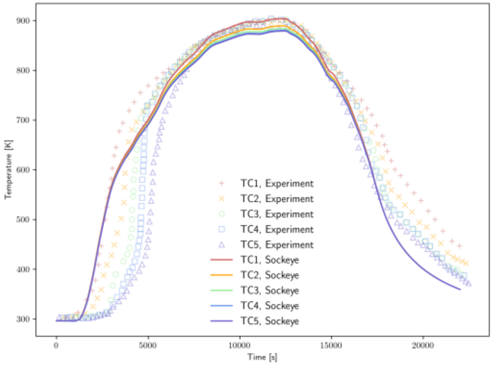
- **Sonic limit assessment:**
  - Used evaporator endcap temperature instead of average core temperature:



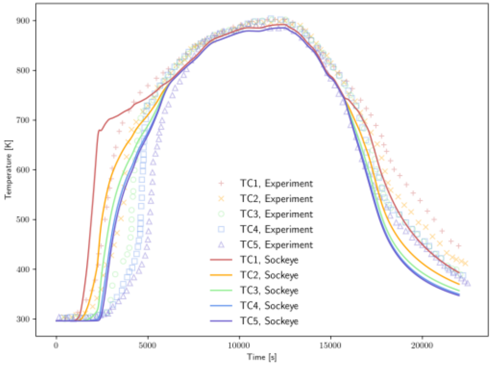
New Conduction Model Approach

- **The *old* conduction model approach limits the heat rate at the cladding boundary.**
- **The *new* conduction model approach limits the heat rate at the evaporator exit.**
  - The thermal conductivity of the vapor core is controlled: $k_{core,min} \leq k_{core} \leq k_{core,max}$.
  - Power through evaporator exit, $\dot{Q}_{evapexit} = \int_{S_{evapexit}} -k_{core} \frac{\partial T}{\partial x} dS$ is compared to analytic limits.
  - k_{core} is modified to renormalize $\dot{Q}_{evapexit}$ for next time step to be equal to $\dot{Q}_{limit}$ (within bounds of k_{core})
  - Results for SAFE-30:

Old



New



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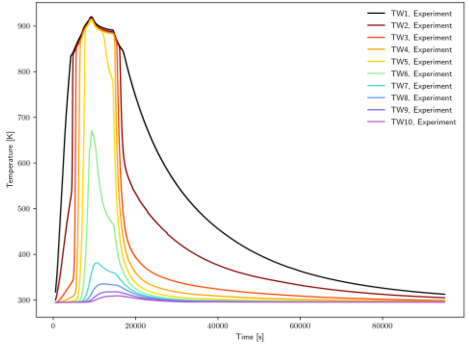
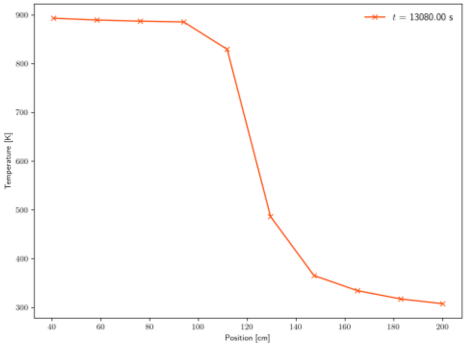
Validation Progress: SPHERE

- **The heat pipe used in SPHERE contains some amount of argon (non-condensable gas).**
  - Amount is unknown, but it can be estimated from measured temperature data:
    - Estimate NCG front position and thus volume of NCG
    - Use Dalton's law of partial pressures and flat-front approximation to work out NCG mass
- **Conduction model needs modification to account for NCGs.**
  - Dynamically determine NCG front location.
  - Use small core thermal conductivity in NCG pool.
  - Such a model is in progress.

Thermocouple values during transient:

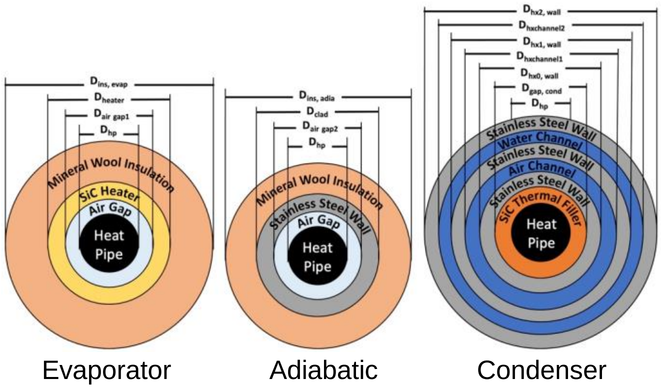


Spatial temperature profile during peak power:



Validation Progress: University of Michigan

- Experimental data obtained from separate-effects experiments at University of Michigan.
- Several layers to the problem complicate setup:



- Boundary conditions are convection + radiation, and there are air gaps present.
- A thermal circuit analysis is being applied to try to get equivalent conductivities.

Wetting Dynamics

- **Currently Sockeye does not include physics to draw fluid up the wick.**
  - The advection terms in the PDEs do not consider capillary pressure, only relaxation source terms.
  - A no-heat-transfer test case confirms that the wick is not drawing up fluid from a pool.
- **The physical ramifications:**
  - Gravity may prematurely drain the wick.
  - Dryout may be predicted prematurely when gravity is not replenishing fluid.
- **The approach to solving this is to modify the PDEs to add a capillary pressure gradient term.**
- **Preliminary tests show fluid movement up the wick in the no-heat-transfer test case.**
- **The rate of rise up the wick has not yet been examined.**