HTTF RELAP5-3D Applications and Assessment

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Overview

- High Temperature Test Facility (HTTF) description
- Recent RELAP5-3D analyses
- Future plans

High Temperature Test Facility highlights

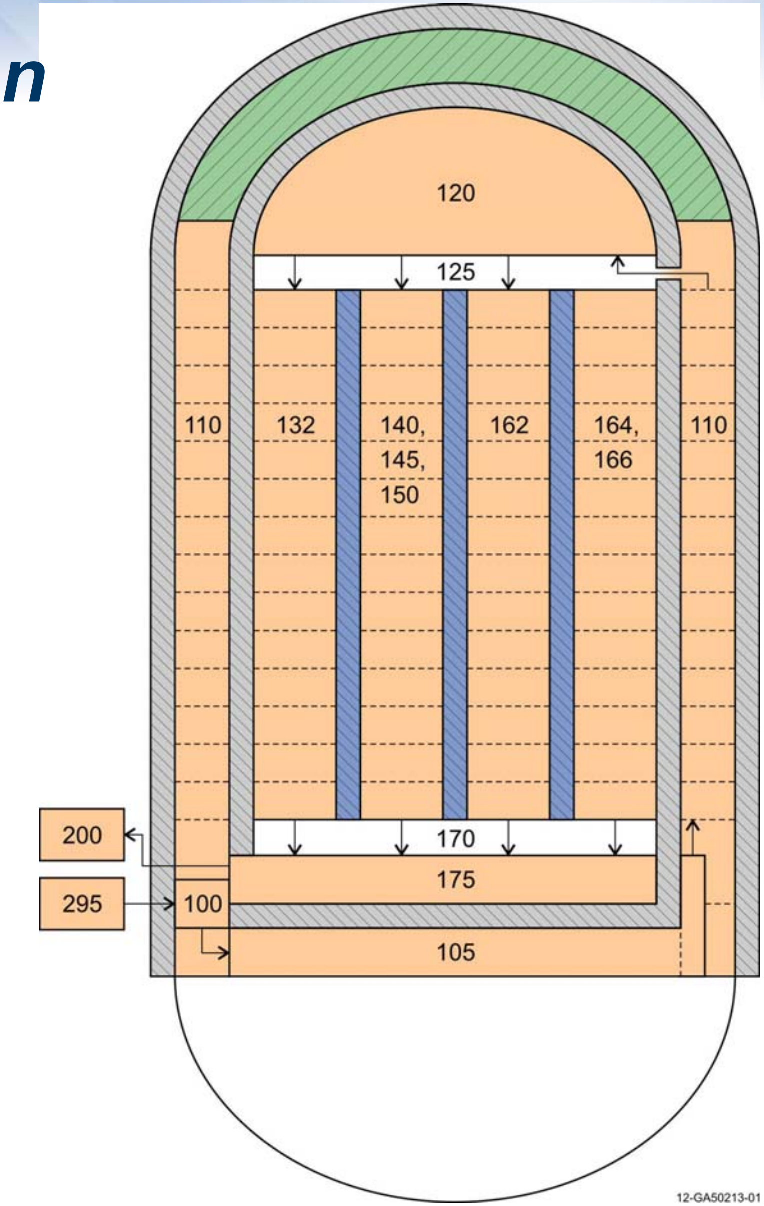
- Integral experiment being built at Oregon State University
- 2.2 MW electrically-heated, scaled model of a high temperature gas reactor
  - Reference is the Modular High-Temperature Gas-cooled Reactor (MHTGR) (prismatic blocks)
  - Large ceramic block representing core and reflectors
  - ¼ length scale
  - Prototypic coolant inlet (259°C) and outlet (687°C) temperatures
  - Less than scaled power
  - Maximum pressure of ~700 kPa
- Primary focus is on depressurized conduction cooldown transient

HTTF RELAP5-3D Input Model Description

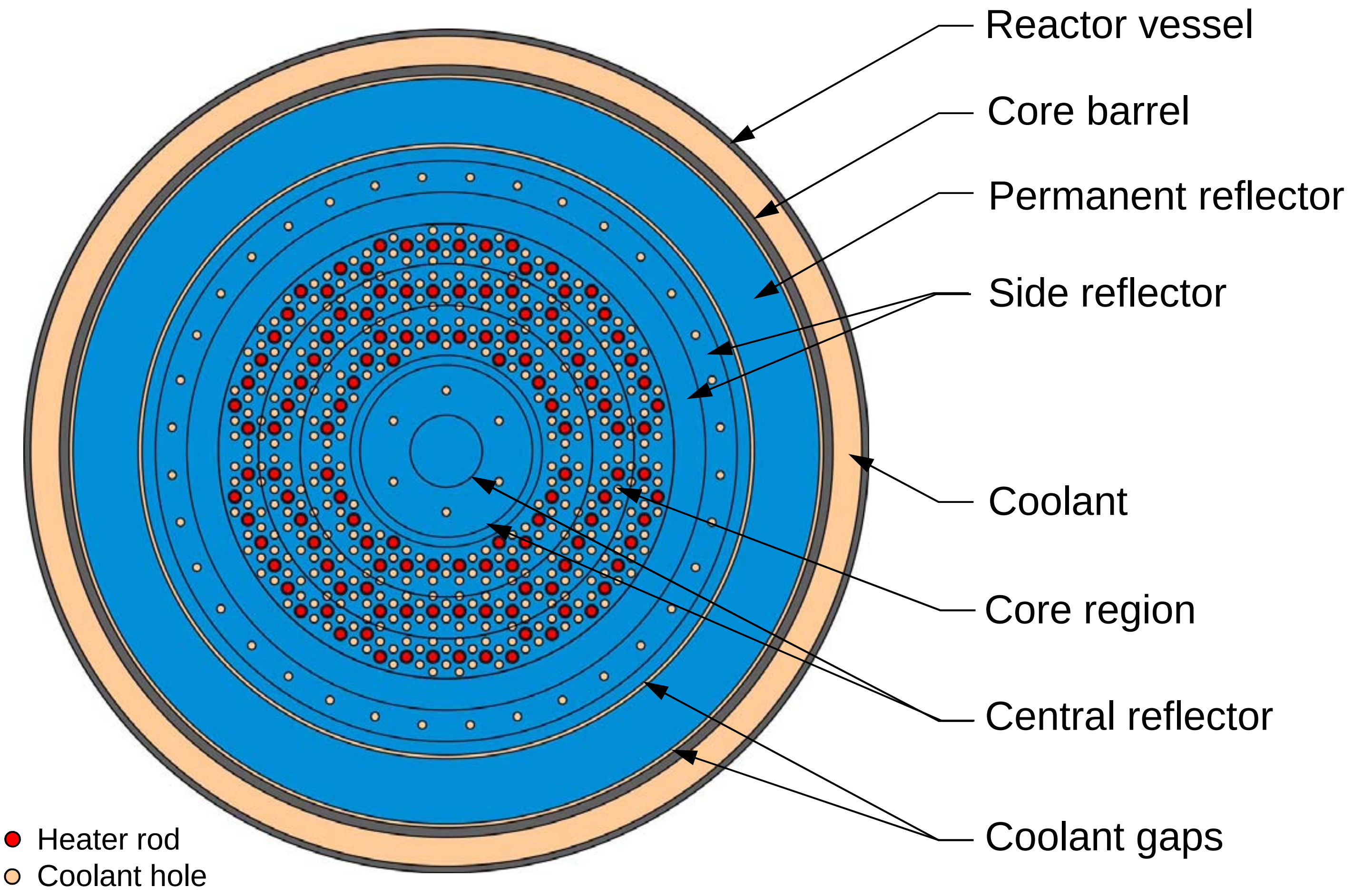
- Four systems
  - Primary coolant
  - Secondary coolant
  - Reactor cavity
  - Reactor cavity cooling system (RCCS)
- Central and side reflector regions divided into regions with or without coolant holes
- 2-D (radial/axial) conduction in all vertical heat structures
- Heater block unit cell centered on the coolant channel
- Radial conduction and radiation inside core barrel
- Radiation from core barrel to vessel to RCCS

Reactor Vessel Nodalization

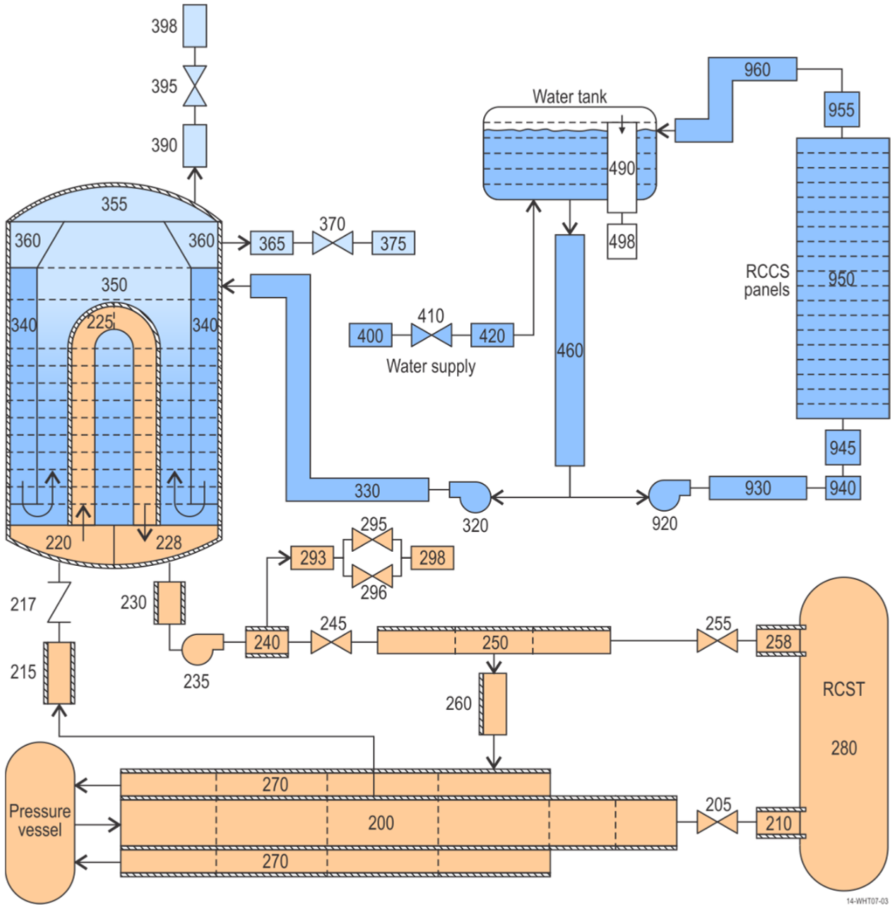
- Multiple flow paths through core
    - Three heated channels
    - Central reflector
    - Side reflector
- Gaps on either side of permanent side reflector not flow-through
- Riser annulus between core barrel and pressure vessel
- No coolant between upper plenum shield and upper head



HTTF RELAP5-3D Core Region Radial Nodalization



HTTF Ex-vessel Nodalization

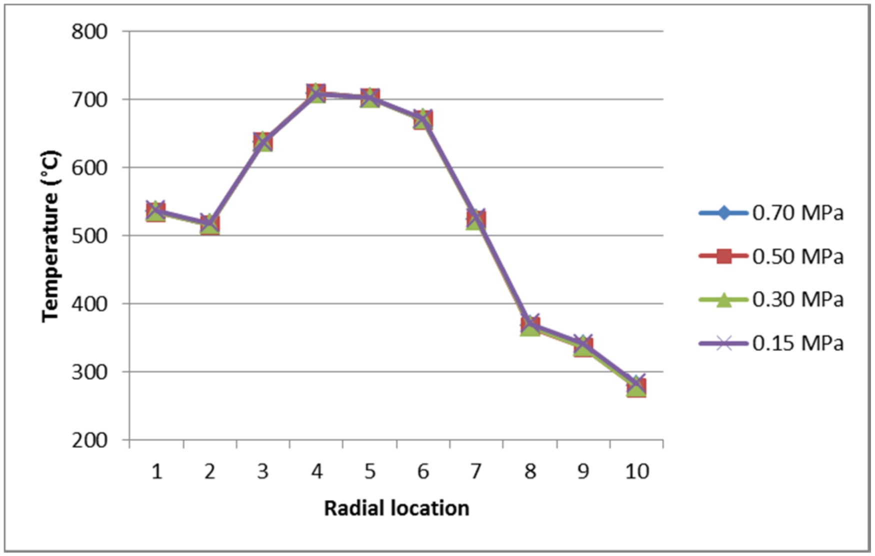


Steady state scoping calculations

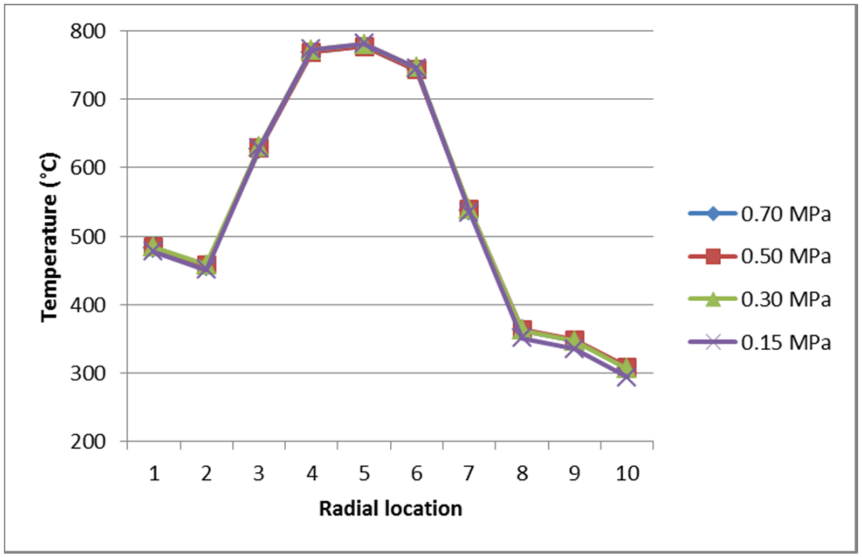
- Effect of reduced power
- Effect of reduced pressure
- Maintain nominal coolant inlet and outlet temperatures
- Can a representative core temperature distribution be maintained?
- Can operational costs be reduced?

Effect of primary coolant system pressure

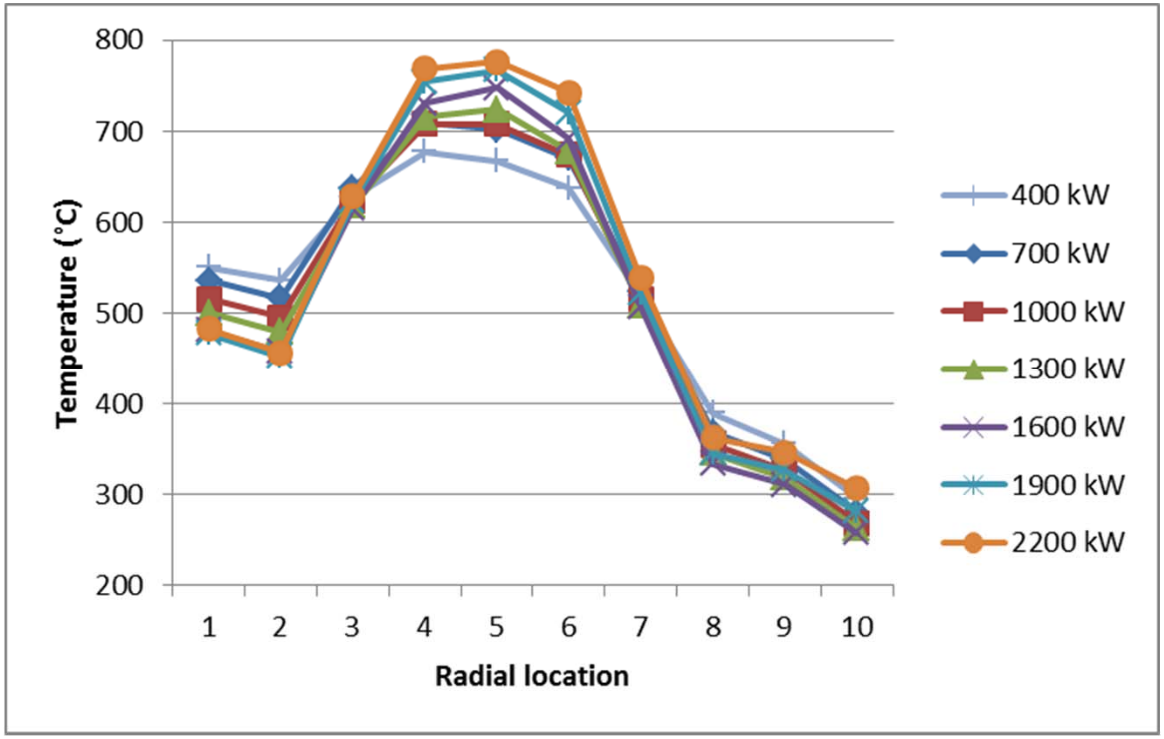
700 kW



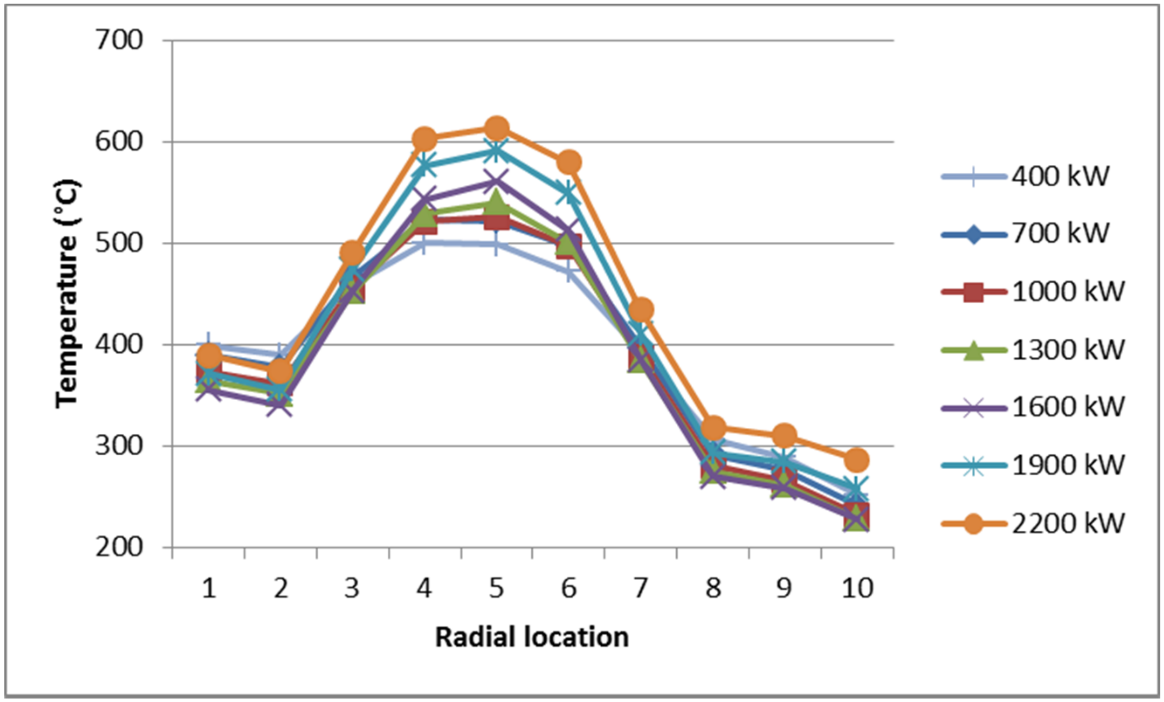
2200 kW



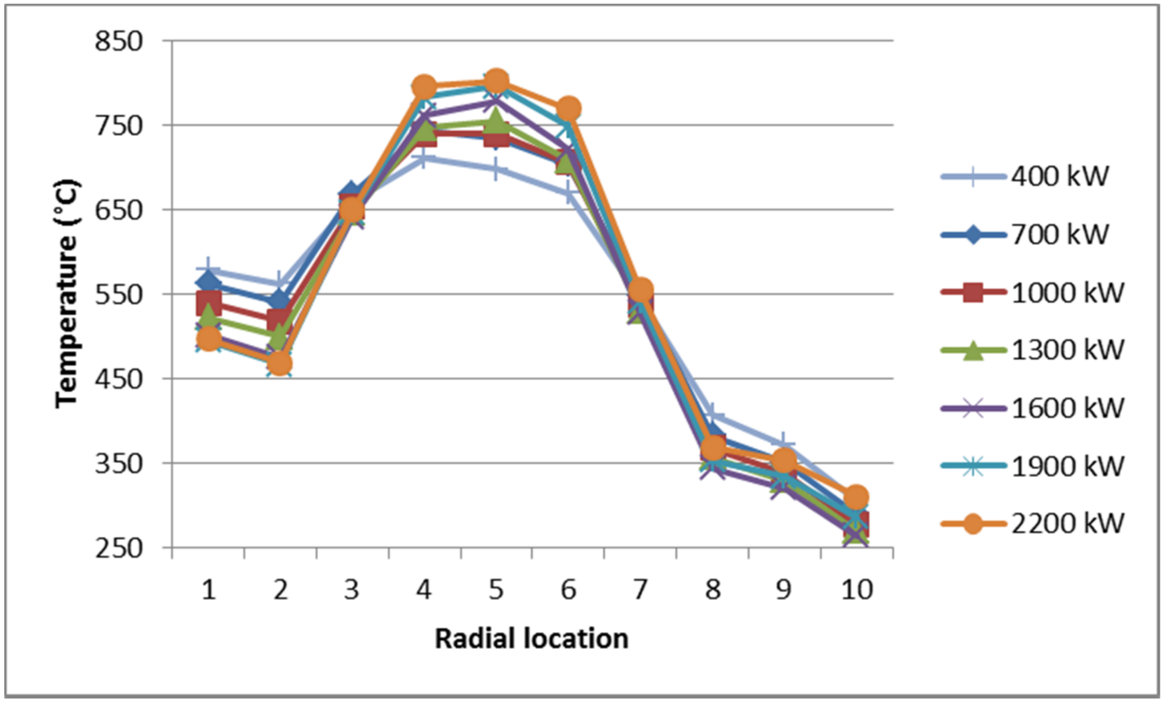
Effect of power on axial average temperatures



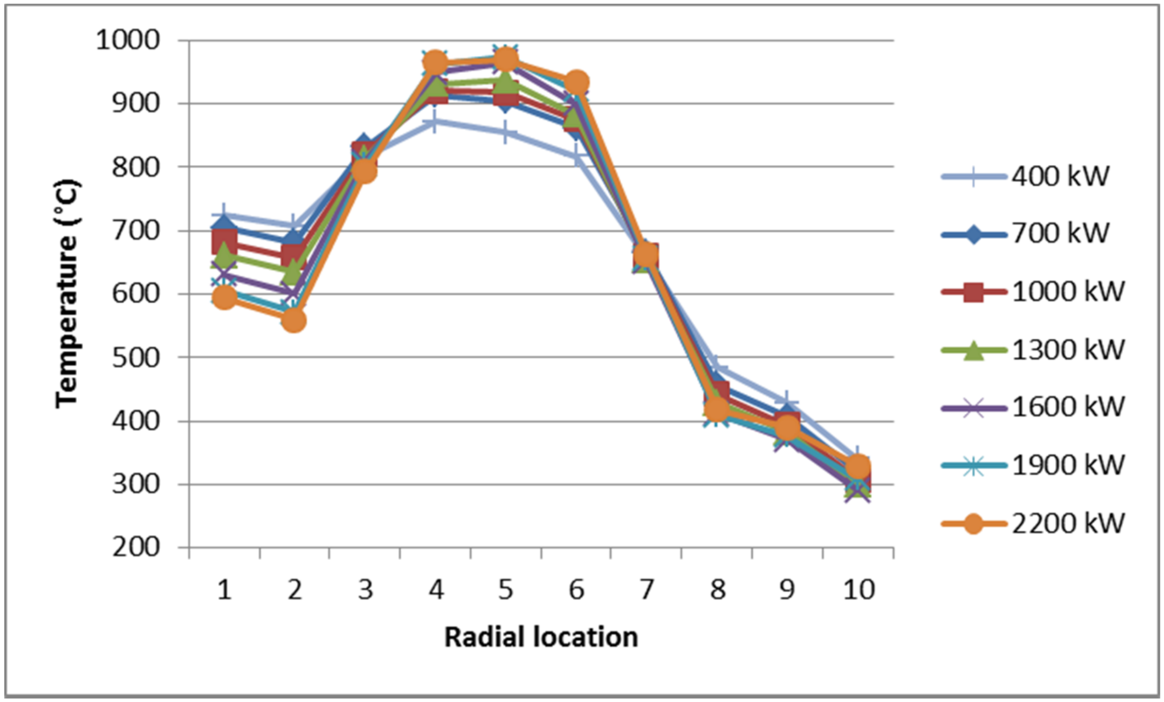
Effect of power on core block 2 temperatures



Effect of power on core block 6 temperatures



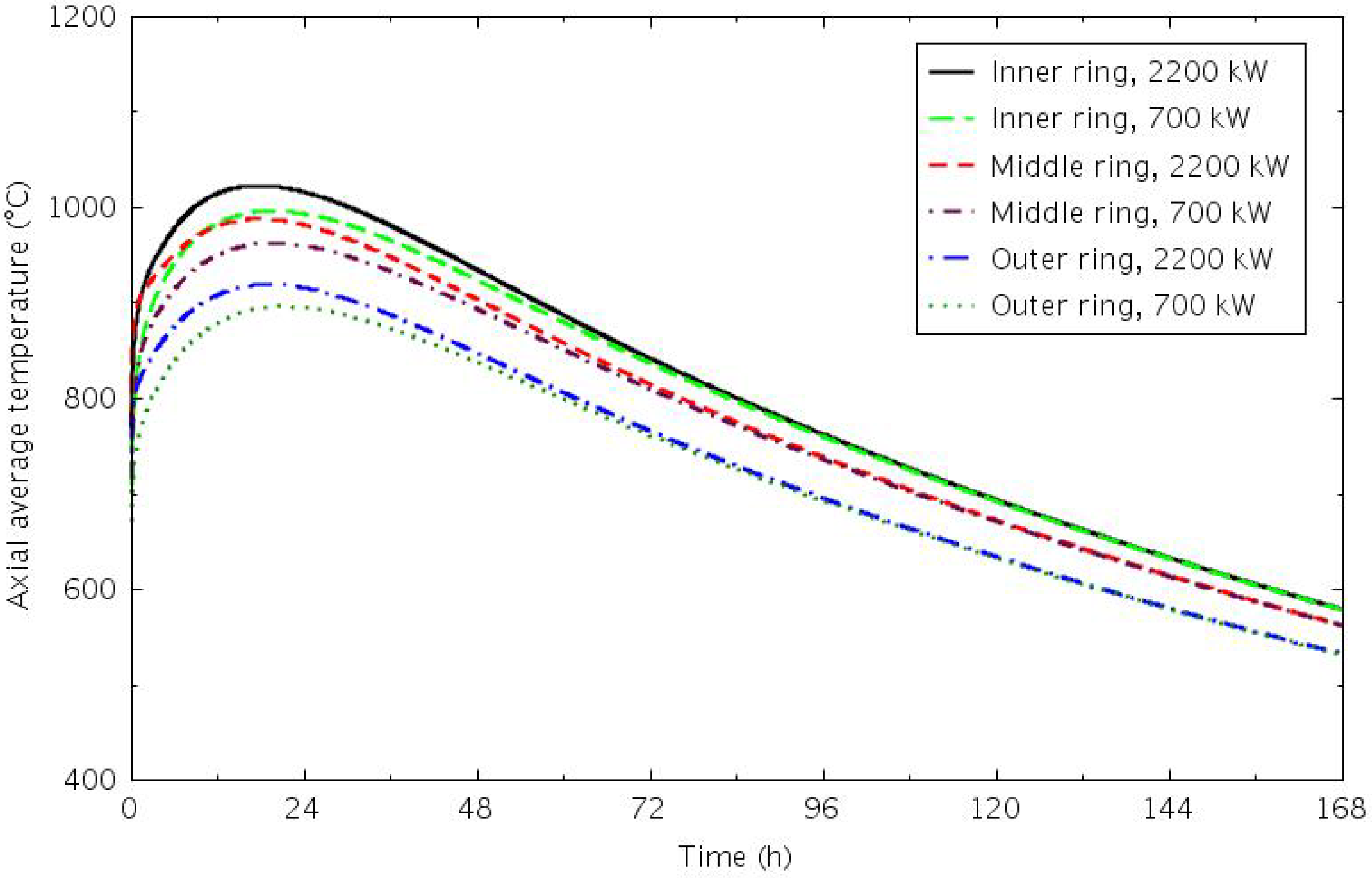
Effect of power on core block 10 temperatures



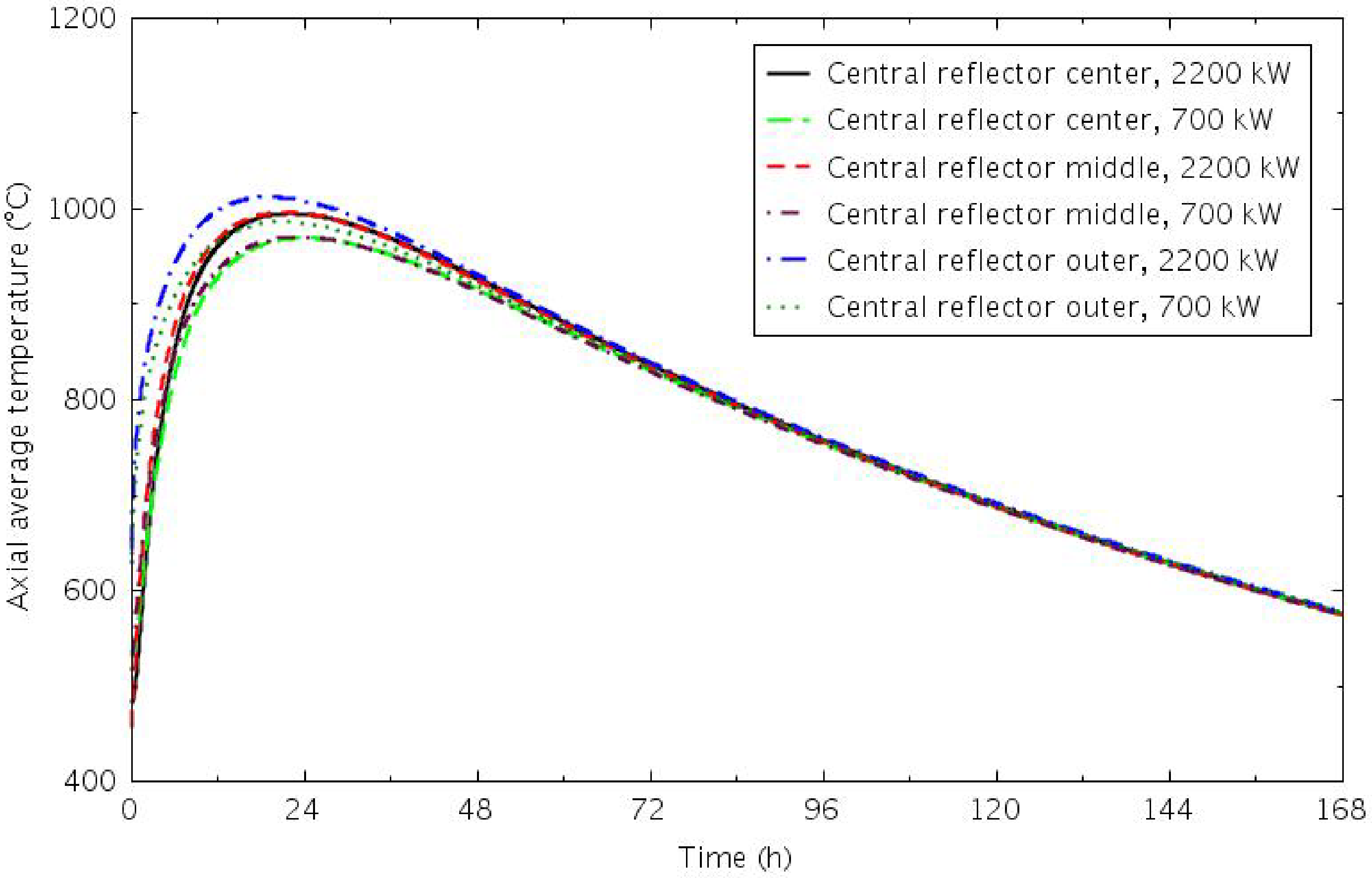
Depressurized conduction cooldown transient

- 5-s forced flow coastdown
- System depressurization valve opened at 3 s
- At 20 s
  - System depressurization valve closed
  - Hot and cold duct break valves opened
  - Loop isolation valve closed
- Scram assumed at transient initiation (0 s)

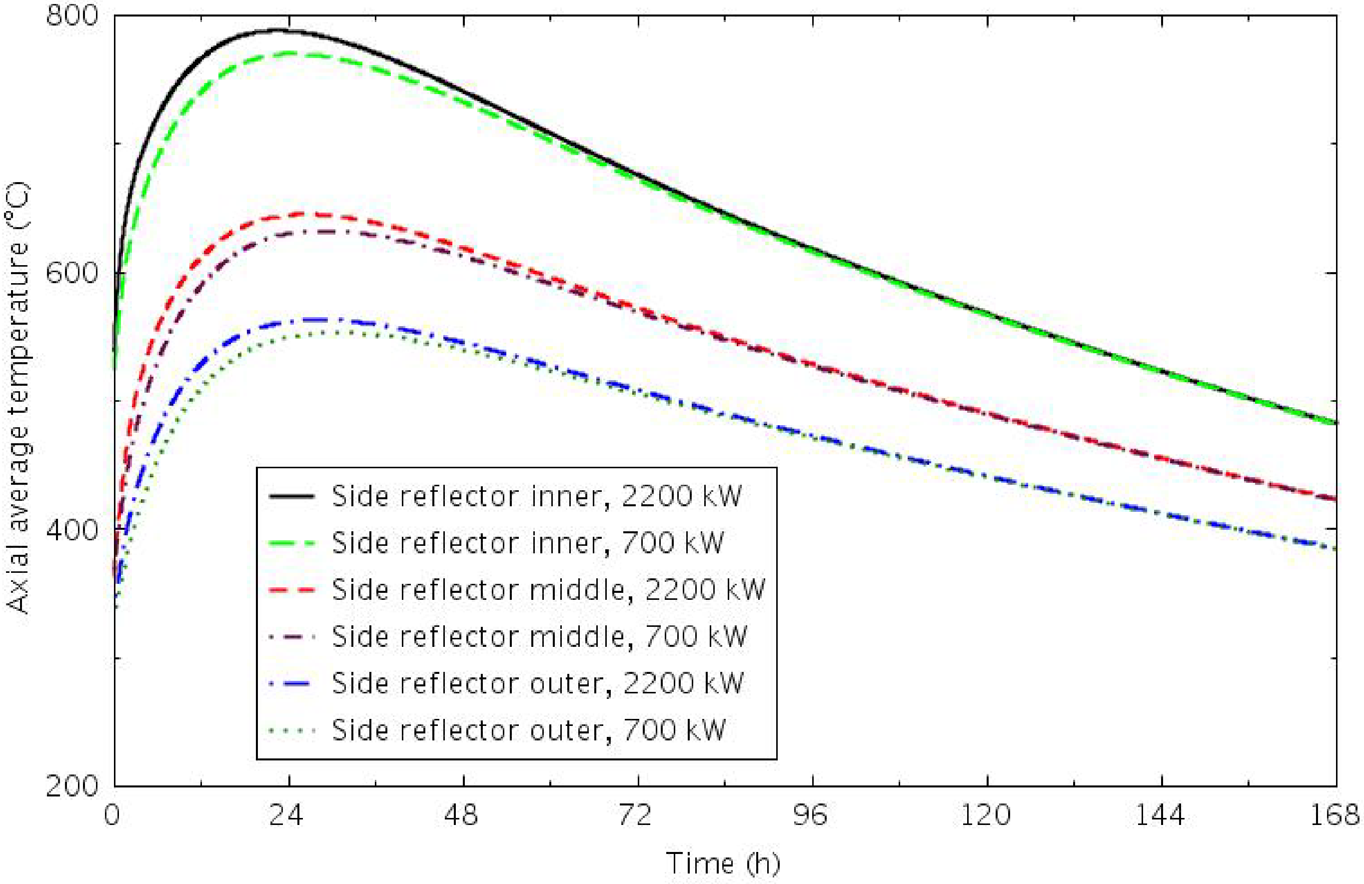
Core ceramic temperature response



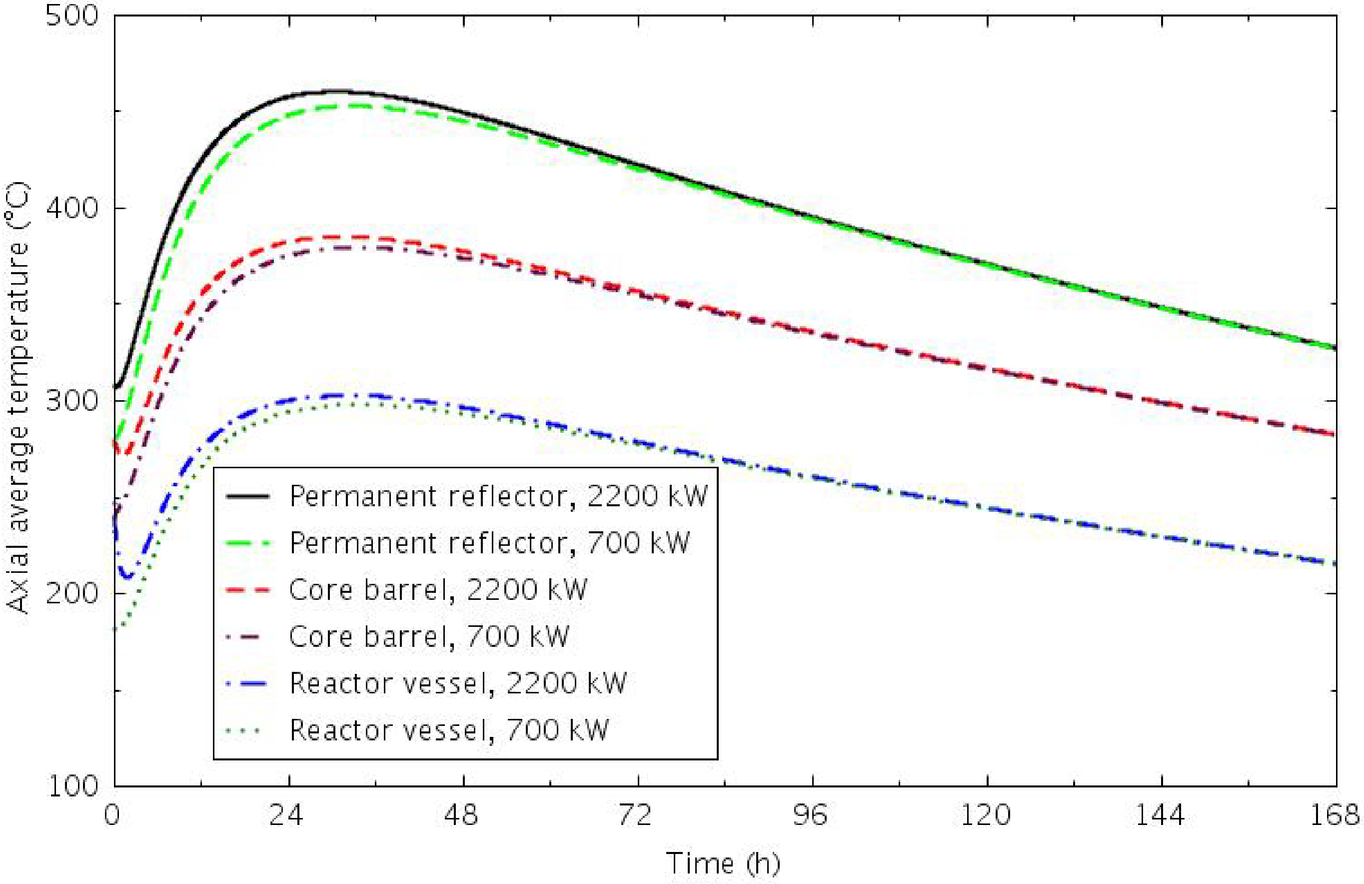
Central reflector temperature response



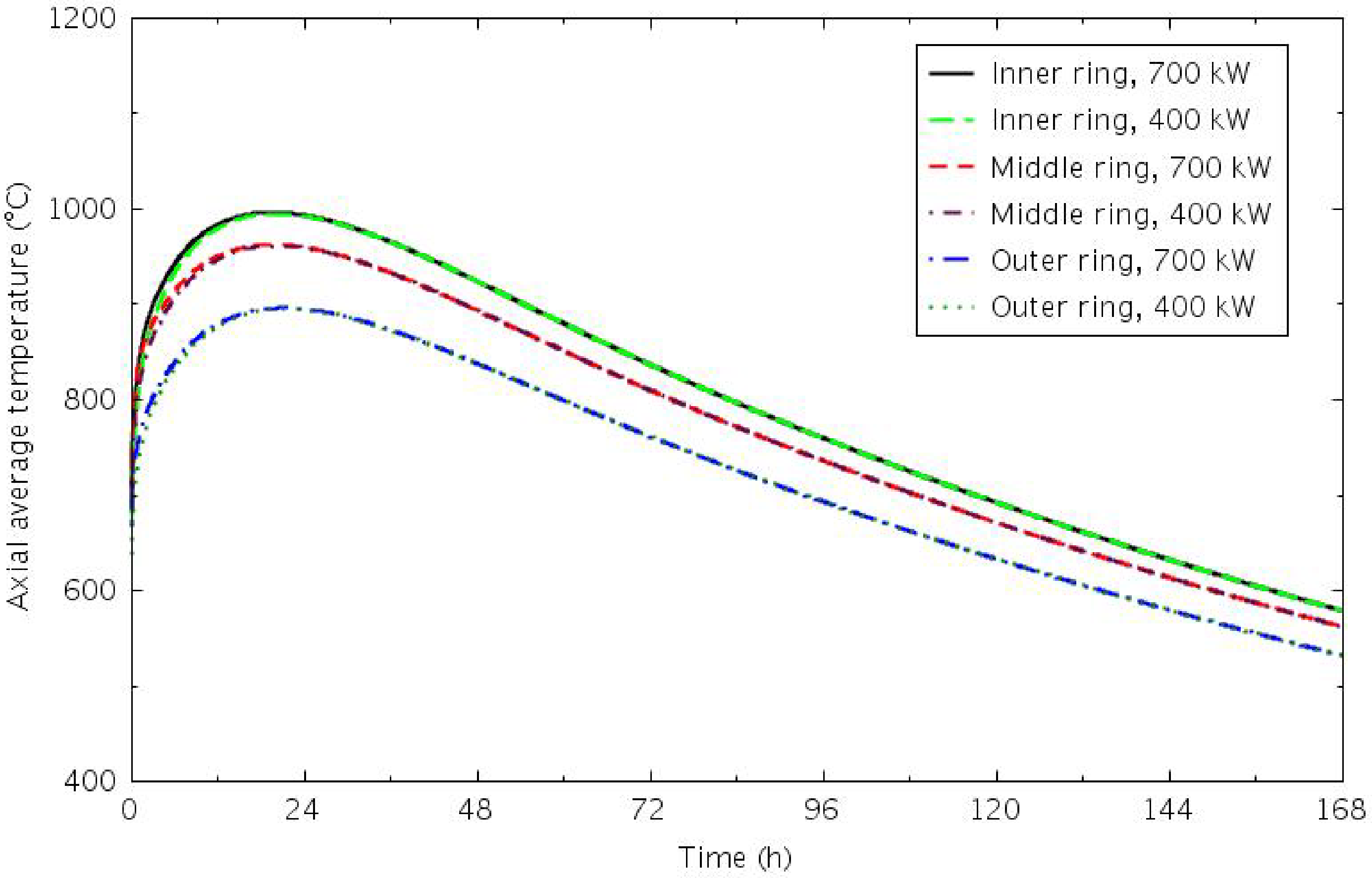
Side reflector temperature response



Outer structure temperature response



How low can the power go?



Summary of results

- System pressure had little effect on core temperature distribution
- In general, decreasing power at steady state
  - Increased the central reflector temperatures
  - Reduced the core temperatures
  - Reduced the side reflector temperatures
- Lower power resulted in lower temperatures during the depressurized conduction cooldown transient
  - Effect not as large as in initial temperature difference
  - Decay power is the same in all cases
- Reduced power operation may be viable for many cases
  - Lower electricity cost
  - Less water usage
- Model must still be benchmarked!

Future plans

- Update model when final drawings and component information is available
- Benchmark model using system characterization test data
- Perform assessment calculations using transient test data
- Provide operational support analyses as needed