Passively Cooling the Steam Generator of the PRISM Reactor

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Background

- General Electric Hitachi (GEH) is looking for a way to passively cool the steam generator on the PRISM reactor during station blackout
- Currently, an actively powered Auxiliary Cooling System (ACS) and a passively powered Reactor Vessel Auxiliary Cooling System (RVACS) are needed to remove the decay heat following shutdown
- The NRC wants ACS to be passive

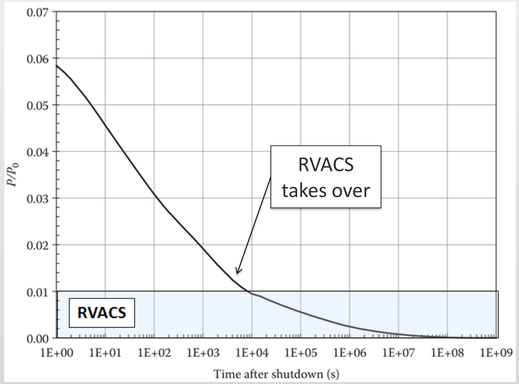

Figure 1: ANS 2005 Standard for Decay Power versus RVACS heat removal capacity

Objective

Design a way to passively cool the steam generator of the PRISM reactor:

- Utilize a Terry Turbine to power a blower on top of the steam generator to provide forced convection and increase heat transfer

Task

- Determine if the passively powered blower will be able to remove the required amount of decay heat from the core

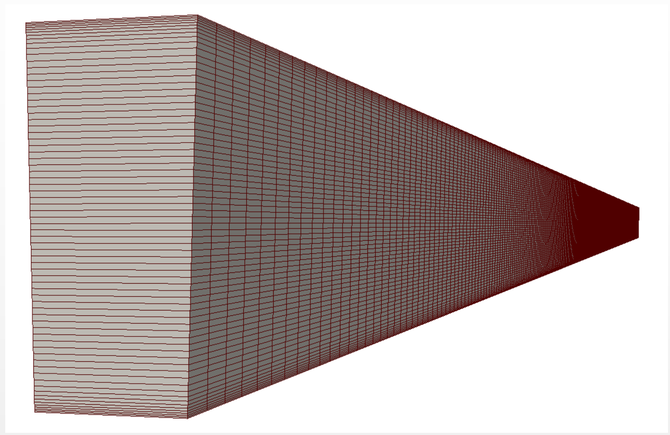

Figure 2: Mesh for steam generator and shroud created in OpenFOAM

Methodology

- Evaluate the heat removal ability of a once through system design versus a continuous loop design
- Use a simplified conservation of energy equation to find the mass flow rate

$$\dot{m} = \frac{Q}{\Delta h}$$

- Generate fan curve with affinity laws
- Use OpenFOAM to determine the heat removal capability of the design
- Use MCNP and ORIGEN to develop a function of decay heat by burning a single fuel assembly in an infinite medium

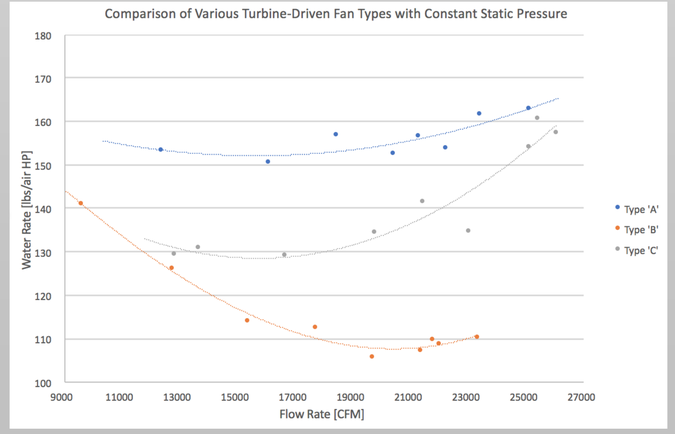

Figure 3: Benchmark turbine-driven blowers for boiler cooling

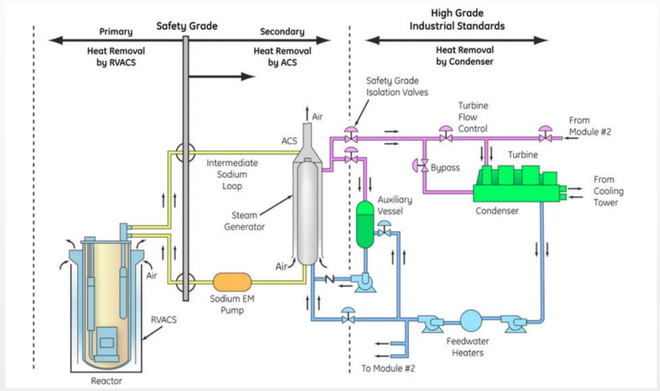

Figure 4. Diagram of the PRISM NSSS

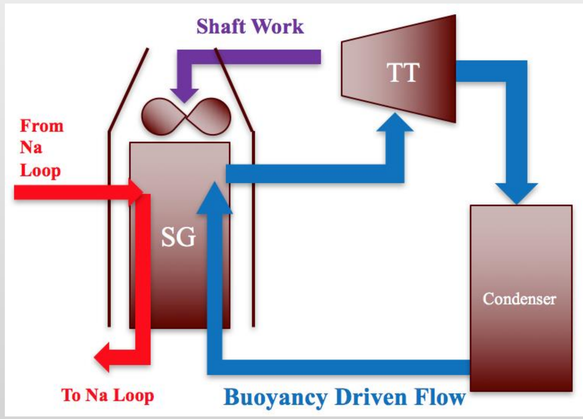

Figure 5: Proposed Bypass Loop for PRISM Steam Generator

Technology Comparison

Once Through SG Design	• Easier to model • Don't have to condense the steam • Will run out of water eventually
Continuous Loop Design	• Difficult to re-determine thermodynamic properties as the cycles progress • Have to determine how much steam to vent so the rest is condensed • System will continue to work for extended periods of time • More complex system • Have to add a passive condenser to the loop

Conclusions & Future Work

- Based on initial calculations, it appears the once through design is feasible and more desirable based on our design requirements
- Couple thermodynamic analysis with Terry Turbine analysis
- Write Python script for continuous loop design
- Couple Terry Turbine output parameters to air mass flow rate required by the CFD model and compare it to benchmark data
- Finalize MCNP and ORIGEN burnup calculations for decay heat model
- Design steam generator shroud dimensions to optimize heat transfer

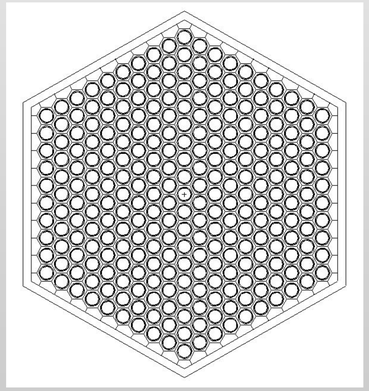

Figure 6: MCNP PRISM Fuel Assembly model

References

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