Chemical Engineering 612

Reactor Design and Analysis

Lecture 21

Nuclear Safety III

Accident Thermodynamics

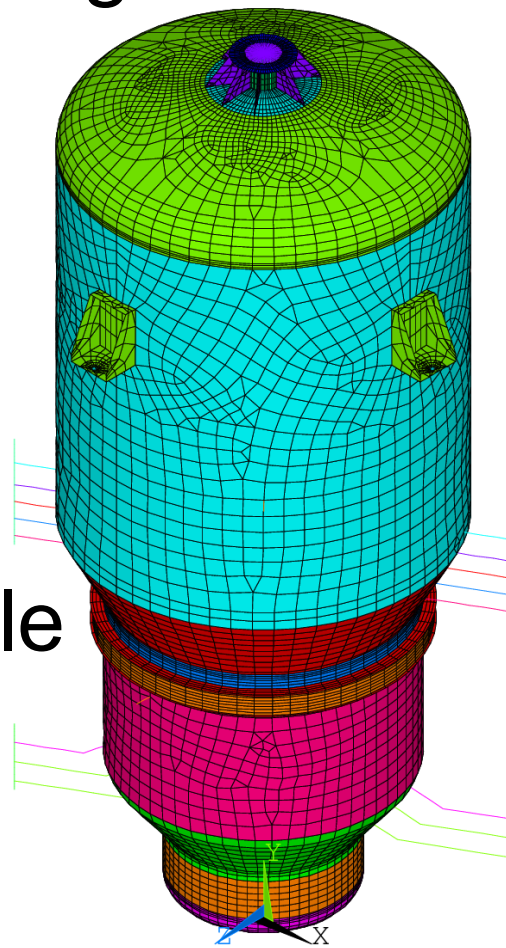
Spiritual Thought

Ether 4:15

"Behold, when ye shall rend that veil of unbelief which doth cause you to remain in your awful state of wickedness, and hardness of heart, and blindness of mind, then shall the great and marvelous things which have been hid up from the foundation of the world from you… be unfolded…"

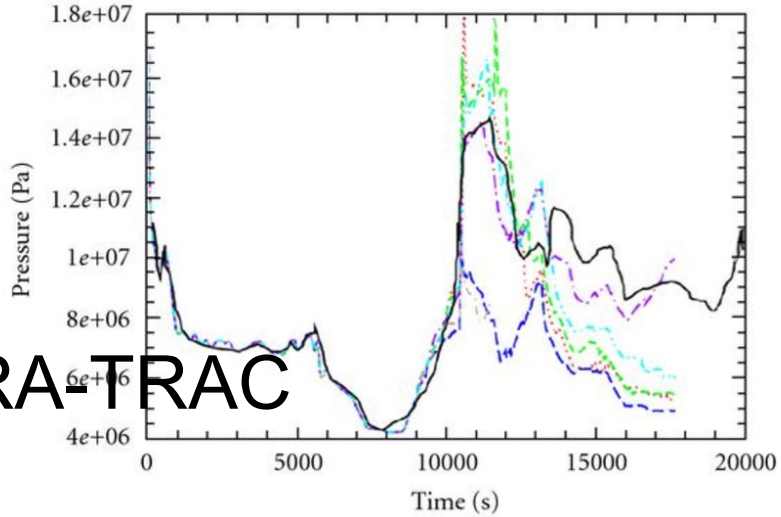
Accident Analysis

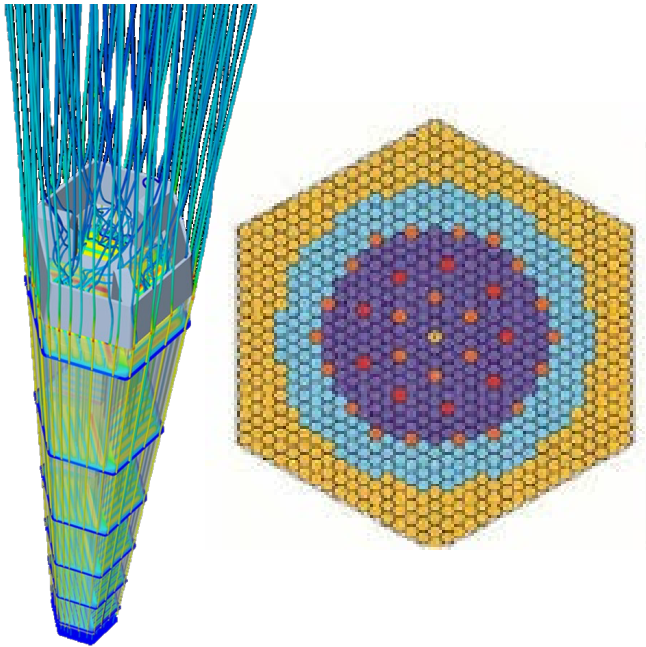
- Much more difficult than reactor design
  - Transient by nature
  - Multiple pathways
  - Multiphysics
  - Multiscale
  - MANY and DIVERSE IE's or LBE's
- Complete Analysis requires multiple coupled codes
  - Computationally expensive
  - Significant full-time engineer hours
  - Highly skilled experts to manage codes



Codes/Physics

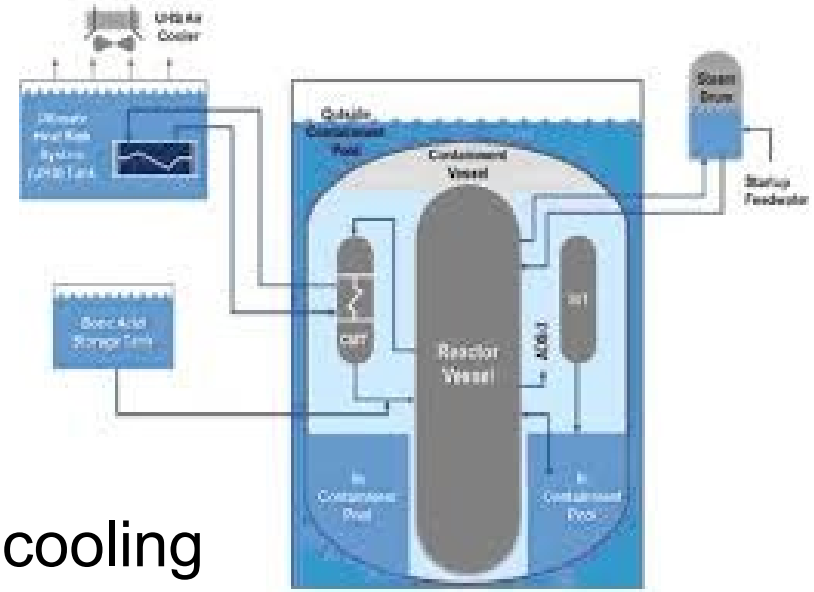
- Neutronics
  - MCNP, PARCS
- Thermal-Hydraulics
  - RELAP5, TRACE, COBRA-TRAC
- Containment Analysis
  - GOTHIC
- Structural Analysis
  - FEA, FRAPTRAN, FRAPCON
- Flow Phenomenology
  - Star-CCM, Fluent, etc.





Approach

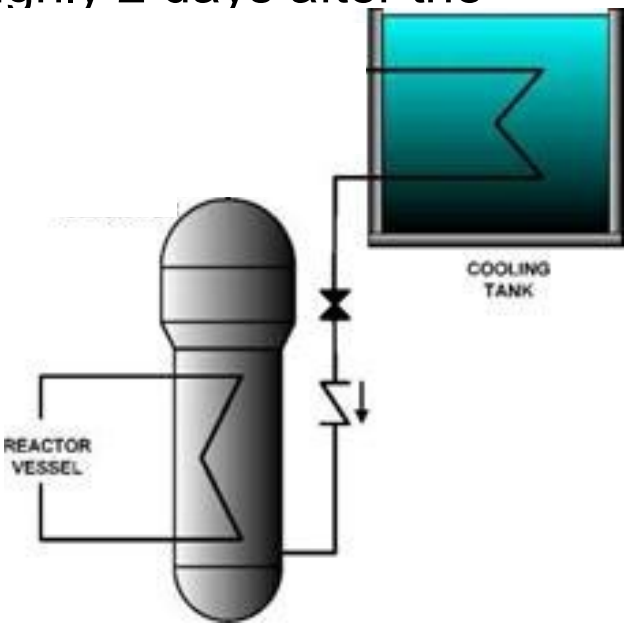
- Simple calculations go 70% of the way
  - Total Cooling capacity
  - End State Calculations
    - Pressure/Temperature
    - Volumes
    - Heating Surplus
    - Heat generation – end of cooling
    - Time to Air cooling sufficiency only



- Then more detailed codes to polish time dependent behaviors
- Last comes full licensing analysis

Volume Calculations

Suppose you are tasked with designing the emergency core cooling water tanks for a 1.1 GWe lead-cooled nuclear power plant (35% efficient). These tanks should have the capacity to cool the reactor for 5 days. You have been asked to divide this cooling into four equally sized, spatially separated tanks that drain via gravity into the core. (the four separate tanks are to prevent a penalty for an aircraft impact eliminating all four tanks simultaneously.) This draining begins when the pressure in the tank matches the pressure in the reactor, which occurs at 1000 psig and this takes place at roughly 2 days after the accident. How much volume should the tanks



Reactor core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Flow calculations

Using the previous example, determine the range of realistic vertical pipe lengths (4 in ID) and tank heights that will satisfy the requirement that the average coolant flow velocity from each tank should be 15 ft/s. Assume a cylindrical tank configuration.

How long would this tank take to drain?