

## LINUX/UNIX

- LINUX/UNIX operating system
- basic UNIX commands
- introduction to VVER reactors: systems, basic TH
- application of RELAP5 code
- modeling philosophy
- basic Flow Models
- basic UNIX commands, Text editor, RELAP5 execution.

## Introduction to TH

- Problem of heat removal from heat-generating surfaces
- Hypotheses of mechanics of solid and heterogenous media
- Thermal Hydraulic Equations for single-phase coolant and multiphase media
- Thermodynamics of heterogenous medium with phase changes. Entropy
- Time and space - Average operators. TH Equations of two-phase medium
- Similarity method. Similarity criteria

## Introduction to RELAP 5:

- RELAP5 basic differential equations
- Vertical Volume Flow Regime Map
- Horizontal Volume Flow Regime Map
- High Mixing Volume Flow Regime Map
- ECC Mixer Volume Flow Regime Map
- Junction Flow Regime Map
- Interphase Friction
- Coefficient of Virtual Mass
- Wall Friction
- Wall Heat Transfer Models
- Wall Heat Transfer Correlation
- Interphase Mass Transfer
- Reynolds number. Forward and reverse flow energy loss coefficients

Finite differences method. Stability and convergence.

## RELAP5 Numerical Solution Scheme:

- Basic Differential Equations
- Semi-Implicit Solution Strategy
- Nearly-Implicit Solution Strategy
- Volume-Average Velocities.
- Numerical Solution of Boron Transport Equation.
- State Equation.

## Special Process Models:

- Choked Flow
- Horizontal Stratification Model
- Abrupt Area Change

- User-Specified Form Loss
- Crossflow Junction
- Water Packing Mitigation Scheme
- Countercurrent Flow Limitation Model
- Mixture Level Tracking Model
- Thermal Stratification Model
- Energy Conservation at an Abrupt Change.

Steady State:

- Concepts
- Calculation Precision and Convergence Criteria

xmgr5 plotting

Hydrodynamic components:

- Common features of components
- Time-dependent volume
- Time-dependent junction
- Single-volume component
- Single-junction component
- Pipe, annulus, examples
- Modeling of hot loop.

Hydrodynamic components:

- Branch
- Pump
- Accumulator
- Separator
- Valve
- Heat structure model
- General data table input
- Trips
- Control Components

Reactor Vessel Modeling

Reactor pressure vessel nodalization (VVER-440 and VVER-1000)

Reactor pressure vessel model Input Deck (VVER-440 and VVER-1000)

Pressurizer modeling, Pressurizer nodalization, Pressurizer model Input Deck

Steam generator modeling (primary and secondary), Steam generator nodalization, Steam generator Input Deck

Plant Control Systems

Lumping Coolant Loops.

Reactor kinetics

Modeling of control rod motion

Boron Control

Heat Structure Models:

Gap Conductance Model, Surface-to-Surface Radiation Model, Metal-Water Reaction Model, Cladding Deformation Model, VVER-440/213 (or VVER-1000/320) problem.

Restart File

LOCA Transients: Small Break LOCAs, Large Break LOCAs, Intermediate Break LOCAs

Pressurized Thermal Shock(PTS): Conditions for PTS, Significant PTS Event Sequences, Modeling steam generator tube rupture

Development of input data set for RELAP5: Data Base, Hand Book, Input Deck.

Code Verification and Validation