3KEYRELAP5 – Improvements and Applications

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Abstract

RELAP5-3D Version 2.4.1.1 coupled with NESTLE core simulation code are utilized at Western Services Corporation (WSC) for real-time full-scope training simulators. The CANDU, BWR and PWR power plant simulators are built using the same technology. The simulation environment software 3KEYMASTER, a product of WSC, is used to model the balance of plant, electrical and control systems. The program executive controls all phases of initialization, progress simulation, results visualization and man-machine interactions. Advanced technology, 3KEYRELAP5, was recently developed at WSC for a RELAP5-3D interface with a 3KEYMASTER object-oriented environment; it includes the input base deck developer studio, nodding graphical editor, control system interpreter and interactive results visualization.

To make interactions between object-oriented interactive 3KEYMASTER and RELAP5-3D efficient and flexible, an additional programming interface layer, R3K, was developed. The interface functionality covers initialization, time step advancement, restart file read/write, and data flow using shared memory. Time-dependent components, logical trips, control variables of constant type, and all minor edit variables with optional lag time parameters are accessible via shared memory, and can be interactively modified from the 3KEYMASTER Engineering Station as well as modified programmatically from C++ routines. Time-dependent component parameters in all existing formats are readily available for model boundary conditions setup. This enables interactive control valve positions, rod movement and equipment trips.

Research on stability with large time steps and floating frequencies techniques for real-time calculations are discussed. The numerical technique is based on limiting the RELAP5-3D internal time-halving iterations, thus keeping the simulator in real time. Accuracy and synchronization issues are discussed and compared to accuracy reduction due to numerical instabilities and following time step reductions.

The 3KEYMASTER graphical editor is used for nodding drawings. The editor includes all RELAP5 components with rich graphical capabilities. All minor edit parameters are available from the nodding drawing when the system is in run mode. Heat structures and 3-D objects parameters visualization are supported. The XML-based input deck editor enables preparation and validation model input definitions.

The advantages of the developed framework are: (1) fast and rich graphics; (2) the use of mature input data deck without introduction of a new set of rules; (3) a full range of real-time simulator tools that are available to the RELAP5 developer, such as interactive change of time-dependent components and control variables, plotting any minor edit parameter, dynamic objects for clock-like devices and dynamically changing colors.

Recent improvements to 3KEYRELAP5 include validation of time-dependent components using original RELAP5-3D routines to protect the simulators from errors coming from BOP and other boundary conditions. Performance of the control system interpreter, SCATER, was improved, and functionality expanded. Results of the on-going effort for parallelization of Thermal-Hydraulic and Reactor Kinetic parts of RELAP5-3D to run on separate processors are discussed. Two full-scope training simulator upgrade projects for Florida Power&Light Company are being developed applying the full range of 3KEYRELAP5 tools. Demonstration of the projects' details and advantages of the developed framework are presented.