Calculation of the 5th AER Dynamic Benchmark with APROS

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ABSTRACT

The hand-out presents the model used for calculation of the 5th AER dynamic benchmark with APROS code.

In the calculation of the 5th AER dynamic benchmark the three-dimensional neutronics model of APROS was used. The core was divided axially into 20 nodes according to the specifications of the benchmark and each six identical fuel assemblies were placed into one one-dimensional thermal hydraulic channel. The five-equation thermal hydraulic model was used in the benchmark. The plant process and automation was described with a generic VVER-440 plant model created by IVO PE.

1. INTRODUCTION

APROS software consists of physical models that are grouped into general and application specific packages. The software is designed to be used with graphical user interface. A typical feature of the software is the requirement for on-line modifications in physical parameters and also in model structure during the simulation.

2. APROS PHYSICAL MODELS

APROS has one-dimensional and three-dimensional core neutronics models. Both models have two energy groups and six delayed neutron groups. In the three-dimensional model the neutron flux equations are integrated over the node volumes, a few approximations are made and the fast and thermal equations are solved using Gauss-Seidel iteration process. The finite-difference type three-dimensional neutronics model is able to describe both hexagonal (VVER) and quadrilateral (BWR and PWR) fuel assembly geometry. For the one- and three-dimensional core models the user can select the five- or the six-equation thermal hydraulic model. The five-equation model is based on the conservation equations of mass and energy for liquid and gas phases and momentum equation for mixture of gas and liquid. In the five-equation model the gas and liquid interface friction is not calculated, but the differential phase velocities are obtained through the drift flux correlations. A separate drift flux model calculates the mass flow rates of the phases. The six-equation model describes the behaviour of one-dimensional two-phase flow. The model is based in the conservation equations of mass, momentum and energy for the gas and liquid phases. The equations are coupled with empirical correlations describing various two-phase phenomena.

3. APROS MODEL FOR THE 5th AER BENCHMARK

In the calculation of the 5th AER dynamic benchmark the three-dimensional neutronics model used. The core was divided axially into 20 nodes according to the specifications of the benchn and each six identical fuel assemblies were placed into one one-dimensional thermal hydra channel. Thus there were altogether 59 thermal hydraulic channels in the core. Each ther hydraulic channel was divided into 20 axial sections. The five-equation thermal hydraulic m was used in the benchmark. The plant process and automation was described with a gen VVER-440 plant model created by IVO PE.

The extent of the model used in the calculation is shown in Table 1.

Table 1. Extent of APROS model in the Benchmark.

	3-D Core	Process Model
Neutronics nodes	6980	-
Thermal hydr. Nodes 5-eq.	590	291
Thermal hydr. Nodes 3-eq.	-	1173
Valves	-	835
Pumps	-	96
Analog signals	-	1277
Binary signals	-	4286
Controllers	-	54

4. RESULTS

The calculations with the model created have indicated that at the initial state of the transient t subcriticality before tuning is some -4300 pcm. The subriticality is tuned to -1500 pcm at the st of the transient. During the initial phases of the transient the process behaviour predicted APROS corresponds well with the behaviour predicted by many other codes.

In the calculations the full power neutronics data file endfb4_full.mat of HEXBU-3D has be used. The control rods have been described with cross sections used previously for similar VVE applications.

Preliminary results indicate qualitatively similar behaviour as with most other codes inn t benchmark. The calculation of this benchmark with APROS is still continuing.