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SAMG Supporting Computational Aid Development Using MAAP-ISAAC Code for PHWR

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1. Introduction

During a severe accident, an analysis of a plant performance including the fission product behavior is an essential part of Severe Accident Management (SAM) and emergency planning. Related with the analyses of these behaviors, there are several integral computer codes, such as the Modular Accident Analysis Program (MAAP) [1], MELCOR [2] and MAAP(1)-ISAAC (called ISAAC (Integrated Severe Accident Analysis code for the CANDU Plants) afterwards) [3], to analyze the accident progression, thermal-hydraulic phenomena, radio-nuclide behavior and transport, and environmental consequences.

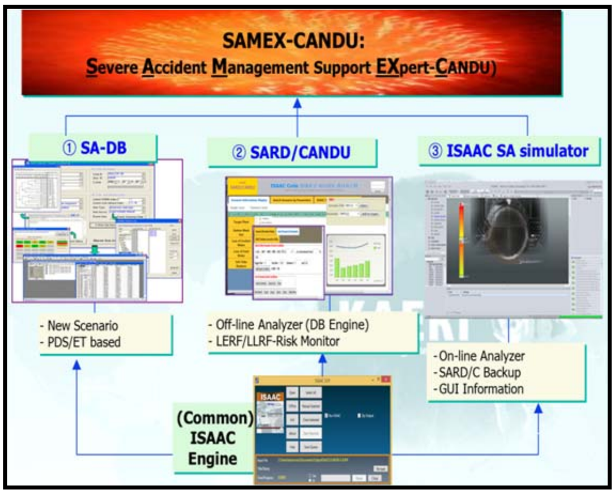

Fig. 1 Decision Supporting Aid for SAM

A decision supporting computational aid, called SAMEX-CANDU, is developed at KAERI to support experts who need to analyze and predict on-going accidents under emergency situations in PHWR plants, as shown in Fig.1. This aid comprises three modules: the Severe Accident analysis Database (SA-DB) based on pre-defined scenarios from a PSA [4], an accident inferring engine (SARD-CANDU), and a severe accident simulator based on ISAAC engine (ISAAC simulator). In particular, an ISAAC simulator, called the PHWR Severe Accident ISAAC Simulator (PSAIS), which can mimic an operator or SAM actions, has been developed with a fine graphic user interface in an interactive way.

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(1) MAAP is an Electric Power Institute (EPRI) software program that performs severe accident analysis for nuclear power plants including assessments of core damage and radiological transport. A valid license to MAAP4 and/or MAAP5 from EPRI is required.

2. Severe accident analysis code development

Fig. 2 MAAP-ISAAC5 Code

A computer tool, ISAAC, has been continuously modified or updated to support analyzing severe accident issues of Wolsong. The ISAAC5 code (see Fig.2) provides a flexible, efficient, and integrated tool for evaluating the in-plant effects of a wide range of postulated accidents and for examining the impact of operator actions on accident progressions. The code can predict the progression of hypothetical accident sequences from a set of initiating events to either a safe, stable, coolable state or to an impaired R/B (Reactor Building) and depressurization

In the recent ISAAC development, the CFVS (Containment Filtered Vent System) filter model provides the functionality in which the released steam and fission products are directed to the filter water pool. The pool water mass increases sharply when the CFVS is activated as a result of steam being condensed, and remains constant during the period when there is no flow through the CFVS filter. The temperature transient shows similar rapid increases corresponding to periods of filter activation, with more gradual increases during the early part of the transient as a result of the decay heat associated with the fission products deposited in the pool. A decrease in pool temperature was observed during the remainder of the transient because of heat dissipation through the filter housing walls. The R/B pressure trend under CFVS operation is calculated by reflecting the change in the CFVS pool. The overpressure control capability using ventilation from containment provides a prolonged source of aerosols flowing into the filter junction. Regardless, we are making an effort to develop more physical models in ISAAC, which is believed to properly account for the specific Wolsong PHWR source terms.

3. ISAAC engine simulator development

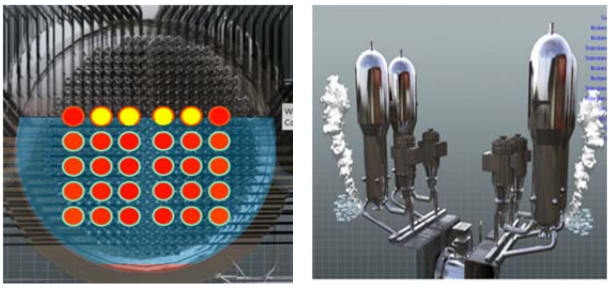

Fig. 3 PSAIS Simulator

The PSAIS [5] was developed as a prototype of a desktop SA graphic simulator with the following features.

- Windows 7/8 Interface
- Pre- and Post-Processor
- Interactive Control
- Animation (see Fig.3)

It was developed as a Windows-based severe accident simulator using ISAAC as its engine. It can simulate the spectrum of physical processes occurring during severe accidents. The output results are displayed in a user friendly graphical format by using a text-based (numerical) output of the ISAAC program. The Windows-based simulator of PSAIS was designed to provide graphical displays of the results through a plotting of the important parameters during the transient simulation. Using these, the users can easily follow the plant dynamics for the PHTS, CV, and R/B. PSAIS consists of the following sub-modules:

- Event summary
- Calandria vessel (CV) view
- Primary heat transport system (PHTS) view
- Reactor building view

PSAIS can be a supporting or supplementary measure to understand the trends of accident progress, and thus can be an emergency staff training tool to implement the SAM strategy. This tool is mainly developed based on the change from the character user interface into graphic user interface, and can be extended in its function afterward in the following:

- SAM strategy automatic display
- Accident progress prediction view
- Operator recovery effect display

4. ISAAC inferring engine development

SARD-CANDU [6] was developed as a prototype of a web-based inferring engine for PHWR SA.

Fig. 4 SARD-CANDU Inferring Engine

The DB management module (see Fig.4) was developed through which the ISAAC outputs are gathered, classified, and then stored on the web according to the accident scenario and characteristics. This means the implementation of support functions for accident management (such as accident inferring and accident progress prediction) using accident data. In other words, this study aims to develop an archetypal module for web-based DB management and accident management support (such as a systematic scenario information display and simple diagnostic/search screen supply), which is composed of the following three elements.

- Construction of ISAAC output DB: accident Scenario DB creation/search/management
- Support of accident management (inferring/prediction): symptom-based accident scenario deduction and scenario-based accident progress prediction
- Construction of accident analysis management system: Web-based construction.

The main capabilities developed in this study are the following.

- Wide range search capability for symptom-based plant status diagnostic or accident scenario deduction
- Accident progress prediction capability including main barrier performance under severe accident conditions
- Web-based operation capability.

5. Summary

ISAAC is being updated to meet the current requirements and expectations. The simplified modeling of the plant allows for fast estimates of the source terms. Inclusion of new severe accident phenomena is expected to allow for a greater confidence in the consequence assessments.

ACKNOWLEDGMENTS

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