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Review

Overview of the standard problems of the ATLAS facility

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A B S T R A C T

KAERI (Korea Atomic Energy Research Institute) has been operating an integral effect test facility, the Advanced Thermal–Hydraulic Test Loop for Accident Simulation (ATLAS), for transient and accident simulations of advanced Pressurized Water Reactors (PWRs). Using ATLAS, a high-quality Integral Effect Test (IET) database has been established for the major design basis accidents of the APR1400 (Advanced Power Reactor 1400 MWe) plant. Several standard problem exercises using the ATLAS database were performed to transfer the database to domestic and international nuclear industries and contribute to improving a safety analysis methodology for advanced PWRs. The ATLAS Standard Problem (ASP) exercises, e.g., two domestic standard problem (DSP) exercises and one International Standard Problem (ISP) exercise, aim at an effective utilization of the integral effect database obtained from ATLAS, the establishment of a cooperation framework among domestic and international nuclear industries, a better understanding of the thermal hydraulic phenomena, and an investigation into the possible limitation of the existing best-estimate safety analysis codes. Three kinds of Small Break Loss of Coolant Accidents (SBLOCAs) were determined as target scenarios by considering their technical importance and incorporating interests from participants. An overview of the ASP exercises is described in this paper.

Contents

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1. Introduction

1.1. Background and brief history

The first Domestic Standard Problem (DSP-01) exercise using ATLAS, whose kick-off was held in June, 2008, was completed successfully by holding a final workshop in April, 2010. A 100% Direct Vessel Injection (DVI) line break test (SB-DVI-08 test) was selected as the ATLAS DSP-01 exercise as a very important scenario for the DVI concept. Though the DSP-01 was the first cooperative program for code validation based on an integral effect database, most major domestic organizations, including industries, universities, and research institutes, have volunteered to contribute to strengthening the technical infrastructure for code validation and to expanding a domestic cooperative network. Technical information sharing and discussions were active between experienced code users. In particular, the water levels of the reactor core and downcomer regions, ECC bypass rate, multi-dimensional phenomena in the downcomer region, loop seal clearing phenomena, and loop flow characteristics were identified as the crucial phenomena for a close investigation from the viewpoint of code modeling. There were unexperienced code users among the participants, and they benefited greatly from this valuable course of exercise. In conclusion, the DSP-01 was supposed to be a major landmark in the validation of the thermal–hydraulic safety analysis codes and provided a lesson that there needs to be a focus on detailed thermal–hydraulic phenomena rather than viewing the overall aspects to contribute to a practical code validation in the DSP exercise. More details can be found in the final comparison report (Choi et al., 2010) and a related paper (Kim et al., 2011).

In parallel with the DSP-01 program, has KAERI pursued an international standard problem (ISP) through meetings of the NEA Committee on the Safety of Nuclear Installations (CSNI) Working Group on the Analysis and Management of Accidents (WGAM-A). The first workshop (kick-off meeting) was held at KAERI in April, 2009 and was completed successfully by holding a final workshop in March, 2011. A DVI line break scenario, e.g., a 50% DVI line break scenario of the APR1400, was selected for the ISP exercise and was numbered by ISP-50. ISP-50 was performed in two phases. In Phase-1, the ISP exercise was performed as a ‘blind’ problem. The experimental results will be locked until the calculation results are made available for a comparison. All participants are requested to submit their calculation results to the operating agency for comparison. In Phase-2, the ISP exercise was performed as an ‘open’ problem with the experimental results released to the participants. More details can be found in the final integration report (Choi et al., 2012a) and a related paper (Choi et al., 2012b).

The second Domestic Standard Problem (DSP-02) exercise was launched in July, 2010 and completed successfully by holding a final workshop in September, 2011. In the kick-off meeting, a 6-inch cold leg break SBLOCA test was selected as a target test item of the DSP-02, and the outcome of the DSP-01 was analyzed and discussed by the participants. Noticeable major outcomes are that the DSP-01 provides an opportunity to major domestic nuclear organizations in pursuing MARS-KS code validation against qualified IET data and in providing a cooperation network. The know-how and expertise of experienced code users were spread among the participants. On the contrary, however, user effects were remarkable owing to great difference in code experience among the code users, and they made the user effects overshadow the possible code deficiencies. In particular, qualification of the code initialization was highlighted to ensure correct transient calculations. It was also suggested for focusing on detailed thermal–hydraulic phenomena, and it was agreed upon that each participant is responsible for providing an additional analysis on at least one special topic in the DSP-02. Special assessment topics relevant to code validation were proposed such as (1) break flow modeling, (2) loop seal clearing behavior, (3) ECC bypass, (4) RPV bypass, (5) heat loss effects, (6) momentum effects of the DVI nozzle, (7) 2-D behavior in the downcomer region, (8) and others. More details can be found in the final comparison report (Choi et al., 2012c) and a related paper (Kim et al., 2013).

1.2. Objectives of the ATLAS standard programs

A best-estimate safety analysis methodology for small break LOCAs including the DVI line and cold leg break accidents needs to be developed to identify the uncertainties involved in the safety analysis results. Such a best-estimate safety analysis methodology will contribute to defining a more precise specification of the safety margin, and will thus lead to a greater operational flexibility. However, such an effort is lacking because the available integral effect test data are not sufficient.