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SAPCE-CAP Linkage Methodology and Preliminary Results

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1. Introduction

As a part of the development project of the domestic design code for licensing purposes of pressurized water reactors, the SPACE (Safety and Performance Calculation Code) and CAP (Containment Analysis Package) code are under development in Korea. The SPACE code has applicability to analysis of the system behavior of nuclear power plant under the various accident conditions. On the order hand, CAP code is focused on the calculation of pressure and temperature of containment compartments. Two codes, of course, were designed to deal with the general thermal-hydraulic problems also.

In other to evaluate conservatively the performance of ECCS equipment; minimum containment back-pressure is conservative, the containment pressure is important boundary condition. In this respect, linking two codes; RELAP5/MOD3 for system code and CONTEMPT4/MOD5 for containment code was tried to calculate the minimum containment back-pressure in the framework of KREM (KEPRI Realistic Evaluation Methodology). These results are used in FSAR of Kori3/4.

For the above same purpose, linking the SPACE and CAP code has tried based on KREM in this research. The target plant is the Shinkori-3/4 nuclear plant; APR1400 type. This plant has quite different design concept from other operating plants such as OPR1000 and WH 3-loop plant. Major feature of APR1400 is that RWST (Refueling Water Storage Tank) is located in plant.

2. SPACE-CAP Link Methodology

The CAP code was developed with different purposes and features from CONTEMPT4/MOD5 code; for example, numerical algorithm, model and correlation, etc. The features of CONTEMPT4/MOD5 used in KREM can be sufficiently interpreted in CAP code such as compartment analytical model, mass and energy transfer model, components, model and correlations.

Figure 1 shows the time synchronization strategy between the SPACE and CAP code. Four step calculations which are classified into four modes finish the whole process of one transient problem. Table 1 describes the applicable period and activation of two codes according to each mode.

Mode1 stands for a pre-blowdown period, Mode2 and Mode3 a blowdown period and Mod4 a post-blowdown. For the condensation model, Tagami and Uchida models can be used in KREM. Tagami model has a variable of pressure peak time (t_{peak}), which is defined as the reflood time in KREM. The CAP, however, can be aware of reflood time during calculation. For this reason, the SPACE uses the initial containment pressure of CAP as back pressure during Mode2. Once, a pressure peak time is determined in Mode2, then CAP, in Mode3, calculate the back pressure using the cumulative blowdown flow and energy calculated during Mode2 from SPACE. During Mode4, time advancement of two codes is same; it's based on SPACE one.

For the conservative calculation, in KREM, a value of four times to original heat transfer coefficient of Tagami is used in blowdown period and 1.2 times of Uchida. These can be modified using a multiplier of CAP heat conductor input variables.

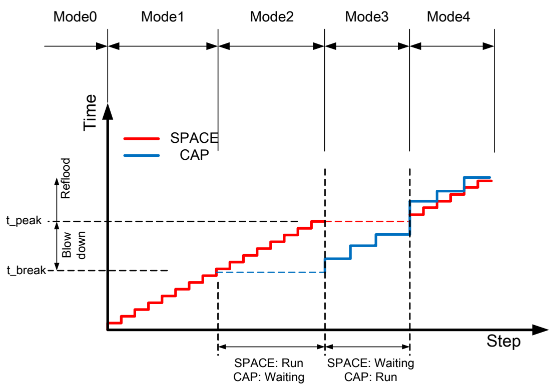

Fig. 1. Synchronization between SPACE and CAP

Table I. Mode description of SAPCE/CAP

Mode	Period	SPACE	CAP
Mode1	$t_0 \sim t_{break}$	Run	Wait
Mode2	$t_{break} \sim t_{peak}$	Run	Wait
Mode3	$t_{break} \sim t_{peak}$	Wait	Run
Mode4	$t_{peak} \sim t_{finish}$	Run	Run

In order to complete one step of time advancement, data transfer between two codes can be possible; mutual dependent each other. Basically, the methodology in linkage of two codes has no limitation, this is, the multiple breaks in multiple compartments are possible.

Figure 2 shows the data transfer flow structure. The SPACE informs the blowdown data (mass and energy flow) to CAP. On the other hand, the CAP offers the thermal-hydraulic conditions of compartments to SPACE. These data pass through the shared memory.

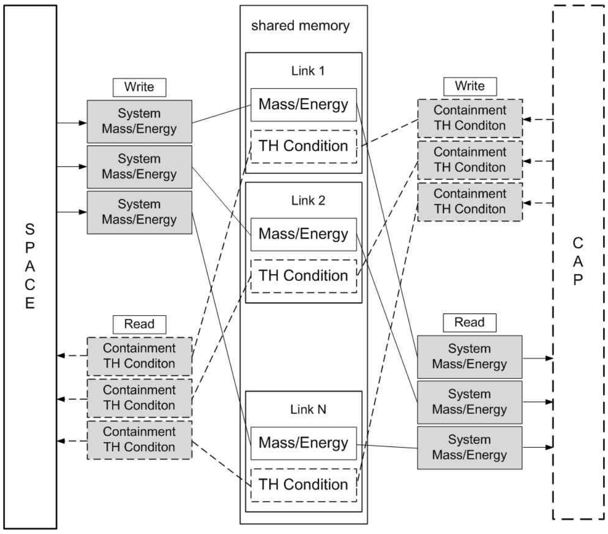

Fig. 2. Data transfer structure between SPACE and CAP

3. Results

Figure 3 shows the condensation heat transfer coefficient calculated by CAP. The pressure peak time, t_P, is detected at 24.1 sec. As expected, heat transfer coefficient is linearly increased before the peak time; it's feature of Tagami model, and decreased exponentially to $1.2h_{Uchida}$ after the peak time. This result reveals that the method which used in the linkage of SPACE and CAP code about condensation heat transfer is agreed with the previous KREM one. Figure 4 shows the containment pressure behavior. Typical back pressure curve of containment are obtained in the SPACE-CAP linked calculation.

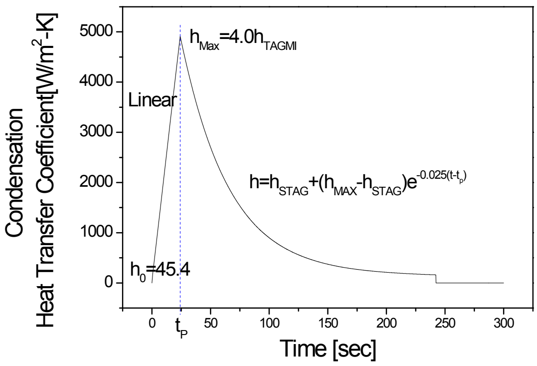

Fig. 3. Wall Condensation Heat Transfer Coefficient

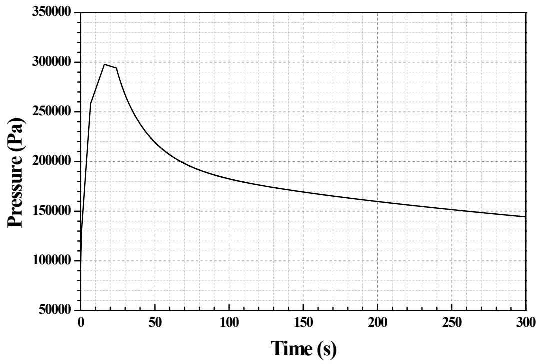

Fig. 4. Containment pressure behavior

4. Conclusions

SPACE-CAP linked calculation is conducted to evaluate the performance of ECCS equipment under LOCA accident for Shinkori-3/4 nuclear plant based on KREM. Two codes are separately executed, transfer data through the shared memory. Due to the nature of Tagami model, four distinct modes are implemented according to time step advancement and data transfer method. The calculation result is in agreement with the previous result by RELAP4/MOD3 and CONTEMPT4/MOD5.

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