Comparison Results on the Basic Phenomena between CAP and CONTEMPT-LT

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1. Introduction

A development project for the domestic design code was launched to be used for the safety and performance analysis of pressurized light water reactors. As a part of this project, CAP (Containment Analysis Package) code has been developing for the containment safety and performance analysis side by side with SPACE. CAP Beta version has been released lately and validation processes are under way currently. Code by code comparison activity is scheduled in the validation processes and the first comparable code is CONTEMPT-LT.

CONTEMPT-LT was developed to predict the long-term behavior of water-cooled nuclear reactor containment systems subjected to postulated loss-of-coolant accident (LOCA) conditions. CONTEMPT-LT calculates the time variation of compartment pressures, temperatures, mass and energy inventories, heat structure temperature distributions, and energy exchange with adjacent compartments, leakage on containment response. Models are provided for fan cooler and cooling spray as engineered safety systems. Any compartment may have both a liquid pool region and an air-vapor atmosphere region above the pool. Each region is assumed to have a uniform temperature, but the temperatures of the two regions may be different.

As mentioned above, CONTEMP-LT has the similar code features and it, therefore, is expected to show the similar analysis performance with CAP. In this study, the code performances were compared for the same phenomena between CAP and CONTEMPT-LT. Code comparison is carried out through two stages; separate and integral effect comparison.

2. Comparison Strategy

The objective of this study is to confirm the current status of CAP performance and draw the improvements. To achieve this, the strategic comparison is necessary so that it is easy to analyze the results and avoid the ambiguities caused by cumulative effects. Two stage comparison processes; separate and integral effect in other, conducted between two codes. Comparison items are as follows. :

- Conductive Heat Transfer of Heat Structure.
- Mass/Energy Blowdown.
- Wall Condensation.
- Interfacial Heat and Mass Transfer.
- Spray Model.
- Fan cooler Model.

The separate effects are analyzed with very simplified model, while the integral effect with real containment model. Table I shows the analysis conditions of two comparisons. Among comparison items, only one item is individually considered in each effect comparison to avoid integral effects as much as possible.

Table I. Conditions of Separate and Integral Effect Test

	Separate Effect	Integral Effect
Volume	1000 m	49400 m^3
Height	10 m	58.118 m
pressure	Ambient	Ambient
Vapor	Pure Air or Mixture	Mixture
Heat conductor	Single material	Multiple material
Wall model	User specified constant	Model and Correlation

3. Separate Effect Comparison

<u>Conductive heat transfer of heat structure</u>

Both codes have the same methodology of conductive heat transfer; 1-D unsteady conduction, convective and condensation boundary condition, finite volume discretization, etc. In this comparison, boundary condition of both sides is specified by the constant convective heat transfer coefficient and the atmosphere is filled with only pure air gas, that is, 0% humidity in order to exclude the condensation effect on the wall surface.

<u>Mass/Energy Blowdown</u>

Mass/energy blowdown phenomena is treated by adding source terms to mass and energy balance equation of vapor region explicitly in both code. CAP has the user option so as to select the target phase to which the blowdown source will be added, while CONTEMPT-LT directly added to only atmosphere. In order to completely define the thermodynamic state of blowdown phase, volume steam partial pressure or total system pressure could be chose by user.

<u>Wall Condensation Model</u>

Both codes use the Uchida correlation for a wall condensation model, which is a favorite model with the containment analysis codes. In this comparison, wall condensation phenomenon between stagnant humid atmosphere and single material heat structure is analyzed.

Interfacial Heat and Mass Transfer

Heat and mass transfer at the pool surface between atmosphere and pool is compared. Both codes use the heat and mass transfer analogy to treat interfacial transfer phenomena. Most noticeable difference of interfacial heat transfer model is the interfacial temperature; a saturated temperature at steam partial pressure in CONTEMPT-LT, while some temperature calculated by iterative solution in CAP.

Spray

The reactor containment buildings of most pressurized water reactors and the drywells of most boiling water reactors are equipped with water spray systems. These spray systems were installed to condense steam and reduce the pressure threat to containment or maintain drywell integrity in the event of a design-basis, large break in the reactor coolant system. Thermodynamic transient behavior by the heat and mass transfer between subcooled droplet produced by spray and atmosphere is compared between two codes.

Fan cooler

Some containment systems contain fan cooler units to circulate the containment atmosphere past cooling coils and thereby remove energy from the atmosphere and condense the steam in the atmosphere. Fan cooler, actually, needs the specific and detailed input data to calculate the best estimated performance. CAP, however, simplifies the fan cooler model with overall cooling capacity supplied by user as in the same manner CONTEMPT-LT do. The case study by the atmosphere humidity were performed and compared with both codes.

All separate effect comparison results of CAP showed the good agreement with CONTEMP-LT in most volume parameters; such as pressure, temperature, pool and steam inventory.

4. Integral Effect Comparison

The integral effect comparison work is also conducted, which consider all separate effects mentioned in Section 3. Fig. 1 and Fig. 2 show the result of integral effect test for pressure and temperature transient. Even if separate effect tests show the agreement between two codes, two results show the deviation from 20 seconds after starting calculation. It, therefore, seems that the close examination is necessary.

5. Conclusion

As part of CAP validation process, a code by code comparison activity was carried out. Through two stages comparison strategy, the separate effect comparison revealed the good agreement, nevertheless, the integral effect comparison showed some difference. The further in-depth study, therefore, seems to be necessary.

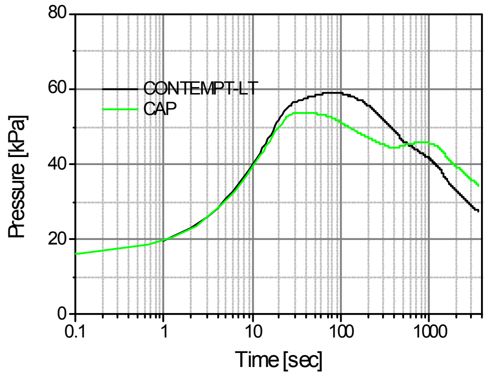

Fig. 1. Pressure Transient of Integral Effect Comparison

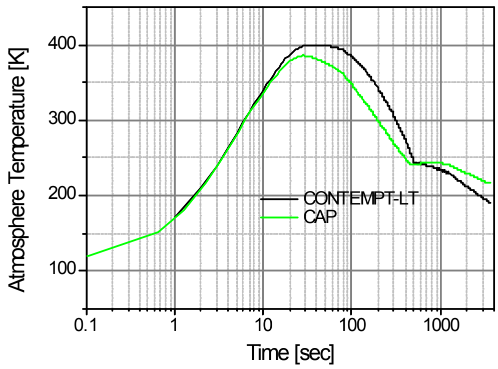

Fig. 2. Temperature Transient of Integral Effect Comparison

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