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Status of SPACE Safety Analysis Code Development

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1. Introduction

In 2006, the Korean the Korean nuclear industry started developing a thermal-hydraulic analysis code for safety analysis of PWR(pressurized water reactor). The new code is named as SPACE(Safety and Performance Analysis Code for Nuclear Power Plant). The SPACE code can solve two-fluid, three-field governing equations in one dimensional or three dimensional geometry. The SPACE code has many component models required for modeling a PWR, such as reactor coolant pump, safety injection tank, etc. The programming language used in the new code is C++, for new generation of engineers who are more comfortable with C/C++ than old FORTRAN language. This paper describes general characteristics of SPACE code and current status of SPACE code development.

2. Main Features of SPACE Code

In this section the main features of SPACE code are described.

2.1 Hydraulic Solver

The SPACE code has two-fluid, three-field governing equations in one dimensional or three dimensional geometry. When modeling in 3D, Cartesian or cylindrical coordinate system is used.

Two types of spatial discretization methods are used in SPACE code. One is staggered mesh spatial discretization method for structured mesh, which is widely used in other existing safety analysis codes. Another approach is collocated mesh spatial discretization for unstructured mesh. The staggered mesh uses different control volumes for solving momentum equation compared with mass and energy equations. The collocated mesh spatial discretization uses same control volumes for all governing equations. Both spatial discretization methods will be able in SPACE code as a user option.

For temporal discretization of SPACE code, semi-implicit scheme is the used. The semi-implicit scheme is widely used in existing LOCA analysis codes. As an option, multi-fluid implicit scheme is also being developed. The multi-fluid implicit scheme will be used in steady-state calculations and for slowly varying, quasi-steady transient calculations. The algorithm for semi-implicit scheme and implicit scheme has been developed and tested for a simple geometry.

2.2 Models and Correlations

The models and correlations provide closure relations to the governing equations. The three flow fields modeled in SPACE code have various interfaces. At each interface, there is heat/mass transfer and frictional forces. The models and correlations for SPACE code provide information on interface heat and mass transfer correlations, interface friction correlations, wall friction and phase separation. Most of these correlations and models are obtained from experimental data. In order to predict interface values correctly, it is necessary to apply the appropriate correlation for that particular flow condition. Therefore flow regime maps for horizontal and vertical pipe flow where reviewed and selected.

2.3 Special Component Model

Special component models cover operation characteristics of a component or physical phenomena that applies to certain components. Examples of special component models are the pump model and critical flow model. Major special component models included in SPACE are listed in Table I.

Table I: List of Special Component Models

Type	Model
Special Component Models	Pump
	Safety Injection Tank
	Pressurizer
	Separator
	SI Mixing
	Valve
	Steam Turbine
Special Phenomena Models	Critical Flow
	Counter Current Flow Limit
	Abrupt Area Change
	Level Tracking
	Off-take

2.4 Heat Structure Model

The heat structure model of SPACE code includes transient heat conduction in rectangular or cylindrical geometry. The boundary conditions at heat structures include convection, user specified temperature, user specified heat flux or user specified heat transfer coefficient. For fuel rod sections, reflood model with fine mesh feature and 2D conduction equation has been developed.

The neutron kinetics model is used to calculate core power. The neutron kinetics model in SPACE code will be point kinetics with ANS decay heat models. If 1D or 3D neutron kinetics calculation is needed, a separate neutronics code will be linked with SPACE code to provide core power.

2.5 Containment Module

Containment module for SPACE code is being developed for analysis of containment pressure and temperature response during postulated accidents and ECCS back pressure calculation purposes. At the end of phase 1 of this project, the containment module will be developed as a separate code from main SPACE code.

3. Conceptual Problem Results

A settle down problem has been calculated as a conceptual problem. The problem solves a 6-cell vertical pipe with initial void fraction 0.5 for all cells. The ends of pipe are closed and there is no bulk fluid flow. As transient is initiated, liquid will move to the lower part of the pipe and vapor will move to the upper part of the pipe(Fig.1). The settle down problem is very simple, but involves various 2 phase flow conditions including counter current flow.

Fig. 2 shows void fraction of each cell as a function of time. For top 3 cells (c110-1~c110-3) the void fraction approach 1.0. For bottom 3 cells, the void fraction becomes 0.0. The results consistent with liquid settle down as a result of gravitational forces.

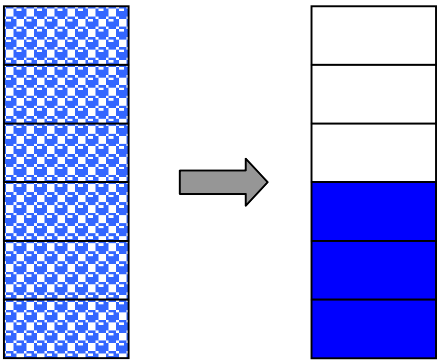

Fig. 1. Settle down conceptual problem

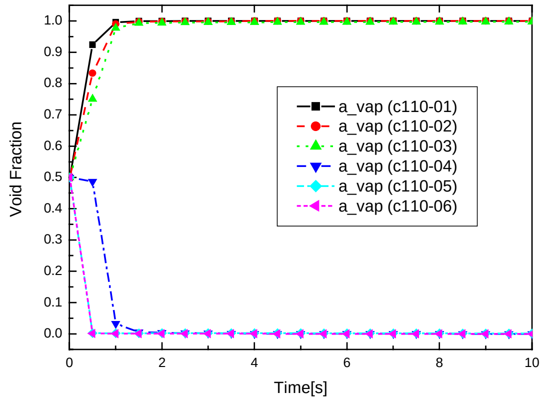

Fig. 2. Void fraction of each cell vs. time.

4. Conclusions

The Korea nuclear industry is developing SPACE thermal-hydraulics code PWR safety analysis. The SPACE code can solve 2-fluid, 3-field governing equation in 1 or 3 dimensional geometry. The programming language for the new code is C++, for new generation of engineers. The code development is still in progress. Several conceptual problems were developed and analyzed with SPACE code. The results show that SPACE code calculates physically reasonable results for simple conceptual problems.

Acknowledgement

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REFERENCES

[1] Annual Progress Report for Nuclear Powerplant Safety Analysis Code Development Project, Korea Electric Power Research Institute, TM.S03.M2008.0017, 2007
[2] Proceedings of 2nd SPACE Code Correlation Development Workshop, Korea Atomic Energy Research Institute, 2007
[3] Numerical Solution Methodology Development of a Multi-D Unstructured Mesh Semi-implicit Scheme, Korea Power Engineering Company, S06NX08-N-1-RD-02, 2008
[4] Development of Multi-fluid Hydraulic Solver Module Using Implicit Numerical Solution Scheme, Korea Power Engineering Company, S06NX08-N-1-RD-04, 2008