Assessment of MARS-KS codes on LBLOCA for CANDU type reactor

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1. Introduction

MARS-KS (Multi-dimensional Analysis of Reactor Safety KINS Standard) code has been developed for the realistic multi-dimensional system to estimate and evaluate the thermal hydraulic phenomena of nuclear power plants.

The purpose of this study is to validate the MARS-KS code for CANDU type reactor. This study presents the comparison of the analysis results of large-break LOCA (Loss of Coolant Accident) for CANDU type reactor between MARS-KS V 1.0 and V 1.2. Furthermore, the CANCHAN (CANDU Channel) component was adopted to compare the basic case. The fuel sheathe temperatures of critical (broken) channel were used to compare the results of each analysis.

2. Modeling Information

2.1 Nodalization

Figure 1 shows the nodalization diagram (Wolsong unit 2 plant). As shown in the figure, the primary coolant system of Wolsong nuclear power plant unit 2 was modeled as two loops. Each of the loops was assumed to have two core paths which represent 95 actual core coolant paths. The entire system was consisting of feeder line, headers (inlet and outlet), steam generators, reactor coolant pumps, pressurizer and safety features. For using the fuel heat up model (only when adopting the CANCHAN component), the 37 rods were modeled as one upper and one lower rod. On the other hand, in the basic calculation, the heat structures for the core were simulated one group element.

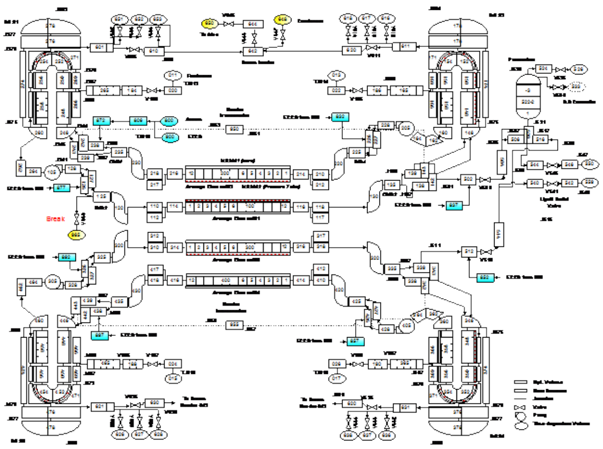

Figure 1 Nodalization diagram for CANDU type reactor (Wolsong-2).

2.2 Calculation conditions

The transient responses of the CANDU type reactor during large-break LOCA were assessed using both MARS-KS V 1.0 and V 1.2. The large-break in primary circuit was considered and all safety systems were assumed to be available during the imaginary accident situation. In the hypothetical LOCA condition, the break of 35% reactor inlet header was assumed. This break size has been known to be the limiting case for the fuel sheath temperatures due to the flow stagnation in the primary loop immediately after LOCA situation. The Henry-Fauske model was employed as a critical flow model in the broken area. After obtaining the initial conditions from the steady state option, the transient condition was calculated with setting time of 200 sec (calculation time).

3. Results

3.1 Comparison According to Code Version

In order to evaluate the calculation performance between MARS-KS V 1.0 and V 1.2, the same input model was used as explain in the previous. Figure 2 and 3 provide the fuel sheath temperature in the critical path calculated from MARS-KS V 1.0 and V 1.2 respectively.

As shown in the figure, the cladding temperatures abruptly rise after the break and the temperatures decline slightly then show the increase and decease

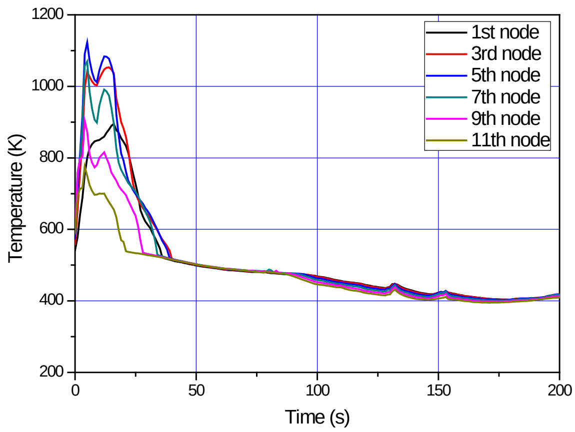

Figure 2 Fuel sheath temperature calculated from MARS-KS V 1.0.

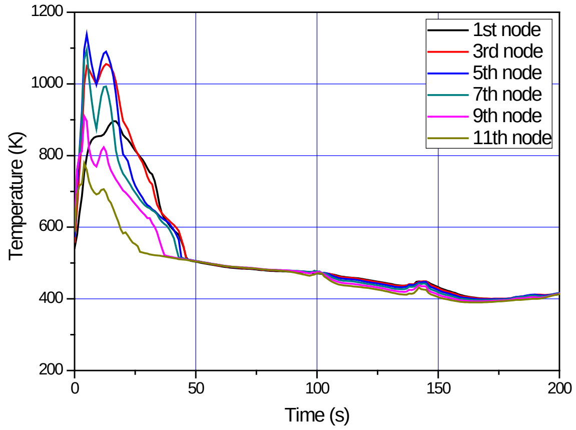

Figure 3 Fuel sheath temperature calculated from MARS-KS V 1.2.

again. The 5th node of the heat structure shows the highest temperature. Though the shapes of the peak temperatures range and values of that can be varied with different critical flow model, this paper only provides the differences from the code version when employing the same choked model.

As shown in the figure (2&3), the trends of the temperature variation look generally similar. However, the significant differences can be founded with detail comparison in the early variation range after the LOCA situation. The peak temperatures calculated from recent version slightly higher than the values obtained from old version. Furthermore, the temperatures from V 1.2 more slowly cool down. The slope during the cooling down range is obviously different between two results. Moreover, the quenching time calculated from recent version reaches almost 50 seconds in comparison with about 40 seconds which is the results from the old. With these results, the MARS-KS V.1.2 can be considered as more conservative than MARS-KS V 1.0 for simulating CANDU reactor.According to the development reports, the CANDU oriented models have been fairly modified in recent version (V 1.2). Therefore, the reliability of calculation of MARS code for CANDU reactor can be seen improved in changing the version.

3.2 Results from Adopting CANCHAN Component

As written in previous, the fuel heat up model was employed for using CANCHAN component. There were not significant differences when the heat up model was not used for the core structures (the pipe component used instead of the CANCHAN).

Figure 4 represents the fuel cladding temperatures of critical path calculated from MARS-KS code V 1.2 using CANCHAN component (the results from MARS is omitted). The 7th node of the heat structure shows the highest temperature (even higher than 5th node). This result can be considerably difference with the previous nodalization. Furthermore, the peak temperature is much higher than calculated with pipe component in all

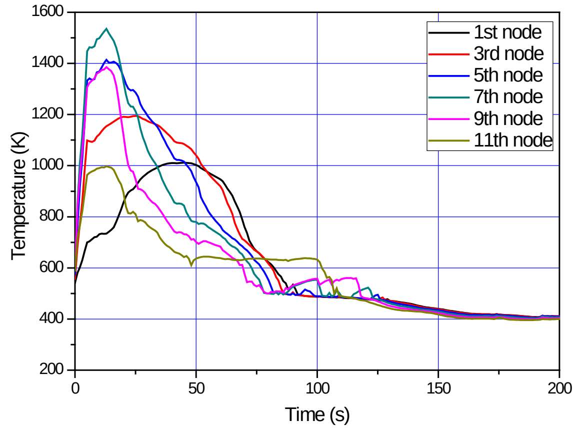

Figure 4 Fuel sheath temperature with CANCHAN component.

nodes of heat structures. The quenching time reaches almost 100 seconds. These results can be obtained even using the old version.

Since the diameter of the fuel elements of CANDU reactor is relatively larger, it shows generally different flow pattern and heat transfer rate with the pipe flow. The accuracy of the calculation for the flow pattern and the heat transfer coefficient has been improved by adopting the CANCHAN component. Therefore, when using the CANCHAN, the calculated temperature of the upper fuel element provided higher compare to the result from employ the pipe model due to the low heat transfer coefficient of the pure steam territory.

4. Conclusion

The assessment results and the comparison between the MARS-KS V.1.2 and MARS V. 3.0 codes for the CANDU type reactor were provided in this paper. And the results obtained from MARS-KS employing the CANCHAN component instead of the pipe model were considered. The peak temperature of the fuel sheath is slightly higher and quenching time is prone to lengthen in the calculation using MARS-KS. Therefore, the MARS-KS can be considered as more conservative. Furthermore, when using the CANCHAN component for MARS-KS, much more conservative results can be obtained.

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