Journal of the Korean Nuclear Society
Volume 35, Number 5, pp.426~441, October, 2003

Assessments of RELAP5/MOD3.2 and RELAP5/CANDU in a Reactor Inlet Header Break Experiment B9401 of RD-14M

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(Received June 11, 2003)

Abstract

A reactor inlet header break experiment, B9401, performed in the RD-14M multi channel test facility was analyzed using RELAP5/MOD3.2 and RELAP5/CANDU[1]. The RELAP5 has been developed for the use in the analysis of the transient behavior of the pressurized water reactor. A recent study showed that the RELAP5 could be feasible even for the simulation of the thermal hydraulic behavior of CANDU reactors. However, some deficiencies in the prediction of fuel sheath temperature and transient behavior in athe headers were identified in the RELAP5 assessments. The RELAP5/CANDU has been developing to resolve the deficiencies in the RELAP5 and to improve the predictability of the thermal-hydraulic behaviors of the CANDU reactors. In the RELAP5/CANDU, critical heat flux model, horizontal flow regime map, heat transfer model in horizontal channel, etc. were modified or added to the RELAP5/MOD3.2. This study aims to identify the applicability of both codes, in particular, in the multi-channel simulation of the CANDU reactors. The RELAP5/MOD3.2 and the RELAP5/CANDU analyses demonstrate the code's capability to predict reasonably the major phenomena occurred during the transient. The thermal-hydraulic behaviors of both codes are almost identical, however, the RELAP5/CANDU predicts better the heater sheath temperature than the RELAP5/MOD3.2. Pressure differences between headers govern the flow characteristics through the heated sections, particularly after the ECI. In determining header pressure, there are many uncertainties arisen from the complicated effects including steady state pressure distribution. Therefore, it would be concluded that further works are required to reduce these uncertainties, and consequently predict appropriately thermal-hydraulic behaviors in the reactor coolant system during LOCA analyses.

Key Words : thermal-hydraulics, RD-14, RD-14M, RELAP5/CANDU, CANDU, LBLOCA, RIH

1. Introduction

There are more than 20 CANDU reactors completed or under construction worldwide and four CANDU nuclear power plants (NPPs) have been operated at Wolsong site in Korea, i.e. Wolsong unit 1,2,3 and 4. Recently, the effectiveness of emergency core cooling system (ECCS) and the core cooling in the absence of flow[2,3,4] have been considered as "generic safety issues" identified by the Canadian regulatory body, CNSC, as being applicable to all or most of the CANDU NPPs in Canada. To provide information on the effectiveness of ECCS in a CANDU reactor, various series of experiments has have been carried out in the RD-14 [6] pressurized water loop at the Whiteshell Nuclear Research Establishment from 1984 to 1987. As a following experimental facility, the RD-14M [7] had been constructed and operated since 1988 to simulate the multi channel behavior.

In previous study [5], several experiments performed in RD-14 facility were analyzed using RELAP5/MOD3.2 [10] and the applicability of RELAP5 in the area of CANDU analyses was demonstrated but some discrepancies were also observed. In the RELAP5 critical header break analysis, there were some discrepancies in the header pressure prediction after ECI injection, sheath temperature behavior, and channel flowrate. These discrepancies were due to the complicated behavior of CANDU specific features such as feeders, headers, and horizontal core channels, etc. In order to analyze the CANDU NPPs more accurately, the CANDU specific models needed to be developed. The RELAP5/CANDU [1] code has been developed since 1998 to give better prediction in the assessment of thermal-hydraulics behavior in an accident condition of CANDU reactor and now still under development. This code has been modified or added in the area of CANDU specific phenomena to the RELAP5/MOD3.2. The important models were selected among the modified or new model using mathematics and engineering judgement based on experimental phenomena. However, it has not been fully assessed for the CANDU reactor.

The present study aims to identify the applicability of the RELAP5/MOD3.2 and the RELAP5/CANDU in the assessment of multi-channel behaviors of the RD-14M tests. The multi channel experiment B9401 [7] was analyzed using the RELAP5/MOD3.2 and the RELAP5/CANDU and compared with the test results. The test B9401 is a 30mm reactor inlet header break experiment with high pressure pumped emergency coolant injection.

2. Descriptions of Facility, Test and RELAP5/CANDU

2.1. RD-14M Facility Description [7]

RD-14 was designed and constructed starting 1981. The RD-14 reference design chosen was two, 5.5 MW, 2-pass with 37-element single channel, (i.e., one channel per pass), with 1:1 scaling of vertical distances throughout the loop. This determined the sizing of piping and various components (e.g., steam generators, pumps, headers). The values for various loop parameters dictated by the choice of reference design were 5.5 MW maximum thermal power per pass, 590 kW/m maximum surface heat flux per pass and 24 kg/sec rated flow rate (one 37-element channel).

The modification of RD-14 to RD-14M provides for the study of the interaction of multiple heated channels in parallel in a full height loop. As multiple channels, five 7-element heated sections per pass were chosen to replace the single, 37-

Table 1 Comparison of Characteristics of RD-14, RD-14M and CANDU Reactor

Parameters	RD-14	RD-14M	Typical Reactor
Operating Pressure (MPa)	10	10	10
Loop Volume (m3)	0.95	1.01	60.
Heated Sections:	37-rod bundles	7-rod bundles	37-element bundle
Number per pass	1	5	95
Length (m)	6	6	12 x 0.5
Rod diameter (mm)	13.1	13.1	13.1
Flow tube Dia. (mm)	103.4	44.8	103.4
Power (kW/channel)	5500.	3x750, 2x950 per pass	5410.
Pumps:	single stage	same as RD-14	same as RD-14
Impeller diameter(mm)	381	381	813
Rated flow (kg/s)	24.	24.	24. (max/channel)
Rated head (m)	224.	224.	215.
Specific speed	565.	565.	2000
Steam Generators:	recirculating U-tube	same as RD-14	same as RD-14
Number of tubes	44	44	37/channel
Tube diameter I.D.(mm)	13.6	13.6	14.8
Secondary heat-transfer area (m2)	41	41	32.9/channel
Secondary Volume (m3)	0.9	0.9	0.13/channel
Heated Section-to-Boiler Top Elev. Difference (m)	21.9	21.9	21.9

element channel. The cross sectional area of the associated below header pipe-work was scaled at 7:37 to preserve heat and mass fluxes in the multi-channel facility. The detailed comparisons between RD-14 and RD-14M are described in table 1.

As noted in reference [7], the large number of non-dimensional groups to be considered precludes the scaling of two-phase flow dynamics with complete similarity. However, if the model is made of a similar solid material and has a similar fluid under the same system pressures as the prototype, scaling is simplified. Reference [7] presents an appropriate set of similarity criteria to be used under such conditions. Using 1:1 scaling of vertical elevations and axial lengths simplifies the scaling of the facility. It is appropriate to choose the piping diameters such that the flow velocities will be scaled at 1:1. This ensures that the characteristic transit times will be approximately equal in both the facility and the reactor.

In RD-14M, consideration was given to the several experimental programs in the design of the loop, the loop peripherals and the loop instrumentation. The experimental programs were categorized into three groups, safety-type transients, process dynamics and control-type transients, and component-type transients.

2.2. Description of Experiment ([7],[8])

A series of experiments to investigate the thermal-hydraulic responses of critical break with emergency coolant injection were progressed in the RD-14M test facility. The experiment used in this study is B9401 experiment - 30 mm inlet header break experiment with high pressure

Table 2. B9401 Test (30mm RIH) Procedure

B9401 Time	RELAP5 Time	Event Description
0	0.	start data gathering
10	10.	open break valve, p14 start
12	12.	step input power to decay level and RCP ramped down
20.6	23.5	ECI isolation valve open
22.8	22.8	Pressurizer tank (surge tank) isolated
116.2	116.2	HP ECI terminated, LP ECI start
231	231.	Primary pumps off
350.7	350.	LP ECI terminated
400.0	400.0	End

pumped emergency coolant injection.

The nominal initial conditions for the first experiment in this series, B9401, were 10.0Mpa(g) outlet header pressure, 4.0MW per pass nominal input power, 4.4 Mpa(g) steam pressure, and 186℃ feed water temperature. Before the experiment, the loop was evacuated, filled and degassed, all instrument lines were vented, and instrument readings were checked and adjusted. The loop was warmed using low power and reduced pump speed. Input power and pump speed were then increased to bring the loop to the desired steady-state single phase starting conditions. The detailed sequence of events during the experiment was described in Table 2.

A programmable pump-speed controller was used in this experiment to simulate pump rundown following a loss of class-IV power. The pump began ramping down at 12s. Cold water was injected into the loop when the primary pressure fell to or below the emergency coolant injection (ECI) pressure. The isolation valves at the ECI pipes to all four headers were opened as soon as the pressure in header 7 fell below 5.5 MPa. As long as the pressure in any header was above 5.5 MPa (pressure in the ECI tank), no ECI water entered that header. When the pressure in any header was below 5.5 MPa, ECI water entered the header at a rate determined by the pressure difference between the ECI tank and the header. Orifices in the ECI injection lines provide scaled simulation of reactor injection flow rate. This experiment was focused on multi channel behavior such as sequential reflooding, unbalanced ECI, etc and this will be described in the result.

2.3. RELAP5/CANDU Code Description [1]

As described in the above, the assessment results [5] of the RELAP5 in the RD-14 tests indicated some deficiencies in the prediction of the heated section sheath temperatures etc. Therefore, the development of RELAP5/CANDU code has been initiated by Korea Institute of Nuclear Safety cooperated with Korea Atomic Energy Research Institute to reduce the identified deficiencies. The RELAP5/CANDU is currently under development. The modifications were performed as following procedure;

1) RELAP5/MOD3.2 gamma version was selected as base code.
2) Identify important process and phenomena in CANDU
3) Prioritization of the selected process and phenomena using engineering judgment
4) The selected and prioritized items were divided into two groups, which were LOCA and non-LOCA, and perform the modification.

Table 3. List of Relevant Initial Conditions Measured and Calculated for the RD-14M, B9401 Experiment

No	QUANTITY	UNIT	Experiment	RELAP5 Calculation	RELAP5/CANDU Calculation*
1	Pressurizer pressure	MPa	9.9	10.05	10.05
2	HD5 pressure	MPa	10.0	10.0425	10.0425
3	DP (HD8-HD5)/(HD6-HD7)	MPa	1.3-1.5	1.5/1.52	1.5/1.52
4	SGs pressure	MPa	4.5	4.4	4.4
5	MCP1 flowrate	Kg/s	21.9	21.6	21.6
6	MCP2 flowrate	Kg/s	21.6	21.7	21.7
7	HS5 mass flowrate	Kg/s	4.0 - 4.1	4.07	4.07
8	HS6 mass flowrate	Kg/s	4.0 - 4.1	3.9	3.9
9	HS7 mass flowrate	Kg/s	4.5 - 4.8	5.1	5.1
10	HS8 mass flowrate	Kg/s	4.5 - 4.8	4.9	4.9
11	HS9 mass flowrate	Kg/s	4.0 - 4.1	4.0	4.0
12	HS10 mass flowrate	Kg/s	3.9 - 4.0	4.16	4.16
13	HS11 mass flowrate	Kg/s	4.0 - 4.0	4.02	4.02
14	HS12 mass flowrate	Kg/s	4.5 - 4.8	5.00	5.00
15	HS13 mass flowrate	Kg/s	4.5 - 4.8	4.98	4.98
16	HS14 mass flowrate	Kg/s	3.9 - 4.0	3.9	3.9
17	SG1 SL flowrate	Kg/s	1.9	2.7	2.7
18	SG1 FW flowrate	Kg/s	2.1	2.7	2.7
19	SG2 SL flowrate	Kg/s	2.0	2.7	2.7
20	SG2 FW flowrate	Kg/s	2.5	2.7	2.7
21	SG1 DC flowrate	Kg/s	-	13.3	13.3
22	HD5 / HD7 fluid temperature	°C	295	295-296	295-296
23	HD8 / HD6 fluid temperature	°C	262	261-262	261-262
24	SG1 DC bottom fluid temperature	°C	- 255	255	
25	FW temperature	°C	187	183	183
26	Void fraction at HS5 outlet	-	-	0.	0.
27	Void fraction at HS8 outlet	-	-	0.	0.
28	MCP speed	rpm	350	372	372
29	SG1 DC level	m	8.7	9.2	9.2
30	PRZ level	m	1.27	1.31	1.31
31	Core total power	Mw	8.14	8.14	8.14

*** RELAP5/CANDU Steady State Reached Conditions are Exactly Same as the RELAP5 Because the Same Restart Plot File was Used**

Until now, the modified and the added models for RELAP5/CANDU are as follows;

1) Critical Flow Model
2) Nuclear Kinetics Model
3) Critical Heat Flux Model
4) Control Model
5) Valve and Spray Model
6) Improvement of Horizontal Flow Regime Map
7) Heat Transfer Model in Horizontal Channel

3. RELAP5 System Model

System models for RELAP5 calculation are shown in Figure 1 and 2, which are basically similar ones found in CATHENA [2,3,4] and therefore may help reduce the effect of nodalization. The system model composes of primary heat transport system including heaters and pumps, secondary system, ECI system, accumulator, and break model. ECI model utilized time dependent volume and time dependent junction and the amount of ECI flow is determined by the system pressure. The heater power distribution profile is assumed flat. The same nodalization was also used to RELAP5/CANDU analysis. In RELAP5/CANDU, seven rods heater section is divided into three-heat structure - two rods in upper, three rods in middle and two in lower but in the case of RELAP5, whole rods are modeled as one heat structure.

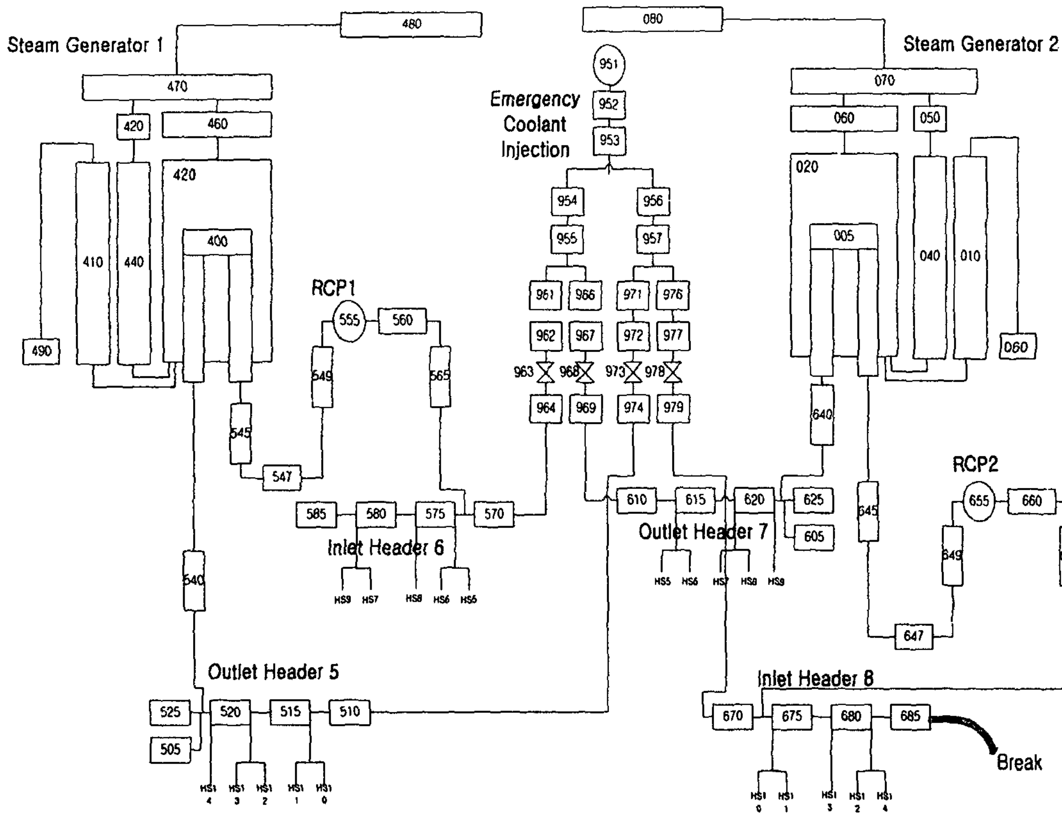

Fig. 1. RD-14M Nodalization Using RELAP5

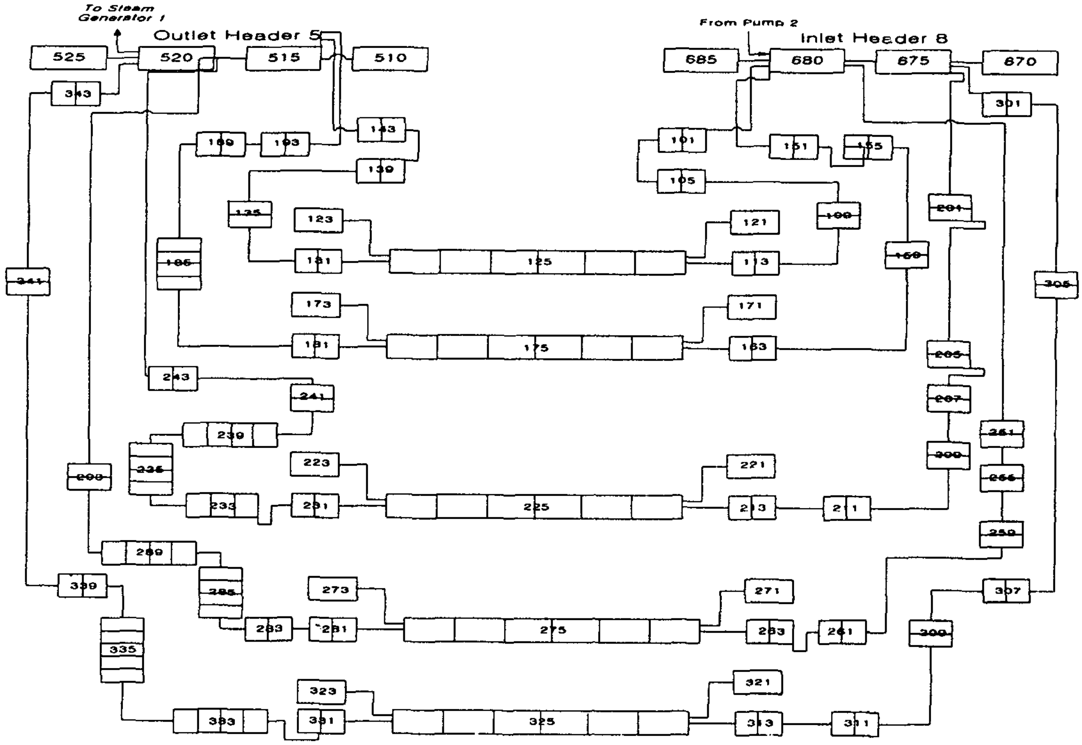

Fig. 2. RD-14M Nodalization of Headers and Feeders Using RELAP5

4. Analysis Results and Comparisons

4.1. RELAP5/MOD3.2 Results

4.1.1. Header Pressure Behavior

B9401 experiment did not measure the break flow, and the pressure behavior was only way to estimate whether the break flow was calculated correctly or not. Generally, break flow quality could vary according to the upstream conditions and depressurization characteristic through the break piping. Initially, the break flow was liquid single phase and the inventory loss was larger than other phase. As primary heat transport system pressure was reduced and the vaporization was occurred, the break flow had vapor. As the void fraction of break flow increases, the break mass flowrate decreases due to decreasing mass flux.

The experiment started at 10 seconds as the valve was opened and RCP (Reactor Coolant Pump) trip and reactor trip occurred at 12 seconds. The break was located in inlet header 8. After the break initiated, the primary system pressure rapidly decreased as the inventory lost. Due to void generation, the slope of the depressurization rate decreased and few seconds later depressurization rate recovered as the ECI injection delivered into the HTS.

In view of depressurization rate, header depressurization is largely determined by break discharge rate and, later it is affected by ECC injection. Emergency coolant injection begins when the selected header pressure drops below the pre-determined injection pressure (header 7, 5.5 MPa). Header pressures determine when and

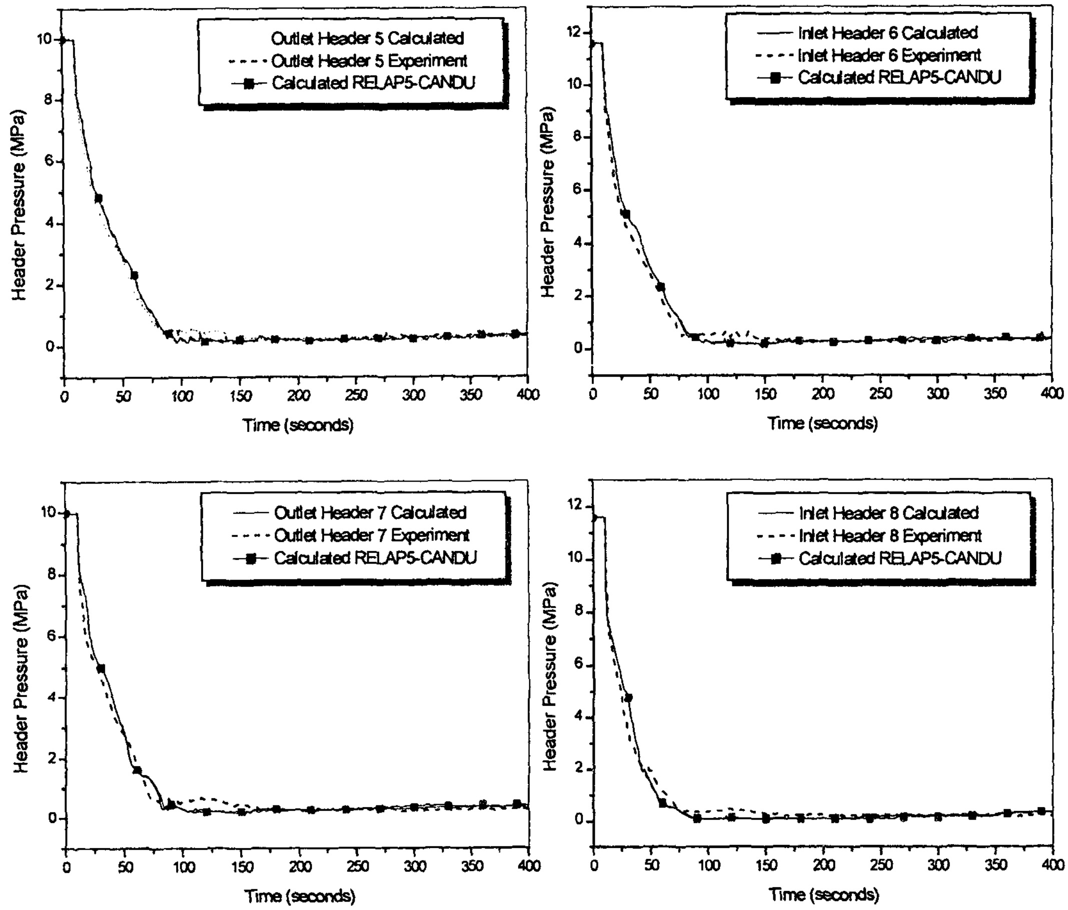

Fig. 3. Header Pressure Behaviors

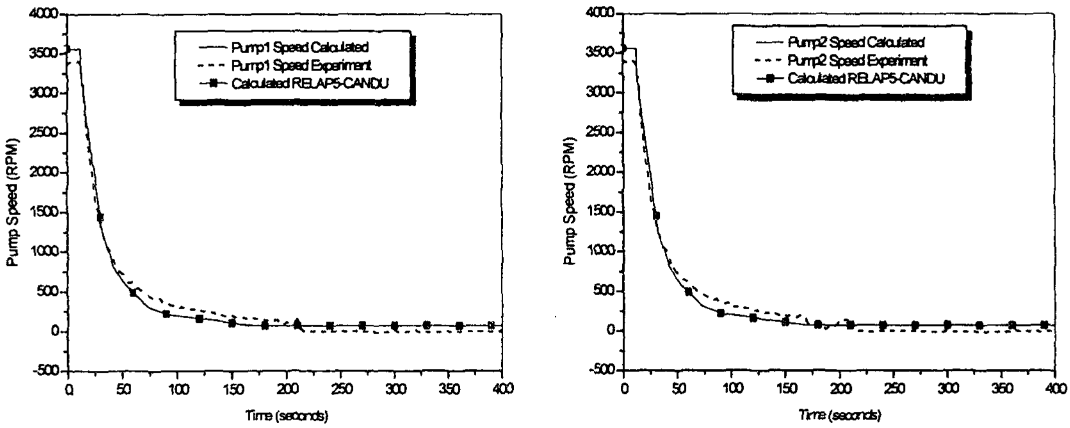

Fig. 4. PHT Pump Speed

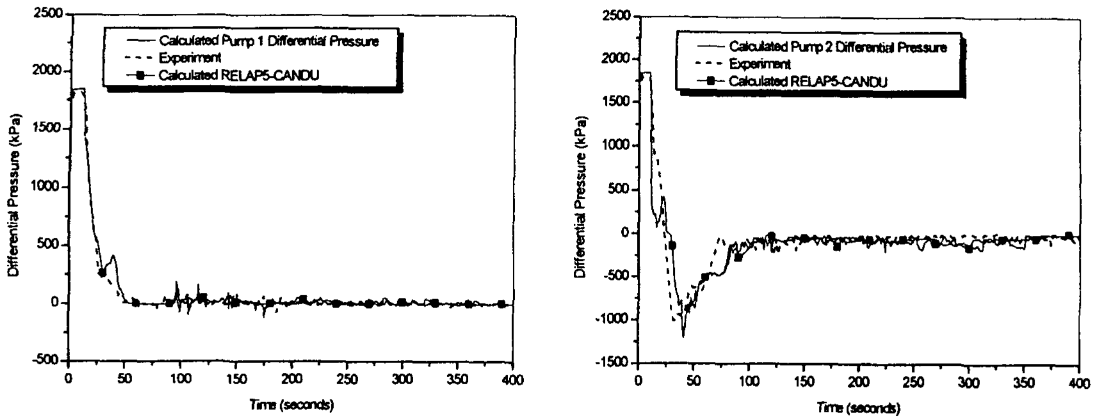

Fig. 5. PHT Pump Differential Pressure

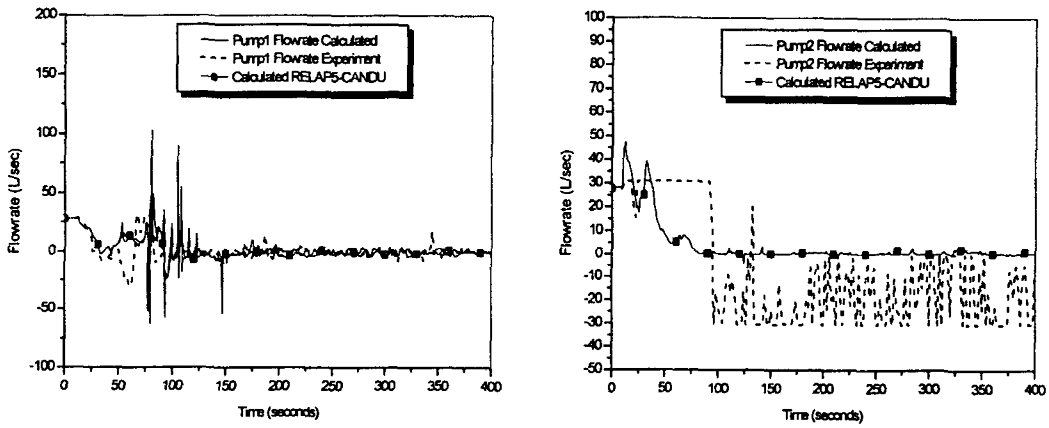

Fig. 6. PHT Pumps Flowrate

at what flowrate the ECC flow enters each header. Since header 8 is the broken header, it has the fastest depressurization rate of the four headers during the blowdown. Header 6 is farthest from the broken header, and has the slowest depressurization rate. Header 7 is an outlet header, and has a depressurization rate between those of header 6 and header 8. Typically, in Figure 3, the header pressure calculated by RELAP5, shows the reasonably good prediction in all headers and the above characteristics were reasonably well shown.

During the break, the primary pump speeds are reduced and ECC flow is initiated causing flows to change dramatically in the primary heat transport system. Header differential pressures (DP) provide an overall indication of flow directions in the below-header portion of the loop (inlet feeders, outlet feeders and heated sections) during the blowdown transient. In Figure 7, RELAP5 predicted the differential pressure between headers reasonably. During this study, it was found that the minor pressure distribution trend differences in steady state would make relatively large differences in transient. In CANDU analysis, steady state pressure distribution should be treated more carefully than that of PWR (pressurized water reactor).

4.1.2. Primary Pumps Behavior

Primary loop coolant circulation was provided by two high-head centrifugal pumps. As mentioned earlier, the primary pumps were ramped down starting at 12 s. In Figure 4,5,6, the oscillations were occurred, but the overall behavior was correctly predicted. In view of differential pressure (Figure 5), the primary pump 1 shows positive differential pressure during blowdown, and the flow direction was negative. On the other hand, the primary pump 2 shows negative differential pressure, and the flow direction was positive. These differential pressure histories of primary pump 1 and 2 behave correctly and good agreement of flow directions and amount of pressure differences across the pumps during the blowdown transient.

As shown in Figure 4, pumps were coast down after pumps tripped. In Figure 6, the pump1 outlet flow decreased due to the pump coast down, and the forces between driving force resulted from break mass flow and pump cost down force was balanced during a few seconds. The flow direction was reversed because the flow split was occurred near pump1 location. For this reason, the flow transient in this location was relatively mild compared with pump2. In the case of pump2, the flow was changed dramatically as the pump2 location was near the break (header 8). The pump2 outlet flow was maintained during the ECI injection was made because the injected ECI water was should spilt out through break but in experiment, the pump outlet flow showed very small flow. It seems that the differences arised from calculation and some errors should exist in calculation. On the other hand, in experiment, the flowmeter' s measuring capability seemed to be limited by 30 L/sec. This limit is very small value to measure those large quantities and, in the reference [7], it is described that the pump2 out flow meter was out of order. The calculation parameters except pump1 and pump2 outlet flows show good agreement with experiment. Generally, in many experiments, the differential pressure is measured instead of the amount of flow and the pump differential pressure is more important parameter because measurement of flowrate has large uncertainty. As shown in Figure 5, the pump1 and pump2 differential pressure were well predicted by the code.

4.1.3. Header ECI Flowrate Behavior

In RD-14M and CANDU NPP, the ECI coolant delivered into each headers and the coolant could cool the heater section. The timing of ECC flow to each header should be different because the system piping are more complex than that of pressurized water reactor and the depressurization behaviors of each header should be different. ECC flowrate to each header are important for analyzing ECC system behavior, and more important, for analyzing the fuel channel behavior. Actually, ECI injection in RD-14M was actuated when header 7 pressure was decreased below 5.5 MPa. After initiation of break at header 8, the header 7 pressure continuously decreased under 5.5MPa at 23.5 seconds. As shown in Figure 8, the calculated ECI flow behavior including injection signal generation time well predicted, but the initiation timing differences were shown in outlet header 5 and 7. In RD-14M calculation, the timings of ECI coolant delivery in each header were determined by the pressure distribution along the piping network including transient two-phase situation. These discrepancies might be arisen

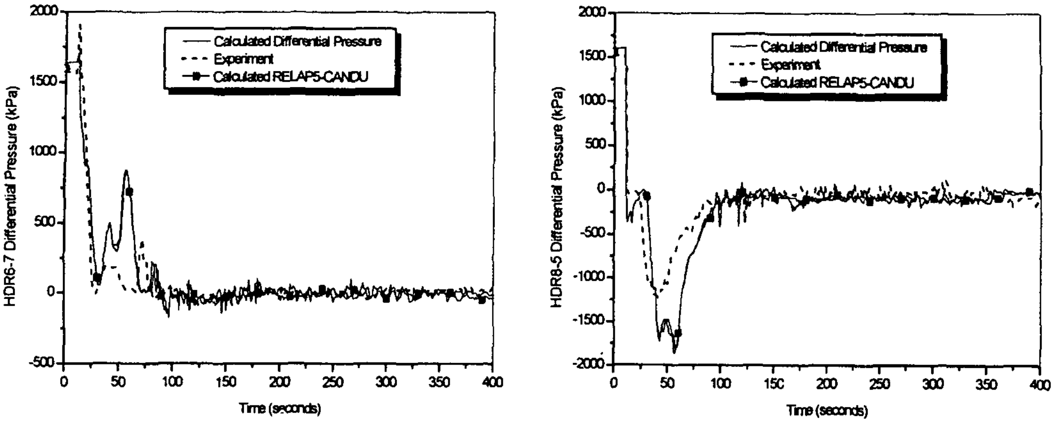

Fig. 7. Header Differential Pressure

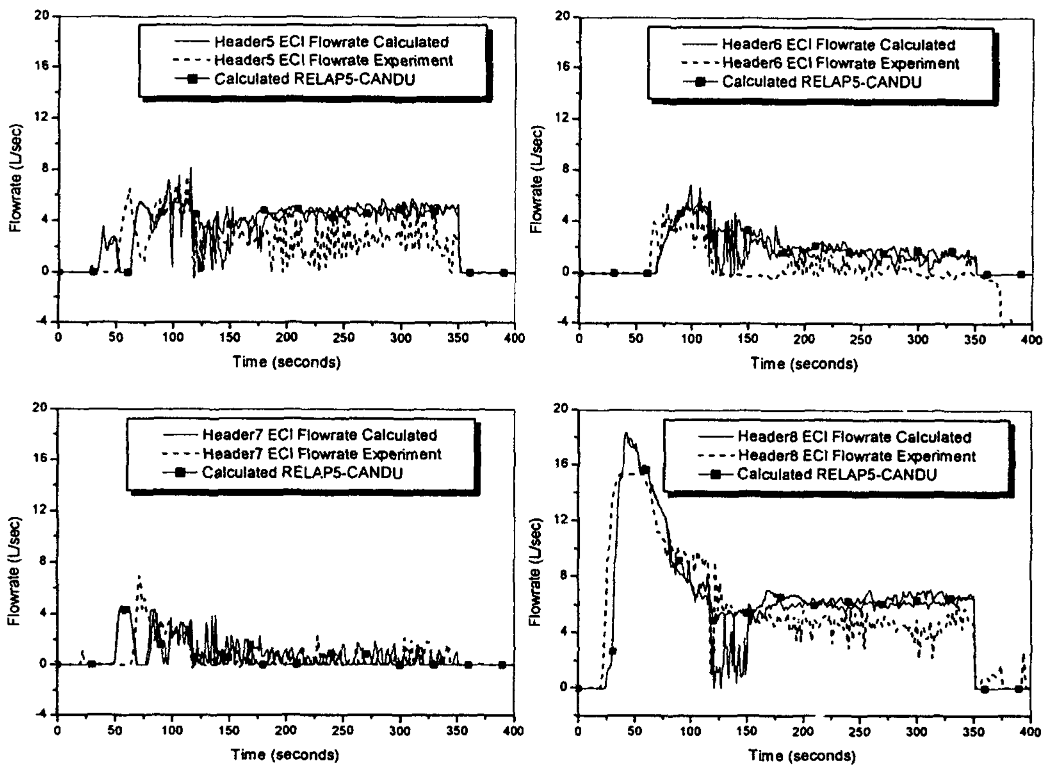

Fig. 8. Headers ECI Flowrate

from the complicated effects, such as small two-phase pressure drop, header model itself, initial/transient pressure distribution in piping network, horizontal flow hydraulics and the predictability of steam condensation, etc.

In view of flow split, header 8 ECI flow was much larger than that of the others because the header was break header. The ECI flow of header

7 was much smaller than that of 5 and 6 as the ECI injection piping connected to header 7 and 8 were included in single branch. The ECI injection lines to 4 headers were grouped - the first is 5 and 6 and the second is 7 and 8. The pressure difference inside second group is much larger than that inside first group and the almost all of ECI water that would be injected into header 7 was injected to header 8. These flow-splitting behaviors among headers were well predicted.

4.1.4. FES (Fuel-Element-Simulator) Sheath Temperatures Behavior of Heated Section

The maximum FES sheath temperature, usually called "Clad Temperature", is often the most important parameter in accident analyses. In test B9401, the maximum FES sheath temperatures occur in the high power channel of the critical (broken) pass, heated section 13 (HS13). The FES temperature excursions in HS13 began immediately at initiation of the break as flow in this channel dropped significantly to a very low value (stagnated channel). The FES temperatures initially rose quickly and then slowed as the heated channel power was reduced to decay levels beginning at about 12 s. Shortly after the onset of the high-pressure ECC injection phase, quenching began as ECC water arrived at the channel. The measured maximum FES temperature is observed at the top pin in the middle of HS13. In Figure 9, the calculated temperatures are not varied through the elevation but varied through the horizontal axis because RELAP5 cannot simulate heat structure elevation difference in the case that the horizontal heat structures exist in one hydraulic volume. Those behaviors can be observed in comparing

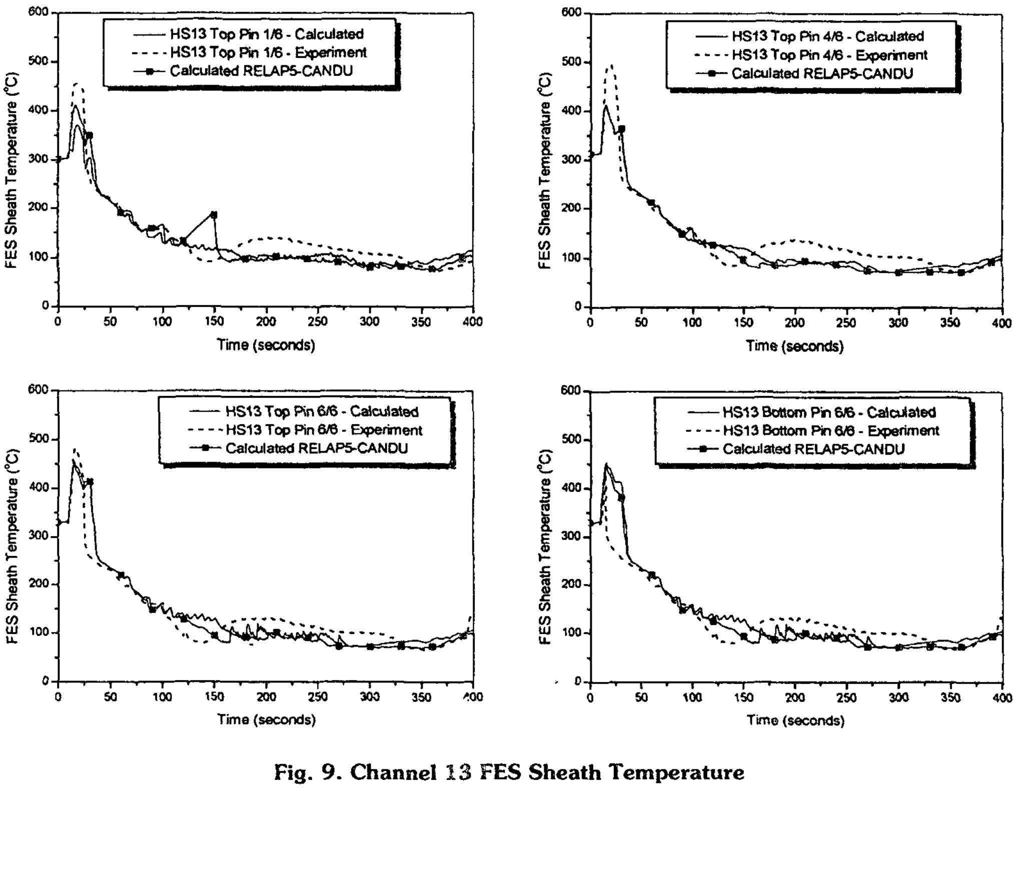

Fig. 9. Channel 13 FES Sheath Temperature

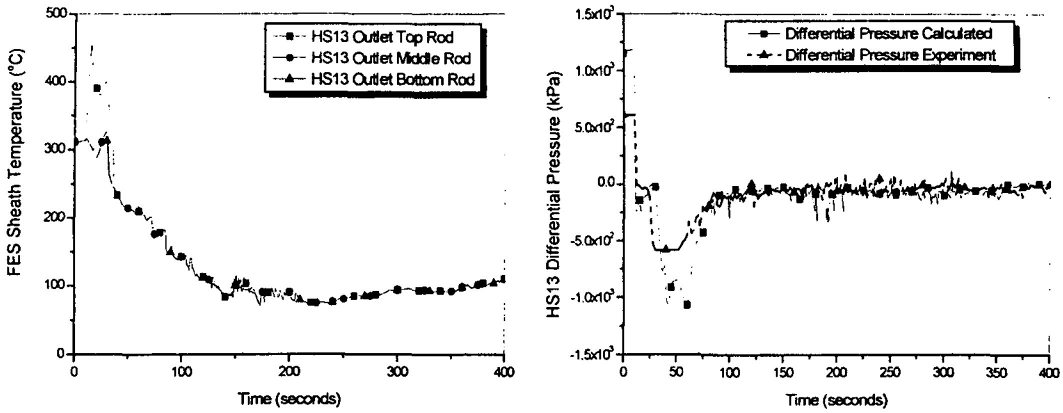

Fig. 10. HS13 FES Sheath Temperature and HS13 Differential Pressure

"HS13-Top pin 6/6" and "HS13-Bottom pin 6/6" of Figure 9. As described in the above experiment, the maximum FES sheath temperature occurred in middle of fuel channel but the maximum temperature location was predicted as outlet. Maximum temperature is also different, 451°C (RELAP5) and 496.7 °C (B9401). It seems that these disagreements arised from the horizontal flow regime and heat transfer calculation, especially, horizontal quenching or reflooding phenomena.

4.1.5. Pressure Drop Behavior Across HS13

In the case of LOCA, the force balance between driving force from break and inertia including pressure loss makes a flow split phenomenon occur. In test B9401, a flow split occurs in at least some of the heated sections of the broken pass following the break. During the initial stage of the flow split, single-phase liquid flows out both ends of the heated section while rapid voiding of the channel occurs. Channel differential pressure, representatively HS13, provides an indication of the flow direction in the channel. In Figure 10, HS13 differential pressure shows that calculated pressure has delayed about 10 seconds due to early initiation of ECI injection into header 5 but overall behavior agreed with experimental results well.

4.2. RELAP5/CANDU Results

In the assessment of the RELAP5/CANDU, nodalization and test condition, etc. were used exactly same as the RELAP5 case. In previous section, header pressure, primary pump, pressure drop across HS13, header ECI flowrate behavior, and FES (Fuel-Element-Simulator) sheath temperatures of heated section were discussed and the limited discussions were made in the area of significant differences.

In view of pressure and pump behavior, there were no differences between two cases because the models which affect pressure behavior were not modified in the RELAP5/CANDU. In the case of fluid temperature, overall behavior showed good agreement with experiment but temperature transient became smooth due to error correction in steam table. The effect of the elevation of fuel rod was shown in Figure 10. The heat transfer rate is larger than that of experiment and the heat

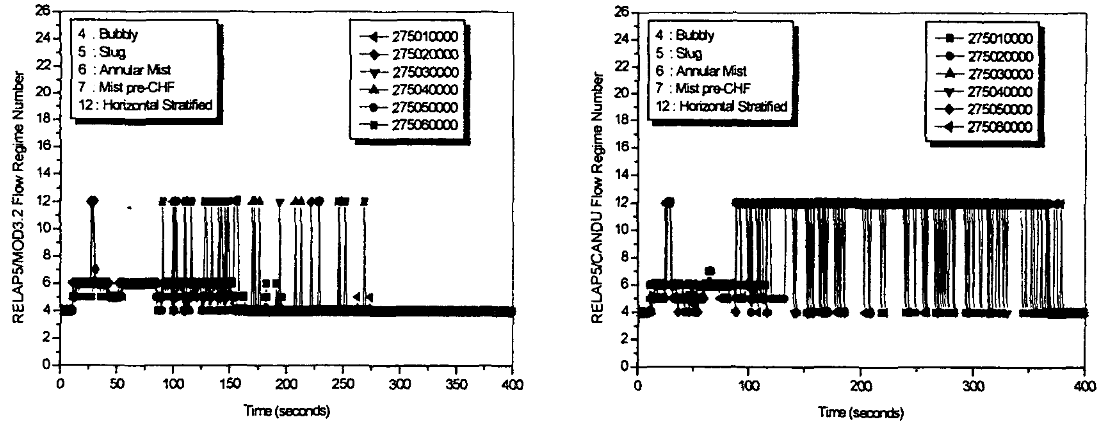

Fig. 11. Flow Regime Comparison

transfer regime under stratified flow condition should be reviewed. On the other hand, during the initial period, the stratification was not significant, and the differences could not be shown. In FES (Fuel Element Simulator) sheath temperature, the hydraulics inside channel was different.

In Figure 11, the RELAP5/CANDU calculation result shows that "horizontal stratified flow" regime appeared more frequently than that of RELAP5/MOD3.2. The "bubbly flow" regime was very frequently appeared during "horizontal stratified flow" due to the mass flux change. The transition criteria between "horizontal stratified flow" and "bubbly flow" regime were already considered in the course of channel model development but will be reviewed again more carefully.

In peak sheath temperature, 464.7° C was observed in exit node of HS13. This temperature was slightly higher than that of the RELAP5/MOD3.2 but it was occurred in the same location. This means that the channel model did not affect the temperature behavior in initial stage and the effect due to channel model may be shown in the later stage when the stratification was dominant. However, the proper investigations were not made because the experiment had no significant temperature excursion in later stage.

4.3. Other Sensitivity Results

4.3.1. Feeder to End Fitting Connection Modeling

In view of pressure, the most significant difference in pressure loss under two-phase condition was nodalization in feeder connection. Originally, the junctions between feeders and test sections were modeled as normal junction without cross flow option but this nodalization predicted unreasonable pressure buildup at the middle of depressurization periods. In this study, in order to simulate the geometry as close as the real situation, the junctions were modeled by cross flow junction model that was neglects 'To-volume' momentum. In the case of normal junction, the pressure drop was adjusted by user input, 'Form Loss'. These two cases were not different during steady state calculation but, in transient under two-phase condition, the system behavior became different. Typically, Figure 12 represents the differences among two calculations and

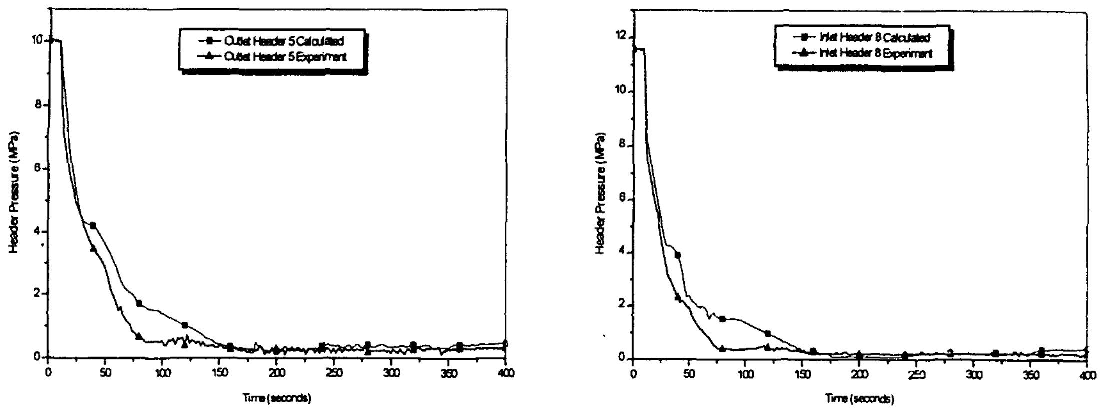

Fig. 12. Pressure Behavior without Cross Flow Option and Fine Loss Adjustment

experiment and the differences of depressurization started at around primary coolant saturation point. This means that the modeling differences allow the depressurization characteristics change.

4.3.2. Break Upstream and Downstream Nodalization and Hreak Flow Model

This nodalization changes were not significant because the system behaviors were governed by the driving forces arising from pressure gradient. Small difference of break flow was not much effective in overall system behavior.

5. Conclusions

RELAP5/MOD3.2 and RELAP5/CANDU simulations of the 30mm inlet header break test in the RD-14M multi channel facility have been performed, preliminarily with an aim to identify the code applicability in a CANDU multi-channel system in comparison with the experimental results. Both codes predicted reasonably the main phenomena occurring in the transient. The conclusions from the present work are summarized as follows:

1) The RELAP5/MOD3.2 predicts reasonably overall thermal-hydraulic behaviors in the multi-channel inlet header break test.
2) Pressure differences between headers govern the flow characteristics through the heated sections, particularly after the ECI. In determining header pressure, there are many uncertainties, arisen from the complicated effects including vaporization/condensation in a small volume, steady state pressure distribution etc. Therefore, it would be concluded that the pressure drop and distribution through headers and channels are more important than that of PWR experiment.
3) The RELAP5/CANDU can show the effect of the elevation of fuel rod on the sheath temperature prediction by using 3 heat structure models for top, middle, and bottom elevations.
4) In B9401experiment, the stratification in the channel and the header was not quite dominant. An experiment where the stratification occurred dominantly such as LOCA without ECI, could be analyzed in the near future to examine the channel model in the RELAP5/CANDU.

Acknowledgement

This work was supported partially by the IAEA under "INTERCOMPARISON AND VALIDATION OF COMPUTER CODES FOR THERMALHYDRAULIC SAFETY ANALYSIS OF HEAVY WATER REACTORS". Special thanks go to Dr. Robert Lyon of IAEA and Dr. David Richard of AECL for their help and support in this study.

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